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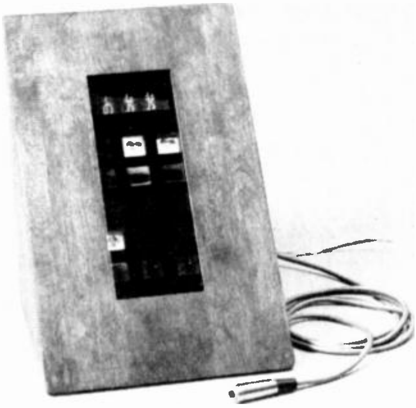
JULY 1977 Vol. 48 No. 7

ON THE COVER

Another great construction project from **Radio-Electronics.** This one updates your TV set with an on-screen digital readout of the time. The clock is built around a character generator from National Semiconductor that provides you with a choice of either a 4- or 6-digit readout of the time. Get started today; turn to page 35.



ELECTRONIC SLOT MACHINE you'll want to build. Digital readout of the score plus realistic odds makes this a great addition to your game room. Construction details start on page 39.

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looking ahead

First 1978 TV's: General Electric was first to demonstrate its new 1978 TV-set models, and they're highlighted by the addition of a random-access digital remote tuner linked to the set by infra-red light rather than ultrasonics. The calculator-like remote tuner uses an 82-channel digital frequency synthesizer, using phase-locked-loop (PLL) circuitry with a quartz crystal reference to select VHF and UHF channels. The tuning panel also contains volume, off-on and mute controls, and adds about $140 to the price of the set as compared with a mechanically tuned non-remote version.

G-E has also extended the VIR "broadcast-controlled" color feature to more sets in its line, and most of its color sets without VIR have a different automatic color system, which G-E hints is directly competitive with RCA's ColorTrak and Zenith's Color Sentry.

RCA chooses: Once again, RCA and Zenith find themselves on opposite sides of the fence. You'll recall that Zenith chose to market the new Sony-developed Betamax system that records two hours on the same cassette. (**Radio-Electronics**, May 1977.) Now RCA has selected a different, non-compatible system, but one that can cram four hours of recording onto a single cassette not much larger than that used in the Betamax.

RCA's system is the VHS, developed by Japan Victor Co. (JVC) as the leading contender against Betamax. However, the version picked has been re-engineered by JVC's parent company, Matsushita Electric, and the tape speed cut in half and track width reduced, with a special noise-reduction circuit added to maintain a signal-to-noise ratio comparable to that of the shorter-playing machine. This is believed to have been accomplished in a manner similar to Sony's speed-reduction program—in fact, Matsushita and Sony are both members of a patent-pooling consortium for home videocassette recorders.

The machine that RCA will introduce late this summer has outstanding tape economy. Since the half-inch tape loafs along at about 0.66 inches-per-second, it uses only about 8.35 square feet of tape per hour in the four-hour mode (it has a two- and four-hour switch), as compared with 10.3 square feet for the two-hour Betamax.

When marketing of the two new machines begins in earnest this fall, it should result in a battle royal, keyed by the ancient Zenith-RCA rivalry. Prices hadn't been announced at presstime, but it's logical to expect the machines to list at $1,000 or more—at least until competition brings them down. Meanwhile, other manufacturers are choosing up sides, and will offer one system or the other—either manufacturing them themselves or buying the decks, as RCA and Zenith plan to do.

In the Sony "Beta format" camp are Sony, Zenith, Sanyo, Toshiba, Pioneer and Sony subsidiary Aiwa. Siding with Matsushita are RCA, Matsushita's subsidiaries Panasonic and JVC, Hitachi, Mitsubishi (MGA) and Sharp. Uncommitted U.S. TV manufacturers include Magnavox and Sylvania, expected to make up their minds soon, and G-E, which may wait till the dust settles.

If you've already bought a one-hour Betamax, Sony is expected to help you extend its recording time with the offer of a two-cassette changer. Although two of Matsushita's American subsidiaries—JVC and Panasonic—are expected to offer the VHS machine here, the third, Quasar, is continuing to market a third system that it calls The Great Time Machine with a two-hour recording time per cassette but incompatible with the other two systems.

Games via cable: Subscribers to Manhattan Cable TV now have the opportunity to match skill with each other in video games, thanks to an enterprising non-profit group called Experimental TV Cooperative (ETC). "The Game Show" is presented once a week on the cable system's public-access channel and lets viewers use Touch-Tone telephones in their homes to operate the games. Here's how it works: The viewer calls the phone number displayed on the screen and he's asked what extra game he wishes to play. After instructions on playing, the playing field is superimposed on the screen, and the caller competes against other callers.

In the game of pinball, the telephone's "1" button activates the right flipper, the "3" the left flipper. In Pong, pressure on "1" moves the paddle down, "3" moves it up. ETC President Dan Fodor, a studio engineer, designed and built the circuitry for the remote game-playing. It processes the frequency tone from the Touch-Tone phone and translates it from a digital to an analog signal for Pong—changes in voltage drive the paddle up or down. In pinball, the digital signal is used without conversion to analog. Other possibilities are being studied, and Fodor says he hopes to develop more complicated games using more Touch-Tone buttons.

And another one: One American and two German manufacturers have tentatively decided to build a completely different type of home videocassette recorder, but it's not expected to be available before 1979, if then. The manufacturers are Bell & Howell in the U.S. and BASF and Robert Bosch (Blaupunkt) in Europe. The system, developed by BASF, is called LVR (*L*ongitudinal *V*ideo *R*ecording). It uses ¼-inch tape with 28 parallel video tracks, moving past a stationary head at 120 inches-per-second. When one track has made a complete pass of the head, the tape reverses and the head is switched to the next track. After all 28 passes are completed, two hours of recording have been made in a single cassette. Claimed advantages of the system are simplicity and low cost. It's believed the LVR may not be offered as a competitor to Beta and VHS.

DAVID LACHENBRUCH
CONTRIBUTING EDITOR

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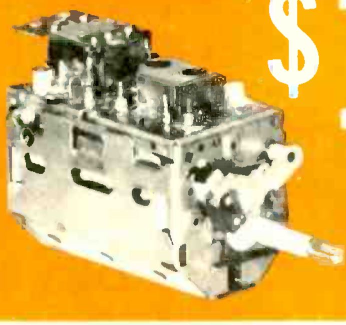

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Movie makers seek injunction against video recorder sales

MCA's Universal Studios and Walt Disney Productions are seeking a court order to stop the sales of Sony Betamax color TV recorders. The grounds: By selling machines capable of recording copyright material, Sony is unlawfully inducing the public to violate copyright law.

The suit seems odd because the law has recognized the individual's right to copy broadcast material ever since tape recorders came on the market. Sony counsel asserts that the movie makers, in licensing their productions for transmission "over the public airwaves," have given implicit consent to have them recorded for private noncommercial use.

According to Sony spokesmen, the film makers are attempting to enforce their copyright not to protect their material, but to pre-empt the market in audio-visual playback disc machines (in which MCA has a substantial investment) and to deprive the public of a technological advance which MCA has been unable to achieve.

The issue is important since Betamax is probably only the first of several video recorders that may appear in the near future. For example, Zenith plans to introduce a system based on Sony technology this year. RCA also has a record-playback system in the works, using Matsushita VHS (*V*ideo *H*ome *S*ystem) video cassette recorder/players built to RCA specifications. Both these items will probably appear late this summer.

If the movie makers succeed in their first strike against the video recorder, it is possible the matter may be carried as far as the Supreme Court, if necessary.

Scientists get atomic fusion with carbon dioxide LASERS

Researchers at the Los Alamos, NM laboratory have achieved fusion reactions on a small scale by bombarding fusion-fuel pellets with carbon dioxide (gas) LASER beams.

The pellets contain a mixture of deuterium and tritium, which join to form helium, giving off great amounts of energy in the process.

Obtaining energy by atomic fusion instead of by fission would have several advantages. A fusion plant would not produce the wide range of radioactive byproducts generated by fission plants; thus, containing radiation hazards would be simpler. The fuel supply would also be practically inexhaustible.

It had been thought previously that the carbon-dioxide type of gas LASER could not be used to produce fusion, that its beams would penetrate too deep into the fuel pellet before its heating effects would be felt. Experiments were therefore made with the much more costly and less efficient glass LASER. However, experiments demonstrated that the heating effect of a carbon dioxide LASER does actually take place near the pellet's surface. Thus the gas LASER, which is ten times as efficient while only one-fourth as expensive as a glass LASER, can be used.

The present experimental system has two converging beams, each delivering 200 joules of energy to the pellet in about one-billionth of a second. (200 joules is roughly the amount of energy required to lift 150 pounds one foot, or to raise 50 grams of water one degree Celsius.) It is expected that the power of each beam can be increased to 900 joules, and that more than two beams can be converged on the fusion fuel.

SMOKEY IN THE SKY

NUMBER ONE AIR BEAR is the handle of this good buddy, who combines CB with his regular work as a policeman and his hobby of flying and aircraft. (The gyrocopter he is flying is one that he made himself.)

National organization offers service manager certification

A certification exam and qualification program for consumer electronics service shop owners, managers and operators has been developed by NESDA, the National Electronic Service Dealers Association.

Called the Certified Service Manager (CSM) program, the examination will test the business knowledge and management skills of service managers and operators in such areas as customer relations, advertising and promotion, record keeping, financial understanding, demographics of the service business, personnel management, product sales, safety and shop layout and design.

Approval of the program was given at the NESDA House of Representatives meeting in Indianapolis in January.

Radio Commission tells boatmen how to get help when in trouble

The Radio Technical Commission for Marine Services has issued, in cooperation with the FCC, a 72-page handbook to help boat owners with marine radios use their equipment efficiently when they are in difficulties. "Knowing *how* to use your radiophone in an emergency could save your life or your boat," advises the Commission.

US Coast Guard ships and stations listen for calls on Channel 16 (156.8 MHz), the distress, safety and calling channel in the VHF/FM band, and on 2182 kHz in the medium-frequency band, which is now single sideband. Citizens band radios are not marine radiotelephones, and the Coast Guard does not monitor CB frequencies.

There are three emergency calls. Most urgent is MAYDAY (French: *m'aidez*, help me), used only if a vessel or its occupants is in "grave and imminent danger." The boatman, after checking to see that his

Continued on page 12

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continued from page 6

radio is on the right frequency, and that there is a break in the traffic, calls MAYDAY three times, gives his craft's name three times and his call sign once. He then gives his message, first telling where he is in relation to known land points. For example:

"MAYDAY, MAYDAY, MAYDAY. This is Blue Duck, Blue Duck, Blue Duck, WA-1234. MAYDAY, Blue Duck; Dungeness Light bears 185 degrees magnetic, distance two miles. Struck submerged object. Need pumps, medical assistance and tow. Three adults, two children aboard. One person compound fracture of arm. Estimate can remain afloat two hours. Blue Duck is a 32-foot cabin cruiser, blue hull, white deck house. Over."

PAN, the next most urgent call, is used when the safety of a vessel or its crew is threatened, as in the case of a man overboard. The SECURITY emergency call is used for an important weather or navigational warning.

NATESA Annual Convention will be held August 25–28

The 28th annual NATESA convention will take place at Carson's Nordic Hills Resort in Itasca, IL (between O'Hare Airport and Chicago) from Thursday, August 25 through Sunday, August 28. A full program of service business management and a "New in Technology" seminar will be blended with a program of interesting tours for the ladies and a visit to an area TV plant.

A single fee of $25 covers all functions. A special block of rooms (at a cost of $33 single and $38 double) have been reserved on a first-come first-served basis. As in the past, meals from Friday breakfast through Sunday brunch are being sponsored by major set manufacturers.

For details, write NATESA, 5908 Troy St., Chicago, IL 60629.

NESDA estimates more than 200,000 electronic service technicians

The number of electronic service technicians in the United States at the beginning of 1977 was 207,212, an increase of 5%, reports National Electronic Service Dealers Association in its annual Electronic Service Industry Business & Manpower Survey. The number of consumer electronics firms also increased, from 66,000 to 70,526, a gain of 6% over 1976.

The NESDA estimate is compiled from official state and city license board records. Since the participating license boards serve a population of 58,920,000, or about 28% of the total population, the extended figures are somewhat arbitrary. Nevertheless, they are useful in accounting for the demographic features of the service industry. For example, it was determined that:

1. Nearly 50% of the businesses are owner-operated, one-man shops.
2. Nearly 50% engage in product sales.
3. Many licensed technicians spend the greater part of their time in sales or management duties.
4. A majority of the businesses hire part-time service technicians to supplement their technical labor force.
5. Many businesses are operated by a technician who holds a full-time job elsewhere.
6. Because license fees are low ($10 in Indiana, for example) many carry a license rather than let it lapse, even though little or no time is devoted to service work.

EIA to run electronics seminars for high school instructors

Sixteen consumer electronics seminars in 14 states are being offered to high school and vocational instructors by the service committee of the Electronic Industries Association (EIA). The courses are designed to help teachers upgrade their curriculum in consumer electronic product service techniques; they emphasize diagnosis and repair of the latest consumer electronic solid-state and other products. Several schools also feature CB service techniques. College credit is offered for completion of the course.

Locations and dates are: Los Angeles Valley College, Van Nuys, CA, August 8–19; University of Northern Colorado, Greeley, CO, July 5–15; Morehead State University, Morehead, KY, July 18–29; Louisiana Vocational & Technical Institute, Shreveport, LA, June 27–30; Macomb County Community College, Warren, MI, June 20–23 and June 27–30; Bemidji State University, Bemidji, MN, July 5–9 and August 1–12); Appalachian State University, Boone, NC, June 20–July 1; East Tennessee State University, Johnson City, TN, July 18–29; Prince William County Schools, Manassas, VA, late summer; Peninsula Community College, Port Angeles, WA, June 20–July 1; Fairmont State College, Fairmont, WV, June 20–July 1; Milwaukee Area Technical College, Milwaukee, WI, July 11–22.

The summer seminar program is sponsored by the Consumer Electronics Show, the industry's biannual trade show, in cooperation with the Electronic Industries Association, Consumer Electronics Group. For a copy of the seminar schedule and contact names and telephone numbers write EIA/Consumer Electronics Group, 2001 Eye Street, N.W., Washington, DC 20006.

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letters

TELEPHONE ACCESSORIES

In my two articles on telephone accessories ("Turn-On Appliances Via Long Distance" appearing in the April 1977 issue and "Amplifier For Hands-Off Telephone" appearing in the May 1977 issue), you omitted a reference stating that these articles were extracts from my book *Telephone Accessories You Can Build.* This book is published by the Hayden Publishing Company, 50 Essex St., Rochelle Park, NJ 07662, and priced at $3.95.

Any readers who found these articles of interest will find many more related projects in my book.

JULES GILDER

VIDEO GAME SCREEN BURN

The "burning in" of television game outlines on the phosphor screen could be reduced by incorporating a circuit in the game to slowly move the entire image around the screen. (Older types of TV camera tubes used in studio cameras such as the RCA TK-14 and TK-42 use a device called an orbiter, which either electronically moves the scanning or optomechanically moves the image.) The movement must be slow enough to be relatively unnoticeable, especially from play to play, and be of sufficient amplitude to displace the image slightly more than the maximum image line width. Additional hardware and/or software will be required to implement this system.

In a hardware game system, counters and a variable delay would move the image down one-scan-line-per-n vertical sweeps. The same counter could control a variable delay in horizontal positioning; however, another counter would allow more random positioning. When the image reaches the lower position limit, the counting (hence the positioning) is reversed. A software game system must accomplish the same steps, and therefore the hardware counters and delays could be used. A complete positioning cycle will likely have a period of about ten seconds, requiring long delay-timing loops and the associated memory requirements.

Although the increased hardware or software required would result in higher cost, the end result should be beneficial to both manufacturer and consumer.

TOM SCHULTZ
Kernersville, NC

I work with commercial-type video games, and up until the last couple of years all manufacturers used just any portable black-and-white TV that would suit their purposes. In every case the picture-tube screens had impressions of the games' outlines burned in.

In all the latest models, a 23-inch Motorola or Ball Brothers monitor is used, these are built for game manufacturers. (The Motorola model number is XM501/XM701.) With these monitors, screen-burn is still very evident. In our case though, since the monitor is not used for regular broadcast viewing, screen-burn is not a big problem.

I don't know how to stop screen-burn. If customers are going to play the video game for long periods of time, perhaps they should turn the brightness down or buy a low-priced black-and-white TV to use just for the games.

I feel it is not the manufacturers' fault that the screen-burn was noticed on the picture tubes. However, I feel they should have warned consumers.

A.W. SCHILDMEIER
Anderson, IN

OUTSIDE BURGLAR ALARM

I have been enjoying **Radio-Electronics** for many years, especially the articles relating to the fabrication of burglar alarms using SCR's and IC's. Every car, home and office needs effective burglar protection, and your publication fills a great need in a burglar-conscious world.

Many readers would appreciate information on how to construct and hook up a peripheral wire which could be buried around the edges of a property and would indicate the presence of any intruder. We also need information on a short-range FM transmitter, activated when a car parked outside the house is disturbed, which would register data at a receiver inside the house.

We would also appreciate more articles on pulsers or flashers that produce an interrupted warning noise or light rather than continuous operation; these should be adaptable to alarms, etc.

R. A. MATTMUELLER
Arlington, VA

SETTING THE METER MOVEMENT STRAIGHT

Your series *"All About Analog Voltmeters"* is very good. However, the discussion on the meter movement in the March issue should be clarified. A taut-band meter movement is a D'Arsonval meter movement too. A D'Arsonval meter movement is one with a coil that moves through a strong magnetic field supplied by a permanent magnet. "Taut-band" refers to the method of suspending the moving coil.

In a taut-band meter movement, the moving coil is suspended by two thin metal ribbons, one on each side of the coil. These ribbons provide the restoring torque for the coil and the electrical connections to the coil.

continued on page 16

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GTE SYLVANIA

LETTERS

continued from page 14

The other method of suspending the moving coil is called pivot-and-jewel. Two tiny pivots, one on each side of the coil, ride in jeweled bearings. The restoring torque and electrical connection to the coil in a pivot-and-jewel meter movement are provided by hairsprings connected to the moving coil.

The major advantage of a taut-band meter movement is elimination of friction. While this does not necessarily improve accuracy, it does allow repeatable measurements. The repeatability of a measurement can be very important when trying to match components or balance circuits.

Another way to improve repeatability of measurements is to add a mirror to the dial. The addition of a mirror does not necessarily improve accuracy or resolution, but it does help eliminate a human reading error, parallax. Parallax error is caused by not looking at the meter from directly in front of it. By lining up the reflected image of the pointer directly behind the pointer, this error can be eliminated. Thus, a mirror dial may be needed if component matching and circuit balancing are required.

GLENN A. LITTLE, Project Engineer
Triplett Corp.
Bluffton, OH

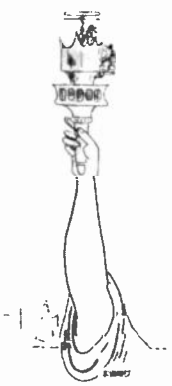
NEW ENERGY SOURCE?

Cut a one-inch square each from an aluminum and a steel pop can. Put a small button magnet at their center. (You may have to tape the magnet to the aluminum.) The magnet will attract a steel ball bearing from about one-quarter inch away through the aluminum, but it will not attract the ball through the steel sheet.

Today we can use a very low power signal to rapidly change germanium or silicon from a conductor to a nonconductor and vice versa. The magnetic bubble memory is now a reality. If we could find some other material that we could change from magnetic (steel) to nonmagnetic (aluminum) with a low power signal, we could solve our energy crisis.

When the ball moves to the magnet, which is behind the aluminum, the ball has energy and today's magnets last for decades.

JOHN W. ECKLIN
Alexandria, VA



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computer corner

JONATHON TITUS, PETER RONY, AND DAVID LARSEN*

THIS MONTH, WE WILL DISCUSS COMPUTER interrupts, with emphasis upon the hardware and software associated with the vector interrupt. The three signals that you use in vector interrupt circuits include INT (input pin-14 on the 8080A), INTE (output pin-16), and $\overline{\text{INTA}}$ (not available on the 8080A but derived externally with additional logic).

The interrupt operation proceeds as follows: An interrupting device supplies a positive-going clock pulse to the INT (interrupt request) input of the microprocessor. The microprocessor recognizes the interrupt request either at the end of the current instruction being executed or while the CPU is in the halt state. Once an interrupt request is recognized, the CPU is inhibited by an internal flip-flop from recognizing another interrupt request. This internal flip-flop can be set (enabled) or cleared (disabled) with the aid of microcomputer instructions: The interrupt flip-flop is disabled (mnemonic DI) by instruction 363, and it is enabled (mnemonic EI) by instruction 373.

When cleared, the interrupt enable flip-flop inhibits interrupts from being accepted by the CPU. The flip-flop is automatically cleared when an interrupt is accepted; it is also cleared by the RESET input-signal applied at pin-12 of the 8080A IC. Output pin-12 (INTE, or interrupt enable) indicates the logic-state of the interrupt enable flip-flop.

An $\overline{\text{INTA}}$ (interrupt acknowledge) control signal is generated by applying the INTA (interrupt acknowledge) and DBIN (data bus in) control signals to a two-input NAND gate (Fig. 1). A logic 1 at DBIN (output pin-17 on the 8080A) indicates to external devices that the data bus is in the input mode. The INTA control signal is a positive clock-pulse that is generated as a status output with the aid of a status latch connected to the 8080A microprocessor. The interesting aspect of the INTA control signal is that it permits you to "jam" an interrupt-vector instruction byte directly into the instruction register within the 8080A. This can only be done during an interrupt, but nevertheless it is a unique and highly interesting operation that is possible with the 8080A microprocessor.

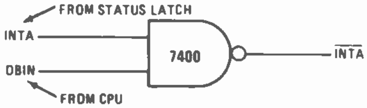
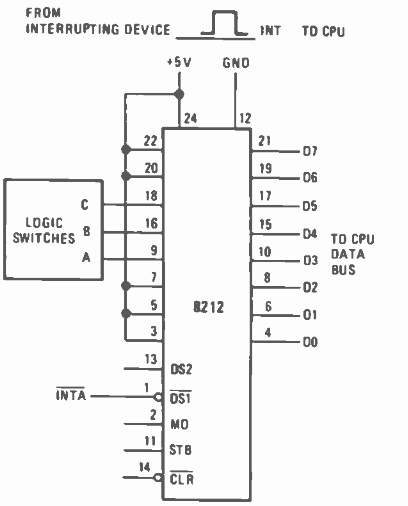


FIG 1

A simple circuit that demonstrates how a single-byte instruction can be jammed into the instruction register is shown in Fig. 2. Assuming that the interrupt enable flip-flop has been previously enabled by instruction 373, the interrupting device must supply a logic 1 input at INT in order to generate an interrupt request. The microcomputer finishes the current instruction, and then generates the interrupt acknowledge signal, $\overline{\text{INTA}}$, that jams the desired vector instruction-byte on the data bus and into the instruction register. Although any instruction byte can be jammed into the instruction register during an interrupt, usually the eight following instructions are used to produce a useful result:



GATED DRIVER

FIG 2

Instruction	Mnemonic	Call the subroutine that starts at:
307	RST 0	HI = 000 and LO = 000
317	RST 1	HI = 000 and LO = 010
327	RST 2	HI = 000 and LO = 020
337	RST 3	HI = 000 and LO = 030
347	RST 4	HI = 000 and LO = 040
357	RST 5	HI = 000 and LO = 050
367	RST 6	HI = 000 and LO = 060
377	RST 7	HI = 000 and LO = 070

continued on page 24

*This article is reprinted courtesy American Laboratories. Dr. Rony, Department of Chemical Engineering, and Mr. Larsen, Department of Chemistry, are with the Virginia Polytechnic Institute & State University. Mr. Titus is president of Tychon, Inc.

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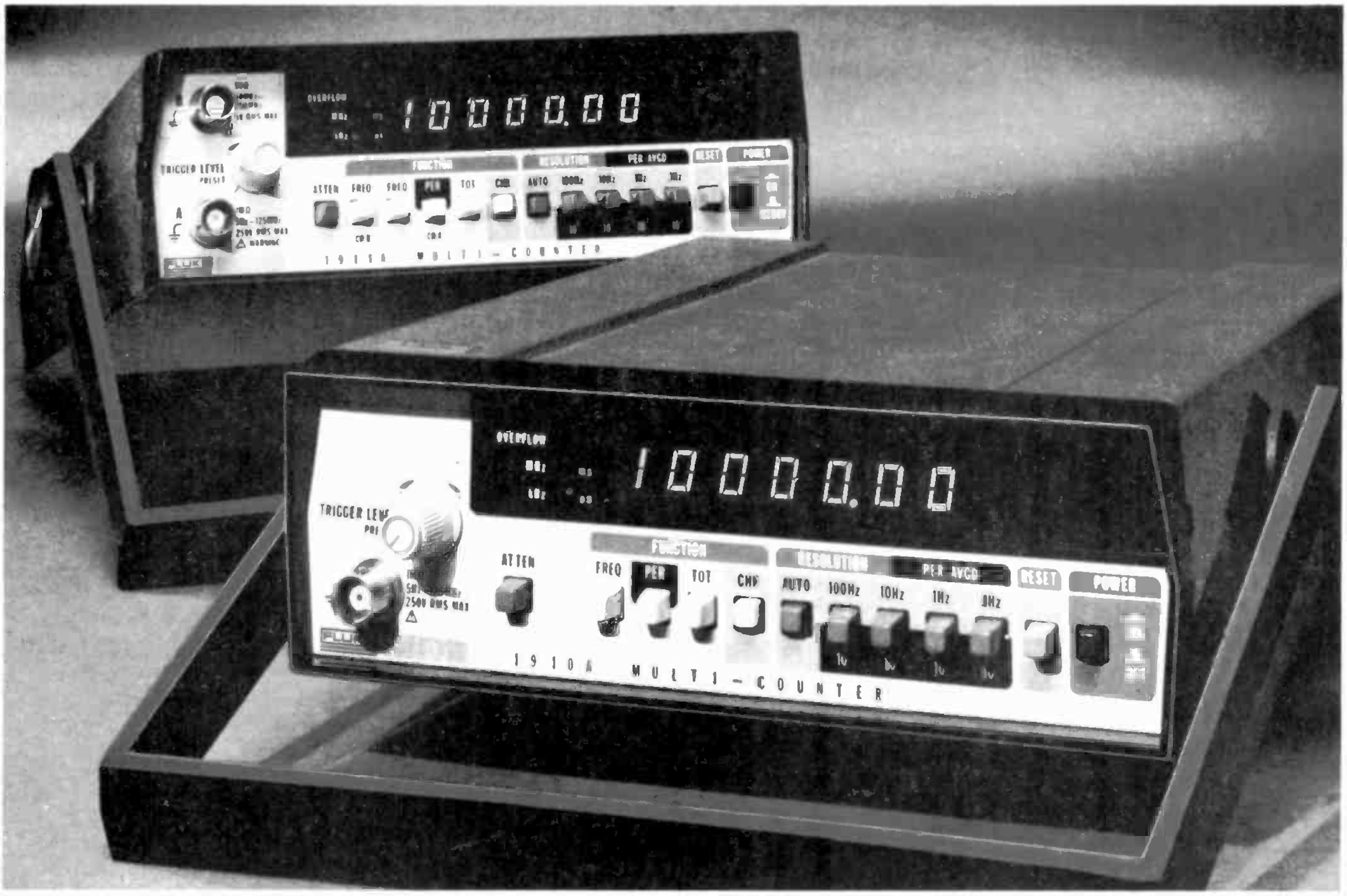

The 1910A and 1911A: counters with confidence in *your* future.

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• Sensitivity:	15 mV /25 mV	vs.	25 mV /50 mV	15 mV /30 mV	vs.	25 mV /50 mV
• Trigger-level control:	Yes!	vs.	(sorry)	Yes!	vs.	(sorry)
• Autoranging:	Yes!	vs.	(sorry)	Yes!	vs.	(sorry)
• Battery Option:	Yes!	vs.	(sorry)	Yes!	vs.	(sorry)
• Multi-function:	f, p, pa, tot.	vs.	f only	f, p, pa, tot.	vs.	f only

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COMPUTER CORNER
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The first sixty-four memory locations are reserved for interrupt *service routines* or *pointers.* These are extremely short programs, often consisting of only a single jump instruction, that tell the 8080 microcomputer what to do or where to go for a specified interrupt condition. Such routines precede the main program and associated subroutines in memory. If interrupts or restart instructions are not used, this portion of memory does not have any special significance.

Figure 3 is probably the simplest priority-encoder interrupt circuit that can be used with an 8080 microcomputer. The Intel 8212 IC is used as an 8-bit three-state buffer that inputs the instruction byte into the instruction register. The 74148 8-line-to-3-line priority-encoder IC has the following truth table:

Inputs								Outputs			
0	1	2	3	4	5	6	7	C	B	A	E0
X	X	X	X	X	X	X	0	0	0	0	1
X	X	X	X	X	X	0	1	0	0	1	1
X	X	X	X	X	0	1	1	0	1	0	1
X	X	X	X	0	1	1	1	0	1	1	1
X	X	X	0	1	1	1	1	1	0	0	1
X	X	0	1	1	1	1	1	1	0	1	1
X	0	1	1	1	1	1	1	1	1	0	1
0	1	1	1	1	1	1	1	1	1	1	1
1	1	1	1	1	1	1	1	1	1	1	0

The letter X means that the logic state is irrelevant.

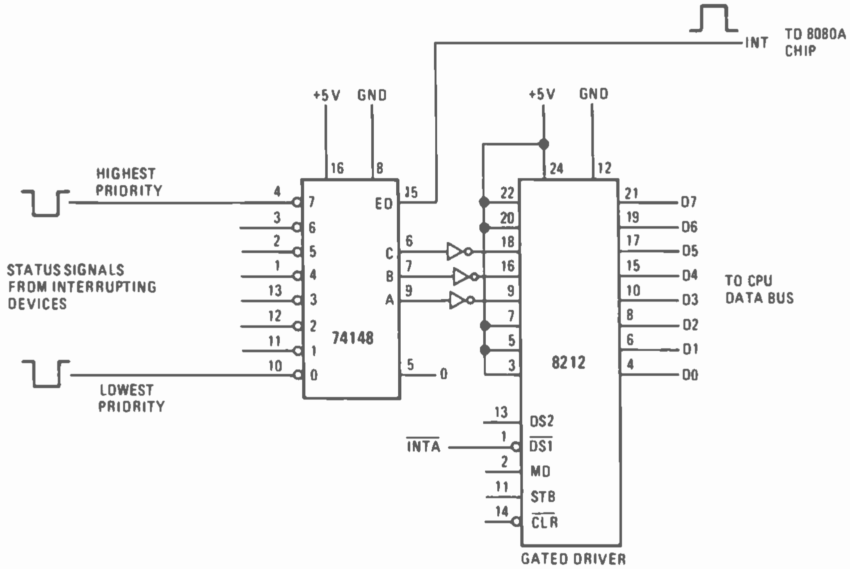


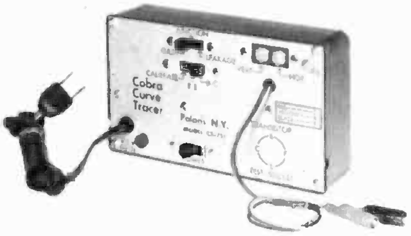
FIG. 3

The purpose of the circuit in Fig. 3 is to input the restart instruction, 3Y7, into the microcomputer. Five of the eight inputs to the 8212 IC are tied to a logic-1 state. The remaining three bits supply the encoded vector-address of the restart subroutine. By virtue of its truth table, the 74148 priority encoder provides eight priority levels. The inputs to this IC should be latched. The IC provides the three-bit binary output that corresponds to the highest valued priority input that is at a logic-0 state. The inverters invert this information to supply the three-bit "Y" component of the restart instruction.

If there is a logic 0 at any of the inputs to the 74148 IC, a logic-1 output will be generated at the E0 output (pin 15). This output serves as the input to the interrupt request pin, INT, on the 8080A chip. Upon receiving an interrupt request, the microcomputer responds with an interrupt acknowledge output, $\overline{\text{INTA}}$, that strobes the selected highest-priority restart instruction into the instruction register. **R-E**

equipment report

Polaris CT-751 Cobra Curve Tracer



CIRCLE 70 ON FREE INFORMATION CARD

I HAVE ALWAYS BEEN FOND OF CURVE TRACERS for transistor testing—they show you a definite pattern. The Polaris Co., 2862 Fulton St., NY 11207, has come up with a compact and versatile unit, their *model CT-751*. All you need is a scope, and any old scope will do. Only three connections are needed: to the vertical and horizontal scope inputs, and ground. The scope is set to EXTERNAL SWEEP.

The Cobra's controls are simple and easy to operate. There are two slide switches at the top of the panel, with the POWER switch at the bottom. Scope connections are made to three screw terminals in the upper right corner. In addition to a miniature transistor socket, there are three color-coded clip leads (with the colors and connections plainly marked on the panel).

Calibration is easy. Just set the slide switch to the CALIBRATE position and adjust the scope controls to get a diagonal line on the screen that runs about half the width of the screen (not critical). This line can slant either way; it makes no difference.

Now you're ready to go. With a known transistor, insert the transistor leads into the socket or clip to the test leads to the transistor. Set the two switches to the JUNCTION and B-E positions. If the transistor is good, you'll see a sharp right-angle pattern on the scope. This may go from the center of the screen to the right and down, or from the left and up. Again, it makes no difference—all you want to see is the "angle." This indicates this junction is good. Now, set the lower slide-switch to the B-C position: the angle should flip 180°, just opposite to what it was. If this happens, both junctions in the transistor are good. If you get a vertical line in either position, the junction is shorted. A horizontal line shows it's open (or that one of the clip leads has fallen off).

You can use this test to identify the leads of an unknown transistor. Just hook them up in any order and try the switches. If you get horizontal or vertical lines, swap two of the leads and try again. If you can find a hookup that will give you the normal "flip" reaction, you can identify the transistor terminals from the colors.

Gain can be checked by setting the switches to GAIN and B-C. A horizontal trace with a "droop" will be seen. The longer the trace before the droop, the higher the gain. For leakage, set the switches to LEAKAGE and B-C. Very high leakage is shown by a vertical line.

You can check any kind of diode on the *model CT-751*—rectifiers, Zeners, tunnel diodes, SCR's, and LED's. Use only the black (emitter) and yellow (base) leads. Set the switches to JUNCTION and B-E. Hook up the diode with the anode to the yellow lead and

continued on page 32

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EQUIPMENT REPORT
continued from page 26

cathode to black. If it's good, you'll see the angle pattern. If the vertical part of the trace slants, this diode has excessive forward resistance. If the horizontal part slants, it has too much reverse leakage. Germanium diodes will sometimes show higher leakage, but silicon diodes should show a very sharp angle.

This test can come in very handy for those very small glass diodes that you need a microscope to see the color coding. Hook the diode up. If you see a vertical line (conducting or short) reverse the leads. If you get a good angle now, the diode is hooked up black lead to cathode, yellow to anode. Tunnel diodes will make a "lazy-S" pattern; this is due to the negative-resistance characteristic of these diodes. SCR's can also be tested: red lead to anode, black to cathode and yellow to gate. You'll see an angle pattern with a small loop near the bend, showing that the SCR is being gated-on. (All these patterns are shown in the instruction manual.)

Junction FET's may also be checked, but it is not recommended that IGFET's or other MOS devices be tested. Several IC's can be checked, especially the transistor arrays and diode arrays, if the basing is known. Phototransistors, photodiodes and photocells can also be checked on the *model CT-751*.

This unit can also be used for in-circuit transistor and diode testing. The patterns you get will depend on how much shunt impedance there is across the junctions in the circuit. In general, a thin vertical line indicates a short and a horizontal line indicates an open circuit. If you can get a good angle on any one of the junctions in-circuit, the transistor is apt to be good. Some will show almost the same patterns as the out-of-circuit tests; others will show only a slight "bend" in the trace.

Small capacitors can be checked in- or out-of-circuit. Use the black and yellow leads, and set the switch to B-E. If the capacitor is good, the pattern will become an ellipse. Very large capacitors will show an almost perfect vertical line.

Variable resistors larger than 6,000 ohms can also be checked. They should show a slanting line. Moving the control shaft should make the line move smoothly from vertical toward horizontal. If the control is noisy, the trace will jitter.

While playing with this instrument, we found another very handy feature. You can check many iron-core inductors—power transformers, vertical output transformers, audio output transformers, filter chokes, etc. If the inductor is good, you will see an ellipse. The higher the inductance, the nearer to perfectly round. If one of the windings on the transformer is shorted, you'll see only a vertical line. Use the largest winding for best results. For example, on an autotransformer vertical output, the primary makes a good ellipse. Short the leads to the yoke winding and the display should be a thin vertical line. To check low-inductance windings, the horizontal gain of the scope may have to be increased. You'll see a long, thin ellipse, but if it is definitely an ellipse, this inductor is good.

The *model CT-751* is a very compact, versatile little instrument that saves a lot of time and won't take up too much space on the bench. **R-E**

NATESA warns that TV games may complicate tube warranties

As every technician knows, phosphor picture tube faces can be damaged if a fixed pattern at fairly high intensity is left on the tube. Oscilloscopes have also been damaged when a line or dot has been etched into the tube face.

Video games now being used with TV sets raise this potential for damage. As competition increases, it's possible that inferior game design will require increasing the brilliance for adequate viewing. This will also help cause such damage.

This puts service people in a vulnerable position in cases of tubes damaged by etching. Manufacturers' policies on replacing within-warranty tubes in which game-etched faces are the only defect differ widely.

NATESA believes servicers must, in all cases needing within-warranty picture tube replacement, inform set owners that this replacement will depend on the policy of the picture tube producer or marketer. Since in many cases, defective CRT's are simply accepted by the warrantor subject to later inspection and approval, servicers are cautioned not to deliver sets in such cases, unless the warrantor issues irrevocable credit. **R-E**

B&K-PRECISION's new 3½ digit DMM

For over two years, our competition has been trying to figure out how B&K-PRECISION could sell a full-feature 3-digit DMM for only $99.95. They've dissected it, analyzed it, and some even asked us how we did it. Well, they can start all over because we did it again!

B&K-PRECISION's new Model 2800 portable DMM features 3-1/2 digit display, auto-zeroing and 100% overrange reading for only $99.95. Basic DC accuracy is 1%. Twenty-two ranges read up to 1000 volts DC or AC, 1000mA and 10 megohms.

All ranges are well protected against overloads. Even if you should accidentally apply +1000VDC to the 2800 while switched to an ohms range, no instrument damage will result. All DC and AC voltage ranges are protected up to ±1000 volts DC or AC. The current ranges receive the double protection of diodes and a series fuse.

For accurate in-circuit resistance measurements, the 2800 measures with high– or low-power ohms ranges. At low-power ohms, less than 0.2 volt is developed across the measured resistance. To forward bias semiconductor junctions, the high-power ohms ranges develop about 2 volts.

B&K-PRECISION also has a full complement of optional accessories for the 2800. Accessories include a carrying case, wire tilt stand, AC adapter/charger, high-voltage probe, direct/isolation probe NiCad Batteries and 10-amp current shunt.

The B&K-PRECISION 2800 may be a mystery to our competitors, but for you—it takes all the mystery out of which DMM to buy.

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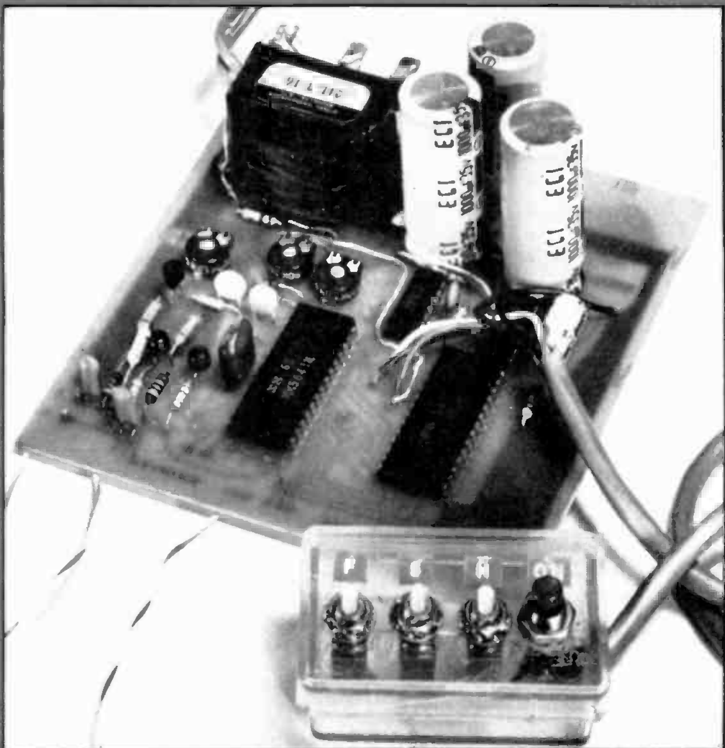
CIRCLE 68 ON FREE INFORMATION CARD

Build this Digital On-Screen TV Clock

This digital clock displays either 4 or 6 digits of time on the screen of your TV set in either the 12- or 24-hour format

FRED BLECHMAN



HERE'S A DIGITAL CLOCK YOU CAN BUILD that displays its numerals on a TV screen. If you own any black-and-white or color TV, you can build the on-screen TV digital clock described here, available in kit form for $29.95, and install it in your TV.

How it works

The schematic is shown in Fig. 1. The MM5318 (IC3) is a Digital Clock IC with multiplexed BCD (*B*inary *C*oded *D*ecimal) outputs. A transformer-powered full-wave rectifier (D1 and D2) provides an unregulated 12-volt DC output that is filtered by C1, C2 and R10. A low-voltage 60-Hz signal is fed into pin 19 of the MM5318 as the timebase signal. Line voltage transients are removed from this signal by R9, D3 and D4. Pin 13 is either connected to ground for a 12-hour display format, or +12 VDC for a 24-hour display. Switches S2, S3 and S4 are for time-setting.

The outputs of the MM5318 are fed directly to IC4, an MM5841 TV Time/Channel Generator IC. (Note: The channel display feature is not used in this project.) This IC contains counters, shift registers, ROM's (*R*ead-*O*nly *M*emories) and many other circuit functions for displaying the numerals on the TV screen. The video signal is available at pin 15 of IC4 and is applied to the TV set through C10, R14, Q3 and R15. (Specific data for this and all other IC's used in this project is available from National Semiconductor Corporation, 2900 Semiconductor Drive, Santa Clara, CA 95051.)

Three gates of IC1, a 74COO CMOS (*C*omplementary-*M*etal-*O*xide-*S*ilicon) IC quad 2-input NAND gate, and C5, R11 and R12 form an external oscillator for the MM5841. This oscillator controls the height of the displayed digits. Another 74COO, IC2, together with C8, C9, R13 and R18, provides timing and gating to control how often and for how long the digits are displayed. Potentiometer R18 determines display interval, and S1 allows you to "call-up" the display on command.

To display the digital characters on the TV screen, the circuit must synchronize with the TV scan. This is done by connecting the TV Clock vertical and horizontal sync inputs to the proper points in your TV circuitry, as described later. Transistors Q1 and Q2 feed these synchronizing pulses to the MM5841 where they trigger outputs on pins 16, 17, 20 and 21. Trimmer R16 controls the horizontal position of the digits on the TV screen, while R17 controls the vertical position.

Construction

This entire project can be built on a perforated board and hand-wired, but the circuit layout and lead lengths

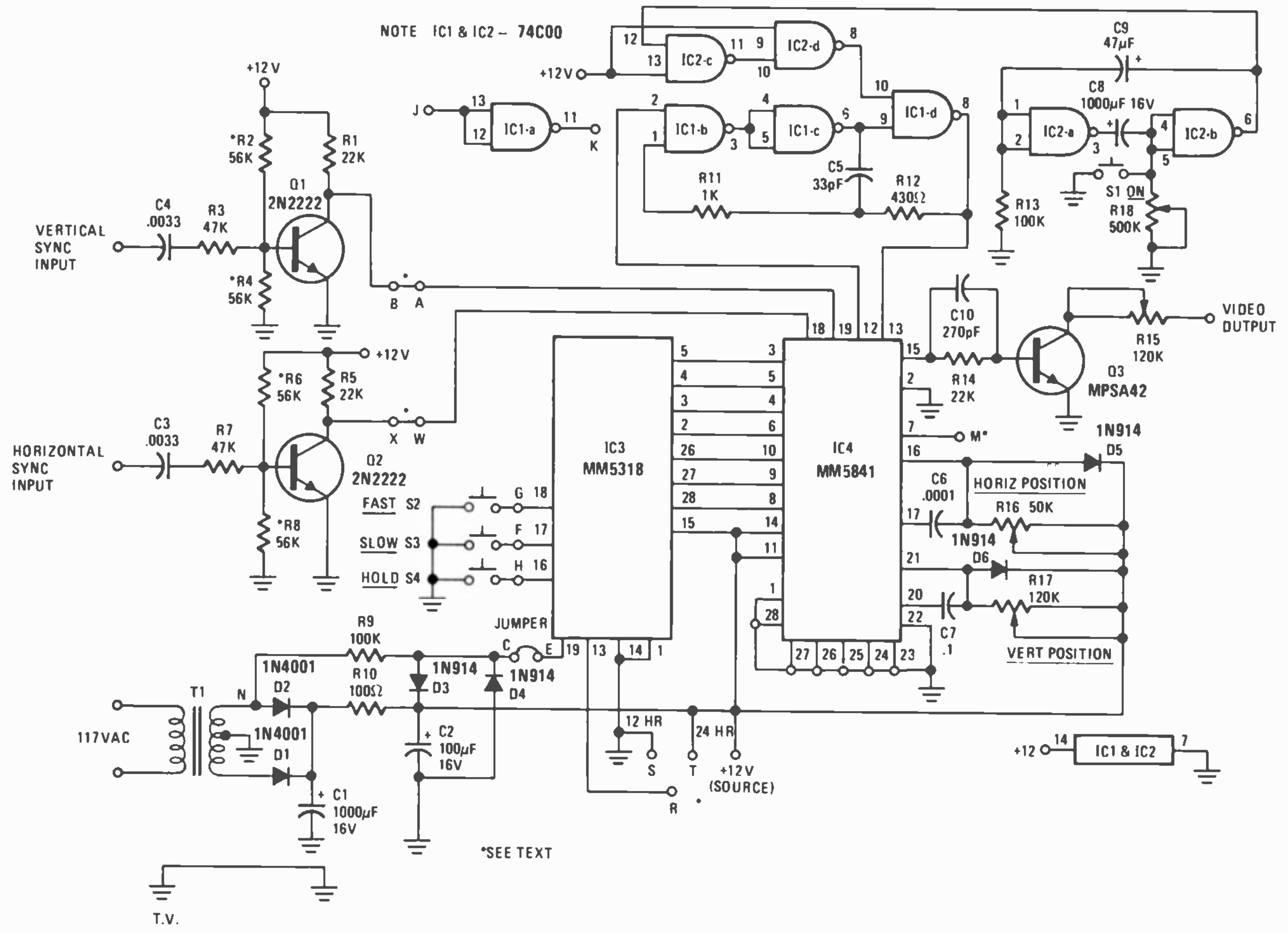


FIG. 1—ON-SCREEN DIGITAL CLOCK requires vertical and horizontal sync pulses from TV circuitry.

would be critical at these frequencies. It is better to use a printed circuit board; the foil pattern is shown in Fig. 2.

Using the PC board and the parts layout shown in Fig. 3, assembling this project is easy. Carefully identify each resistor and be very sure to observe polarity when installing the diodes and those capacitors that are polarized. The transistors must be installed with the flat sides as shown.

Start by installing the components on the PC board. Do *not* install R2, R4, R6 or R8 at this time; they will be installed later. Next mount the transformer to the PC board with two No. 6-32 × ⅜ screws and nuts. Solder power diodes D1 and D2 (be careful not to confuse these with the smaller signal diodes) to the two top outside lugs of the transformer, with the cathodes (banded end) soldered into the PC board holes below. Various jumper wires are needed to complete the wiring and select options. Most jumpers are on top of the board. Run a jumper wire from the upper center transformer terminal to the PC board hole below. Also add jumper wires from the two bottom transformer terminals to the holes below them. Jumper point N on the PC board to the junction of D2 and the transformer terminal. (If your transformer is not the one specified in the parts list, you can determine the proper connections by referring to the schematic and the PC board layout.) Jumper points E and C on the PC board. Jumper IC2 pin 13 and IC2 pin 9 to +12V. There are convenient +12V holes in the board near R16 and just above C2.

On the *bottom* of the board, IC4 pin 11 should be jumpered or shorted to the

R-E TRIES IT

The On-Screen TV Digital Clock was tested by connecting it to a Heathkit GR-25 color TV receiver. The performance was completely satisfactory. When first connected, the time display was located in the center of the screen. There was some de-focusing from right to left with the seconds digits as sharp as you would want, the minutes slightly out of focus and the hours badly blurred.

The positioning pots were adjusted to place the display in the upper right corner of the screen. Next, we experimented with the video output (whiteness) control to see what effect it had on the display. By backing off the control, we reduced the distortion in the display so all digits were equally sharp and bright without a trace of color.

Connections

After reading the input-signal requirements, we studied the waveforms available at various points in the GR-25 and examined the chassis for possible connecting points on the top side of the PC board. Both grids of the vertical multivibrator were driven by sawtooth waves with a fast falltime. We installed R2—as instructed in the article—and tacked the vertical sync lead on to pin 2 of the 6GF7 vertical multivibrator.

A reversed sawtooth with a fast risetime was present at the junction of the two horizontal phase detector diodes. Since this was a test point, it proved to be a convenient spot to pick up the horizontal sync signal. Resistor R8 was installed on the clock PC board as directed.

The clock's video output was fed into the set's video output circuit through test point TP7 at the output of the video amplifier. Since, in this set, this point is also connected to a terminal on the SERVICE switch, this would be an equally convenient point to feed in the video.

PARTS LIST

All resistors are 1/4-watt, 10% or better, unless otherwise noted

R1, R5, R14—22,000 ohms
R2, R4, R6, R8—56,000 ohms
R3, R7—47,000 ohms
R9, R13—100,000 ohms
R10—100 ohms
R11—1000 ohms
R12—430 ohms
R15, R17—120,000-ohm trimmer, horizontal PC mount
R16—50,000-ohm trimmer, horizontal PC mount
R18—500,000-ohm, horizontal PC mount
C1, C8—1000 μF, 16-volt, electrolytic
C2—100 μF, 16 volt, electrolytic
C3, C4—.0033 μF, disk or Mylar
C5—33 pF, disk
C6—1000 pF, disk or Mylar
C7—0.1 μF, Mylar
C9—47 μF, 16 volt, electrolytic
C10—270 pF, disk
Q1, Q2—2N2222 or equal
Q3—MPSA42 (Motorola) or HEP S0027
D1, D2—1N4001 or equal
D3-D6—1N914 or equal
IC1, IC2—74C00 Quad 2-Input NAND Gate
IC3—MM5318 Digital Clock (National)
IC4—MM5841 TV Time/Channel Generator (National)
S1-S4—SPST pushbutton switch
T1—117-volt primary; 16 volt, 150 mA, secondary. (Signal Transformer No. 241-3-16 or equal)

The following parts are available from Interfab, 27963 Cabot Rd., Laguna Beach, CA 92677: A complete kit of parts, including PC board, for $29.95 plus $1 shipping. Order No. DC-12 TV Clock Module. A PC board is available separately for $4.25 plus 50¢ shipping. California residents add state and local taxes as applicable.

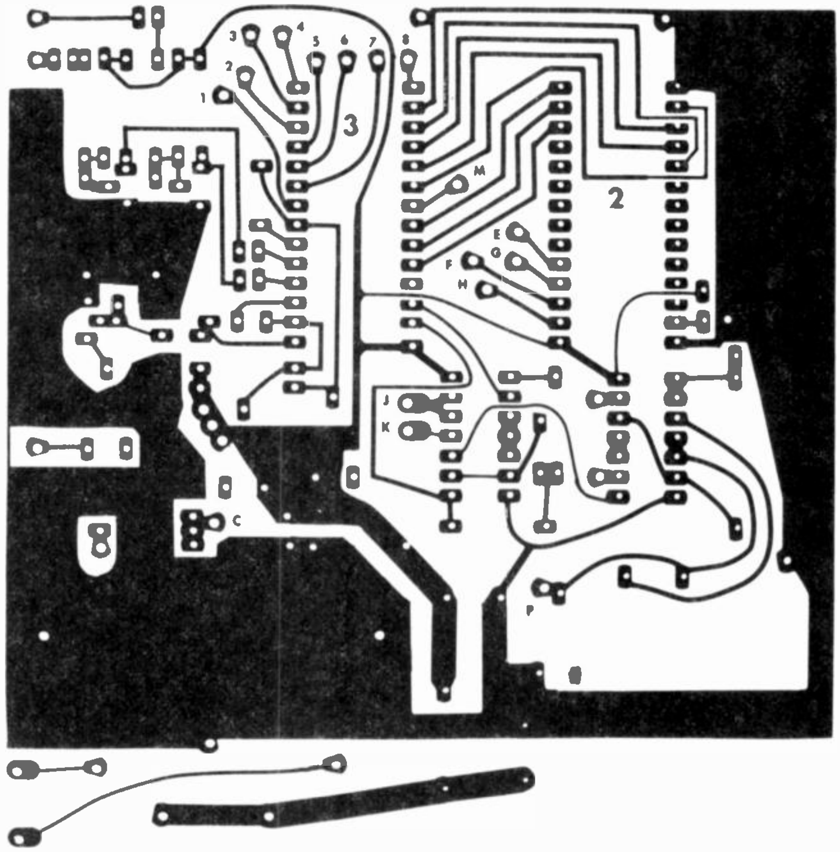


FIG. 2—FOIL PATTERN shown actual size.

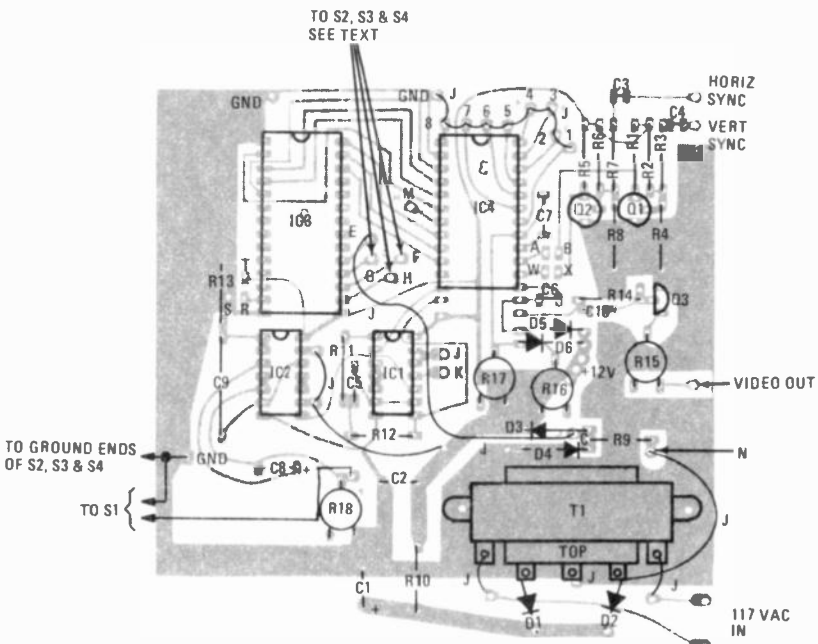


FIG. 3—COMPONENT PLACEMENT diagram.

printed-circuit trace (+12V) that runs between pins 11 and 12. Also, using a single bare wire that "snakes" from point-to-point, connect IC4 pins 1, 22, 23, 24, 25, 26, 27 and 28 (numbered 1-8 on the PC board) to ground near point 8.

Now you have to select some options. Do you want 4 digits (hours and minutes) or 6 digits (hours, minutes and seconds) to appear on the screen? For 4 digits, jumper point M (pin 7, MM5841) to ground. For 6 digits, jumper M to +12V. Do you want a 12 or a 24-hour display format? Jumper point R (pin 13, MM5318) to ground (point S) for a 12-hour format, or to +12V (point T) for a 24-hour display.

Four switches are used, and they can all be mounted on a single panel or in a small plastic box. Switch S1 should be readily accessible since it is used to manually call-up the display. It is a pushbutton type switch; if you want to be able to leave the clock display on for extended periods, use a slide or toggle SPST switch instead. The other switches are used for time setting and can be less accessible—you might even want to hide them behind a panel to prevent tampering. Using multiconductor or ribbon cable, wire one side of all switches to ground. Then wire the other switch terminals as follows: S2 to point G; S3 to point F; S4 to point H. These are pins 18, 17 and 16, respectively, of the MM5318.

Installation

Installing the TV Digital Clock into

your TV involves both physical and electronic connections. **Caution:** When installing this project in your TV set, remember that most TV's have a "hot" chassis wired directly to one side of the AC line. Make sure the chassis is at ground potential before you start working on it.

To begin with, you must connect the TV Clock board to a constant source of 117-VAC 60-Hz power—it must be powered even when the TV is off. You *could* do this by running a separate line cord to a wall socket, but it really makes

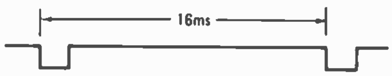


FIG. 4—PULSE TRAIN required at pin 19 of IC4.

Similarly, the horizontal sync is taken from the horizontal oscillator, with a typical TV circuit shown in Fig. 6. Look for a positive-going pulse with a fast risetime used for horizontal retrace, and install R8. Figure 7 shows the input needed at point W (IC4, pin 18) resulting from a signal with a fast risetime fed into C3. If you can't locate a signal with a fast risetime right away, keep looking, since there's only one spare inverter on the Clock PC board! If you used a positive-going signal for the vertical sync, then you can use a negative-going signal and inverter here, jumpering X to J and K to W, and installing R6 instead of R8. It's simpler, however, to find a positive-going horizontal signal and use R8 with a jumper

Using the TV Clock

With the TV set in operation, press switch S1. The digital time should appear somewhere on the screen for approximately 4 to 6 seconds, as determined by the time constant of R13 and C9. The time will appear automatically every 1 to 8 minutes, determined by C8 and the setting of potentiometer R18. Adjust R18 to a comfortable interval. To adjust the location of the display on the screen, hold down S1 and adjust

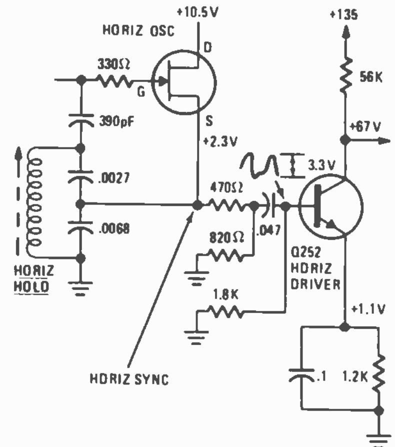


FIG. 6—TYPICAL HORIZONTAL OSCILLATOR showing location of horizontal sync pulses.

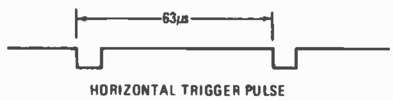


FIG. 7—PULSE TRAIN required at pin 18 of IC4.

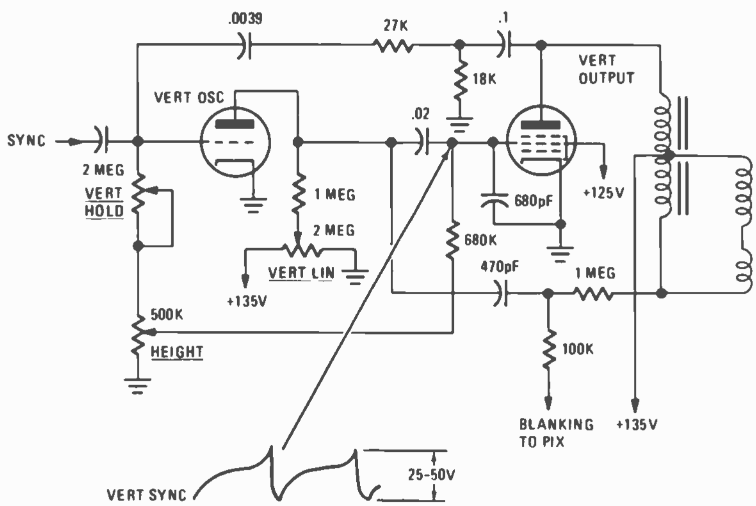


FIG. 5—TYPICAL VERTICAL AMPLIFIER showing location of vertical sync pulses.

more sense to connect the TV Clock board to the points in the TV where the AC power enters. Wire these points to the 117-VAC input pads on the TV Clock PC board. Also, be sure to connect a wire from the TV Clock board ground to the TV set ground.

Vertical sync can be taken from the vertical oscillator or vertical amplifier. You are looking for either a positive-going sync pulse with a fast risetime or a negative-going sync pulse with a fast falltime used for vertical retrace. A positive-going sync pulse requires R4 to be installed; a negative-going pulse requires R2. The pulse needed at point A (IC4, pin 19) is shown in Fig. 4. This results from a positive-going pulse fed into C4. Fig. 5 shows a typical vertical amplifier circuit. If you can't locate a positive-going pulse with a fast risetime (there's one there someplace!) and the output signal from Q1 is the inversion of the one shown in Fig. 4, there's a spare inverter section (IC1-a) at points J and K on the PC board. Use R2 and jumper B to J and K to A to invert the signal. If you find the preferred signal with a fast risetime, use R4 and jumper B to A directly.

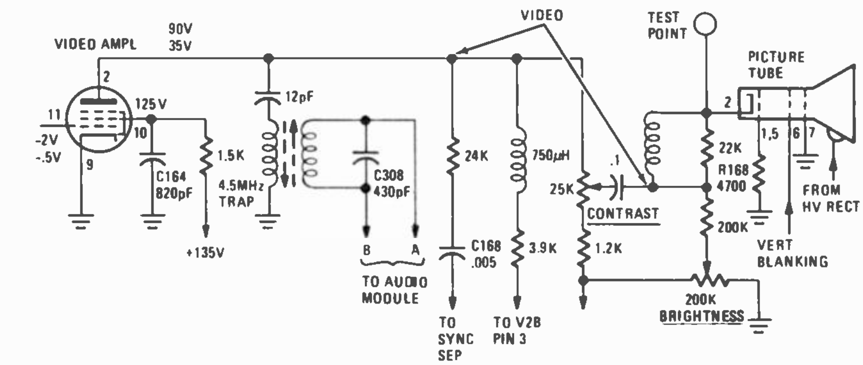


FIG. 8—TYPICAL VIDEO AMPLIFIER showing points where video from clock can be inserted.

directly from X to W, and ignore the spare inverter.

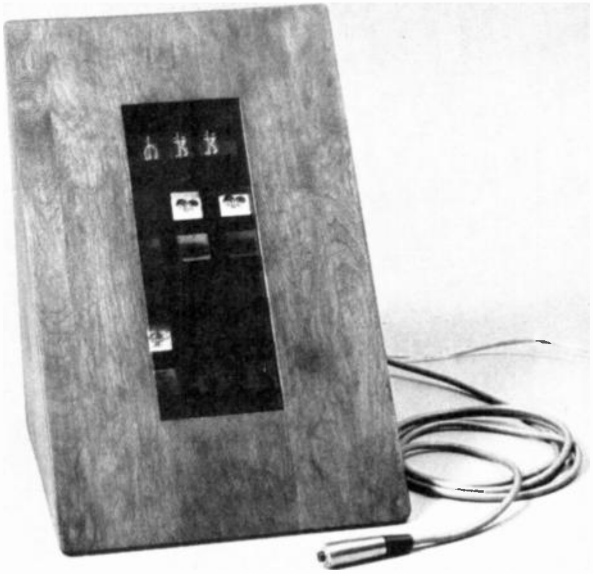
Now check your TV to see if it's operating normally and that no distortion is present as a result of this conversion.

The video output of the TV Clock circuit can be connected to the plate of the video amplifier or even on the brightness control. A typical video amplifier circuit is shown in Fig. 8. Use an oscilloscope to select a point where white images are noted by a *decrease* in voltage. The point of the tie-in should not have a DC voltage greater than 250 volts.

potentiometer R17 to control the vertical position of the display, and potentiometer R16 for the horizontal position. The brightness (whiteness) of the display is adjusted by R15.

To set the time, use a known time standard, such as the number provided by your phone company. Pressing S2 advances the hours once a second, pressing S3 advances the minutes once a second, and pressing S4 "freezes" the display until it's released. Simply advance the time slightly ahead of real time, and depress S4 to hold the count until the real time "catches up" with the displayed time. **R-E**

Build This Electronic Slot Machine



Here's a device that will make a nice addition to your den. It has, in addition to the display symbols, a 3-digit readout of the running tabulation of all winnings

GREGORY W. HART

ANYONE LOOKING FOR A UNIQUE AND CHALLENGING project will find this Electronic Slot Machine well worth the time and energy. Costing only $50 to $60 for parts, this digital project yields a form of entertainment that few people have access to.

One of the primary considerations in designing this project was that it must lend itself entirely to those of us endowed with vast quantities of natural laziness. This being the case, the arm that is normally pulled to initiate a "play" is replaced with a remote pushbutton switch. The numerical readout of an internal accumulator keeps a running tabulation of all winnings and automatically decrements each time the PLAY pushbutton is depressed.

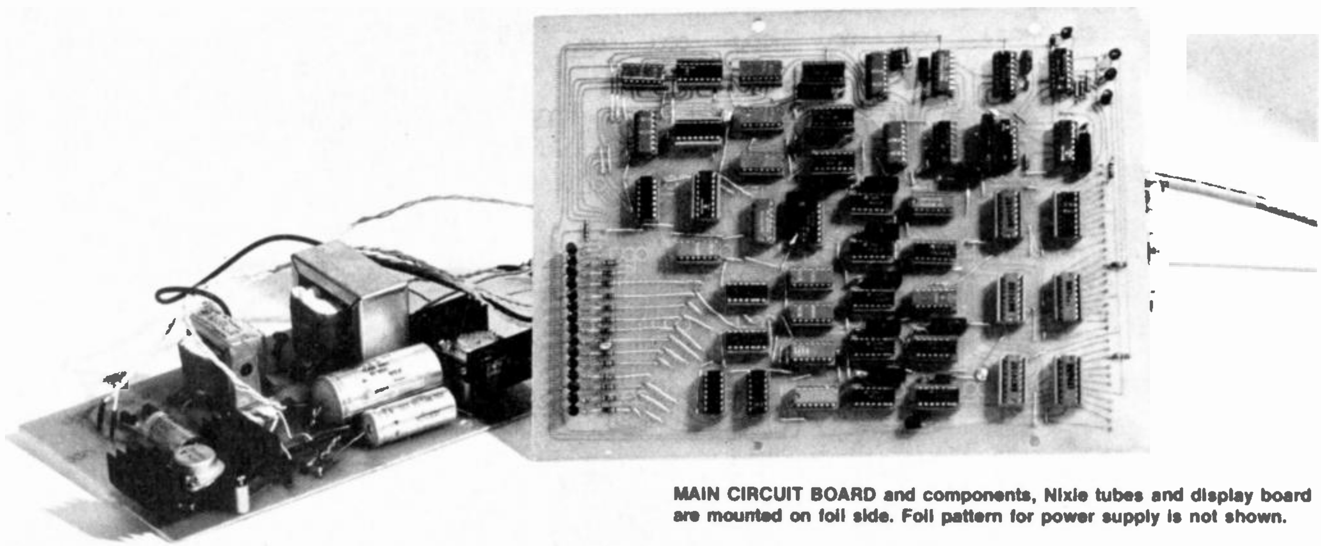
The actual display consists of 35-mm slides (unmounted) of whatever object you wish to use. The standard display symbols used in slot machines are: cherries, oranges, plums, bells, and the word jackpot. Also watermelons, lemons, genies, and others are often used. The slides are arranged in 3 columns of 5 slides each. Each slide is mounted over an individual lamp for illumination.

To start, a RESET pushbutton located on the back panel is depressed. This presets the numerical readout to a count of 10. With the slot machine reset, a PLAY lamp located above the display-symbols lights and a play cycle can be initiated by depressing the PLAY pushbutton. During the play cycle, one slide in each column lights sequentially–one slide in the first column, then one slide in the second column and finally, a third symbol in the last column. At this point, if the combination of symbols results in a payoff, the numerical readout is incremented accordingly. The PLAY lamp lights automatically to enable another play cycle.

When the power is first turned on, the digital circuitry quickly assumes a quiescent state and the readout displays some large number. It is necessary to clear the accumulator and preset a count of 10 by depressing the RESET pushbutton.

How it works

Referring to the block diagram shown in Fig. 1 and the complete schematic shown in Fig. 2, the RESET pushbutton



MAIN CIRCUIT BOARD and components. Nixie tubes and display board are mounted on foil side. Foil pattern for power supply is not shown.

triggers reset one-shot IC3. The output of the reset one-shot clears the up-down counters IC42, IC43 and IC44. The accumulator is comprised of these three up-down counters. The readout is now 0-0-0. The output of the reset one-shot triggers one-shot (IC4) to generate a delay, which insures that the accumulator is reset before the payoff sequence is initiated. The trailing edge of the delay-pulse triggers a payoff one-shot (IC34) that gates ten pulses into the up-down counters, setting the accumulator to 0-1-0. Each time a play cycle is completed, the accumulator is decremented by 1. After the RESET pushbutton is depressed, ten play cycles can be completed with no payoffs before a 0-0-0 is displayed and the play cycle is disabled.

With the slot machine reset, the PLAY lamp is on and the PLAY pushbutton can initiate a play cycle when depressed. The PLAY pushbutton triggers IC1. The output of IC1 enables five other circuits. Simulating a coin being played, IC1 decrements the accumulator by one count, resulting in a readout of 0-0-9. The three wheel-spin one-shots (IC9, IC10 and IC11) are also triggered at this time. The wheel-spin one-shots allow the display to give the appearance of spinning wheels. The time duration is set so that they stop in sequence, each being on longer than the previous one by a few seconds.

The oscillator enable one-shot (IC2) enables IC8-a, which allows the pulses to enter the three decade counters IC12, IC13 and IC14. These counters have their decoded outputs connected to the odds-determining gates IC18 to IC21. The gates are wired to give a predetermined number of chances for each display symbol to light. The output of the oscillator enable one-shot also dis-

PARTS LIST, MAIN BOARD

All resistors are 1/4-watt, 10%, unless otherwise noted

R1, R4, R13–R27, R35, R43—1,000 ohms
R2—10,000 ohms
R3, R5—33,000 ohms
R6, R7, R11—20,000 ohms
R8—300 ohms
R9—1100 ohms
R10—13,000 ohms
R12—27,000 ohms
R28—3900 ohms
R29, R30, R32—12,000 ohms
R31—17,000 ohms
R33—36,000 ohms
R34—130,000 ohms
R36—15,000 ohms
R37, R39, R41—240,000 ohms
R38, R40, R42—510 ohms
C1, C10, C11—100 μF, 6 V, electrolytic
C2, C3, C7–C9, C14, C15, C16—220 μF, 6 V, electrolytic
C4, C5—10 μF, 6V, electrolytic
C6, C18—1.6 μF, 6V, electrolytic
C12, C13—150 μF, 6V, electrolytic
C17—2.2 μF, 35 V, electrolytic
Q1–Q19—2N3417 or equivalent
IC1–IC5, IC9–IC11, IC31–IC37, IC40—74121 monostable multivibrator
IC6, IC20, IC22–IC25—7410 triple 3-input NAND gate
IC7, IC8, IC18, IC19, IC21, IC26–IC30, IC41—7400 quad 2-input NAND gate
IC12–IC14, IC39—7490 decade counter
IC15–IC17—7442 BCD-to-decimal decoder
IC38—7430 8-input NAND gate
IC42–IC44—74192 synchronous decade up/down counter
IC45–IC47—7441 BCD-to-decimal decoder
Lamps 1–16—6-volt miniature, Sylvania, G-E, Hudson, Tung-Sol type 328, 337, 345, 380 or 381
Display tubes 1–3—0-9 type Nixies
Misc.—35-mm slides, cabinet, printed circuit board, lamp display board, hardware, two pushbutton switches.

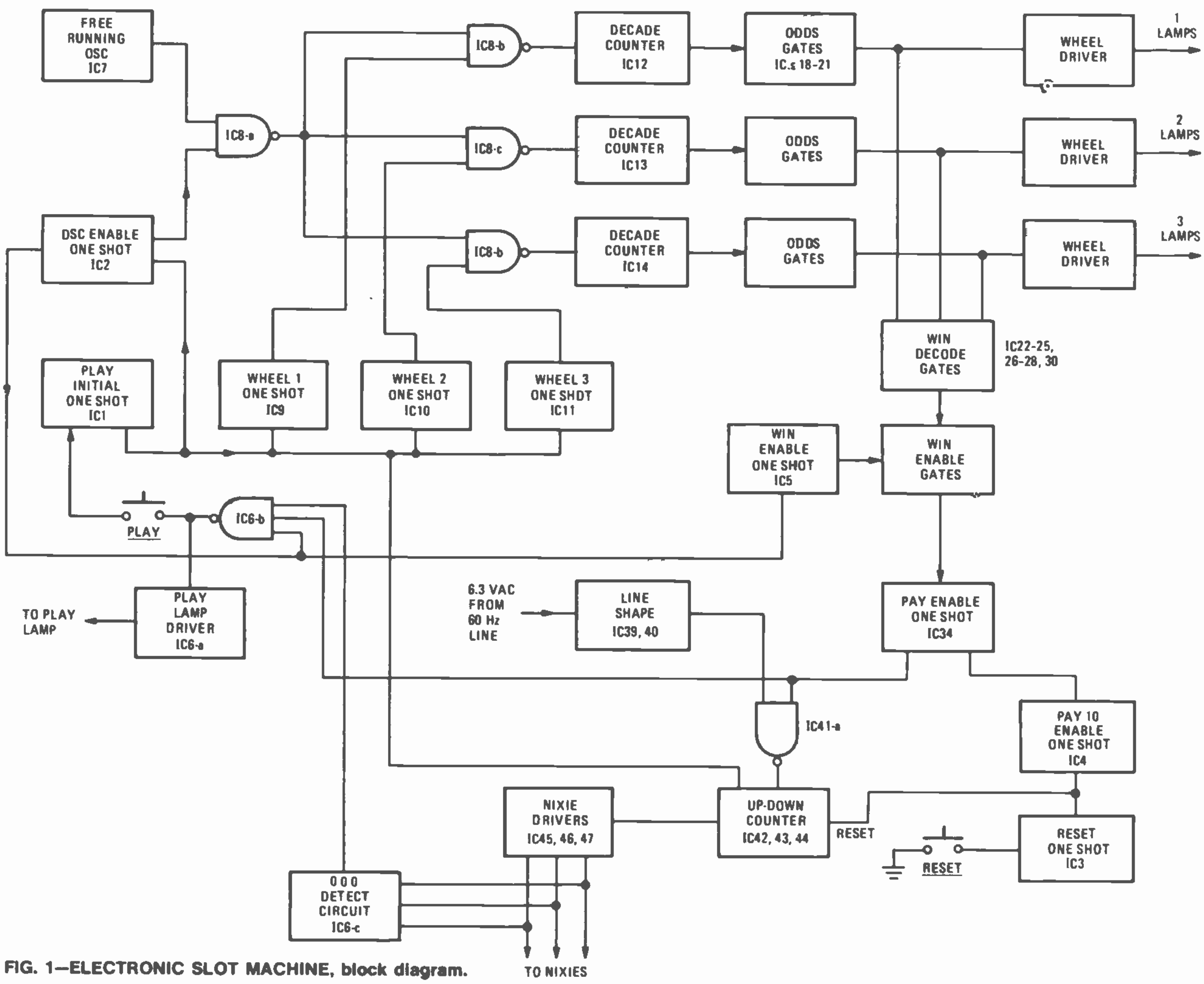


FIG. 1—ELECTRONIC SLOT MACHINE, block diagram.

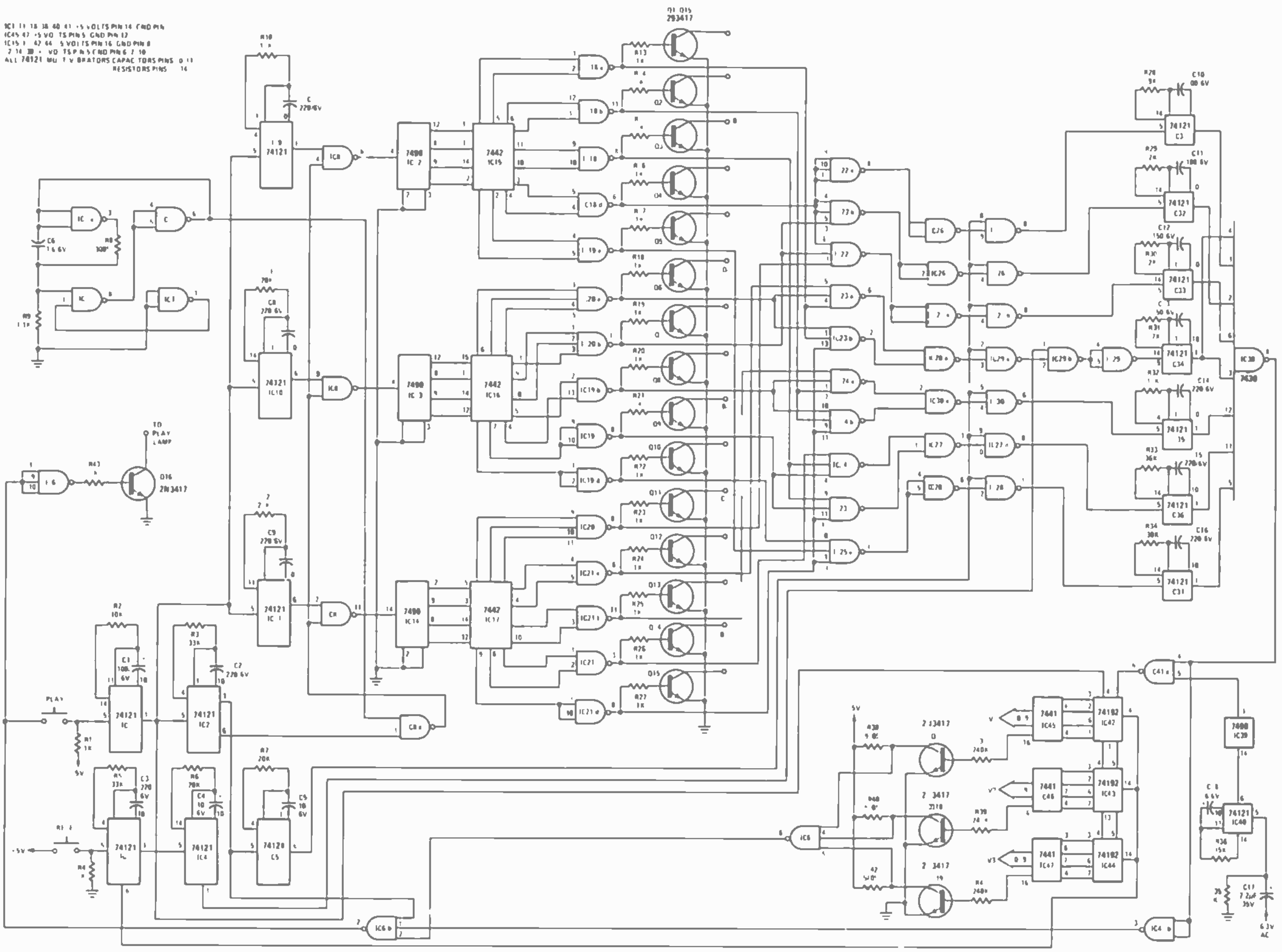


FIG. 2—THE COMPLETE SCHEMATIC. Numbers inside boxes in Fig. 1 refer to the IC's in this diagram.

TABLE I

Payoff	Wheel 1	Wheel 2	Wheel 3	Odds Out of 1000 Chances
2	Cherry	not Cherry	not Cherry	200
5	Cherry	Cherry	not Cherry	60
8	Cherry	Cherry	Cherry	18
10	Orange	Orange	Orange	12
10	Orange	Orange	Jackpot	6
15	Lemon	Lemon	Lemon	8
15	Lemon	Lemon	Jackpot	4
20	Bell	Bell	Bell	4
20	Bell	Bell	Jackpot	2
100	Jackpot	Jackpot	Jackpot	2

ables the PLAY lamp to indicate that a cycle is in progress and the PLAY push-button will have no effect if depressed.

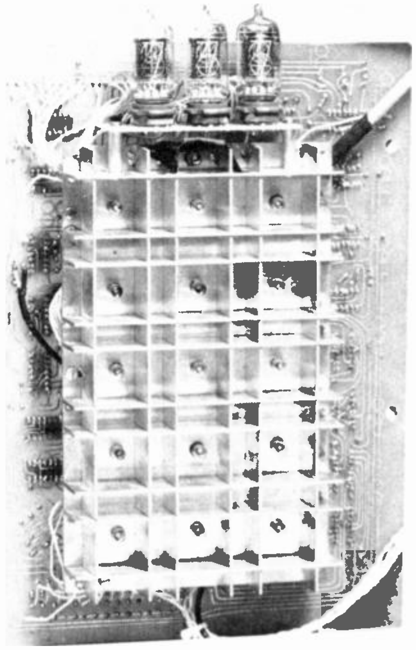
The outputs of the odds gates feed the inputs of gates IC22-IC25, IC26-IC28 and IC30. These gates determine if a winning combination is displayed after the wheels have stopped. On the trailing edge of the oscillator enable output, the win-gate enable IC5 is triggered to generate a narrow strobe pulse that enables all the win combination lines to see if any winning combination exists. If there is no winning combination, the PLAY lamp will light and the machine will be ready for a new cycle to be initiated. If a winning combination does exist, the appropriate number of pulses are gated into the accumulator.

Construction

Construction is straight-forward. The main circuit board (Fig. 3) is assembled first. Over one hundred jumpers are to be installed, as shown in Fig. 4. This number could have been reduced by using a double-sided circuit board, but the added cost and effort did not justify its use. After all the jumpers are in place, install the IC sockets or Molex type pins, then mount the components. The power supply may be laid out on a separate PC board or in spare places in the cabinet. Mount the regulator and pass transistor on small heat sinks for cooling.

The display can be fabricated from whatever materials are available. I used a PC board because it is sturdy and easy to work with. After piecing the display together in egg-carton fashion with the squares the size of 35-mm slides, holes are drilled in the center of each square through the back panel to accommodate the lamps. The lamps can then be press-fitted into the holes and the flanges soldered to the foil of the back panel, eliminating all wires connecting to the common supply bus of the lamps. When all circuits are wired it is ready to test. First check the power supply output voltages before connecting it to the main circuit board. If all voltages check out, then connect the power supply to the machine and check its operation. If the same combination repeats numerous times, it may be necessary to alter the values of the oscillator components slightly. They are C6, R8 and R9. The payoff rates are adjusted with the timing resistors as described previously.

The payoffs are shown in Table I along with the corresponding odds. The payoffs are the same as many real



MAIN CIRCUIT AND DISPLAY BOARD, foil side view.

machines while the odds are far better. Due to the large value tolerances in electrolytic capacitors such as those used for the payoff one-shots, resistors R28-R34 will have to be changed to obtain the payoffs listed in the table. (A variation of 20-30% from the capacitance values listed is not uncommon.) In addition to the payoff one-shots, the wheel one-shots and oscillator enable one-shot (IC9, IC10, IC11 and IC22, respectively) may also need to be fine-adjusted to obtain a satisfactory pulse duration.

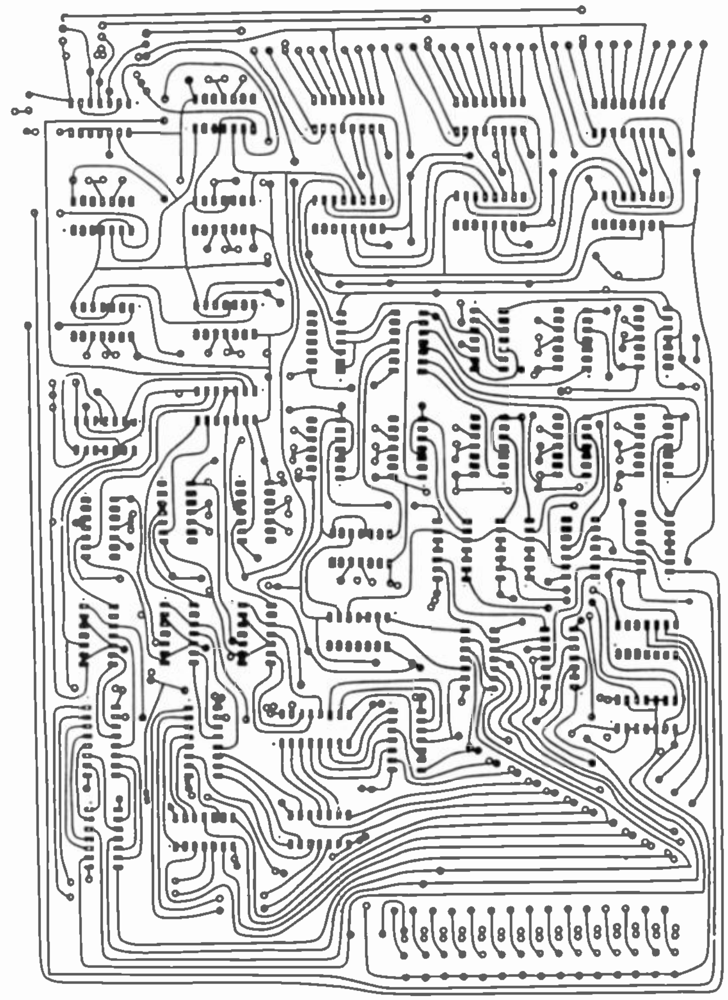
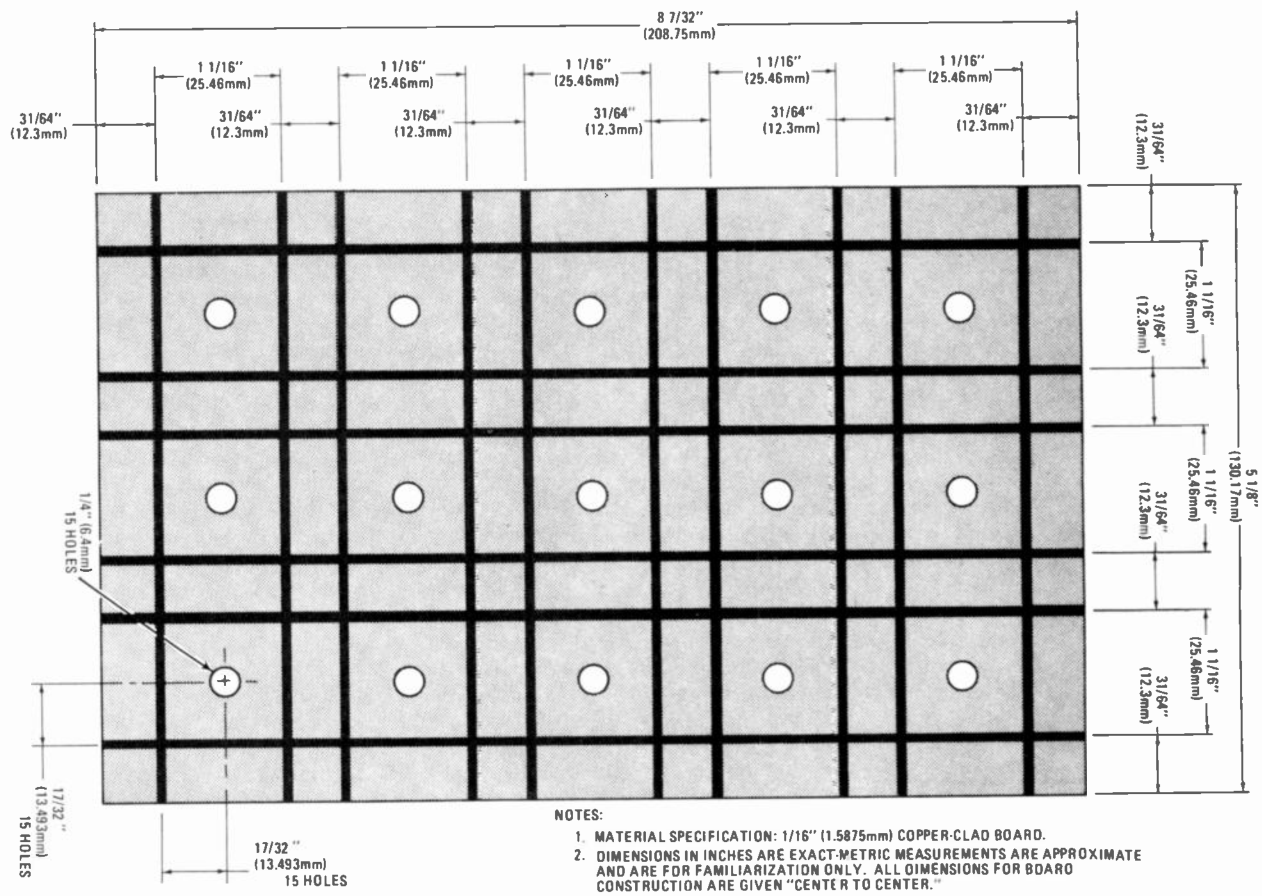


FIG. 3—PRINTED CIRCUIT LAYOUT for the Electronic Slot Machine, shown half size.



NOTES:

1. MATERIAL SPECIFICATION: 1/16" (1.5875mm) COPPER-CLAD BOARD.
2. DIMENSIONS IN INCHES ARE EXACT-METRIC MEASUREMENTS ARE APPROXIMATE AND ARE FOR FAMILIARIZATION ONLY. ALL DIMENSIONS FOR BOARD CONSTRUCTION ARE GIVEN "CENTER TO CENTER."

THE DISPLAY AND LAMP BOARD.

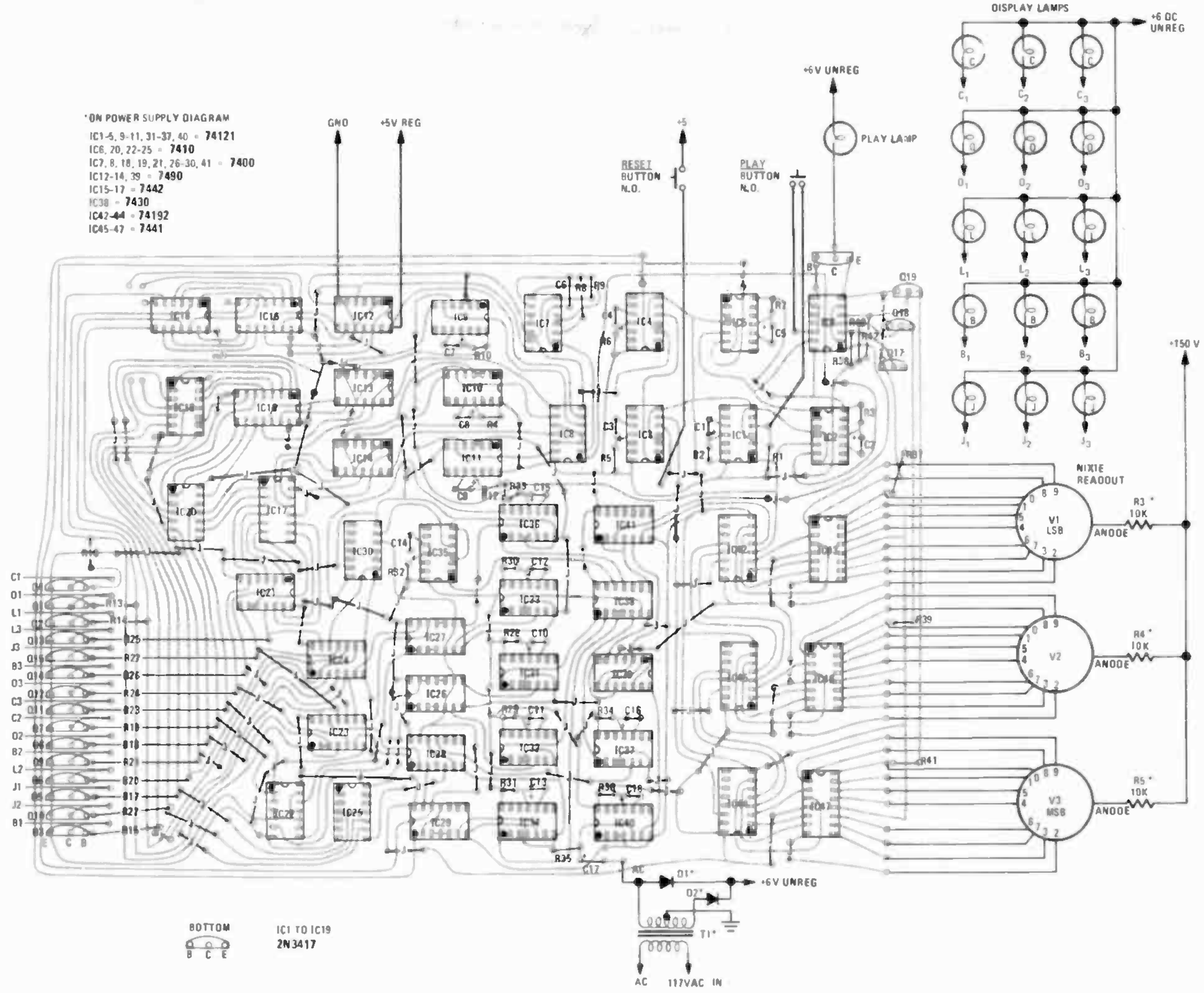


FIG. 4—THE BOARD LAYOUT, showing jumpers and leads to components mounted on panel.

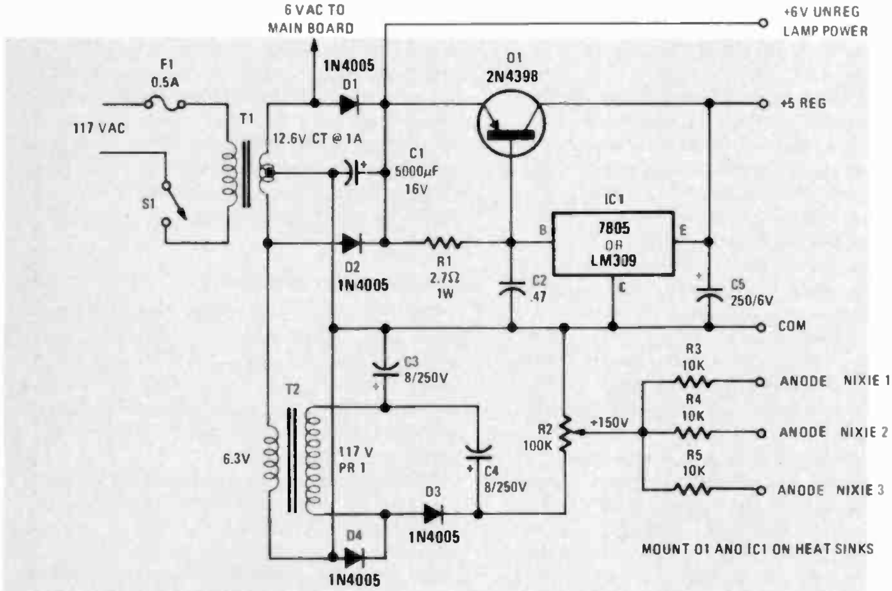


FIG. 5—THE POWER SUPPLY circuit.

PARTS LIST, POWER SUPPLY

R1—2.7 ohms, 1 W
R2—100,000 ohms, 1/2 W pot (fixed resistors may be substituted)
R3–R5—10,000 ohms, 1/4W
C1—5,000 μF, 16 V, electrolytic
C2—0.47 μF, 50-V disc
C3, C4—8 μF, 250 V, electrolytic
C5—250 μF, 6 V, electrolytic
IC1—7805 or LM309, 5 V, 1A voltage regulator
D1–4—IN4005 or similar
Q1—PNP 2N4398 or equivalent
F1—fuse, 1/2 A
S1—SPST power switch
T1—transformer, 12.6 V center tapped, 1 A
T2—transformer, 6.3 V, 0.6 A

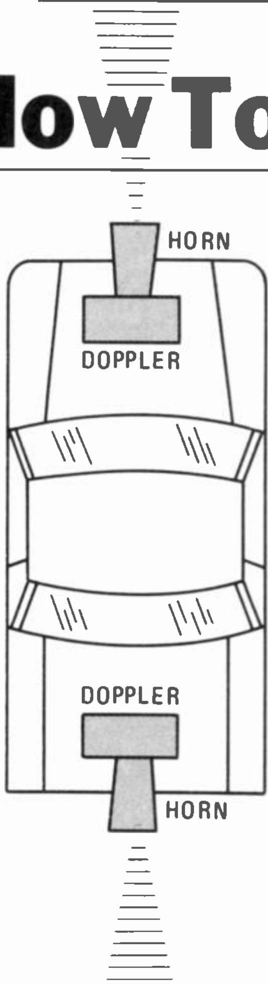
To check the payoffs it is necessary to trigger the payoff one-shots manually or the play cycle would have to be initiated many times. The one-shots are triggered by momentarily applying a ground to pin 5 of the circuit to be tested and observe the accumulator to note the payoff. Simply increase the resistor for more counts or decrease for less.

The remote PLAY switch should be located no more than a few feet from the machine. Use grounded shielded cable because of the normally high input of the play one-shot.

The schematic shows a potentiometer on the high-voltage output. This control is used to set the brilliance of the display tubes. Adjust it for minimum setting needed to prolong the life of the tubes. After the control is set, it can be replaced with fixed resistors if desired.

Many extra features can be added, such as a lamp to indicate a jackpot, or an audible alarm to indicate a jackpot or any payoff. A mechanical arm can be constructed or a slot to accept coins could be made, which would cause a play cycle each time a coin was deposited. A word of caution on the use of coins: it is illegal to gamble in most states and a heavy fine or imprisonment could result if the slot were used for other than hobby purposes. **R-E**

How To Design



Automotive Anti-Collision Systems

Part I—*An in-depth look at the different types of systems and the various design considerations, with enough information for the advanced hobbyist to build his own*

MARTIN BRADLEY WEINSTEIN

WITH JUST A LITTLE INSIGHT INTO THE PROBlems and technologies involved, it is now altogether possible for the average electronics hobbyist to design and construct a relatively sophisticated automotive anti-collision system at reasonable cost.

We're going to take a look at the history of electronics in collision-avoidance systems; at how the various present-day technologies can be put to use and at some of the hardware that is available today. We will define the problems that are encountered when designing collision-avoidance systems and take a look at fully active systems that almost drive your car for you. Finally, we will look at what goes into designing a personal system for our own use and at constructing some of the hardware we'll need.

The history of collision avoidance

Every car today carries the original piece of hardware designed specifically to reduce the chance of a collision: the horn. But operation of the horn is entirely too dependent on operator judgment, and does little to enhance his awareness of conditions around him. Similarly, the headlight and other lamps nevertheless assumes that all other drivers on the road are competent.

But more interesting things started happening in the late 1960's and early 1970's. Researchers at Bendix, Ford, Sylvania, RCA and elsewhere were working on approaches to the collision-avoidance problem using RADAR's, LASER's and ultrasonics.

In these days before fuel embargos, the major threat to the future of the automobile was a lack of roadspace. Since anti-collision devices were designed to avoid collisions, their main objective was to permit a greater traffic density. Thus, the same roads could handle more cars.

The Ford plan

Ford Motors established a Transportation Research and Planning Office to analyze America's transportation needs into the twenty-first century, to coordinate other corporate studies and to administer their development and execution. They saw a need for what would eventually become an Automatic Highway.

Here, some form of mechanical or electronic control, centrally located, would coordinate conventional vehicular traffic (for automobiles equipped as required by legislation with the necessary interfacing and control equipment) to move smoothly at high speed even when closely spaced.

Before the boldly optimistic Automatic Highway could be achieved, however, two other plans seemed likely candidates for interim development. These were called Automatic Headway Control (AHC) and Minigap. Both were designed to avoid rear-end collisions and make long-haul driving a little less of a chore.

AHC used a cruise-type speed control, a RADAR and an on-board computer. It kept the vehicle at the preset speed until the RADAR saw the car ahead getting too close. Then, under computer control, the brakes would be applied to slow the vehicle and maintain a safe following distance. The prototype, unfortunately, was not a very smooth-operating system. It would pull the car forward at full speed, apply full braking, and keep repeating this jerky process as long as there was a car ahead.

Under Minigap, whole trains of cars are linked up electronically to a specially-equipped lead vehicle, specifically designed to travel the freeways just to let you leave the driving to them.

But credit is certainly due Ford's Electronic Systems Research Department for getting so far so soon. Ford, by the way, also worked with an infrared diode LASER and a side-by-side solid-state infrared semiconductor sensor. It was mounted near the rear of the vehicle and pointed backwards. A tricycle, toddler or terrier, for example, would reflect the low-power LASER back to the sensor and trigger a buzzer. The system was activated with the ignition key inserted and the transmission in Reverse, Park or Neutral. The buzzer would sound for three seconds and a warning lamp would light up until the obstacle disappeared. The system was designed for an effective range of about 10 feet.

The Sylvania approach

The Sylvania Wakefield Development Laboratory, meantime, was working on another approach. Since LASER and RADAR systems must first *illuminate* their targets with RF or light, they are called *active* systems. Sylvania was looking at using ultrasonics in a *passive* system.

The Sylvania system generated no ultrasonics of its own, as some SONAR's and, more specifically, SODAR's used in such applications do. Instead, it concentrated on listening for the ultrasonic sounds generated by such vehicle functions as tire against roadway, engine operation and exhausts.

One natural advantage of the Sylvania approach is, of course, that trees and billboards and stopsigns and guard rails and such don't generate ultrasonics, so they can't cause false triggering. They can cause false triggering in RADAR and LASER systems, as well as in active ultrasonic systems.

The prototype was designed to be installed in a tail-light assembly or sideview mirror pod, facing towards the rear of the car to detect oncoming vehicles. While it would respond to vehicles travelling at about 35 MPH or faster, its maximum range was only about 25 feet. A little math shows that even its best-case warning for a situation where the vehicle in which the system is installed is stopped is under a half second before a collision occurs. For a situation where both vehicles are in motion with a relative velocity of just under 1 MPH, this response improves to almost 20 seconds. So clearly, where the threat is the worst, the system is worst-suited to warn of it.

The RCA RADAR system

One of the more technically sophisticated, if bulkier designs to come along was proposed and prototyped by RCA. It involved a 9-GHz vertically-polarized transmitter, an 18-GHz horizontally-polarized receiver and a special license-plate-size reflector. The reflector included microstrip diode filters and acted as a frequency doubler, retransmitting the vertically-polarized 9-GHz signal as a horizontally-polarized 18-GHz signal.

The transmitted signal was about 100 mW with a 4 to 5-degree beamwidth to restrict coverage to the same lane. The electronics package was 17 × 8 × 2 inches and designed for mounting at the center front of the car.

One advantage of the RCA design was the immunity it demonstrated against false triggering from such objects as trees and signs. And the frequency doubling scheme also minimized mutual interference from oncoming vehicles similarly equipped.

The system was intended to provide both relative speed and relative distance, with speedometer information fed into a signal processor to reduce the chance of false triggering from stationary vehicles.

The system involved several disadvantages, however. For one, the electronics package was too big to be practical. If placed high, it blocks necessary air flow to the vehicle cooling system. Higher, it blocks the driver's vision. Lower and it blocks the front license plate required in many states and becomes susceptible to stones, gravel and other road hazards.

Furthermore, at 100 mW, the RCA RADAR is two to five times as powerful as many similar aircraft altitude RADAR's. Granted, the earth is a bigger target than a car, but RADAR altimeters have to work over several miles, not just the 100 yard range of the RCA system. The unavoidable spectrum cluttering at 9- and 18-GHz would certainly have unwelcome side effects. So this very ambitious, very sophisticated approach appears to be an unfortunate example of overkill.

Bendix ASC system

Adaptive Speed Control (ASC) is the Bendix system that ties together a cruise-type speed control with what Bendix and the National Highway Traffic Safety Administration call the Automotive RADAR Brake, or simply RADAR Brake.

The Bendix system is the most difficult to outline, but only because it has gone through a great deal more development. In fact, Bendix has just been contracted by the NHTSA to construct two prototype RADAR-brake-equipped vehicles for actual driver tests.

While several different microwave frequencies have been used during the course of Bendix RADAR brake development, a few salient points have emerged that are common to all approaches.

The systems have all been designed for a minimum 300-ft operating range. Both range and range rate (relative speed) information is determined through a combination of AM and FM modulation of the transmitted signal and some very sophisticated analysis of the return echo. The systems have been developed to limit the possibility of mutual interference to one occurrence in every hundred million encounters (roughly once in a lifetime).

And probably most important, the system designs call for only aiding the driver—warning him first that the collision is oncoming, and then only in the absence of an override signal or an affirmative driver reaction (like hitting the brakes himself) will the system engage braking itself. When it does, it brakes hard to discourage driver dependence on the system.

Much of the technical and human factors that will be considered here on the subject of electronic design for collision avoidance is with the support and insight engendered by the people and publications Bendix so kindly provided.

The state-of-the-art

The purpose of this article is to provide you, as an individual hobbyist, with insight to get you started building if not at least thinking about your own electronic anti-collision system. So far, though, we've looked at what large corporate and government efforts have provided. Now we have to look at what we can do on our own, affordably. And for that matter, just what we can do on our own, period.

As we discuss the various hardware approaches to sensing, analysis and control, we will from time to time refer to specific pieces of equipment and their approximate prices. You are, however, encouraged to investigate any other competing merchandise you can find, and to share new information as well as project ideas with other readers by submitting it to: "Letters to the Editor" **Radio-Electronics**, 200 Park Ave. South, New York, NY 10003.

We will deal, specifically, with infrared diode LASER, Doppler RADAR, ultrasonic SODAR, control and display interfacing, and microcomputer analysis. But, as in any design problem, a definition of the problem is our first requirement.

The operating environment

The rigors of environment within a car can make many modern technologies unusable or very difficult to use without special precautions. Equipment in a passenger compartment in a Northern climate might experience a temperature range from −40°C (−40°F) to 80°C (175°F). Consider that exterior temperatures tend to hit −10 or −20°F at least once or twice a winter up North. And on days when it's 90°F in the shade, the glass windows of your car tend to make things even worse. True, a system may not have to operate at quite those extremes. Nevertheless, designing for a temperature range less than −20°F to 140°F (−30 to 60°C) may be unwise. Under the hood, temperatures can reach 300°F (150°C).

Passenger compartment vibrations are in a range from roughly 10 to 60 Hz at 5 g's or less. Shock acceleration, however, can reach 30 g's sustained over 10 milliseconds. These are quite severe, however, and a design that permits operation against a 10-g shock should be adequate.

Also, consider the environmental difficulties exterior to your car. Fog can disperse, diffuse, reflect and otherwise inhibit systems based on visible light. Infrared systems see through most fogs and mists, so your system should include infrared light if any. The LASER that we will discuss assumes infrared operation.

RADAR's too can be inhibited by atmospherics, like raindrops and snowflakes. As the object size approaches the RADAR's microwave wavelength, it presents a viable target and a return echo.

Bendix, in their recommendations, suggested that the 36-GHz RADAR they first tried (because of favorable antenna size and comparative ease of beam shaping) was too susceptible to backscatter returns. They found an additional 6 dB of noise immunity to this clutter by going to a longer-wavelength 22.125-GHz RADAR. Our RADAR system will operate near 10.525 GHz. And, of course, there's the problem of making the installation waterproof.

Stopping the car

Just how sensitive a collision-avoidance system has to be depends on just how much reaction time it has available. That includes not only the time it needs to recognize a threat and react to it, but also, of course, how long it takes to bring your car to match-speed, often a full stop. And that's different for every car, every road and every kind of weather.

Worst-case analysis is no good here. The difference between good brakes on a good dry road and sloppy brakes on a bad, icy road can be a factor of five. Nor can we assume the maximum speed you will ever go to be 55 MPH. Typical coefficients of friction for dry, wet and icy surfaces are 0.825, 0.3, and 0.15, respectively. To give you an idea of just how much "friction" that is, assuming a top-notch braking system capable of stopping at 90% of the maximum surface coefficient of friction, a vehicle travelling at 50 MPH would take 120, 300 and 600 feet, respectively, to come to a full stop on dry, wet or icy roads.

Vehicle speed

Your speed can do more than just tell you how fast you're going. In conjunction with a PROM lookup-table, it can tell you how far your car will travel under full braking before coming to a complete stop. When added to the relative speeds of the car in front of you and the car behind you, the same PROM can tell you their braking distances, too.

Your vehicle's speed can also be used as the basis for a notch filter to help eliminate returns from overhead signs, bridges, guard rails and such. This can be done through software in a microcomputer-based system or through analog reformatting, analog-to-digital or other conversion techniques in less "intelligent" systems. Remember, Doppler microwave RADAR's compare their received and transmitted frequencies and output a difference signal. This signal represents 31.4 Hz-per-MPH of relative velocity. If your vehicle is doing between 10 and 60 MPH, relative to stationary objects, a Doppler will output 314 to 1884 Hz. This is in the low audio range and easily filterable.

Your vehicle speed can be coupled with other data for useful outputs unrelated to collision avoidance. Coupled to a fuel flow gauge, miles per gallon is an easy first output. And when connected to the fuel tank gauge, a plethora of outputs become available. Imagine for example a video display in your car reading: LOW FUEL! ONLY 1.5 GAL LEFT. AT 45 MPH AND 15.6 MPG. YOU HAVE 23.4 MILES 31 MINUTES TO EMPTY.

Vehicle speed data

The easiest way of obtaining speed information is from the type of generating transducer available through Quest Electronics (P.O. Box 4430, Santa Clara, CA 95054). It is, in fact, a small generator that fits into the speedometer cable line either at the transmission or at the speedometer, depending on the car. It generates a voltage related to speed that can be coupled to a 566 Voltage Controlled Oscillator to produce a frequency related to speed. Proper clocking and latching of that frequency gives a direct BCD latched output that can be bused, displayed, or queried by software.

Sometimes, though, it isn't desirable to display every mile-per-hour increment. Where speeds can change rapidly, as in the 0 to 15 MPH range, readouts that occur only every several MPH (0,2,5,8,10,12,15, for example) may be less confusing. Or simply leaving the original equipment speedometer installed and operating in conjunction with the digital display, if used, may offer a more suitable alternative.

The BCD speed information (in 1-MPH increments) can be used to address a Braking Distance Look-Up PROM directly. The PROM can then be made to output in tens of feet, BCD, in its four least significant bjts (assuming an 8-bit PROM word length), and in hexadecimal hundreds of feet in its four most significant bits. This permits an output range from 0 to 1590 feet, in 10-foot increments, more than enough at even illegal highway speeds.

The stopping-distance information listed in the table below indicates a driver reaction

SPEED IN MPH	DRIVER REACTION DISTANCE*	VEHICLE BRAKING DISTANCE	TOTAL STOPPING DISTANCE
20	22	22	44
25	27.5	34.5	62
30	33	50	83
35	38.5	67.5	106
40	44	88	132
50	55	138	193
60	66	199	265
70	77	293	370

*BASED ON 3/4 SECOND REACTION TIME
DISTANCES IN FEET

time of 0.75 seconds and a vehicle braking distance of approximately 0.055 times the square of the vehicle speed (speed in MPH, distance in feet).

The use of a data selector and three separate lookup tables is strongly recommended. One table would indicate braking conditions under the penalties of an icy highway, one for wet roads and one for dry. Logic outputs from Schmitt triggers hooked to temperature and humidity sensors just inside the car's front bumper could drive the data selector/demultiplexers directly or through an addressed data bus. The block diagram for the stopping-distance circuit is shown in Fig. 1.

It is recommended that the results of the PROM lookup be latched, either through specific gate hardware or in RAM, so that the entire system can be strobed regularly, rather than continuously queried.

In any discussion here of stopping distance, it is interesting to note the approach taken in the Bendix ASC system. A system

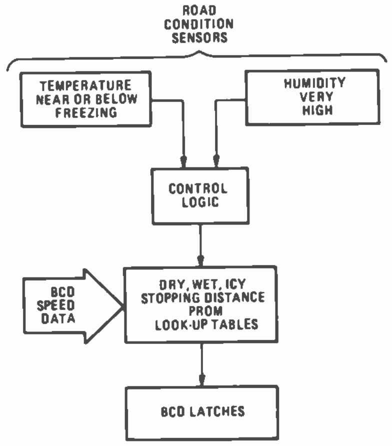


FIG. 1—STOPPING DISTANCE circuit. Speed information is used to address PROM's that contain digitalized stopping distance charts. Parallel memories are included for braking distance under various road conditions (i.e., dry, wet or icy.) Road condition sensors determine which parallel memory will be selected.

voltage determined just how the ASC would react. A positive control voltage caused acceleration; a zero control voltage indicated the system was at its desired distance from the nearest vehicle and at the desired speed and maintained that speed; a negative control voltage backed the throttle off; and a more negative control voltage initiated braking.

The system control voltage, E, was determined by the formula

$$E = (R - R^*) + 3R'$$

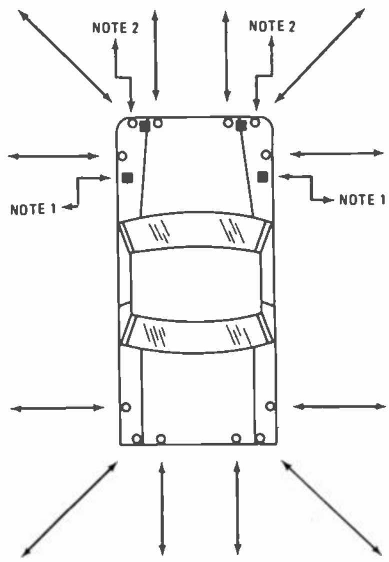
Where R is the actual distance from the nearest vehicle in feet; R* is the desired distance from the nearest vehicle in feet; and R' is the range rate (relative velocity, defined as postitive when the vehicle ahead is faster and pulling away, negative if he's getting closer). In addition, R*, the desired distance from the nearest vehicle range, was defined as fifty feet greater than the number of miles-per-hour the equipped vehicle is traveling. So, for example, if an ASC vehicle is traveling at 45 MPH, its desired R* is 95 feet.

LASER sensors.

The first thing we want to know about the geography external to our vehicle is whether or not an obstacle is present and if one is, where. To accomplish this, a number of small LASER retroreflective sensor modules can be placed strategically around the vehicle. One suggested arrangement is shown in Fig. 2.

A pair of LASER's at each side is aimed low. One, side-facing, is intended to determine whether or not a curb or similar barrier is immediately adjacent. The other, forward facing, is aimed at the wheel path. This is intended to look for unusually abrupt surfaces, as occur at more severe chuckholes.

The other 12 LASER units are aimed at about thigh level. These look specifically for adjacent vehicles. Returns from these sensors are compared, in some cases, with returns



NOTE 1: VERY NEAR GROUND LEVEL–SEARCHES FOR CURBS, BARRIERS

NOTE 2: AIMED AT WHEEL PATHS, AIMED LOW–SEARCHES FOR SEVERE CHUCKHOLES

FIG. 2—LASER SENSOR PLACEMENT. Infrared LASER's are modulated and decoded to prevent false triggering. The LASER's are placed and aimed strategically about the vehicles body so that any adjacent vehicle will be detected by at least one LASER.

from other sensors to determine the validity of a blip.

The units themselves are infrared diode LASER's. Infrareds were chosen because of their necessary ability to see through most fogs, rains and snows. The LASER is modulated at an audio rate generated by the Voltage Controlled Oscillator section of a phase-locked-loop. (The block diagram of a basic LASER system is shown in Fig. 3.) The infrared photodetector at the PLL input is then sensitive only to this particular infrared

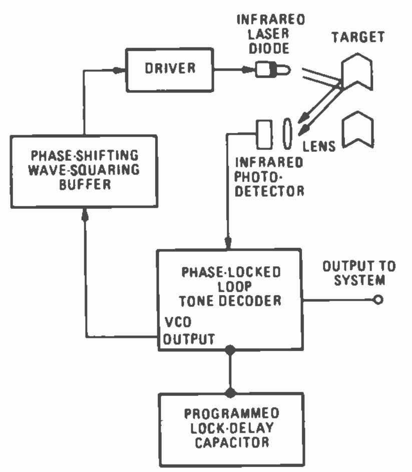


FIG. 3—LASER MODULE uses a 567 PLL tone-decoder IC to modulate the infrared diode. Infrared phodetector receives the modulated infrared if there is an object present to reflect it.

LASER return. Furthermore, the phase-locked-loop can be programmed to delay before indicating. This filters out fleeting returns from picket fences, telephone poles and the like. The 16 LASER PLL outputs are assigned to two 8-bit addresses for software interrogation.

continued next month

HI-FI

TIM Distortion—how it affects your system

Why does a tube amplifier sound better than a transistorized one? The answer lies in the recent discovery of a new type of distortion

LEN FELDMAN
CONTRIBUTING HI-FI EDITOR

JUST WHEN THE AUDIO INDUSTRY WAS smugly settling back with the knowledge it had succeeded in reducing harmonic distortion and intermodulation distortion to almost unmeasurable (and certainly inaudible) levels, our selfsatisfaction was rudely interrupted by the discovery of a new form of distortion called TIM (*T*ransient *I*ntermodulation *D*istortion). Not that its discovery came as a surprise. Audio experts had long been puzzled by the fact that two amplifiers having identical frequency response, identical harmonic and intermodulation distortion and even identical power output capabilities still sounded different—even when connected to identical loudspeakers. Obviously, we weren't measuring everything that needed to be measured.

Gradually, the puzzle began to be pieced together. Some of the pieces related to that elusive difference between the sound of tube-type amplifiers and latter-day solid-state amplifiers. Strangely, the best of the old tube amplifiers never was able to boast the low percentages of THD and IM claimed by the new generation of transistorized equipment and yet, to many ears, they still sounded better. Terms such as "warmer" sound were used (the warmth, in this case, having nothing whatever to do with the heat generated by those energy-wasting tube filaments) to denote the special nature of tube sound. It was thought at first that the difference in transfer characteristics between tubes and linear solid-state devices was responsible in some subtle way for the differences in sound perceived by critical listeners. But designers were able to make solid-state amplifiers which, when tested with steady-state signals at least, displayed exactly the same transfer characteristics and overload waveforms as did the earlier tube amplifiers; and still the audible differences persisted.

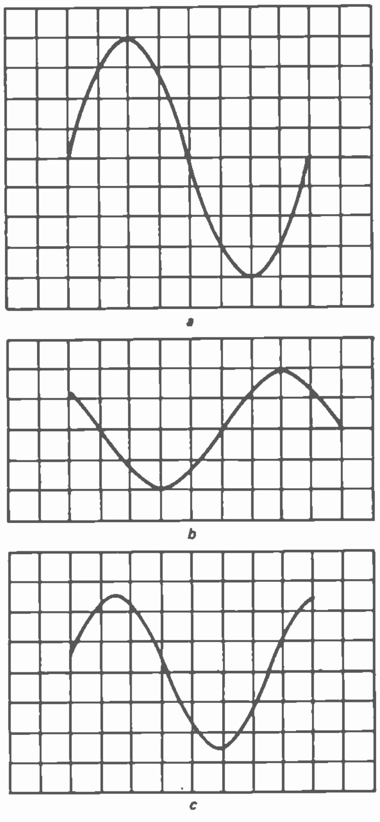


FIG. 1—SINUSOIDAL SIGNAL applied to the input of an amplifier is shown in *a*. Feedback signal is half the amplitude of the input signal and delayed by an additional 45° as shown in *b*. Resultant input to first stage of amplifier is shown in *c*.

As early as June, 1972, Matti Otala of Finland began publishing papers on TIM (*Journal of The Audio Engineering Society*, Vol. 20, No. 5), and he as well as others have been investigating this phenomenon ever since. Studies seem to correlate the relationship between a high TIM level and the poor sound quality we have been attributing to certain amplifier designs for many years.

What is TIM

As most readers know, solid-state amplifiers use negative feedback to improve frequency response and reduce harmonic distortion. Solid-state amplifiers in the past were designed with greater amounts of feedback than in earlier tube designs. This practice stemmed in part from the fact that earlier transistors were limited in bandwidth capability and the application of huge amounts of feedback helped to flatten frequency response and extend it to beyond audible limits.

In general, the feedback signal is subjected to a finite time-delay caused by reactive components and by the transit time of the amplifying devices themselves, so that the feedback signal arrives at the input somewhat delayed in time. As shown in Fig. 1, if a pure sinewave is fed to an amplifier and the delay amounts to as much as 45° of lag between the input signal and feedback signal, the *net* signal will still be perfectly sinusoidal in shape.

To illustrate this, let's assume that the sinewave in Fig. 1-a is the input signal, and that the out-of-phase feedback signal is one-half the amplitude of the original signal and is shown in Fig. 1-b. In this case, if the feedback signal is exactly 180° out-of-phase with the input signal, the input would be reduced in amplitude by 6-dB. However, due to the reactance of the feedback loop, the feedback signal is delayed by an *additional* 45°. The feedback signal is now 225° out-of-phase with the input signal. Because of the additional 45° phase shift, the *net* input signal is now reduced by something less than 6 dB (Fig. 1-c) but it still retains its *exact* sinusoidal shape—somewhat displaced in time from the original input. The feedback has not fully performed its function, but neither has it introduced any new form of distortion beyond any that already existed in the original input waveform.

Now let's consider what would happen under the same circumstances if the input signal had been a step-function, such as a squarewave. *Musical* signals have often been compared to such steep-rising functions, especially when the music contains a high degree of transient information or fast instrument attack-times.

Figure 2 shows a squarewave input signal of the same frequency used in our earlier sinewave example. Again, for simplicity, we are assuming that circuit and feedback delay is the same as in the earlier example. The input signal is shown in Fig. 2-a and the time-displaced feedback signal (which should have uniformly reduced the net input level by half) is shown in Fig. 2-b. Because of the step-function nature of the waveform, the net input amplitude has actually *increased* in the positive going direction by 6 dB for the first eighth of a cycle. This is because the instantaneous amplitude of the feedback signal is in-phase with the input signal and adds to it rather than subtracting from it, as shown in Fig. 2-c.

Even if the step function we had selected were a short-term nonrepetitive one (as in music), while the net input amplitude might not have increased initially, the desired input-signal amplitude reduction that the feedback should have accomplished would not have taken place because of the time-delayed feedback.

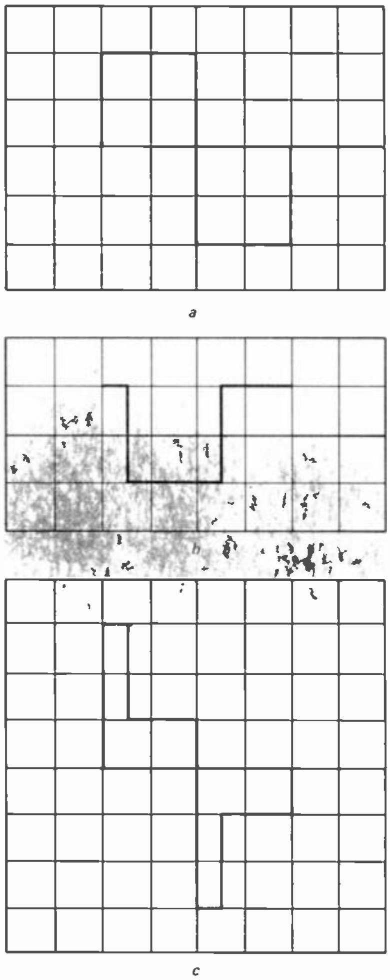


FIG. 2—SQUAREWAVE SIGNAL applied to the input of an amplifier is shown in *a*. Feedback signal is shown in *b*. Resultant input to the first stage of amplifier is shown in c.

For example, if the amplifier in question had an input sensitivity of 1 volt for full-rated output and if a properly reduced input signal (by feedback) were well within that limit, the absence of feedback could drive the amplifier well beyond its clipping level for that short period of time. Remember, too, that in our examples we used a very moderate 6-dB feedback, whereas in practical situations the loop feedback might well be 40 dB or even more. If, in the presence of non-time-delayed feedback, a given input signal was enough to drive an amplifier to, say, its rated output of 20 watts, absence of the required 40 dB of feedback for however short a time period would, in theory, require that the same amplifier produce an instantaneous peak-power output of 200,000 watts—something it obviously cannot do.

In Fig. 3 we have artificially created this kind of situation. A step-function was fed into an amplifier where the feedback network produced a time-delay so that the sharp, positive-going

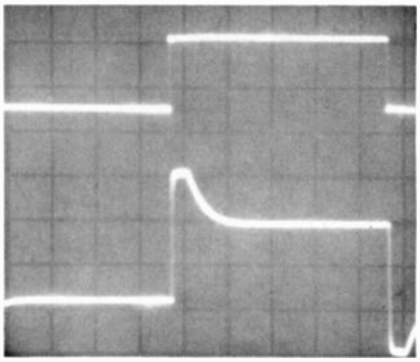


FIG. 3—SQUAREWAVE input signal is shown in upper trace. Lower trace shows output of amplifier in which feedback signal was greater than 180 out-of-phase.

leading edge of the waveform was not subjected to the required feedback. We see that the leading edge of the waveform drives the amplifier severely into clipping, even though a short time later, the amplitude is reduced by the late-arriving feedback to an acceptable nonclipping level. (The lower trace of Fig. 3 is the amplifier output; the upper trace is the input signal.)

In an actual music-listening situation, things become a lot more complicated. For one thing, we are not dealing with simple step-function signals, but with complex signals in which step-functions

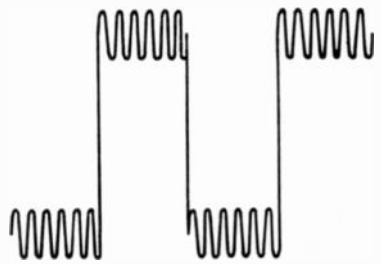


FIG. 4—TIM TEST SIGNAL consists of a 6-kHz tone superimposed on a 500-Hz squarewave.

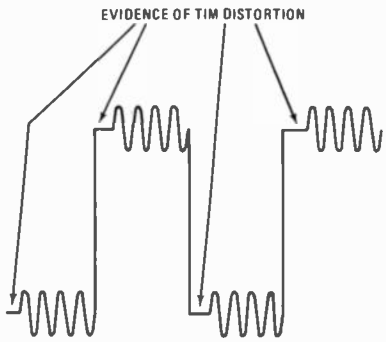


FIG. 5—TIM DISTORTION appears as distortion in the 6-kHz tone after a transition of the squarewave.

at one frequency may be mixed with other sinusoidal signals or step-functions at higher frequencies. One means of detecting the presence of TIM would be to use an input signal consisting of a 500-Hz squarewave mixed with a 6000-Hz tone whose amplitude is one-fourth or one-fifth that of the lower frequency squarewave signal. Figure 4 shows such a TIM test signal. If this TIM test signal is applied to an amplifier and levels are adjusted so that the peak power output is somewhat lower than the amplifier can deliver on a continuous sinewave basis, evidence of TIM would appear as shown in Fig. 5. During the fast risetime and falltime of the 500-Hz squarewave, the momentary absence of properly out-of-phase feedback has "blurred" the first cycle of the superimposed 6000-Hz signal, because the amplifier has been driven into clipping.

Another method of viewing TIM has been proposed using a spectrum analyzer. Again, the basic squarewave/sinewave composite signal is used as a test signal fed to the amplifier. The test signal shown in Fig. 4 was fed to a spectrum analyzer. The result is shown in Fig. 6, which shows the odd harmonics of the squarewave component of the test signal while at the center of the screen we see the 6000-Hz component.

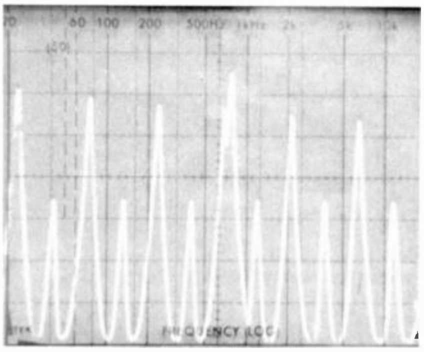


FIG. 6—TIM TEST SIGNAL displayed on spectrum analyzer. The 6-kHz tone appears in the center of the screen while other components are odd-harmonics of the squarewave.

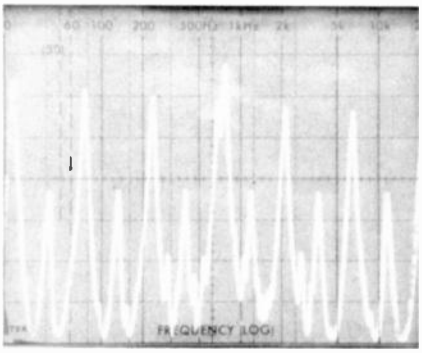


FIG. 7—OUTPUT OF AMPLIFIER fed with TIM test signal. Spectrum analyzer shows additional sideband components resulting from TIM distortion.

Figure 7 shows a partial spectrum analysis of the output waveform that reveals sideband components to either side of the 6-kHz center-spike which were not present in Fig. 6. These extraneous components are indicative of TIM, although they do not easily lend themselves to numerical interpretation. In both Figs. 6 and 7, *linear* frequency sweep was used, and the frequency notations appearing at the top of the screen should be ignored.

A single number for TIM

While several methods for detecting TIM have been described, no single method lends itself to its quantization. It would be desirable to express TIM as a number, in much the same way as we do with harmonic or intermodulation distortion. A relatively simple way to come up with a meaningful TIM number has been suggested by the engineering staff of Lux Corporation of Japan. In this proposal, the same sort of combination squarewave/sinewave test signal is used. The same squarewave source (onto which the higher-frequency sinewave is superimposed) is also applied to a unity-gain inverter stage. The test signal is then fed to one channel of a stereo amplifier, while the inverted squarewave is fed to the opposite and identical channel. Outputs from both channels are then combined in a summing network (which may be made up of passive components), adjusted so that the out-of-phase squarewave components are cancelled as perfectly as possible. What remains is the 6-kHz component that contains distortion every time the rapid step-function of the composite test signal took place. This residual 6-kHz signal is then simply fed to a conventional harmonic distortion analyzer and its distortion content is read as a simple percentage. The entire suggested setup is shown in Fig. 8.

Using this suggested method of TIM measurement, Lux Corporation has already introduced an amplifier with a published TIM specification of 0.05%.

This first attempt at quantifying TIM may not be perfect. Obviously, if the noninverting and inverting amplifier channels are not completely identical, differences in the shape of the out-of-phase squarewave components of the two signals will prevent perfect squarewave cancellation, and non-TIM related distortion components will affect the analyzer's reading. Nevertheless, the approach is fairly simple and can be duplicated in reasonably well-equipped test and service laboratories for at least a "first look" at TIM in a quantitative way. **R-E**

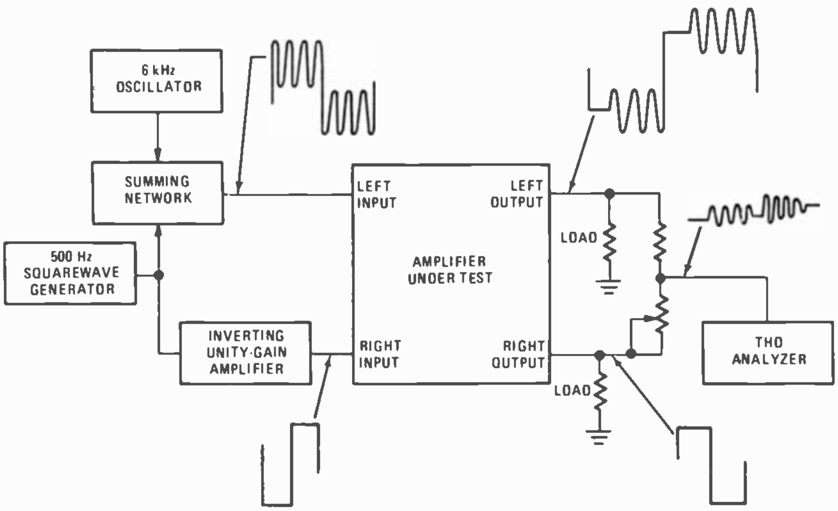


FIG. 8—TEST SETUP for measuring TIM distortion.

Service agencies are warned on warranty service contracts

With the new California warranty legislation, and pending warranty bills in other states, service agency contracts will probably be revised to keep within the new laws. But states NATESA (National Alliance of Electronic and Television Service Associations): "We are appalled with the wording of some contracts servicers are being asked to sign, and caution all service agencies to study such contracts, and possibly seek legal counsel before signing."

Among the "potentially dangerous clauses" is an agreement ". . . to adhere to service policies as set forth from time to time . . ." The servicer agrees, in other words, to conditions the warrantor may set up at a future date.

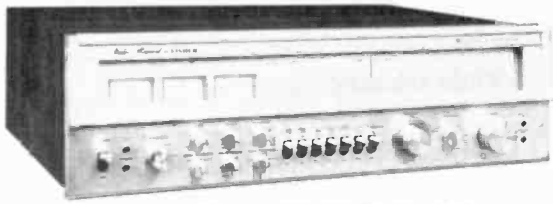
Another dubious clause is ". . . use only genuine parts." This could force the servicer to stock a complete line of resistors, capacitors, etc., carrying the brand name of each warrantor who insisted on it, rather than using such parts out of the servicer's stock, as is present practice. It could also mean long delays in completing service, while parts were back-ordered.

The servicer is even asked to agree "to indemnify and hold the product warrantor blameless against any demand, claim suit by any action or omission for the service station . . . or otherwise." The "otherwise" could cover an almost infinite range of cases. Such provisions, NATESA warns, would put the entire "monkey" on the servicer's back.

Some clauses on agreed rates, worded so as to be subject to a wide range of interpretation, could result in real financial trouble for the servicer.

The NATESA warning concludes it is not the intent of servicers that warranty service agency contracts should not protect the interests of the warrantor. "We believe they should protect the interests of the product purchaser and the servicer as well. Servicers should not sign contracts that do not provide such tri-partite protection."

Radio-Electronics Tests Fisher RS-1080 AM/FM Stereo Receiver



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CIRCLE 99 ON FREE INFORMATION CARD

LEN FELDMAN
CONTRIBUTING HI-FI EDITOR

FISHER CORPORATION, HAVING COMPLETED ITS corporate reorganization, has now undertaken the job of recapturing its proper share of the high-fidelity component market. The company recently introduced a new line of receivers as part of its long-famed "Studio Standard" line, the most powerful and expensive being the *model RS-1080* shown in Fig. 1. The design is new, including a light-colored front panel using a gold background behind the slightly sloped dial-area cutout and dark-colored frequency calibration numerals for easy visibility. Above the blue frequency numerals is a series of red indicator words that illuminate to denote program source, activation of the FM Dolby decoding feature and reception of a stereo FM signal. A 0-to-100 linearly calibrated logging scale below the FM and AM frequency scales helps pinpoint favorite stations.

To the left of the frequency scales, but within the dial opening area, are three separate meters: one for AM and FM signal strength; a center-of-channel FM tuning meter and a multipath indication meter that is adjusted for a minimum indication while orienting an outdoor FM antenna.

All controls are located across the bottom of the panel: A toggle-type power on/off switch, a SPEAKER selection switch (that selects one or two out of three pairs of speakers or headphones only); BASS, TREBLE and BALANCE controls; an extra BASS SELECTOR switch plus an associated BASS RANGE boost control; and a TAPE MONITOR switch with positions for two tape decks and for dubbing from one deck to another. Seven small toggle switches come next, centered on the lower portion of the panel. These switches take care of tone-control defeat, mono/stereo mode selection, low- and high-cut filter switching, loudness circuit, FM muting and Dolby decoder switching. A master VOLUME control calibrated in discrete dB steps has an illuminated pointer for easy viewing of volume settings. There is also a program selector switch, followed by a large station tuning knob (coupled to a highly effective flywheel/dial pointer) and a pair of jacks for possible connection of a third tape deck.

A hinged, pivotable AM ferrite-bar antenna on the rear panel (Fig. 2) swings down and out to disclose the external AM, 75-ohm coaxial and 300-ohm antenna terminals as well as the phono and auxiliary input jacks. Chassis ground terminals are located below, while centered on the rear panel are the two

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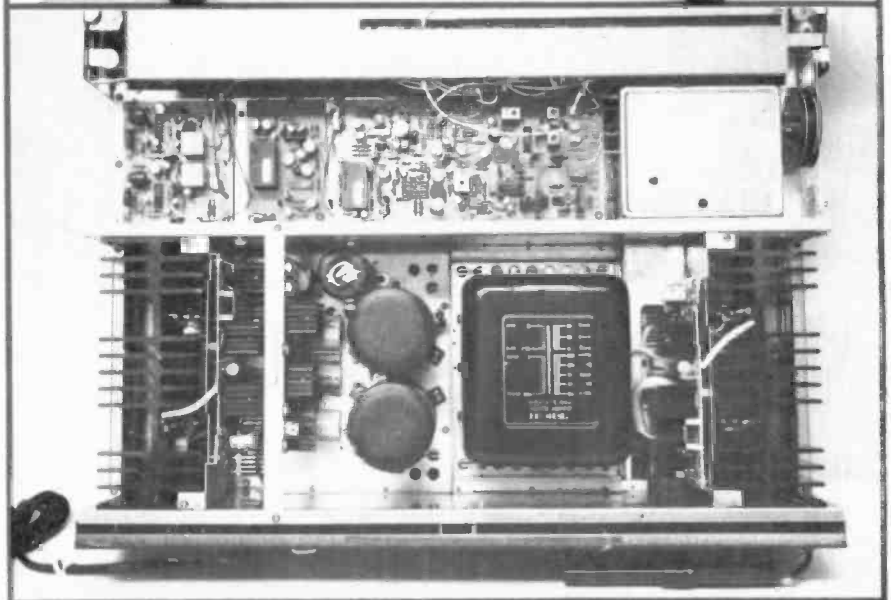

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MANUFACTURER'S PUBLISHED SPECIFICATIONS

FM TUNER SECTION:
Usable Sensitivity: Mono: 1.7 μV (9.8 dBf); Stereo: 4.3 μV (17.9 dBf). **50-dB Quieting Sensitivity:** Mono: 2.5 μV (13.2 dBf); Stereo: 34 μV (35.8 dBf). **Signal-to-Noise Ratio:** Mono: 72 dB; Stereo: 70 dB. **Distortion:** Mono: 0.15% at 1 kHz, 0.15% at 100 Hz, 0.18% at 6 kHz; Stereo: 0.25% at 1 kHz, 0.3% at 100 Hz, 0.4% at 6 kHz. **Capture Ratio:** 0.8 dB. **Selectivity:** 75 dB. **Image Rejection:** 100 dB. **Spurious Rejection** 100 dB. **AM Suppression:** 65 dB. **Stereo Separation:** 1 kHz: 50 dB; 10 kHz: 36 dB. **Subcarrier Rejection:** 70 dB. **SCA Rejection:** 66 dB.

AM TUNER SECTION:
Sensitivity: 280 μV (Internal Antenna). **Selectivity:** 45 dB. **S/N Ratio:** 55 dB. **Image Rejection:** 70 dB. **IF Rejection:** 80 dB.

POWER AMPLIFIER AND PREAMPLIFIER SECTION:
Power Output: 170-watts minimum continuous watts per channel, 20 Hz to 20 kHz, 8-ohm loads. **Total Harmonic Distortion:** 0.1%. **Damping Factor:** 30. **Input Sensitivities:** Phono 1 & 2: 2.0 mV; Aux and Tape: 150 mV. **Phono Overload** 300 mV. **S/N Ratio:** Phono: 70 dB; Aux and Tape: 82 dB; Residual at minimum volume: 100 dB. **Tone Control Range:** Bass: ±12 dB at 100 Hz; Treble: ±12 dB at 10 kHz. **Filter Response:** Low Cut: –6 dB at 30 Hz; High Cut: –6 dB at 5 kHz.

GENERAL SPECIFICATIONS:
Power Requirements: 120 volts, ±10%, 60 Hz, 1000-watts maximum. **Dimensions:** 23¾ W × 16¹⁵⁄₁₆ D × 7⅜-inches H. **Weight:** 65 lbs. **Suggested Retail Price:** $899.95.

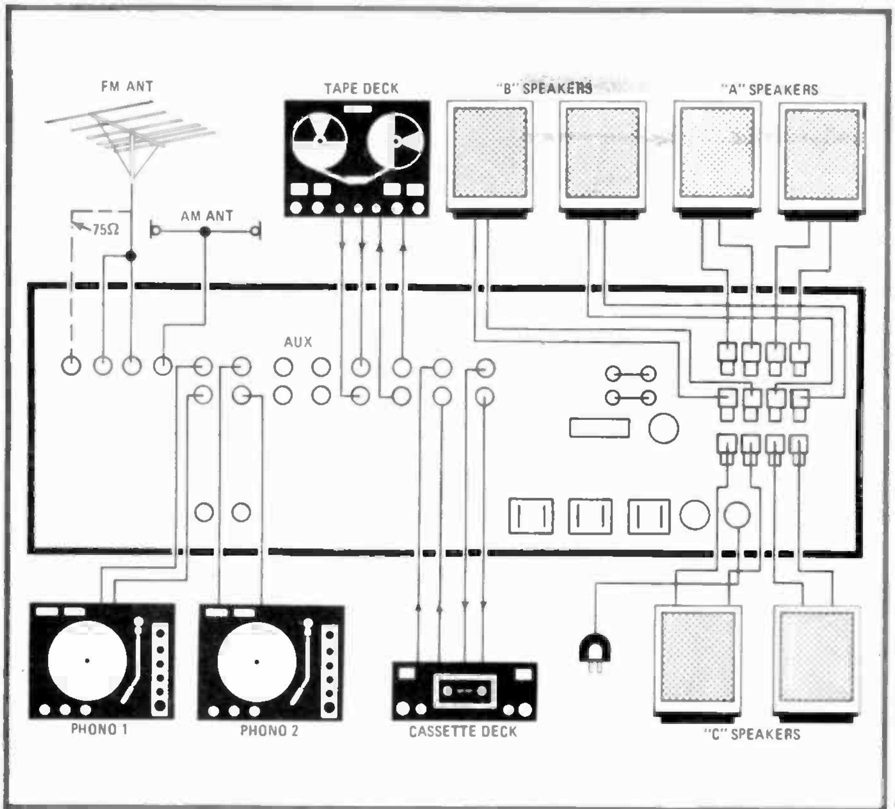

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TABLE I
RADIO-ELECTRONICS PRODUCT TEST REPORT

Manufacturer: Fisher — Model: **RS-1080**

FM PERFORMANCE MEASUREMENTS

SENSITIVITY, NOISE AND FREEDOM FROM INTERFERENCE	R-E Measurement	R-E Evaluation
IHF sensitivity, mono: (μV) (dBf)	1.7 (9.8)	Excellent
Sensitivity, stereo (μV) (dBf)	16.0 (29.3)	Fair
50-dB quieting signal, mono (μV) (dBf)	2.7 (13.8)	Excellent
50-dB quieting signal, stereo (μV) (dBf)	33.0 (35.6)	Excellent
Maximum S/N ratio, mono (dB)	77	Superb
Maximum S/N ratio, stereo (dB)	70	Excellent
Capture ratio (dB)	0.9	Superb
AM suppression (dB)	65	Excellent
Image rejection (dB)	100 +	Excellent
IF rejection (dB)	95	Excellent
Spurious rejection (dB)	100	Excellent
Alternate channel selectivity (dB)	77	Very good
FIDELITY AND DISTORTION MEASUREMENTS		
Frequency response, 50 Hz to 15 kHz (±dB)	+0, –2.0	Fair
Harmonic distortion, 1 kHz, mono (%)	0.11	Very good
Harmonic distortion, 1 kHz, stereo (%)	0.12	Excellent
Harmonic distortion, 100 Hz, mono (%)	0.10	Excellent
Harmonic distortion, 100 Hz, stereo (%)	0.20	Good
Harmonic distortion, 6 kHz, mono (%)	0.06	Superb
Harmonic distortion, 6 kHz, stereo (%)	0.22	Very good
Distortion at 50 dB quieting, mono (%)	0.75	Excellent
Distortion at 50 dB quieting, stereo (%)	0.55	Very good
STEREO PERFORMANCE MEASUREMENTS		
Stereo threshold (μV) dBf)	16.0 (29.3)	Poor (see text)
Separation, 1 kHz (dB)	53	Superb
Separation, 100 Hz (dB)	46	Excellent
Separation, 10 kHz (dB)	38	Excellent
MISCELLANEOUS MEASUREMENTS		
Muting threshold (μV) (dBf)	20 (31.2)	Poor (see text)
EVALUATION OF CONTROLS, DESIGN, CONSTRUCTION		
Control layout		Excellent
Ease of tuning		Very good
Accuracy of meters or other tuning aids		Excellent
Usefulness of other controls		Excellent
Construction and internal layout		Very good
Ease of servicing		Very good
Evaluation of extra features, if any		Excellent
OVERALL FM PERFORMANCE RATING		Very good

pairs of tape-out and tape-in jacks. Preamp-out/main amplifier-in jacks, three sets of piano-key spring-loaded speaker terminals and one switched plus two unswitched AC receptacles are at the right of the rear panel.

The internal layout is shown in Fig. 3. Power amplifier modules are mounted adjacent to symmetrically positioned massive heat sinks on either side of the large power transformer and electrolytic filter capacitors. Figure 4 shows the variety of associated equipment that can be used with this receiver.

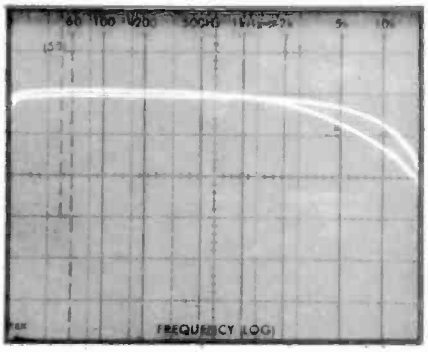
Circuitry

Eleven separate major circuit boards are used. A five-gang variable capacitor is used in the FM front end, which also uses two dual-gate MOSFET RF stages, a dual-gate MOSFET mixer and a local oscillator with a separate buffer stage. The phase-linear IF section of the receiver has solid-state pretuned ladder-type filter circuits followed by a double-tuned quadrature detector. The stereo multiplex decoder contains a phase-locked-loop circuit. The circuit for driving the multipath meter also uses a phase-locked-loop arrangement.

Each preamplifier-equalizer circuit uses a differential amplifier input, followed by single-ended push-pull output stages. The familiar Baxandall tone control circuitry is preceded and succeeded by buffer amplifier stages. Complementary push-pull output stages in the main amplifier section of the receiver contain four power transistors in each channel, two of which are paralleled for the positive and negative halves of the drive circuit. A separate protector circuit assembly using a power relay protects speakers from possible damage.

FM performance measurements

Results of our FM measurements are listed in Table I. Evidently, the stereo threshold settings, as well as the signal strength required to overcome the otherwise effective



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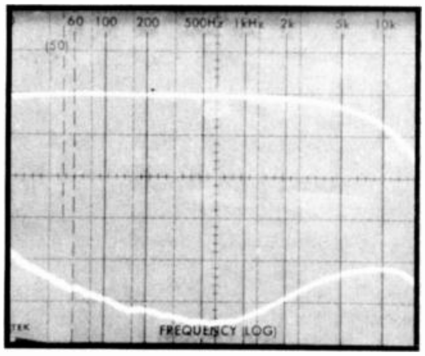
muting circuit of this tuner section, were somewhat misadjusted. Signal strengths required were considerably higher than specified. In all other respects, however, the tuner section performed well, providing 50 dB of quieting with only 2.7 μV (13.8 dBf) of signal applied in mono and 33 μV (35.6 dBf) for the same quieting in stereo. Signal-to-noise in mono was 77 dB, while in stereo the best quieting was 70 dB—as good as many high-priced receivers are able to do in mono. Total stereo harmonic distortion was almost as low as in mono for all but the highest audio test frequencies, with readings of 0.12% at 1 kHz, 0.2% at 100 Hz and a very low 0.22% at the higher 6-kHz test point.

Figure 5 shows the frequency response

(including de-emphasis) for the normal, 75-µs de-emphasis circuit (lower curve) and for the built-in 25-µs de-emphasis associated with the Dolby circuitry. The sharp rolloff above 18 kHz illustrates the effectiveness of the low-pass filter to remove any residual 19-kHz carrier products at the output.

Figure 6 displays the excellent overall separation characteristics of the stereo multi-



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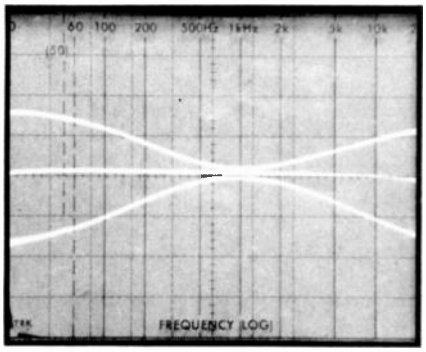
plex section of the receiver. Vertical divisions on the scope face correspond to 10 dB; the upper trace represents the desired-channel output, while the lower trace shows the attenuated output from the opposite channel.

Amplifier section

The power amplifiers delivered 182 watts per channel, at mid-band frequencies, with both channels driving 8-ohm loads. Even at 20 Hz, the amplifiers delivered a bit more than their rated 170 watts-per-channel and, at actual rated output, distortion for a 1-kHz signal was a mere 0.0085%. Table II lists these and other amplifier and preamplifier section measurements. The phono preamp-equalizer section was virtually impervious to overload, showing audible distortion with input signals as high as 330 mV, as against 300 mV claimed.

The BASS and TREBLE tone control range is shown in Fig. 7. The extra bass control selector and range controls referred to earlier



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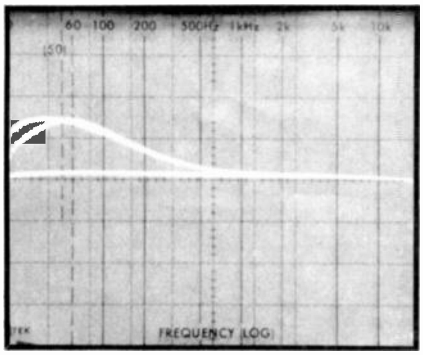
introduce controllable amounts of bass boost at selectable frequencies of either 45 Hz or 80 Hz. Figure 8 shows the maximum amount of boost available at these center frequencies. However, it should be understood that by adjusting the bass range control, any degree of lower-bass boost up to and including the curves shown can be introduced. This bass-boost circuit is extremely useful in compensating for loudspeakers that are somewhat deficient in bass at their lower octaves and does not seriously affect upper bass or mid-range frequencies.

While the low-frequency filter was designed with a slope of 12 dB-per-octave (see Fig. 9), the designers chose to limit the slope of the high-frequency filter to a more moderate 6 dB-per-octave. This filter is less



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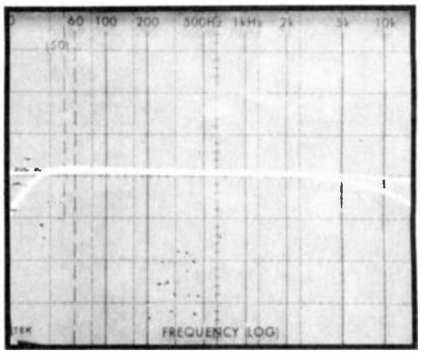
effective in removing hiss and scratch than a more steeply sloped high-frequency filter. However, Fisher engineers maintain that too steep a slope at the high end of the response curve tends to cause audible distortion in musical fidelity when the latter filter is used.

Summary

Our overall product analysis for this high-powered receiver, along with summary comments, will be found in Table III. In general, the unit peformed well both as a high-



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powered preamplifier/amplifier component and in its AM and FM tuner functions. The *Model RS-1080* seems well worth its suggested selling price and ranks high among the ever-expanding new group of superpowered receivers. **R-E**

Table III appears on page 84.

TABLE II

RADIO-ELECTRONICS PRODUCT TEST REPORT

Manufacturer: **Fisher** Model: **RS-1080**

AMPLIFIER PERFORMANCE MEASUREMENTS

	R-E Measurement	R-E Evaluation
POWER OUTPUT CAPABILITY		
RMS power channel, 8-ohms, 1 kHz (watts)	182	Very Good
RMS power/channel, 8-ohms, 20 Hz (watts)	173	Very Good
RMS power/channel, 8 ohms, 20 kHz (watts)	170	Good
RMS power/channel, 4-ohms, 1 kHz (watts)	193	
RMS power/channel, 4-ohms, 20 Hz (watts)	187	
RMS power/channel, 4-ohms, 20 kHz (watts)	175	
Frequency limits for rated output (Hz-kHz)	13-20	Good
DISTORTION MEASUREMENTS		
Harmonic distortion at rated output, 1 kHz (%)	0.0085	Excellent
Intermodulation distortion, rated output (%)	0.02	Very Good
Harmonic distortion at 1-watt output, 1 kHz (%)	0.06	Excellent
Intermodulation distortion at 1-watt output (%)	0.05	Excellent
DAMPING FACTOR, AT 8 OHMS	35	Good
PHONO PREAMPLIFIER MEASUREMENTS		
Frequency response (RIAA ± dB)	+ 0.5	Good
Maximum input before overload (mV)	330	Superb
Hum/noise referred to full output (dB) (at rated input sensitivity)	70	Very good
HIGH LEVEL INPUT MEASUREMENTS		
Frequency response (Hz-kHz, ± dB)	13-22, ±1 dB	Good
Hum noise referred to full output (dB)	85	Very good
Residual hum noise (min. volume), (dB)	95	Very good
TONAL COMPENSATION MEASUREMENTS		
Action of bass and treble controls	See Fig. 7	Good
Action of secondary tone controls	See Fig. 8	Excellent
Action of low-frequency filter(s)	See Fig. 9	Excellent
Action of high-frequency filter(s)	See Fig. 9	Good
COMPONENT MATCHING MEASUREMENTS		
Input sensitivity, phono 1 phono 2 (mV)	2.2/2.2	
Input sensitivity, auxiliary input(S) (mV)	200	
Input sensitivity, tape input(s) (mV)	200	
Output level, tape output(s) (mV)	200	
Output level, headphone jack(s) (V or mW)	280 mV	
EVALUATION OF CONTROLS, DESIGN, CONSTRUCTION		
Adequacy of program source and monitor switching		Very good
Adequacy of input facilities		Very good
Arrangement of controls (panel layout)		Excellent
Action of controls and switches		Excellent
Design and construction		Excellent
Ease of servicing		Very good
OVERALL AMPLIFIER PERFORMANCE RATING		Very good

Here's a rundown of the important facts that every user and potential purchaser of digital multimeters should know.

What You Should Know About DMM's

CHARLES M. GILMORE*

THERE ARE A GREAT MANY DIGITAL MULTIMETERS on the market, everything from pocket size to expensive lab-grade instruments. It is important for every potential purchaser of these instruments to know what makes one instrument different from another as well as every user to know the little nuances that come into play when taking readings.

General features

Often the features are what make one instrument stand out from another. The potential DMM buyer should have a good knowledge of an instrument's features and how he can use them. The purchaser often needs to make a tradeoff between features, so careful consideration of one feature against another is in order if he is to gain maximum use from the DMM investment.

The digits. One of the strange terms developed by the DMM manufacturers is an expression "half digit." It is perfectly clear what a three-digit DMM is, and what a four- or two-digit "machine" (as they are sometimes referred to) is, but a three-and-one-half-digit machine sounds like something run through a saw. The term "half digit" has been coined to indicate a DMM with 100% overrange capability. This is also referred to as "1999" (three-and-one-half-digit) capability. In a similar manner, the term three-and-three-quarter-digit machine has come to mean a DMM with 3999 capability. Whenever terms such as these are used, it is wise to inspect the specifications very carefully to determine their exact meaning. Good specifications give a numerical upper limit to each of the instrument's ranges, and also specify overrange capability.

The resolution of the instrument is directly limited by the number of digits in the display. A three-and-one-half-digit DMM has a *resolution* of one part in two thousand or 0.05%. For example, the 1-volt range has a full-scale value of 1999 millivolts, and the resolution is one millivolt. Four-and-one-half-digit machines have resolutions of one part in twenty thousand or 0.005%, but unless the noise is very low, this resolution may not be useable; there may be instability in the last few digits at all times. The two-and-one-half-digit instrument has a resolution of one part in two hundred, or 0.5%.

A two-and-one-half-digit or a three-digit DMM should be considered as a replacement for a good analog multimeter, as far as accuracy and resolution are concerned. Accuracy generally lies between 0.5% and 1.5% with 0.5% resolution or more. The three-and-one-half and four-digit machines generally have accuracies between 0.5% and 0.05%, with 0.05% resolution. Such resolution and accuracy generally suffice for even the most exacting service work and home experiment. Four and one half digits or more generally indicate an accuracy of 0.05% or better with 0.005% resolution and should be considered laboratory instrumentation.

Power sources. Most DMM's today offer battery as well as power-line operation. A few, either the very exotic or the very inexpensive, do not. The battery is often an option at extra cost, especially if the batteries are rechargeable. In a few DMM's the batteries are required for operation, as the AC supply/charger does not have the current capability to operate the DMM alone.

When considering battery operation, note the type of cells used. Replacing an odd-sized cell may be both difficult and expensive. Rechargeable cells that are physically and electrically interchangeable with zinc-carbon or alkaline cells have an advantage. Temporary substitution permits portable operation, even if the batteries were not charged the night before. All cells have a finite life expectancy, and today none are particularly cheap. Therefore, if there is no need for a portable instrument, and expense is a consideration, battery operation may not be worth the price. Battery operation is not confined to field use; even in the bench situation, it may be an advantage in making a voltage measurement with the DMM floating at a potential above the allowable common-mode voltage of the instrument.

For truly portable operation, the operating time from a full charge is an important specification. For extremely constant use, an operating time of eight hours may be needed from a single overnight charge. If the DMM is to be operated intermittently during the course of a working day, and is to be kept on a charger overnight, an operating time of four to six hours will be quite satisfactory and probably cheaper.

Status indication. Digital multimeters have many modes of operation. With either an autoranging instrument, or one being operated at some distance from the user, some form of status indication is convenient. Status indication displays the DMM function and range being used. Usually this takes the form of lighted indicators in the display window. Overrange decimal point and polarity are the most frequently included status indicators. Be certain these three indications are easily

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understood. Blinking or blanking of the display is frequently used to indicate an overrange condition. Illuminated + and − symbols most frequently indicate the polarity of the DC measurements.

The sample rate specification indicates the number of conversions in one second. Commonly this figure is about three to five per second. With seven-segment displays, sample rates in excess of five per second may create readings that are difficult to read.

Warm-up time. Many instruments specify a period of time required before the instrument is within its specifications. Quick warmup may cost extra, but if high accuracy and rapid portability are requirements, as in certain types of service work, it may be a feature worth paying for.

Operating temperature range. The accuracy specifications of a DMM have a temperature dependency. This is usually specified in one of three ways. First, a temperature range over which the DMM may be operated within its published specifications may be stated. Second, the DMM may be given an accuracy specification at 25°C, and a derating figure for temperatures other than 25°C. Third, the permissible operating temperature range of an instrument regardless of accuracy is important. Cold climates may find the instrument kept in an unheated portion of a service truck. The instrument with an operating temperature range of zero degrees Centigrade and above may well not operate on a moderate winter day!

Size and weight. The physical characteristics of a DMM make it portable. They also contribute to price and complexity. Again, keep the intended application in mind to make the best cost/value tradeoffs.

Displays. The light-emitting diode (LED) is one of the most popular displays in use with DMM's. Other displays in use are the ten-character neon display (Nixie)®, the seven-segment neon display, fluorescent display, and liquid crystal display (LCD). LED's are popular because of their good brightness, excellent contrast and low cost. Neon displays, both ten-character and seven-segment, have the highest brightness but at a slight increase in cost, combined with the requirement for a high-voltage power supply. Neons also tend to generate some slight RF noise. Fluorescent displays have never been too popular, although they generally require less power than LED's or neon. Fluorescents are subject to interference from static electricity and have poor contrast. Extremely low-power operation make LCD's popular. They also have a potentially low cost, but also, however, have the lowest contrast ratio. Certain types of LCD's don't wash out in direct sun light, but most will freeze at moderate temperatures and become completely useless. The life expectancy of LCD's is one hundredth or less that of the neon or LED displays.

When considering displays, size must be given some thought. DMM displays will run from 0.1 inch high to displays with a character height of 0.6 inches or more. Often the user is never more than the length of the test leads from his DMM. In such case, small displays are no hindrance, and permit a smaller, more portable design. On the other hand, if readings may be required at a greater distance, larger displays are necessary. Again, the instrument's use must be considered.

Specifications

The number of specifications associated with the DMM is extensive. Unfortunately, many of the variations from DMM to DMM are the subtly specified nuances that make all the difference to the user when the instrument is on the workbench.

The DC voltmeter

Ranges. One of the first questions facing the potential buyer is defining full scale on a particular multimeter. They are specified one of two ways: either with full scale being a multiple of 10 (1, 10, 100, 1000, etc.) with usable overrange capability specified as a percentage (typically 100%); or full scale is specified as the maximum possible reading encompassing all usable ranges (often 1.999). For example, a DMM may be specified as having 1 volt full scale with 100% overrange, thus indicating useful operation to 2 volts, or the same DMM may be simply specified as having a 2 volt full scale. These ranges are further limited, as the full indicated capability of the meter may not be useful on the highest voltage range. For example, a DMM with a 1999 full scale may not be able to read over 1000 volts DC and even lower on AC, even though 1999 volts is apparent at first glance. This is usually due to the danger of voltage breakdown of internal components.

Accuracy. Specifications differ by manufacturer as well as by the accuracy of the meter being specified. A meter specified with very high accuracy will have more sophisticated accuracy specifications as compared to those of the meter with limited accuracy. Simple accuracy specifications are given as "±% of full scale, ±1 digit." The "plus/minus one digit" portion of the specification is caused by an error in the digital counting circuits, the "plus/minus percentage of full scale" includes ranging and A/D conversion errors.

One of the most sophisticated specifications is "±% of reading, ±% of full scale, ±1 digit." Such a specification is usually confined to instruments in the 0.05 to 0.01% class.

An additional specification may qualify the accuracy of the instrument at temperatures other than 25°C. Temperature specifications are of two forms: either a temperature coefficient, per cent per degree centigrade, with which the user may calculate the exact deviation from the 25-degree specification, knowing the ambient temperature; alternatively, accuracy is specified over a complete temperature range such as 15°C to 35°C.

Other limitations may be placed on the accuracy of the instrument. These include the effects of line voltage variations, humidity, altitude and time. These limitations are of little interest to the person making general use of the multimeter. However, some manufacturers, not knowing where their instruments will be used, issue all-encompassing specifications. One thing you can be sure of—the more inclusive the specifications, the higher the cost of the instrument!

Input impedance. Most DMM's have a 10-megohm DC input impedance. A few have an input impedance of one megohm. Input impedance may have a tolerance specified. This is important when using the meter with an external multiplier resistor. Some voltmeters offer very high input impedance on the lowest DC input ranges. Input impedances on such DMM's may be in the 100 to 1,000 megohm range.

Response time. This consists of two factors: first, the basic cycle rate of the A/D converter; second, the time required to charge capacitances in the input circuits. This time may be long if there is input filtering. Response time is the number of seconds required for the instrument to settle to its rated accuracy. In lieu of response time, some manufacturers simply give the number of conversions per second.

Protection. Specifications indicate the amount of line frequency AC overload each range will tolerate without damage. This is especially important when using the instrument in industrial or semi-industrial applications, where accidental contact with 120 or 240-volt AC is quite possible.

Normal mode rejection ratio. NMRR indicates the amplitude of AC (usually line frequency) interfering signal impressed on the DC being measured that will affect the least significant digit (see Fig. 1). The ratio of the interfering signal to the voltage represented by the least significant digit is usually expressed in decibels (dB). For example, an instrument reading 100.0 millivolts DC is specified to have 60 dB NMRR. The least significant digit indicates 100 microvolts. Thus 100 mV (100 millivolts) will not affect the reading in the least significant digit; any signal greater than 100 mV may. NMRR depends upon the instrument timing and may have to be adjusted for changes in power-line frequencies: 50, 60 or 400 Hz.

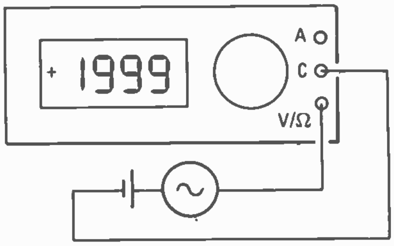

FIG. 1—TEST SETUP FOR NMRR (Normal Mode Rejection Ratio). Amplitude of the AC series signal is increased until the least significant digit of the display is changed.

Common Mode Rejection Ratio. CMRR specifies the instrument's ability to reject signals applied between earth ground and a point common to the high and low input terminals of the instrument. There is no CMRR specification if the instrument's low terminal is at earth ground. Fig. 2 indicates

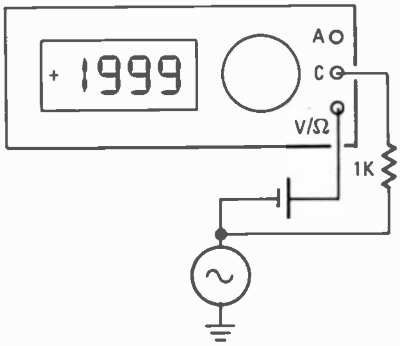

FIG. 2—COMMON MODE REJECTION ratio is measured in much the same way as NMRR. Neither terminal of the meter may be grounded during the measurement.

the common method of measuring CMRR. The one kilohm resistor in series with the low terminal is generally included with any CMRR specification. This resistor represents a typical source resistance of DC signals under actual measurement conditions. Current flowing in the common mode path flows through the 1,000-ohm resistance. The voltage generated across the resistor is converted to a normal mode signal, which is rejected by the instrument's NMRR. Occasionally CMRR is given less the NMRR. Generally, the CMRR includes NMRR. As with NMRR, CMRR is given at power-line frequencies. CMRR worsens with increasing frequency.

DC CMRR, or the floating capability of an instrument, is often limited by the breakdown voltages of the input circuitry. This specification indicates the greatest DC potential the low terminal of the voltmeter may have above earth ground.

The AC voltmeter

Range specifications are identical in nature to those given for the DC voltmeter. The high-voltage range may have an upper voltage limit considerably less than expected from a front panel reading; 750 volts is common.

Accuracy. AC voltmeter accuracy is generally given in the same way as the DC voltage accuracy. However, accuracies are normally only for measurements of sinusodial signals with less than a specified amount of harmonic distortion (usually ½%). AC to DC converters, which are normally average or peak responding but RMS reading, require this limitation; if other than sinusodial waveforms are measured, the accuracy specification no longer holds. This is not true if the instrument employs a true RMS converter. These are not common and are very expensive. The normal range for AC accuracy is 0.5% to 1% for the average or peak responding RMS calibrated instruments.

DMM, Heathkit IM-2202

Most AC voltmeters specify frequency response, indicating the instrument's ability to measure high-frequency signals, and the expected inaccuracies over a specified frequency range. The limits to AC frequency response are normally from 20 Hz to 10 kHz or 50 kHz, depending on the instrument.

Input impedance specifications of the DMM should include not only the resistive value to be expected (usually 1 or 10 megohms), but also the value of capacitance between the input terminals. This is generally about 100 pF.

Response time. AC voltmeter response time includes all time specified in the DC voltmeter as well as the response time of the AC converter. AC response time may be six to ten times greater than in the DC voltmeter.

Input protection indicates the amount of voltage overload which may be applied to any range without damage. A separate DC limit may be indicated to cover input coupling capacitor breakdown. Overloads from sources outside the specified frequency range of the instrument may not have as great a protection range.

Common mode rejection ratio. AC CMRR is defined and measured in the same manner as it is for the DC voltmeter.

Noise. Some of the very good voltmeters indicate the RMS value of noise contributed by the converter, the input amplifier, and any other source within the instrument. A noise specification is required only on very high resolution, sensitive instruments.

Ammeters

Ranges. Ammeter ranges are given as full scale readings, and may include an overrange specification. A number of instruments do not have extensive ammeter ranges; other meters commonly extend to 1 ampere full scale. Some instruments have DC capabilities only. Ammeter ranges vary extensively, so these specifications must be carefully read. All ammeter ranges have full overrange capability, therefore, a 1-ampere meter usually gives 2-ampere capability.

Accuracy. Ammeter accuracies will be slightly lower than those of the associated voltmeter, as the accuracy of the shunt must be included. The ammeter accuracy may be further degraded with high-current shunts.

Voltage drop. When inserted into the circuits, the ammeter shunt causes a maximum voltage drop when measuring full-scale currents somewhat larger than the full-scale value of the lowest voltmeter range of the instrument. This may be as much as 10 or 20% higher than the voltage range, to cover resistance in series with the shunt, especially on the highest current ranges where the shunt value is usually 0.1 ohm. On very low current ranges, the shunt resistance is relatively high. For example, a 200 pA range on a 200-mV meter will have a 100-ohm shunt.

Protection. Most DMM's have a fuse in series with the ammeter shunts that opens if the maximum current is exceeded. It is wise to note fuse types. A few DMM's use very unusual fuses, and keeping a few spares on hand may save time and trouble.

Response time. The ammeter response time should be similar to that of the corresponding voltmeter.

The ohmmeter

Ranges. The lowest ohmmeter range on most DMM's is higher than expected. Usually the first range is 100 ohms. A 100-ohm range will give 0.1 to 1 ohm resolution. The upper limit of the ohmmeters found in DMM's is either 1 or 10 megohms, 10 megohms being more desirable. Ohmmeter ranges are found in decade steps between 100 and 16 megohms. All ranges have full overrange capability, so a 10-megohm meter normally gives 20 megohm capability.

Accuracy of the ohmmeter measurements is related to the accuracy of the DC voltmeter and the precision of the constant-current sources. The accuracy specification may be somewhat reduced for measurements on the uppermost range, but for most ranges the error is no greater than twice the DC error.

Measurement currents. Some DMM manufacturers only specify the current applied by each resistance range to the unknown resistance, while others specify both the current and the maximum open-circuit voltage applied to the circuit being tested. Some DMM's have special low voltage ranges that do not forward-bias semiconductor junctions.

Response Time. Resistance measurements normally have a response time close to that of the DC voltmeter. The uppermost range, however, may have a response time considerably slower than that of the other ranges.

Protection of the ohmmeter is important, as the constant-current generator is easily damaged if a high external voltage reaches it. Protection may differ for AC and DC, and may vary to some extent with the resistance range being protected. Protection against the power line is especially desirable. Accidental contact with this high potential is not at all uncommon, and a DMM without 120-volt AC ohmmeter protection is vulnerable to extensive damage. Many DMM ohmmeter circuits employ a very small fuse as part of the protection. Once again, this fuse may be difficult to locate and obtaining a few spares is wise.

Applications, error sources

An applications section on DMM's seems almost extraneous. After all, the instrument measures current, voltage and resistance. While this is true, there are a few special situations in which the DMM is used that are worth discussion.

Probably the first impression after using the DMM is the feeling: "How did I ever get along without this instrument?" This attitude results from increased convenience. A three-and-one-half-digit, autopolarity machine rarely needs range changes when working with most circuits. One range, such as the 20-volt one, gives all the resolution required. Without having to reach for the polarity switch, there is nothing to do but take measurements.

For example, a three-and-one-half-digit machine on the 10-volt range has a full-scale reading of 19.99 volts. Most power supplies of modern analog circuits can easily be checked to the nearest 10 millivolts, and the base-emitter voltage drop of transistors still checks to two significant figures (again the nearest 10 millivolts). Such measurements give more than necessary resolution. Semiconductor measurements with 10-millivolt resolution are in the range of voltage for a forward-biased diode that changes with temperature.

Needless to say, the DMM is not without its pitfalls. Erroneous actions based on DMM readings, assuming more accuracy than exists, or readings with too much resolution are frequent. For example, instructions in one Heathkit oscilloscope manual directs the kit builder to adjust a control until voltage on the collector of each of two deflection transistors is equal; then to adjust another control to set both collectors at 100 volts. A number of kit builders have found this task particularly frustrating and next to impossible. The reason: a DMM was being used which had far more resolution than called for. Adjustments were being made to the nearest few tenths of a volt which need only have been made within a few volts. Adding a factor of ten to the setability of a control can make the difference between one that is simple and one that is difficult to adjust.

In a similar case, an error is often made when a voltage is not exactly the value that is

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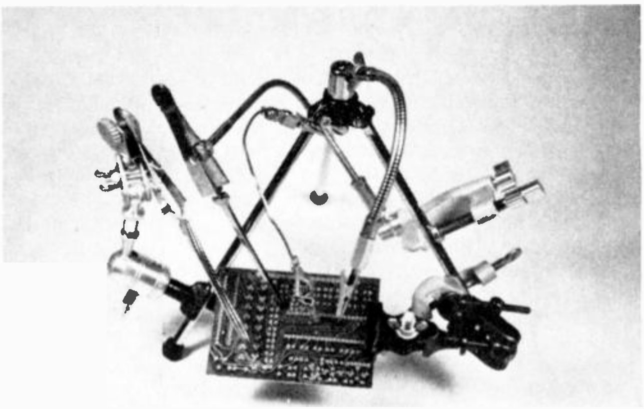
Extra Hands For The Hobbyist



Built from commonly available parts, these devices will make printed-circuit board assembly easier and more pleasurable

EARL R. SAVAGE, K4SDS

WHEN ARE TWO HANDS AND TEN FINGERS NOT ENOUGH? WHEN ARE two eyes and tri-focal glasses not enough? . . . Right!—when you are working on solid-state circuits.

As parts have undergone the change from small and miniature to sub-mini and even micro, my normal-size fingers and otherwise adequate eyes have caused more and more problems. I just can't seem to be able to hold a board, a part on that board, solder and an iron all at the same time. I can't see those minute solder bridges or what's happening on one side of the board while making adjustments on the other. [In fact, I never could see around corners!]

Does all this sound familiar to you? Have you looked longingly at some of those expensive construction aids that have limited use potential? Well your frustration is over. On these pages you will find a system of aids that is as inexpensive or as expensive as you choose to make it. Best of all, it is endlessly versatile.

This system is based upon the fact that a thread size of ¼ × 20 has become standard in a number of applications. As you will see, I have raided photography, science laboratory and plumbing supply houses as well as hardware stores to find parts for the system. Because of the same-size threads, all the parts are completely interchangeable. Just a few of the possible combinations are shown here.

FIG. 1—BASE SUPPORTS for the holders and viewers.

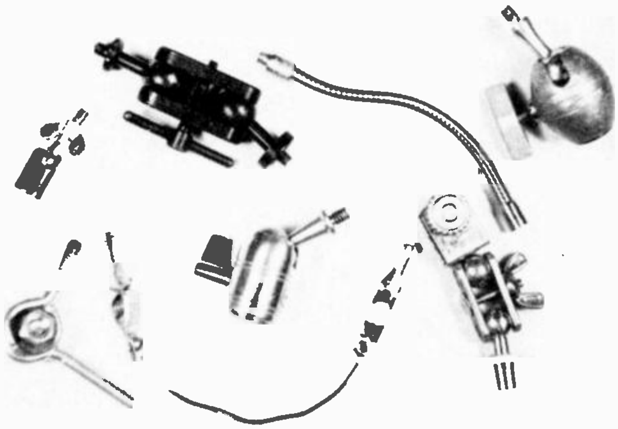


FIG. 3—FLEXIBLE JOINTS allow exact positioning of parts.

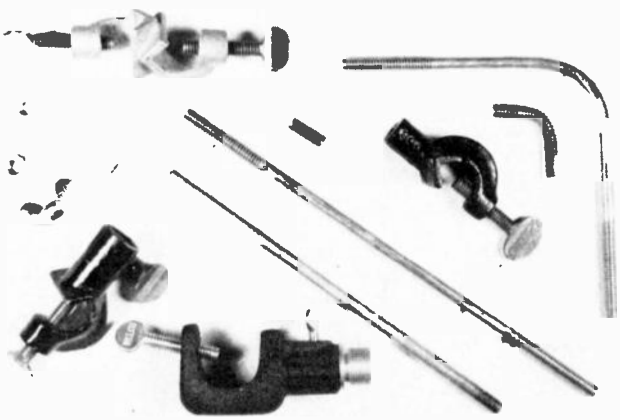


FIG. 2—CONNECTORS for attaching various components of the system.

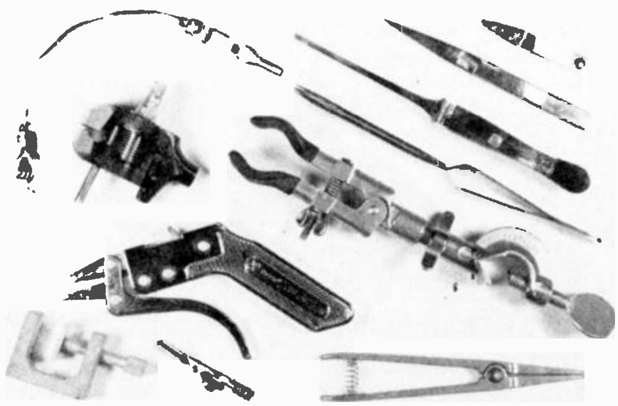


FIG. 4—HOLDING DEVICES firmly grasp just about any type of part or tool.

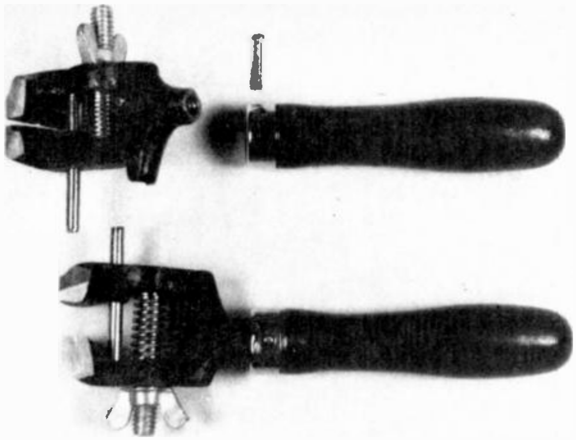


FIG. 5—PIN VISE is converted into PC board holder by drilling and tapping.

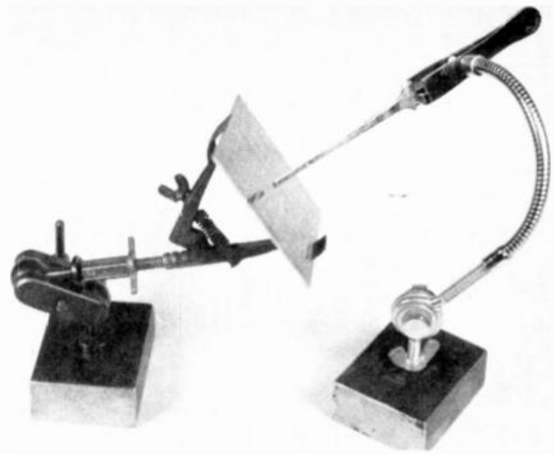


FIG. 7—PC BOARD HOLDER is built from a test-tube holder.

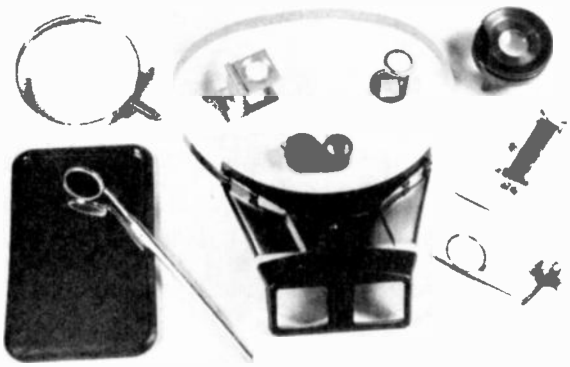


FIG. 6—VIEWING DEVICES are a great aid when doing close-up work.

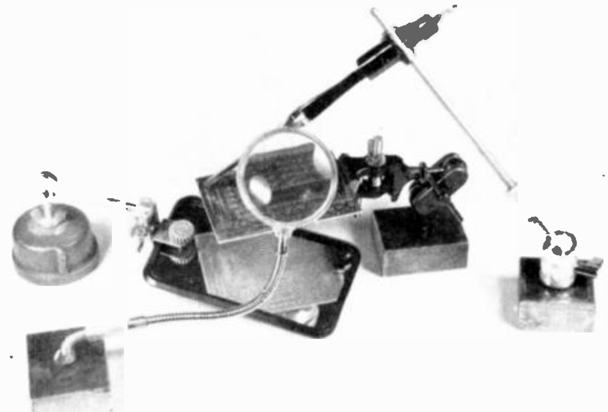


Fig. 8—TYPICAL SYSTEM is one of the many possibilities.

My system began several years ago and has grown as I discovered new and useful parts. Undoubtedly, I have only begun to explore the possibilities. Once you get started, you will turn up many additional useful components and combinations.

Each holder and viewer consists of certain basic parts: base, connectors, joints, and the holder or viewer, itself. Let's look at each of these and then at some of the many ways they can be put together.

Bases

Several types of bases are shown in Fig. 1. The C-clamps and photography clamps (with universal joints) are very useful. They can be attached to the top of the workbench or shelf, to the lip of a cabinet or chassis, or even to a brick on the bench. The tripod with its universal head has a wide base and can be placed on any surface.

The most useful bases are of the homebrew variety. One is a rectangular block of metal cut to about 2.5 × 5 × 7 centimeters, then drilled and tapped with ¼ × 20 threads. Lead blocks may be cast for this purpose. The other is a pipe cap also drilled and tapped. Pipe caps are available in many sizes and may be filled with lead to increase weight and stability.

Connectors

The connectors shown in Fig. 2 come from a variety of sources. Some are pieces of laboratory apparatus that will not only clamp on rods and the like but are, themselves, threaded with our standard ¼ × 20.

The rods are made from sawed-off bolts, threaded rod stock and bathroom tank float rods. Various types of nuts should be in your collection. The "connecting nut," just to the right of the hexagon nut, is especially useful. It is about 3-cm long and threaded all the way through.

Flexible joints

A joint of one kind or another must be used in each assembly or the device would be of very limited value. Several types are shown in Fig. 3. The simplest is, of course, a piece of heavy wire between two alligator clips.

Two different ball-and-socket joints and three tripod heads are also shown. They will permit movement in any direction. The small flexible rod is extremely useful.

Of special interest is the joint in the lower left corner of Fig. 3. It is made with two standard eye-bolts, two of washers and a bolt. This joint is quite inexpensive and versatile but not as convenient to use as a ball-and-socket or tripod head.

Holding devices

A number of different types of devices for holding wires and small parts are shown in Fig. 4. Several require special comment. One of the larger self-closing tweezers has been drilled and tapped on one side of the handle.

The PC board holder was made from a pin vise. Figure 5 shows how this was done. The handle was removed by pulling the holding pin. After the projecting shank of the vise was sawed off, the new base was drilled and tapped. When attached to a universal joint, this holder will position a board or other large component in any conceivable manner.

Viewing devices

Many kinds of viewing devices are of help to the hobbyist. A few of these are shown in Fig. 6. The 8 × 14-cm mirror is very useful for watching the results on one side of a board or panel while working on the other side. The small dental mirror will often prevent your having to disassemble equipment to check an otherwise inaccessible spot or part.

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Step-by-step TV Troubleshooters Guide

THERE ARE MANY, MANY CIRCUITS IN A MODERN color-TV chassis. If we are to service them as fast as possible, we must *know* each one of them, and what they do. We also have to know what they do when they're not working. These are the "fault-reactions," and are the key clues to the location of the trouble. One of the most important (and one that the customer notices quickest if it goes bad!) is the sync separator. Like all the others, if we pick it out of the schematic and look at it all alone, it is not very complicated. It has a very simple purpose: it clips off the sync pulses from the TV signal and distributes them to the two sweep oscillators. That's all.

Most of them are now called "sync separators." At first, they were called "sync clipper" which is really more descriptive. A composite video signal is shown in Fig. 1. The bottom 75 percent of its amplitude is the video signal; the top 25 percent is the sync. The sync-separator literally clips off the top 25 percent which is nothing but sync. The "sync porches" shown are at the black level; above that level the picture tube is cut off. (Actually, most sync separators are set to clip just a little *above* the black level. This keeps the video out of the sync, and vice versa. More on this later.) The video signal used for this is usually picked off somewhere in the video output stage. You may find that the *video* portion is slightly compressed; that's all right since we're going to throw it away anyhow. The sync must *never* be compressed. Fig. 1 shows the "clip-line" for proper sync-separation.

How do we clip the sync off? We feed the video signal into a stage which is *biased* so that it won't conduct at all until the signal reaches a certain level. Let's say the grid signal has a P-P amplitude of 50 volts and we want only the top 12.5 volts of it. So, we simply put a negative bias of −37.5 volts on the grid of the sync separator tube. The tube will remain deep in cutoff until the signal reaches a voltage high enough to make the grid positive, or +37.5. Now, it will conduct only during the sync interval and neatly clip off the top 25 percent of the signal. Most sync-separators will amplify the signal; so we'll find a "composite sync" output that will run somewhere around 35–40 volts P-P in tube stages. Figure 2 shows this waveform at a 30-Hz sweep rate. Remember it. We said "tube"; transistors do exactly the same thing. Only the DC voltages are different as well as the polarity. Transistors are excellent sync-separators due to their characteristics. They love to clip!

The smaller pulses in Fig. 2 are the horizontal sync. The larger ones are the vertical sync. These can be hard to see in some cases, but look for them. They'll usually make a notch in the top of the composite sync waveform.

Having clipped off the two syncs, we now have to get them to the proper sweep oscillators—vertical and horizontal. This is easy; we take advantage of the fact that we have a very low-frequency sync, at 60 Hz for vertical, and a high-frequency sync at 15,750 Hz for horizontal. These can be separated quite simply. (In fact, the actual "separation" of the syncs into individual parts is done in the sync-separator output circuit, by the components shown in Fig. 3.)

The vertical sync is cleaned up by feeding it through an RC network. This is an integrator. (If you want to go far enough back into basics, the vertical sync pulse is actually made up of quite a few horizontal sync pulses! This circuit puts them back together so that the output is one clean sync pulse at the vertical frequency.) It does that by developing a charge on the shunt capacitors and discharging through the resistors. The high-frequency horizontal sync pulses see a very low impedance in the shunt capacitors, so they are grounded.

The horizontal sync is even simpler. All we do is feed it through a very small coupling capacitor that offers a very high-impedance to the low-frequency vertical sync, which doesn't get through. We get *enough* of the horizontal sync through to do the job. This is how it works, when it's working. Now let's see what can happen to it and what symptoms it causes when it's not working. Knowing the fault reactions is very important in finding out what's wrong.

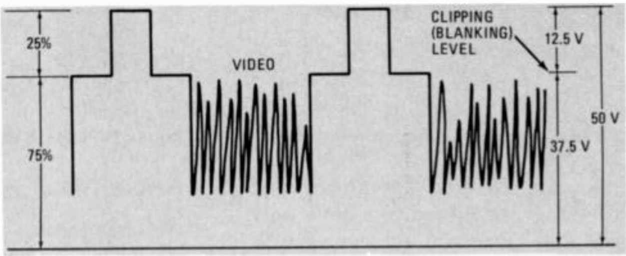

FIG. 1—A TYPICAL VIDEO SIGNAL. The figures at left are normal sync/video percentages; those at the right are typical bias voltages that might be used to make the sync-separator stage clip off the sync.

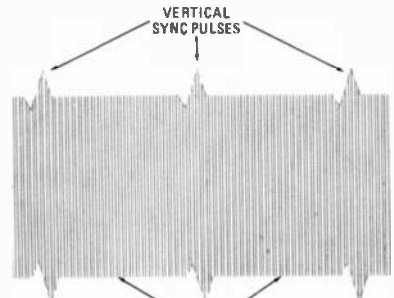

FIG. 2—THE COMPOSITE WAVEFORM at the sync separator output.

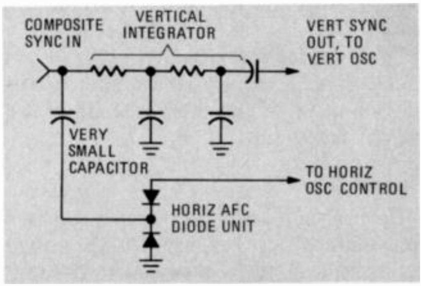

FIG. 3—LOW AND HIGH-PASS circuits channel the vertical and horizontal sync pulses to their respective oscillators.

Normal reactions.

We have two different types of reaction in the vertical and horizontal sync circuits. The horizontal sync "works on phase." It's fed into a phase detector where it's compared to a reference pulse from the oscillator output. If the phase is different (oscillator trying to go off-frequency) the phase detector develops a small DC correction voltage. This is applied to the oscillator to pull it back in phase. It doesn't take a great deal of sync *voltage* to make it work.

The vertical sync is different. The oscillator is actually fired or triggered by the sync itself. The oscillator will have a stage with a gradually rising voltage curve. The sync comes in on this curve so that it fires the oscillator just a split microsecond before it would normally trigger itself. This makes the oscillator lock with the sync. In the absence of sync, it can free-wheel.

This gives us one of our key reactions to help us locate the cause of the trouble. If a fault in the sync-separator causes a loss of sync *amplitude*, you will see this show up as a *vertical* sync problem long before the horizontal sync is affected at all. It's possible to lose so much vertical sync that the picture won't even try to lock, yet the horizontal oscillator will be quite stable.

This is one of the easier ones. A weak tube, a leaky transistor, an off-value resistor or leaky capacitor, and you can lose sync amplitude. In older sets with separate parts in the integrator, the shunt capacitors usually leaked and pulled down the sync amplitude. The newer type integrators can do the same thing if they're defective, so check them if this kind of trouble is found.

Since the horizontal sync circuits are so simple (one little coupling capacitor), loss of horizontal sync is also pretty simple. If the coupling capacitor isn't open, the conductors on the PC board may have a hairline crack somewhere between the sync-separator out-

Faults in the horizontal and vertical sync circuits can be isolated quickly if you know the symptoms and follow a logical step-by-step troubleshooting procedure.

JACK DARR
SERVICE EDITOR

put and the center tap of the AFC diode unit. A good quick-check for this is to take the diode unit out and check on the center terminal for the horizontal sync pulses. Cold solder joints are a good cause for this, too!

Let's pause for a moment. Note that I have frequently mentioned the use of a scope. This is because the scope is the *only* instrument you can use in these circuits to actually *measure* and verify the presence of the syncs. The DC voltages are important, of course, but the scope is the only instrument that will tell you exactly what is happening and where the trouble is. There are several eyeball tests that are very handy, which we'll get to soon, but for the final analysis and fault-location you *must* use a scope (until someone develops an IC instrument with a readout that says, in a sweet recorded voice, "You have 27.9 volts of vertical sync at this test point, with a slight distortion of the top!.")

Typical symptoms

The Well-Calibrated Eyeball can be quite a help. Look at the picture and move the two hold controls to see what they do. If both controls have the normal effects on the picture, the sweep oscillators are *working*. If you have only *one* picture visible, but it floats up, down or sidewise without locking, you have lost all sync. Since this is obviously a complete loss of both the horizontal and vertical sync, you check the only stage that handles both of them at once—the sync separator.

If the vertical sync is weak and unstable but the horizontal sync is good, this could be due to a loss of sync amplitude. Scope the sync-separator output and check the P-P voltage. This isn't shown on all schematics, but a ballpark figure for tube sets is something like 35–40 volts P-P. If this voltage is up to normal or close, the vertical sync is OK at the integrator input. Follow it through to the integrator output. This can be done much more easily if the vertical oscillator is disabled. Ground the grid of the output stage after turning the brightness down. Now you can see if you are getting any vertical sync at all through the integrator. Polarity of the vertical sync is determined by the point where it is fed into the oscillator. If it goes to a grid, it's usually positive going; to a plate, negative going.

If the integrator output is too low, lift one of the legs and the ground. It can be checked with an ohmmeter. Normal resistance end to end will be somewhere around 180K, give or take a few. From either end to the ground terminal, a very high resistance. A low resistance reading here indicates leakage in the shunt capacitors. Too much resistance end-to-end indicates a bad resistor. If the integrator goes up to 2-3 megohms, you'll lose sync amplitude.

Caution: *before* making any tests for vertical sync, check the vertical size and linearity controls. If these are set so that the raster is overscanned too much, you'll have a case of "fake sync trouble." This distorts the oscillator waveform at the firing point so that the sync can't trigger it properly. Set up the raster so that it is overscanned not more than ½-inch top and bottom, then go on with the troubleshooting.

Eyeball test. With the vertical hold control, roll the picture slowly downward. When the blanking bar gets to a point about two inches from the bottom of the screen (minimum), the picture should snap into sync momentarily then keep on rolling. That snap indicates that vertical sync *is* present. If the picture rolls smoothly on through the bottom without even slowing down, there is no vertical sync.

Second clue: Due to the nature of the waveform, the picture should lock-in when the hold control is turned the opposite way, until you reach the "break-out" point. It should then go upward very rapidly. This is common terminology; because of this reaction a picture going down is "rolling," and one going upward very fast is "flipping." Try this on a working set and you'll see. If you can make the picture go upward very *slowly*, once again you have no vertical sync at all. Start with the composite sync; if it's present check the integrator.

Horizontal sync

The horizontal sync has a different kind of reaction. Most of the troubles in horizontal sync turn out to be due to bad parts in the oscillator or AFC. If you do have one of the rare cases where there is a loss of the horizontal sync pulse, the reaction will be like this: the oscillator will make a single picture. The hold control will make this "set up" and maybe even hold for a few seconds. However, when you move the horizontal hold control even a little bit in either direction, out you go. Normal reaction should be a good hold for quite a bit of rotation of the hold control before it falls out.

Make this check. Kill the horizontal AFC by grounding the AFC grid of the oscillator, or the AFC diode unit in transistor sets. Now, adjust the horizontal hold control until you get a single straight-sided picture that will hold momentarily, though it will drift slowly from side to side. This tells you that the horizontal oscillator *is* able to run on frequency, and is reasonably stable. Take the ground off the AFC and the picture should lock in tight and hold for quite a bit of rotation of the hold control. Check for stability by changing channels; this interrupts the horizontal sync. However, if the picture falls *out* of sync when you put the AFC back, there is an AFC problem.

Unbalanced AFC diode units cause most of these problems. It's faster to take the old one out and put in a new one. If this clears it up, fine. There are three types of AFC diode units—common-cathode, common-anode and series It is much better to use an exact duplicate of the original! If it gets worse after you replace the diodes, make sure that you got the correct type! The first two are not polarized; the series type definitely is!

Odd sync problems

If the sync seems to be fairly steady, but the picture jitters in either direction, you could have a fault in the sync separator. Once again you'll have to use the scope. This can be caused by incorrect clipping action, which lets some of the *video* signal get through with the sync. Sync must always be clean pulses; the video signal is constantly varying and it is this variation in the sync that causes the jitter. Check all DC voltages on the sync separator. If the set uses a noise-canceller circuit, check the setting of the control. If it is set too tight, instead of punching out noise pulses, it punches out most of the sync as well. Set it completely off and see if that helps.

Thermal drift of resistors in the sync-separator stage can cause problems like "It

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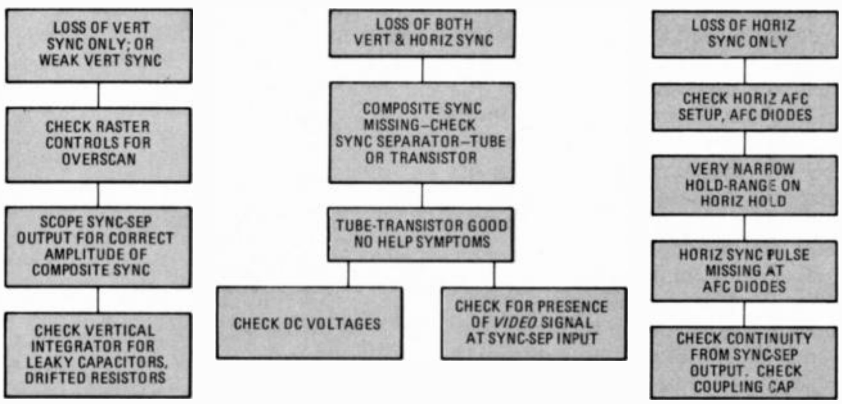
TROUBLESHOOTING CHART—Sync circuits



CB RADIO

Automatic Noise Blankers— How they work

Many circuits have been developed and incorporated intc CB transceivers to automatically reduce noise. Here's an in-depth look at several of these circuits and how they work

ROBERT F. SCOTT
TECHNICAL EDITOR

IN AN EARLIER ISSUE, WE DISCUSSED AUTOmatic noise limiters and described typical circuits as used in CB radios. We saw how noise—either "hash" or hiss on one hand and impulse-type noise pulses on the other—is limited in audio circuits so it does not exceed the level of audio signals resulting from the detection of RF carriers with an average percentage of modulation.

Figure 1-a is a representation of a 100% modulated carrier with superimposed noise pulses. For the convenience of illustration, the noise pulses are held down to about twice the level of the modulated carrier. Actually, noise may be hundreds or thousands of times stronger than the desired signal.

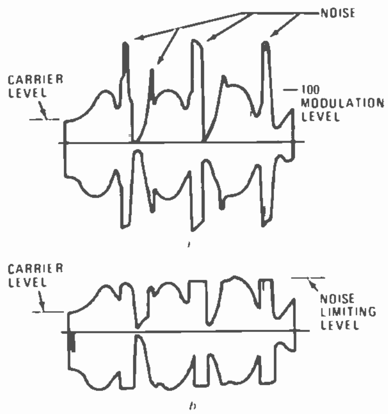


FIG. 1—NOISE PULSES superimposed on a 100% modulated carrier is shown in *a*. Noise limiter adjusted to clip at 100% modulation level clips noise peaks so they do not exceed audio signal as shown in *b*.

Figure 1-b shows how a noise limiter—adjusted to clip at the 100% modulation level—clips noise peaks so they do not exceed the amplitude of the audio signal recovered from the incoming Citizens band signal.

The automatic noise limiter is most effective in combatting hiss and "hash" which are composed of continuously overlapping random pulses of the type generated by neon signs, small electric motors and power-line leakage. The automatic noise limiter circuit is usually set to a level corresponding to 70-80% modulation. Remember, however, that the interference cannot be completely eliminated, it is simply limited to a level where it does not make the average incoming signal totally unreadable.

Impulse noise is generally produced by electrical circuits. The noise peaks often have very high amplitudes with durations seldom exceeding 50 to 60 microseconds. The repetition rate may vary from spasmodic to a continuous 400-Hz.

In addition to having an adverse effect on signal readability, high-amplitude noise pulses develop AGC action that desensitizes the receiver. In some cases, when the noise level is high, receiver sensitivity is reduced until only the strongest signals can be received.

Although the duration of the average impulse-type noise pulse may be less than 25 microseconds and seldom exceeds 60 μs, some pulses are of longer duration. One unfortunate characteristic of impulse noise is that a very narrow pulse is delayed and broadened as it is passed through highly selective circuits. The greater the circuit selectivity, the more the pulse is stretched and delayed.

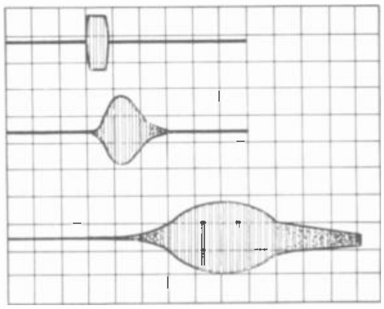


FIG. 2—IMPULSE-TYPE NOISE PULSE is shown in upper trace. Middle trace shows noise pulse after it is amplified by IF amplifier with a 5-kHz bandwidth. Lower trace shows effect of IF amplifier with a 2-kHz bandwidth.

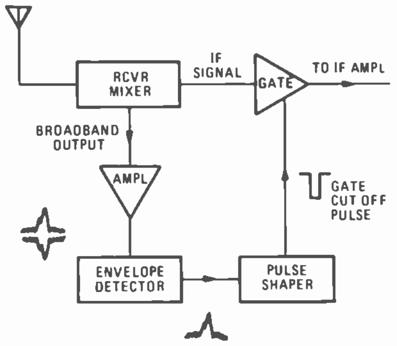


FIG. 3—NOISE BLANKER uses a gate in series with the IF signal. Gate opens for duration of noise pulse.

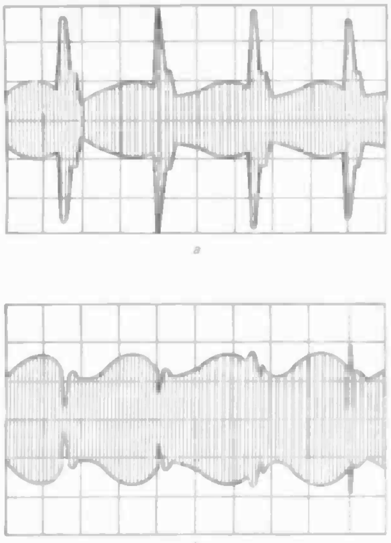


FIG. 4—NOISE PULSES superimposed on carrier is shown in *a*. Output of IF amplifier with noise blanker operating is shown in *b*.

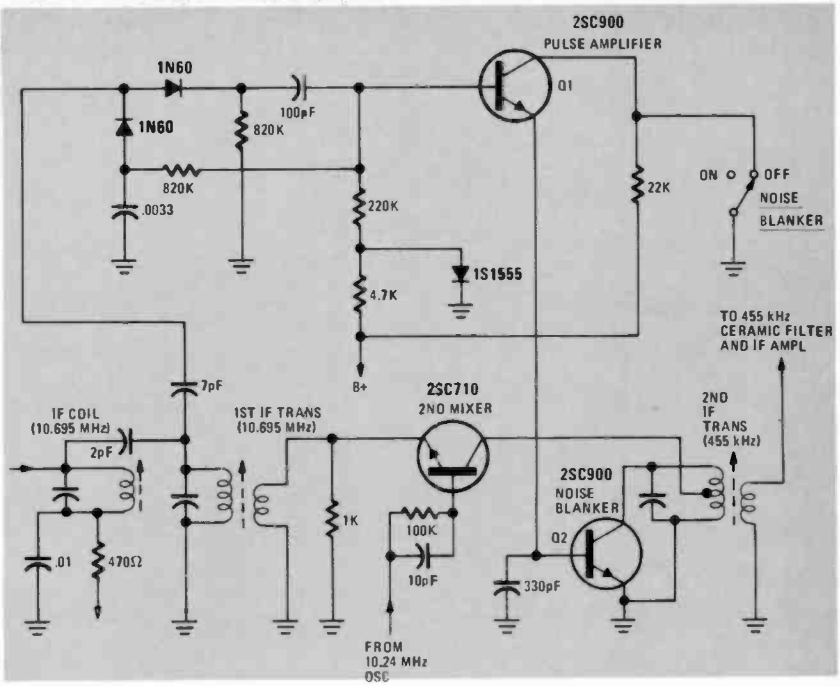


FIG. 5—NOISE BLANKER CIRCUIT used in the Midland *model 13.882C.*

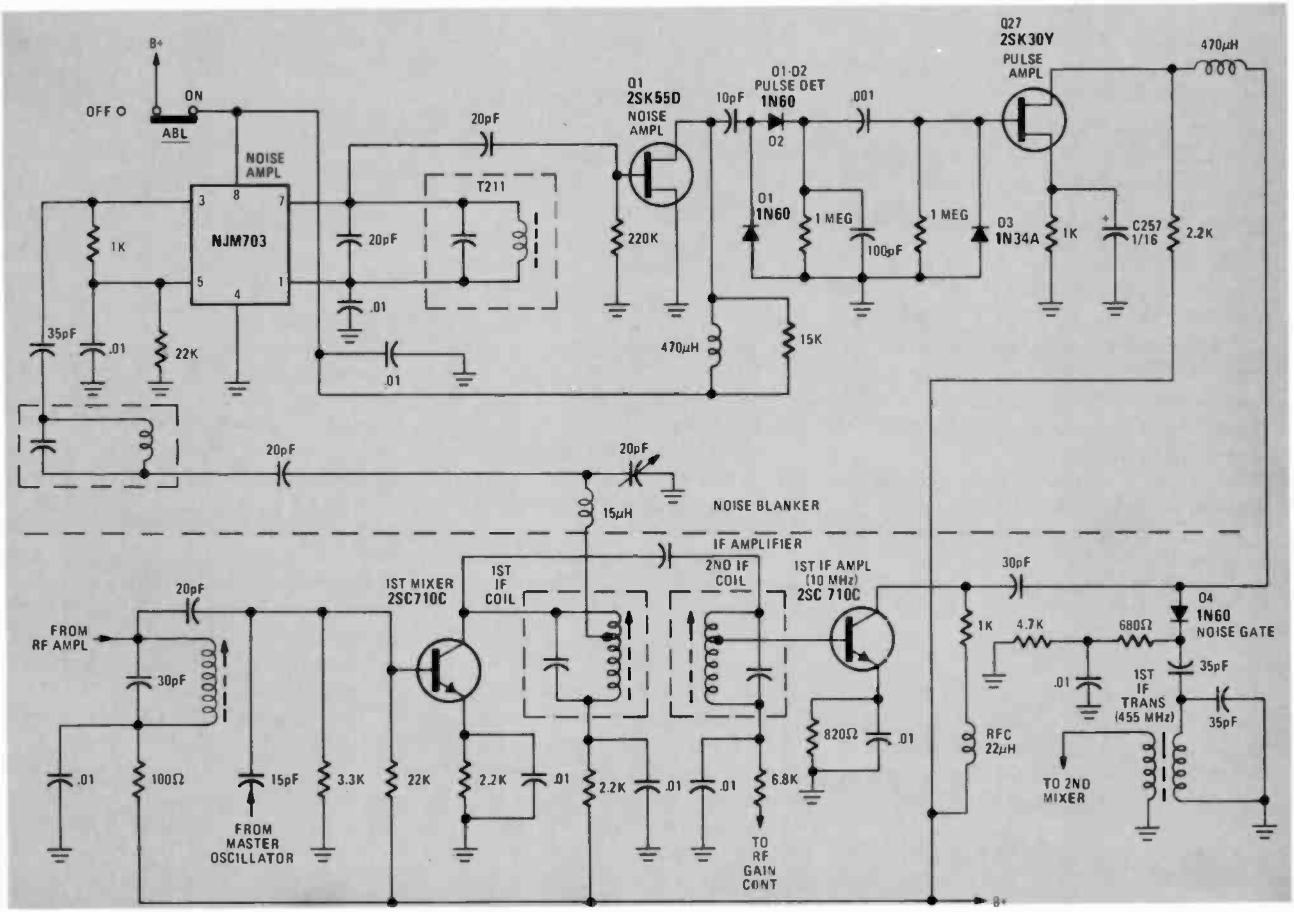


FIG. 6—NOISE BLANKER CIRCUIT used in the Pace *model CB145.*

This is caused by amplifier overload and ringing in the tuned circuits.

Figure 2 is a representation of an impulse-type noise pulse (top trace) as it is delayed and lengthened by IF amplifiers with 5- and 2-kHz bandwidths. We can see that as selectivity is increased, the pulses are lengthened.

How noise blankers work

The noise blanker—also called an RF or IF noise silencer—is most effective when combatting impulse-type noise. It is a concept developed by J. J. Lamb and described in the technical press early in 1936. Basically, the noise blanker (Fig. 3) taps off a portion of the incoming signal close to the receiver input—before it gets to the highly selective IF circuits. Filters and detectors extract the noise peaks which are shaped and amplified. The pulses are then polarized so as to open a gate in series with the IF signal path for the duration of the noise pulse.

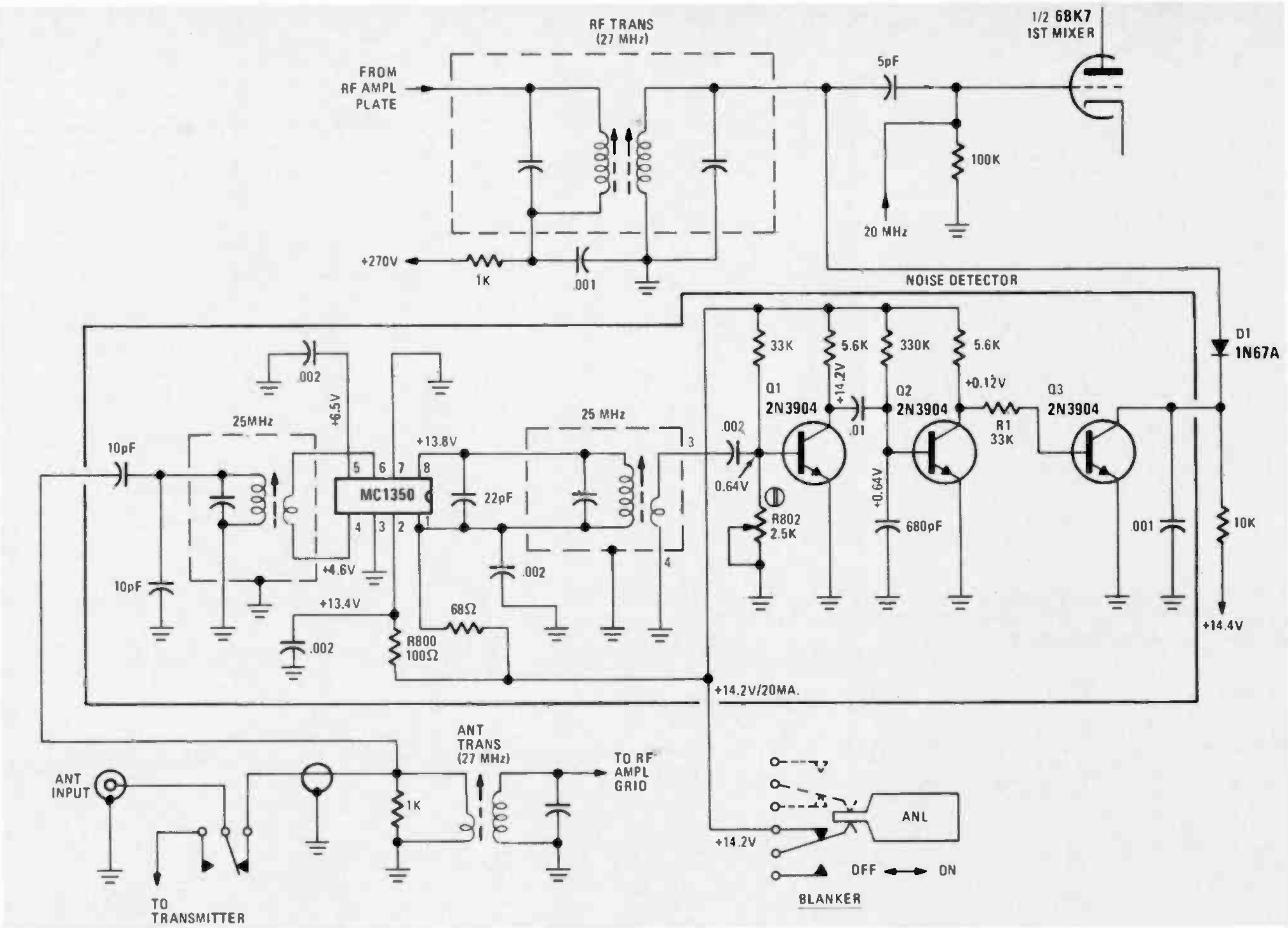


FIG. 7—NOISE BLANKER CIRCUIT used in the Tram *model D201*.

The duration of the individual noise pulse is very short compared to the interval between pulses. Thus, the receiver is silenced or muted during the noise period. The upper trace in Fig. 4 represents a modulated carrier with high-amplitude noise pulses superimposed. Figure 4-b represents the signal at the output of the IF amplifier with the noise blanker operating.

Practical noise blankers

The noise blanker used in the Midland *model 13.882C* is one of the simplest that we've seen (Fig. 5). It is connected between the outputs of the first and second mixers. The composite IF signal and noise voltages are picked up at the output of the first mixer. A voltage doubler-type detector strips the noise pulses off the incoming signal and shapes and feeds them to Q1, the noise pulse amplifier. Q1 is biased so it conducts only during the duration of each noise pulse. As it does, Q2 is driven to conduction so it appears as a momentary short circuit across the primary of the first IF transformer.

In this application, the noise signal is tapped off a wideband 10.695-MHz IF transformer whose selectivity is not great enough to appreciably delay or broaden the noise pulses.

Figure 6 shows the noise blanker used in the Pace *model CB145* transceiver. The signal at the collector of the first mixer is the IF composed of 23 discrete frequencies centered around 10 MHz. A portion of this signal is amplified in the first IF amplifier and then fed to the 1N60 noise-gate diode (D4) in series with the primary of the 455-kHz IF transformer.

A portion of the signal at the first mixer is passed through L–C filter networks to accentuate the noise and then fed to the noise-amplifier IC where it is amplified still further. Noise amplifier Q1 feeds the noise signal to a voltage-doubler-type pulse detector.

The noise information is detected and shaped and fed to the anode of noise gate D4. When a negative-going noise pulse reaches D4, the diode cuts off for the duration of the pulse so that noise on the IF carrier cannot be further amplified and detected to adversely affect readability and receiver sensitivity.

A pre-IF noise blanker

The Tram *model D201* base transceiver uses the noise blanker in Fig. 7. Noise is picked off the antenna input and is detected, amplified and rectified to develop signals that ground the input to the first mixer.

Noise is picked up from the primary of the antenna transformer and fed through a capacitance network and a 25-MHz RF transformer to the NC1350 IC used as a high-gain 25-MHz amplifier. The amplified 25-MHz noise signal is fed to the base of Q1. This transistor is normally biased to cutoff by the voltage drop across the 2.5K potentiometer in its base circuit. Positive-going noise pulses turn on Q1 and turn off Q2 so its collector swings to V_{cc} (+14 volts DC). This 14 volts, dropped through R1, is fed to the base of Q3. Transistor Q3 turns on instantly and the voltage on its collector drops to zero.

Normally D1 is back-biased and is not conducting. As Q3's collector approaches zero, the reverse bias is removed from the noise-gate diode. Diode D1 now appears as a closed switch that shunts all signals to ground through transistor Q3 for the duration of the noise pulse.

By detecting the noise pulse at the antenna terminals, ahead of the selective and high-gain circuits in the receiver, noise-pulse delay and duration are kept to a minimum. **R-E**

State of SOLID STATE

An in-depth look at a telephone dialer circuit built around two IC's from Motorola, a voice actuated switching circuit for CB transceivers and a single IC switching regulator

KARL SAVON
SEMICONDUCTOR EDITOR

DIGITAL TECHNIQUES ARE NOT ONLY AT WORK IN SOPHISTICATED telephone switching centers but are finding their way into home and office telephone equipment as well. Off-the-shelf integrated circuits can be wired into a standard telephone to convert it to keypad operation. Not the same as *Touch-Tone,* the system simulates the sequential pulsing of the dial mechanism it replaces. Redialing capability is built in and expansion to repertoire and many other features are possible.

Binary to phone-pulse converter

The new Motorola MC14408/MC14409 IC's take a parallel binary or BCD input and produce a chain of output pulses compatible with conventional telephone circuits. Parallel input data originates from digital control electronics, keypads or memory circuitry. The number of output pulses is equal to the normal 1-2-4-8 weighting of the 4-bit binary input with one exception. Input codes 0001 (1_{10}) through 1001 (9_{10}) produce one through nine output pulses, respectively. The exception is 0000. This does not produce zero pulses but transforms to ten pulses corresponding to the operation of the zero on a telephone dial.

Figure 1 shows the MC14408/MC14409 pulse-converter wired to the companion MC14419 2-of-8 keypad-to-binary encoder. The MC14419 scans a keypad with up to four rows and four columns of switches and converts contact closures to the appropriate 4-bit encoded outputs.

The pulse converter has an on-chip oscillator that is tuned by an external L–C network. The oscillator frequency determines the dialing rate. When adjusted to 16 kHz, the oscillator output is divided for a 10 pulse-per-second dialing rate. Doubling the frequency to 32 kHz doubles the dialing rate to 20 pulses-per-second. One of the two oscillator pins is the clock output that drives the clock input of the MC14419.

Keypad switches mechanically oscillate or bounce when they are closed. There is a time interval measured in tens of milliseconds after the initial switch closure during which the contact status is indeterminate. Debounce circuitry must be used to delay the sensing of the switch to ensure reliable operation. Time delays are conventionally generated by monostable timing circuits or by defining time intervals with digital frequency divider chains. Driving the clock input of the keyboard-to-binary encoder with the output from the pulse-converter oscillator provides the necessary debouncing.

Valid input data is indicated by a positive going pulse on IC2 pin 3. When IC1 switches this lead high, IC2 reads the data encoded on the four input lines. The four-bit word is entered into a memory register. Classified as a FIFO (*F*irst *I*n, *F*irst *O*ut) memory, the digits are recalled and transmitted in the same sequence in which they were entered. The digits are stored until a new number is keyed in. When redialing the number, the stored number is recalled and transmitted without reentering it. If the called number is busy or the call is interrupted, IC2 pin 10 is switched low causing the redial operation. The pulse on pin 3 enters each digit up to a maximum of 16. If more than 16 digits are entered, the circuit ignores them.

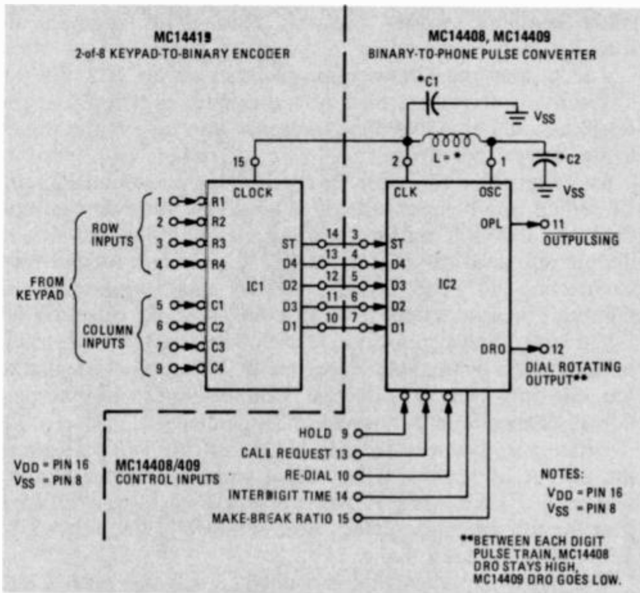


FIG. 1—PHONE DIALER uses two IC's to drive a standard rotary-dial telephone line from a keypad.

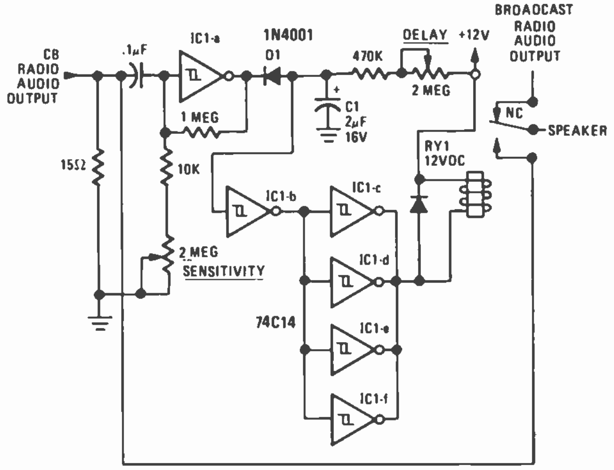


FIG. 2—AUTOMATIC VOICE ACTUATED SWITCHING circuit switches car speaker from broadcast radio to CB transceiver when a CB call comes in.

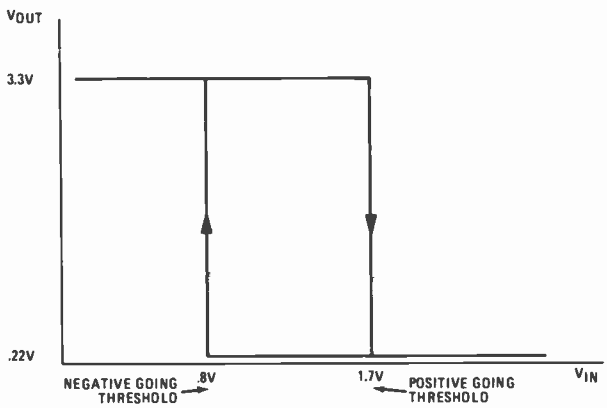


FIG. 3—HYSTERESIS CHARACTERISTIC of Schmitt trigger.

One possible feature prompted by the redialing capability is an automatic resequencing arrangement. External logic can be designed so reception of a busy signal will continually trigger redialing until the call is completed.

The MC14408/MC14409 IC's include a facility for controlling the interdigit pauses. Raising the voltage on pin 9 inserts pauses between the digit pulse-groups. The pause does not take effect until any in-progress digit pulsing is completed. More complex systems use this feature to lengthen the interdigit pauses according to specific requirements.

The output pulse-train appears inverted on IC2 pin 11. Typically, it drives the base of a transistor that replaces the telephone dial contacts. This transistor also inverts the pulses to the correct polarity.

Interdigit timing is controlled by the logic level on IC2 pin 14. When pin 14 is at a logic 0 level, the interval between digits is 300–400 milliseconds at the 10 pulse-per-second dialing rate and 150–200 ms at the 20 pulse-per-second rate. Connecting pin 14 to V_{DD} (the positive supply) increases the interdigit interval to 800–900 and 400–450 ms, respectively.

The make-break ratio (duty cycle of the output pulse-train) is determined by the voltage on pin 15. When pin 15 is tied to V_{DD}, the duty-cycle is 33 percent. Connecting pin 15 to a logic 0 level changes the duty-cycle to 39 percent.

Differences between the MC14408 and MC14409 relate to the output of pin 12. This output indicates that a dialing sequence is taking place. The MC14408 keeps pin 12 high over the full dialing sequence while the MC14409 switches to a low level between digits.

The power supply voltage is connected between pins 16 and 8 and can be 3–6 volts over the −40 to +85 degree Celsius temperature range. Current drain of the McMOS (Motorola CMOS) is low, under 550 microamperes with a 5-volt supply.

The circuits are packaged in plastic or ceramic DIP's. Quantity pricing is $6.98 for plastic and $9.08 for the ceramic package in quantities of 100 to 999 units. More information is available from Motorola Inc., Integrated Circuit Division, Technical Communications Group, 3501 Ed Bluestein Blvd., Austin, TX 78721.

AVASC system

Mobile CB'ers often want to monitor a channel while listening to their broadcast receiver, tape deck or whatever. Project Support Engineering has developed an automatic voice actuated switching circuit (AVASC).

Figure 2 is the schematic of the unit which connects between the CB and the audio output terminals of the broadcast radio, and the automobile speaker. It gives priority to the CB set by disconnecting the broadcast radio whenever the audio output from the CB radio is above a variable threshold.

The six inverter-like symbols in Fig. 2 are the six Schmitt triggers in the single 74C14 hex Schmitt trigger IC. Inside each of the triangular symbols is a representation of the two-state hysteresis characteristic of the Schmitt trigger circuit. Figure 3 shows this characteristic. The output voltage is either 0.22 or 3.3 volts over the full input voltage range except for the short regenerative switching times (vertical traces). Between the 1.7-volt positive-going threshold and the 0.8-volt negative-going threshold, the output can be either of its two stable states depending on the previous input.

Assume the output voltage is high and input increases towards 1.7 volts along the upper horizontal line in Fig. 3. When the input equals or exceeds 1.7 volts, the device switches and forces the output low as indicated by the arrow on the vertical line on the right. Once this state is reached, the output will not return to the high state until the input drops to 0.8 volts along the lower horizontal and leftmost vertical lines.

Referring back to Fig. 2, the first Schmitt trigger (IC1-a) detects the audio output of the CB receiver. Feedback around the stage is a convenient method of controlling input sensitivity. The SENSITIVITY control varies the amount of feedback. Sensitivity is adjusted similar to squelch so that noise is just below the trigger level. CB receiver squelch will actually take care of the noise problem making this a noncritical adjustment.

The output of the first stage is rectified by D1 and stored in capacitor C1. Notice that the polarity of D1 is such that detected signals pull the capacitor voltage toward ground. To delay the circuit recovery, the diode acts as a peak detector and the capacitor is returned to the +12-volt supply through the 2-megohm DELAY potentiometer and 470,000-ohm resistor. The delay circuit keeps the CB output connected to the speaker from 0–15 seconds after the circuit is activated so that pauses or drop outs do not result in truncated syllables. The peak detector action pulls the capacitor quickly towards ground and then rises more slowly when the detector diode is back-biased. Increasing the resistance of the DELAY control decreases the charge rate and increases the time delay before the circuit switches back to the car radio.

From capacitor C1, the signal moves on to IC1-b and then the paralleled group of the four remaining Schmitt triggers. Relay RY1 is driven by the increased current capacity of the paralleled devices. The relay coil is connected to the positive supply and pulls in when the outputs of IC1-c through IC1-f are low.

Suggested retail price for the AVASC unit is $29.95 and inquiries should be directed to Project Support Engineering, 750 N. Mary Ave., Sunnyvale, CA 94086.

Microcomputer update

Ohio Scientific Instruments has formally released their prototyping and development systems for the MOS Technology 6502 and Motorola 6800 microprocessors. The line includes CPU, 4K RAM, I/O, video graphics, floppy disk and prototyping boards.

The $29 *model 400* (board and documentation only) is an 8 × 10-inch board that can be equipped with a microprocessor, 1024 bits of RAM, and a front panel in its minimum configuration. It can be expanded to include 512 bits of ROM, an RS232 or TTY interface, and a I/O Peripheral Interface Adapter. The $139 *model 412-A* version has a 6502 microprocessor, eight 2102 memories, a monitor PROM and a teletype interface.

The *model 420* Memory Board is equipped with 4096 of either 8- or 12-bit words built up from 2102 memory IC's.

They also have a unique learning plan in which you start out with their *model 315* Computer Trainer and then trade it in for a kit of computer system boards. The company is developing high-level languages, subroutines and games. For more information, write Ohio Scientific Instruments, 11679 Hayden Street, Hiram, OH 44234.

New modules have been added to TI's Microprocessor Learning System. A total of four modules are now available including the basic microprogrammer.

The *LCM-1001* Microprogrammer Module uses Texas Instruments 4-bit slice parallel-processor with manual stepping and LED monitor indicators. Macroinstructions are stored in the *LCM-1002* Controller Module. Each macroinstruction is made up of 8 or 16 microinstructions. Instructions are stored in a 256 × 20-bit PROM distributed on 5 IC's. The *LCM-1002* has a memory data register, instruction register and a program counter. Random Access Memory is contained in the *LCM-1003* Memory Module. The read/write memory is organized into 1024 12-bit words. The third add on is the *LCM-1004* Input/Output Module with four 4-bit input and four 4-bit output ports.

Details are available from Texas Instruments Incorporated, Inquiry Answering Service, P.O. Box 5012, M/S 308, Dallas, TX 75222.

Switching regulators

Switching regulators have long been recognized among the most efficient methods to regulate power. Practical systems tend to get complicated and once again the integrated circuit has come to the rescue.

Silicon General's SG1524 has all the control circuitry for a switching regulator on the single 16-pin IC. Figure 4 shows the block diagram of the device. The IC has an internal 5-volt reference regulator. An externally tuned R–C oscillator is the timebase for the system and provides pulse outputs for driving external switching transistors. A second signal from the oscillator is sawtooth shaped to form an input to the comparator.

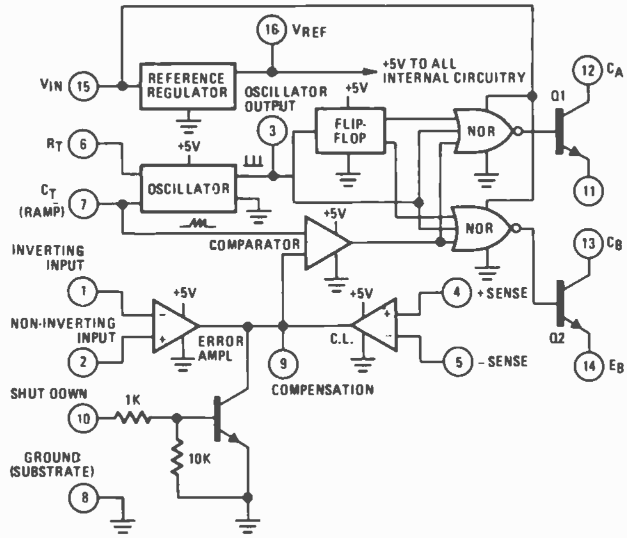


FIG. 4—SWITCHING REGULATOR control circuitry is contained in a single IC.

As the output voltage of the regulator tries to change in response to load variations, the pulse width of the signal modulating Q1 and Q2 changes to correct for the load variation. Two transistors can be driven by the pulse steering flip-flop so single-ended or push-pull circuits are accommodated.

In a typical system, the SG1524 produces 5 volts at 5 amperes with a 75-percent efficiency and 0.2-percent line and load regulation. Current drain of the IC itself is under 10 mA. Price of the 0–70°C version is $6.75 in 100-piece quantities and is in distributor stock. For more information, write Silicon General, 7382 Bolsa Ave., Westminster, CA 92683. **R-E**

ARCING ACROSS CAPACITOR

I keep getting an arc across C123 in this Admiral 14K2086-9 chassis. This is the capacitor on the bottom of the high-voltage winding of the flyback. I replaced it with a 0.004 but it still arcs over.—S.G., Franklin, NC.

Your best bet would be to replace the capacitor with either an Admiral part or an exact replacement: for example, Centralab's *GAP-402* should do. Also, check the high-voltage rectifier tube just for luck.

(Feedback: "It *was* a bad 3DF3 high-voltage rectifier tube. I got an exact replacement part for C123, and all is rosy now.")

METER CAUSES HIGH-VOLTAGE LOSS

After finding several other problems in a Philco 3CR41 hybrid (some other technician had been at it), I tried to check the horizontal output tube cathode current. When I put the milliammeter in series, I lost the high voltage and everything. Found the problem in the low-voltage regulator circuit. Are these really critical? Still don't know why my meter killed the high voltage.—G.B., APO, Seattle, WA.

The easy one first; your milliammeter killed the high voltage because it needs something like a 0.5 µF bypass capacitor across it. In quite a few sets, the inductance of the meter coil is evidently enough to upset this circuit.

Second question: Yes. All of the low-voltage supplies in these hybrid sets are critical. That's why they use the regulator circuits. Operation is directly proportional to the value of the low DC voltages, especially in sets with solid-state horizontal output stages.

VIDEO DETECTOR FAILURE

The video detector diode goes out after about a week of operation on this G-E. I've checked everything I can think of with no success. I seem to remember reading something about this a good while ago.—J.M., Nashville, TN.

You did read this, and this is the place. I ran into the same problem quite a while ago, in the same set. The cure is to replace the diode with a high-voltage RCA type 125844.

You'll find the same problem in some small solid-state Truetone sets, too. In these, the detector diode is inside the last IF shield can. (Never did find out why these diodes blew out!)

BOOST-BOOST VOLTAGE LOW

I have a weird problem. My B++ voltage in this set ought to be +1100 volts, and it's only about +700 volts. The boost voltage is normal at about +850 volts and the high voltage and sweep are OK. I don't understand it.—P.Q., Detroit, MI.

I don't either, but here's a suggestion. Check to make *sure* that you have installed that boost rectifier correctly. If it's backward, you'll get just this symptom. (If you have done this, you owe me fifty cents royalty; I invented this trick several years ago.)

(Feedback. "Here's fifty cents.")

R-E's Service Clinic

Focus troubles

Out-of-focus circuits

JACK DARR
SERVICE EDITOR

This column is for the service technician's problems—TV, radio, audio or industrial electronics. We answer all questions submitted by service technicians on their letterheads individually, by mail, 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 Avenue South, New York, NY 10003

THE CLINIC MAILBAG HAS BEEN PACKED lately with quite a number of problems that are obviously in the focus circuitry. Oddly enough, checking my reference books shows little coverage on this. This is a very important part of the set. Even more important, focus problems can cause symptoms that can mislead you.

Example: If you lose the focus voltage completely, the raster will be absent though the high voltage will probably still be up to an acceptable level. If you forget this fact, you may be running around checking the picture tube bias voltages and so on for some time.

While we're here, let's clear up a common misconception. This is "I get good focus on a close-up shot but on a long shot it's not focused." This isn't possible. All the focus voltage does is focus the *raster*. If you can see the horizontal scanning lines sharp and clear, the focus circuitry is good. It makes no difference whether the picture is a closeup or long shot. If you hear this complaint from the customer, check the *raster*; if the scan-lines are sharp at all times, there's no focus problem. The discrepency between a closeup and long shot is due to the lens of the TV camera.

With that out of the way, let's look at the two major circuits used to obtain the focus voltage in color TV sets. The old original circuits use a small rectifier tube; 1V2, etc. The rectifier tube is fed from the high-voltage pulse developed at the plate of the horizontal-output tube. This pulse has an amplitude of at least 5–6 kV. The pulse is rectified and filtered and used as the source for the focus voltage. Normal should be between 4500 and 5500 volts. Figure 1 shows a typical circuit. Focus voltage on most of the larger picture tubes must be from 16.8- to 20-percent of the high voltage.

Here's a handy-dandy clue that is obtained with two simple measurements. Since the high voltage and focus are always fed from the *same source* (the pulse from the horizontal-output tube), if you find a set that does have high-voltage but no focus voltage, you can instantly eliminate everything but the focus circuit itself, which has about 6 components. This works the other way, too. If you have normal focus voltage but no high voltage, you have a problem

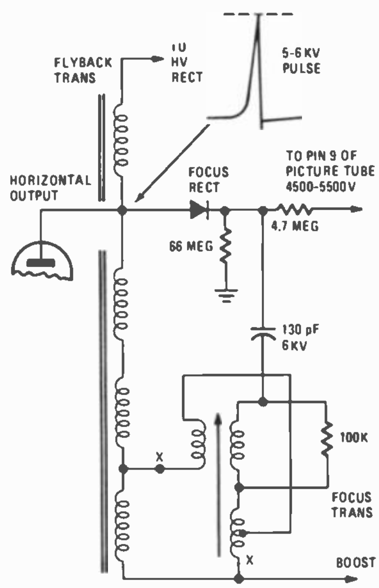


FIG 1

in high-voltage rectifier alone; only about 3 components here. This will apply to practically all tube and hybrid sets, and to many solid-state sets.

The focus coil shown in Fig. 1 should really be called a focus transformer, but no one does. This circuit works by comparing the phase relationship of two pulses in the windings, it holds the focus voltage *down* to the proper value. One set of pulses is taken directly from the flyback. So, if you find a set with all the symptoms of a shorted flyback, such as high cathode-current in the horizontal-output stage, and so on, be sure to check the focus coil *before* you replace the flyback. The test is easy. Disconnect the two leads going to the flyback (marked "X" in Fig. 1), turn it on and recheck the current. If the current goes down and the high voltage goes up—the focus transformer is shorted. The focus voltage will rise to about 5500 volts and the chances are you'll have a pretty well focused raster.

One of the more common troubles is burning up of the focus-rectifier tube socket. Some of these are very hard to fix; the optimists riveted them in. Now there is a fast-fix for this. Clear up the mess and cut the heater leads. Tape these well and put them away. If there is a contact or two left on the socket, move the plate supply lead to it. If not, install

continued on page 68

SERVICE CLINIC

continued from page 66

a terminal strip. Now, just hook in one of the solid-state focus rectifiers and away you go. The only thing to watch is clearance from ground so that it won't arc. It also helps to install the new rectifier with the right polarity.

The solid-state rectifiers are used in all solid-state sets and quite a few hybrids. These are made of a great many tiny selenium diodes stacked on one another in a very small tube. It is possible for a number of these diodes to short or develop leakage. If this happens, the focus voltage will go away down although the high voltage will stay up. This gives you the typical symptom of no raster, but great globs of fuzzy color moving around on the screen. You'll probably find the focus voltage down to around 2,000 volts. The globs of color are the objects in the picture, very badly defocused.

One more problem that can be a fooler. If the picture defocuses (loses the scanning lines) *only* in white or highlight areas that gets worse as brightness is raised, this is not a focus problem. It's quite apt to be a very weak picture tube; brightness is apt to be quite low at the same time. For a definite test, read the focus voltage. (I should have said this before, but focus voltage should always be read with a high-voltage probe, so that you do not load the circuit too much.) Check the picture tube for emission.

Some time ago, while looking for a cheaper way (or trying to get around a patent) another focus circuit showed up. This was pretty simple in theory; a huge voltage-divider was connected right across the high-voltage supply to ground, and tapped off the focus voltage. A good sized variable resistor was included so the focus voltage could be varied. To avoid loading the high voltage supply, these resistors are up into hundreds of megohms; 250–400 megohms is typical with a 15-megohm variable for adjustment. In some, high-value fixed resistors were added below the focus control, with instructions to jumper across them if the focus voltage couldn't be set high or low enough. If this circuit is "designed in", OK; however, I wouldn't recommend doing this in cases where you can't get the focus voltage right. The divider is almost sure to be defective if the high voltage is correct. Figure 2 shows this.

The first of these were made up of small resistors in series. (One friend assured me with a straight face that they contained 27 million 470-ohm resistors

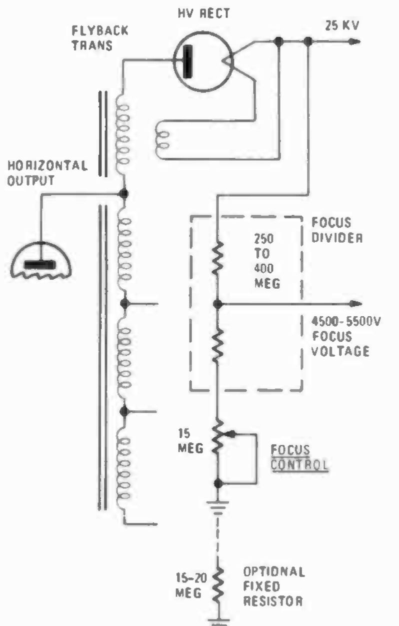


FIG 2

in series.) If some of these break down and burn, the total resistance of the divider changes and away goes your focus voltage. It may be high or low depending on where the fault is in the divider. Replacement is always best. If you add fixed resistors to get the focus right, you're just asking for a callback; that divider will continue going farther off value.

How much focus?

One reader had a problem in the focus circuit. He had about 20 kV of high voltage, and the focus read about 1.5 kV. (His was a small set using a 10VABP22 picture tube.) For some reason the focus voltage was not given on the schematic; it used a divider and was marked "Do Not Measure." This is nonsense since it can always be read with a high-voltage probe, just like the high voltage. Anyhow, the 10VABP22 tube spec's showed 20 kV for typical operation, with focus voltage between 3200 and 4300 volts. So, this one was easy; didn't even have to wipe off the crystal ball. I recommended replacing the focus divider resistor. If you run into a similar situation, with an unfamiliar picture tube, check the spec's in the book to make sure.

Intermittent focus

The focus circuit is normally considered a "dry circuit"—no *current* flow. There is a very small current in the 66-megohm resistor used in the older circuit, and a small current through the focus divider. However, the picture tube's focus electrode acts like a grid—

continued on page 74

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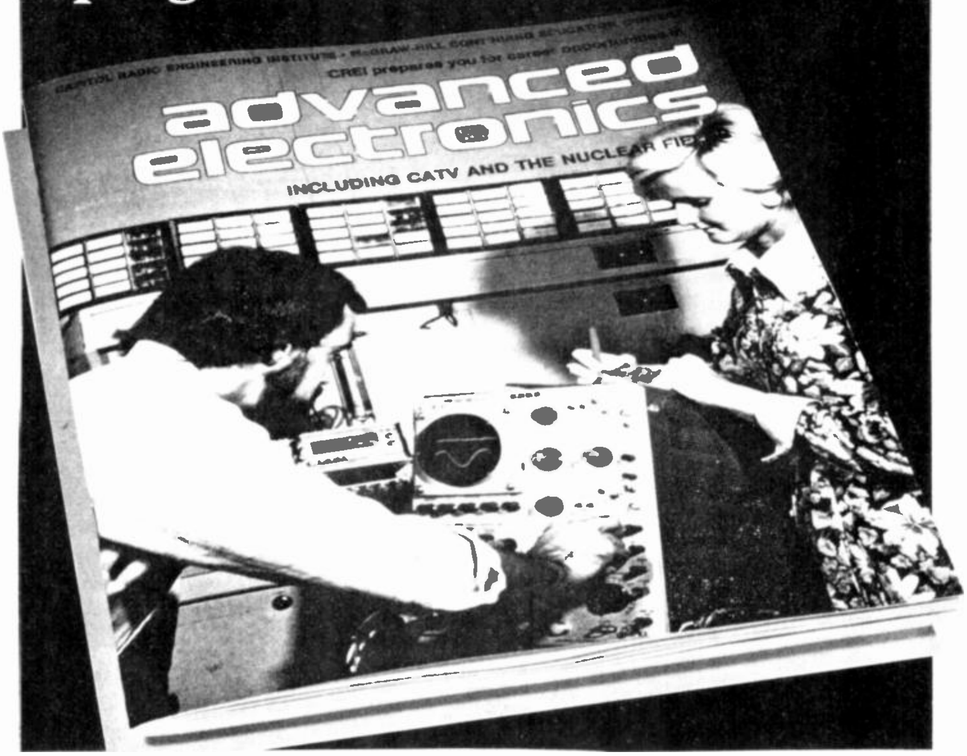

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SERVICE CLINIC

continued from page 69

all it needs is a high potential to develop the correct field.

You can have intermittents here too, as in any other circuit. The key clue will be defocusing of the scanning lines. Check the focus voltage at the source to see if there is any variation. One possible cause of this is burning of the series resistor used between the focus-voltage source and the picture tube—ballpark value is about 4.7 megohms. There is normally a very small drop across this, mainly due to meter loading. However, if this breaks down and almost opens up, it can cause problems. This is easy to check, by taking a reading from pin 9 on the picture tube socket to the focus voltage source. If it's high, change it.

Another oddball is intermittent loss of focus, though there is no change in the supply. In one case, this happened at intervals of almost exactly 1.5 seconds. If you run into this, pull the socket off the picture tube and check the focus pin which is usually pin 9. If this shows a light-greenish powdery substance, look out. Check the socket contact and clean it. This is some kind of weird oxide that forms on conductors carrying a high voltage. It is mildly corrosive and will cause a high (and variable) resistance

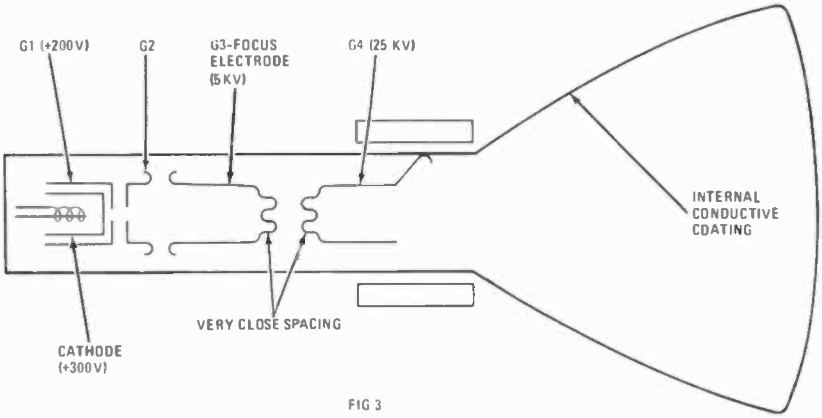


FIG 3

between the socket contact and the base pin. If you can't clean up the socket contact, you should replace the socket. This was the cause of the 1.5-second flashing just referred to, and it has been known to cause other focus problems.

High focus voltage

Speaking of oddballs, some of you may remember a Clinic a while back. It dealt with a case in my own shop. There was intermittent loss of focus, and I read more than 10 kV on the focus on two different voltmeters with high-voltage probes. (The first thing I suspected was my meter.) I wrote this up and asked for ideas on where the double focus voltage was coming from. I got a lot of answers. There were quite a few different solutions, all of them entirely possible.

It turned out that the 66-megohm glass-film resistor was open with definite signs of arcing between 2 or 3 turns of the spiral. However, the same symptom showed up with this resistor completely out, and then with a new resistor. All other parts checked out by substitution. Some time during the proceedings, the trouble disappeared, and after cooking, the set was sent home and is still working.

Later, after the column was published, I discovered something about the construction of color picture tubes that I honestly did not know. (Of course, this takes in a wide area, but I had never had occasion to look it up—found it while looking for something else, as usual.) Figure 3 shows the design of the electron guns in the standard color picture tube. G1 is the control grid, G2 the screen and G3 the focus "grid". I knew what the DC voltages should be on these. Now, here's the one I didn't know. Look at G4, which is very closely spaced to G3. The DC voltage on G4 is 25,000 volts! I was always under the vague impression that the high voltage was applied only to the shadow mask, screen and inner dag coating.

So, here was a very likely explanation of the source of the high voltage on the focus. There was a particle short between G4 and G3; somehow, I accidentally managed to blow it off or knock it loose. Aren't they simple after we find out what happened? Thanks very much to all of the nice guys who wrote in about that.

So there you are. In cases where you seem to have high-voltage problems, always remember to check the focus voltage. You can do it at the same time you're reading the high voltage since you should always use the high-voltage probe anyway.

One more thing. The newer sets using voltage triplers and quadruplers for the high voltage usually pick off the focus voltage from a tap on the tripler. The same tests still apply. R-E

Readers Questions on next page

reader questions

IF FAILURE

I'm having trouble keeping an RF-oscillator/IF network in a model 60HPB1 Chevrolet automobile radio. I've changed it three times in two months. Tried different makes, no good. Dealer checked voltage in the car and says it's OK. I've about had it!—C.B., Antigo, WN.

I can see why: this can be highly nonhabit-forming. Frankly, I have no good idea as to the cause, but I suspect that the car's electrical system is causing *transients*. Could be a dirty slip-ring in the alternator or even a loose connection somewhere. Transistorized circuits dislike any kind of transients.

You might try adding a good sized iron-core hash-choke and a couple of capacitors in the battery lead to the set. This might help hold down the transient voltages. Just for luck, scope the car's DC supply while turning things off and on, running the motor at various speeds, etc. to see.

HORIZONTAL HASH

This RCA KCS-156AA chassis has me stopped. I haven't had much experience yet. I get a loud buzz in the speaker and the horizontal oscillator is very unstable. If I turn the hold control full counterclockwise, I lose the high voltage. I checked things and found that the + 170-volt line reads correctly, and there is an AC component at the same frequency as horizontal sweep. The horizontal oscillator won't come to the right frequency and the waveform is distorted. What section of the circuitry should I check now?—V.H., APO, NY.

No more tests needed. You have found the trouble. The presence of a horizontal-frequency signal on the DC supply means that one of the filter capacitors is very, very open. The resulting *feedback* through the DC power supply is messing up your horizontal oscillator and also causing the buzz in the sound. Replace the filter capacitors.

HORIZONTAL DRIVE LOSS

I keep losing the horizontal drive on this little Sony Micro-TV. The emitter-follower shorts and away we go. However I can feed external drive to the horizontal output and get high voltage, sweep, etc. The emitter-follower transistor is marked 2D65 on the schematic. Can't find an exact duplicate that will work. Is there something that I might have overlooked?—G.P, Boca Raton, FL.

Doesn't look as if you missed much of anything. However, there is some confusion in the schematic. The transistor marked Horizontal Drive is connected as a diode. The DC voltages (0.2 volt) from base-to-emitter indicate that this one should be a germanium type. The number probably should be 2SD65. Try a new one here; if this is bad it could be killing your emitter followers.

(Feedback: "Bingo. Actually, I took the audio driver transistor, which is a 2SD64, tried it and the thing works fine. Subbed G-E-59 for the audio transistor, and it works too.")

AFC DIODES ACTING UP

Here's one for your dog files. An Electrohome C-7 came in with the classic symptoms of AFC trouble. So I checked the AFC diodes. Fine. Checked all the other parts, comparison pulse, sync, etc, no dice. Came coffee time and I pulled the cheater cord. My VTVM was still hooked to the AFC grid of the horizontal oscillator.

When the cord was pulled, the voltage should have dropped to zero. Instead, it went to 4 volts and stayed there. Coffee postponed; sat there and scratched my head. It finally dawned on me. It had to be those diodes. I clipped each one and checked. The voltage on the AFC grid disappeared but one of the diodes read 4 volts. It was acting like a battery! A new AFC diode unit fixed the set. I wonder if things like this could be behind some of those horizontal dogs that we run into? I have since seen one other AFC diode unit, of a well-known make, do the same thing.

Thanks to Ed Pugh, of Grenfell, Saskatchewan, Canada, for this wild, weird one.

HIGH-VOLTAGE PROBLEM

I've had a Heath IO-104 scope since 1974. The problem is repeated failures in the +1400-volt supply. The rectifier diodes and the filter capacitors short out. These have been replaced several times with the same results. Please help.— A.E.B., Palma de Mallorca, Spain.

The answer to this kind of problem would be a generous dose of *derating*. The diodes can be replaced with something like a color TV solid-state focus rectifier that has a rating of 8000 volts. These are typically rated at 2.0 mA, and the CRT beam current in a scope shouldn't be more than about 250 μA maximum.

The 1800-volt capacitors used aren't rated high enough. An 1800-volt type used on a 1400-volt supply doesn't leave too much margin; only 400 volts, and this obviously isn't enough. You could put two in series, but I dislike this on general principles. Try something like a 2000- or 2500-volt type. With the low current drain from this supply, the capacitor may not have to be that big. A great many similar power supplies use only 0.05 μF filter capacitors.

(Feedback: "The scope is now working. Thanks!") **R-E**

new products

More information on new products is available from the manufacturers of items identified by a Free Information number. Free Information Card follows page 88.

STEREO RECEIVER, *Model AR-1515* has an output of 70 watts, minimum RMS, per channel into 8 ohms with less than 0.08% total harmonic distortion from 20-20,000 Hz. FM sensitivity is 1.8 mV, and selectivity is 100 dB. Hum and noise are 65 dB below full output in the phono mode,

and 80 dB below full output on high level sources. The *AR-1515* is $549.95 in kit form. The unit offers digital frequency readout with AM and FM broadcast frequencies displayed in ½-inch LED's —**Heath Co.,** Dept. 350-07, Benton Harbor, MI 49022

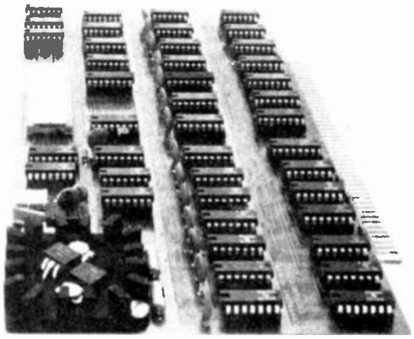
CIRCLE 50 ON FREE INFORMATION CARD

ELECTRONIC MULTIPLE-PLAY MANUAL TURNTABLE, *Model 1000* incorporates two motors; a smooth-running 24 pole 300 rpm synchronous motor to drive the turntable, and a second motor to control the cue and change cycle. The turntable stops rotating when cued or in cycle to facilitate reading the record label and provide more precise cuing control. The unit has an optional remote control that duplicates

all of the functions performed by the touch buttons on the unit plate, including cue, pause, reject, and change of records. Other features include electronic speed control using frequency to control speed through a Wien bridge oscillator; the B.I.C. tone-arm system, refined with a new CD-4 position on its anti-skating control; and computer-designed shock mounts $279.95.—**British Industries Co.,** Westbury, NY 11590

CIRCLE 72 ON FREE INFORMATION CARD

CPU CARD is based on the Z-80 microprocessor. The fastest known available version has a clock rate of 4 MHz. The card is designed as an easy way for the user to apply the Z-80 IC to his circuitry. The card is plug-compatible with



existing microcomputers. Priced at $295.00 in kit form, or $395.00 assembled.—**Cromemco,** 2432 Charleston Rd., Mountain View, CA 94043.

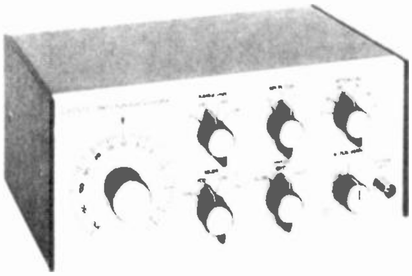
CIRCLE 73 ON FREE INFORMATION CARD

INSTANT CHILLER, *Stock No. 1669-30S*, contains 30 ounces of this manufacturer's popular *minus 62* chilling spray. Priced at ony 50¢ more

than the 15-ounce product. Includes a free, 24-inch extension spray nozzle.—**Tech Spray,** P.O. Box 949, Amarillo, TX 79105.

CIRCLE 74 ON FREE INFORMATION CARD

SWEEP/FUNCTION GENERATOR, *model 390*. This new 0.2-Hz to 200-kHz instrument is the practical answer to many of the signal-source needs of design labs, schools, audio repair shops and hobbyists. The *model 390* generates discrete sine, square, and triangle waveforms in either linear or logarithmic sweep with a choice of slow, medium, or fast rates. Has a 50-ohm



output impedance and complete attenuation controls. Calibrated tuning dial has a 1,000 to 1 range over any one of four frequency ranges. Attenuator: 0 to 62 dB with switching in 10-dB steps and potentiometer vernier. Priced at $169.95.—**Eico Electronic Instrument Co., Inc.**, 283 Malta St., Brooklyn, NY 11207.

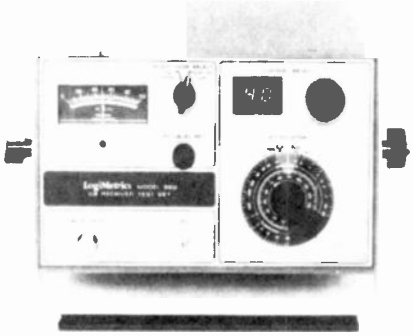
CIRCLE 75 ON FREE INFORMATION CARD

OCTAVE EQUALIZER (stereo). *Model SE-10* has 10 slide controls for each channel, one control for each octave of frequency The equalizer

uses eight IC s, 2 FET's, and 5 transistors plus an IC-regulated power supply and offers independent channel gain control from −12 dB to +6 dB. There is a low-impedance (600-ohm) output and 16 operational amplifiers in the four low-frequency sliders of both channels. The kit is $249.00; assembled, $349.00. Wood cabinet is optional.—**Dynaco**, Coles Rd., Box 88, Blackwood, NJ 08012.

CIRCLE 76 ON FREE INFORMATION CARD

CITIZENS BAND RECEIVER TEST SET, *model 980*, has a fully leveled RF output for selecting the present 40 channels. The large, bright LED readout displays the channels selected. The output attenuator is continuously adjustable from 0.03 microvolt to 20 millivolts, calibrated in



both voltage and dBm, with an accuracy of ±1 dB. Leakage level from the box is less than 0.1 microvolt The attenuator has a continuous 5-watt reverse-power handling capability to eliminate damage due to inadvertent transmitter keying. Priced at $1,195.—**LogiMetrics, Inc.**, 121-03 Dupont St., Plainview, NY 11803.

CIRCLE 77 ON FREE INFORMATION CARD

NMOS MICROCOMPUTER KIT, *Educator II,* is an 8-bit microcomputer system in kit form. The *Educator II* contains an NMOS 8-bit MPU, PIA, 128 × 8-bit static RAM: two TTL 512 × 4-bit ROM's and a TTL clock circuit. The NMOS components are the HEP versions of the popular M6800 microcomputer products. *Educator II* uses the full instruction set and address modes of the MC6800 MPU. The clock frequency is approximately 625 kHz. An executive program, residing in the ROM's, contains routines for examining and modifying memory locations and MPU registers, servicing interrupts, transferring programs to and from cassette tapes, searching tapes for specific programs and a routine to test the finished kit. The executive uses 14 bytes of RAM for a scratchpad; the remaining 114 bytes are for user programs. An optional 128 × 8-bit RAM can be added to the PC board for larger user programs. Included with the kit is a comprehensive construction/instruction manual. *Educator*

II retails for $169.95.—**Motorola Semiconductor Products, Inc.,** Box 20924, Phoenix, AZ 85036
CIRCLE 79 ON FREE INFORMATION CARD

new books

MOS DIGITAL IC's, by George Flynn. Howard W. Sams Co., Inc., 4300 W. 62 St., Indianapolis, IN 46206. 176 pp. 8½ × 5¼ in. Softcover $5.95.

The reader will find a wide range of information about MOS and CMOS devices, from basic construction and theory of operation to circuit applications in MOS Digital IC's. The book deals primarily with specific devices that are available off the shelf from many manufacturers and distributors. A wide cross section of devices is included to provide insight into other IC's that use similar circuits and/or logic.

Beginning with MOS basics, the book continues through CMOS NAND and NOR gates, CMOS, and PMOS applications, NMOS devices, and finally into certain complex MOS IC's. Charts and tables of currently available CMOS units are given in five appendices. The book is liberally illustrated with circuits, block diagrams, logic truth tables and diagrams of time sequences.

WIND/SOLAR ENERGY, by Edward M. Noll. Howard W. Sams & Co., Inc., 4300 W. 62 St., Indianapolis, IN 46206. 208 pp. 8¼ × 5¼ in. Softcover $7.95.

This book is an introduction to the practical use of sunlight in the construction of solar power supplies and the conversion of wind energy to electricity. Several practical supplies are described in detail. More elaborate yet moderate installations are discussed, and methods of making your house or small business more self-sufficient are described in terms of electrical needs. This book includes an appendix that lists addresses of suppliers and sources of material and informaiton concerning solar power and related subjects. **R-E**

CIRCLE 19 ON FREE INFORMATION CARD

STEP-BY-STEP

continued from page 59

works fine for about an hour and then the picture falls out or begins to jitter, etc." To speed up locating these parts, try heating and cooling all resistors in the sync circuitry. This will save all that waiting time. No *normal* part will be affected by this: if heating or cooling any of the resistors causes a change in the picture, change it. You can apply heat by holding the tip of a soldering iron on the body of the part. You can cool them with spray-coolant. Don't get too enthusiastic with the heat on transistors! You can overheat them and cause damage. Just a little heat is enough. Cooling them doesn't seem to do any particular damage. You will often find thermal transistors; which will get hot, then go bad. Some of them will come back when cooled!

Sync clipping

It is possible for the AGC setting to cause sync problems. If there is something wrong in the AGC or video stages, you can clip off the sync instead of the video. Needless to say, this will show up instantly on the scope. In all cases of oddball troubles, be sure to scope the video signal applied to the input of the sync separator. Too many of us overlook this. If you suspect AGC problems, clamp the AGC with a bias box and see if this won't clear up the trouble. R-E

DIGITAL MULTIMETER

continued from page 55

expected. For example, the output voltage of a regulated power supply is specified to be 15 volts plus or minus 0.5% (75 millivolts). On inspection, with a DMM, the voltage is found to be low; 14.90 volts. Here is a case for concern if circuits powered by this supply are not meeting specifications.

However, it is well to do a little thinking before immediately repairing or adjusting the supply. First, is the problem the circuit is showing likely to be caused by a power supply 25 millivolts below spec.? The likelihood is not. Therefore, the real problem must be determined first. Once the major problem is discovered and repaired, all specifications can be checked. If all specs are fine, it may be that readjusting the power supply to its correct voltage will do no more than throw off the calibration. The product may well have been initially calibrated and adjusted with the low power supply.

The caution being implied in both examples above may be stated as "Don't overuse your DMM!" DMM's are like calculators in this respect. Most of the electronics we work with is designed about ten per cent tolerances. When needed, the DMM has high accuracy and resolution, but when it is not needed, learn to disregard it.

Peaking and zeroing are two adjustments common to electronic circuits, especially those employing tuned circuits. Peaking or zeroing with a digital instrument is not easy. The analog meter gives a very good idea of trend. On the other hand, to use a digital meter for this purpose the mind must act somewhat like a digital computer. First, it must take one reading, then a second. Second, it must compare the two readings and determine which of the two is the larger. Then and only then can one know if the adjustment is in the right direction.

Often the resolution of the DMM shows the strangest things. Some of these are good, and some bad. The DMM with one millivolt resolution easily shows voltage drops across a printed circuit foil. Perhaps this voltage drop is the culprit. Then again, perhaps the circuit will completely ignore this minute voltage, and so should you. As noted before, the DMM often exposes variations in semiconductor components with temperature. Unless the circuits being analyzed are extremely critical in nature, few if any problems occur from this source.

Circuit loading becomes much more noticeable when the DMM is used. A DMM with 10 megohms input impedance will load a 50-kilohm circuit by 0.5%, unnoticeable on the analog voltmeter, but a sizable change with 0.05% resolution.

AC measurements are especially susceptible to erroneous readings. Frequently, the accuracy of the AC measurement is an order of magnitude (factor of ten) less than the resolution of the instrument. For instance, a reading may be taken to the nearest 10 millivolts; however, the accuracy may be only 100 millivolts. As noted in specifications, the total harmonic distortion of the sinusoidal signal being measured must be low to insure the rated accuracy. Remember, the eye can just notice distortion of 3% or more on an oscilloscope, so don't be fooled by a clean-looking sinewave. **R-E**

WORKBENCH ACCESSORIES
continued from page 57

Subminiature connections and solder bridges can be seen easily with a magnifying lens. Some fit on eyeglasses; some fit like an eyeshade; some are hand held and some will attach to the connectors.

Putting it all together

By this time it should be obvious that the one great advantage of this system is versatility. There is no end to the odds and ends of pieces you will find to add to the system. There is no limit to the different ways you will discover to put them together. Figure 7 shows a PC board holder made from an old test-tube clamp. It will also hold a small chassis or other similar part—even a pencil soldering iron.

Figure 8 shows an involved but not useless set-up. The PC board is held firmly while the tweezers hold a wire or part to be soldered. The magnifying glass lets you really see what's going on and the mirror provides an unobstructed view of the reverse side. All this and you still have two hands to do the work!

That's just how easy and useful this system is. Pick up some parts and assemble the holders and viewers you need. Stop calling on wife, children and friends only to hassle them because they don't hold things in the right place and motionless. Be independent: Hold your own! **R-E**

R-E TESTS FISHER RS-1080

continued from page 52

TABLE III

RADIO-ELECTRONICS PRODUCT TEST REPORT

Manufacturer: **Fisher** Model: **RS-1080**

OVERALL PRODUCT ANALYSIS

Retail Price	**$899.95**
Price Category	**High**
Price/Performance Ratio	**Very good**
Styling and Appearance	**Excellent**
Sound Quality	**Excellent**
Mechanical Performance	**Very good**

Comments: In designing and marketing a high-powered receiver, Fisher did not concentrate solely on audio power, but created a well-balanced full-featured receiver that, in many ways, rivals the performance obtainable from separate components costing considerably more. The unusual circuit driving the separate multipath meter more effectively minimizes multipath interference through careful orientation of one's outdoor FM antenna than do dual-purpose meters or even those extra scope output jacks intended for connection to a separate oscilloscope. Built-in Dolby decoding (including the correct 25 μs de-emphasis characteristic) adds to the value of the receiver, particularly if there are such programs broadcast in your listening area. The extra bass-boost control, with its variable center frequencies of 45 Hz and 80 Hz, helps enormously in bringing out that last octave of bass from speakers that could not be improved using a conventional bass-boost control without disturbing upper-bass and lower mid-tones.

Our sole criticism of measured performance was of factory settings of the stereo threshold and the muting threshold, both of which, we later learned, were not set within manufacturer's limits (but easily could have been). We would hope that ours was the rare case rather than typical.

The *RS-1080* has more than enough power output for driving even the most inefficient loudspeaker system. Sound from records was particularly good, with musical transients coming through uncolored and with little apparent distortion. The front panel is engineered for easy use, despite the many control features provided—a good job of human engineering. Of course, any receiver of this power output had to be big—so big that shelf-mounting it would be impractical unless you own shelves that are over 18" deep, and capable of supporting its 65-pound weight.

next month

AUGUST 1977

- **Videocube**

  It's an RF modulator that interfaces a video game or microcomputer directly to the antenna terminals of your TV set. This easy to build device meets FCC type acceptance specifications.

- **Build The Ultimate Digital Clock**

  This one includes a countdown timer, alarm, date and time, with a simultaneous readout of all four functions. The timer can easily be interfaced to a relay for controlling appliances.

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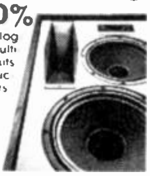

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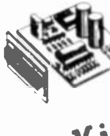

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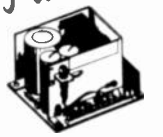

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SN7448N	.69	SN74180N	.67
SN7450N	.14	SN74181N	1.94
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SN74LS04N	.28	SN74LS191N	1.80
SN74LS05N	.28	SN74LS192N	1.80
SN74LS08N	.23	SN74LS193N	1.80
SN74LS09N	.23	SN74LS194AN	1.30
SN74LS10N	.23	SN74LS195AN	1.30
SN74LS11N	.23	SN74LS196N	1.40
SN74LS12N	.25	SN74LS197N	1.40
SN74LS13N	.65	SN74LS221N	1.30
SN74LS14N	1.35	SN74LS240N	2.50
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SN74LS22N	.23	SN74LS244N	2.50
SN74LS26N	.37	SN74LS247N	1.30
SN74LS27N	.27	SN74LS248N	1.30
SN74LS28N	.30	SN74LS249N	1.30
SN74LS30N	.23	SN74LS251N	1.50
SN74LS32N	.33	SN74LS253N	1.50
SN74LS33N	.37	SN74LS257N	1.40
SN74LS37N	.37	SN74LS258N	1.40
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SN74LS47N	1.10	SN74LS283N	1.35
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		CD4071BE	.24
		CD4072BE	.29
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		CD4075BE	.29
		CD4076BE	1.05
		CD4078BE	.24
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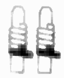
WIREWRAP



Cut & Stripped #30 Kyner Wire In Red, Yellow, Blue, White, Green or Orange. All lengths overall. 1" strip on each end.

	100	500	1000
3"	.82	2.60	4.71
3½"	.86	2.81	5.12
4"	.90	3.00	5.52
4½"	.94	3.21	5.93
5"	.98	3.42	6.34
5½"	1.02	3.63	6.75
6"	1.06	3.83	7.16
6½"	1.10	4.04	7.57
7"	1.14	4.24	7.98
7½"	1.19	4.45	8.39
8"	1.23	4.65	8.80
Add'l. inches	.10	.41	.82

On 250 ft. Rolls $4.00 10/$30 (mix)

Gold Wire Wrap IC Sockets High Quality Closed Entry Type

	1-9	10-24	25-99	100-199
8	.44	.40	.36	.34
14	.38	.37	.365	.35
16	.42	.41	.39	.37
18	.70	.65	.60	.55
22	1.30	1.20	1.05	.95
24	.90	.85	.80	.75
28	1.30	1.20	1.05	.95
40	1.60	1.50	1.30	1.25

HOBBY WRAP TOOL

$34.95
With Free Wire

250	2½"
250	3"
250	3½"
100	4"
100	4½"
100	5"
100	6"

We also Stock:
- Wire Wrap Boards
- 7400 & 74LS00 IC's
- Processor Support Chips

Call or Write for catalog
(213) 797-4002 or 797-4007

Orders under $10 or COD's add $1.00, other orders shipped UPS ppd. Bank Americard and Master Charge.

Hand Wrap UnWrap Strip Tool
$5.95 with $2 free wire.

Page Digital Electronics
1701 East Orange Grove Blvd
Pasadena, California 91104

CIRCLE 36 ON FREE INFORMATION CARD

DIGI-KEY CORPORATION
Quality Electronic Components

DON'T FORGET OUR DISCOUNTS WHEN COMPARING PRICES

PRICE BREAKTHROUGH ON 74LS'

74LS00	.28	74LS30	.28	74LS90	.57	74LS157	.75	74LS248	.79
74LS01	.28	74LS32	.33	74LS92	.57	74LS158	.75	74LS249	.79
74LS02	.28	74LS37	.33	74LS93	.57	74LS160	1.02	74LS253	.84
74LS03	.28	74LS38	.33	74LS107	.39	74LS161	1.02	74LS257	.75
74LS04	.29	74LS40	.28	74LS109	.39	74LS162	1.02	74LS258	.75
74LS05	.29	74LS42	.67	74LS112	.39	74LS163	1.02	74LS266	.39
74LS08	.29	74LS47	.79	74LS113	.39	74LS164	1.02	74LS283	.79
74LS09	.29	74LS48	.77	74LS114	.39	74LS168	1.14	74LS290	.65
74LS10	.28	74LS51	.28	74LS125	.49	74LS169	1.14	74LS293	.65
74LS11	.28	74LS54	.28	74LS126	.49	74LS170	1.73	74LS365	.67
74LS12	.28	75LS55	.28	74LS132	.81	74LS173	1.34	74LS366	.67
74LS13	.47	74LS73	.39	74LS136	.39	74LS174	1.06	74LS367	.67
74LS14	1.02	74LS74	.39	74LS138	.73	74LS175	.84	74LS368	.67
74LS15	.28	74LS75	.53	74LS139	.73	74LS190	1.18	74LS386	.39
74LS20	.28	74LS76	.39	74LS151	.75	74LS191	1.18	74LS670	2.34
74LS21	.28	74LS78	.39	74LS153	.75	74LS196	.86	71LS95	.77
74LS22	.28	74LS83	.79	74LS154	1.10	74LS197	.86	71LS96	.77
74LS26	.33	74LS86	.39	74LS155	.75	74LS247	.79	71LS97	.77
74LS27	.33			74LS156	.75			71LS98	.77

INTEGRATED CIRCUITS — TTL, CMOS, LINEAR & MOS

7400	.21	7476	.32	74181	2.15	4012	.23	4520	1.14
7401	.21	7480	.70	74182	.79	4013	.40	4527	1.68
7402	.21	7482	.70	74184	2.19	4014	.96	4528	.88
7403	.21	7483	.70	74185	2.19	4015	.96	4585	1.23
7404	.21	7485	.89	74188	3.50	4016	.40	2102-1	1.99
7405	.21	7486	.28	74189	3.50	4017	1.05	8080A	24.95
7406	.25	7489	2.19	74190	1.23	4018	1.05	CA3046	.75
7407	.25	7490	.44	74191	1.23	4019	.23	LM2111N	1.25
7408	.21	7491	.70	74192	.88	4020	1.14	LM309K	1.80
7409	.21	7492	.44	74193	.88	4021	1.14	LM324A	1.28
7410	.21	7493	.44	74194	.88	4022	.96	LM340T-5	1.25
7411	.21	7494	.70	74195	.88	4023	.23	LM340T-6	1.25
7412	.21	7495	.70	74196	.88	4024	.84	LM340T-8	1.25
7413	.25	7496	.70	74197	.88	4025	.23	LM340T-12	1.25
7414	.89	74100	1.28	74198	1.49	4026	1.68	LM340T-15	1.25
7416	.25	74107	.30	74199	1.49	4027	.40	LM340T-18	1.25
7417	.25	74109	.33	74251	1.09	4028	.89	LM340T-24	1.25
7420	.21	74121	.35	74279	.55	4029	1.14	LM3900N	.88
7421	.25	74122	.44	74365	.67	4030	.23	LM3909N	.69
7423	.35	74123	.61	74366	.67	4033	1.51	MC1456V	1.00
7425	.35	74125	.40	74367	.67	4034	3.50	MC1458V	.53
7426	.25	74126	.40	74368	.67	4035	1.14	MC3302P	1.15
7427	.33	74132	.70	8093	.40	4040	1.14	NE536T	3.24
7428	.28	74141	.88	8094	.40	4041	.79	NE540L	2.04
7430	.21	74145	.70	9095	.67	4042	.79	NE555V	.48
7432	.25	74147	1.63	8096	.67	4043	.70	NE556A	.88
7433	.30	74148	1.30	8097	.67	4044	.70	NE560B	3.83
7437	.25	74150	1.16	8098	.67	4046	1.86	NE561B	3.83
7438	.25	74151	.70	75150	1.16	4049	.40	NE562B	3.83
7440	.21	74153	.65	75450	.88	4050	.40	NE565A	1.25
7442	.53	74154	1.03	75451	.61	4051	1.26	NE566V	1.28
7443	.63	74155	.70	75452	.61	4052	1.26	NE567V	1.36
7445	.70	74156	.70	75453	.61	4053	1.26	uA709CV	.44
7446	.70	74157	.70	75454	.61	4060	1.58	uA710CA	.44
7447	.70	74160	.88	75491	.81	4066	.79	uA711CA	.53
7448	.70	74161	.88	75492	.84	4071	.23	uA723CA	.60
7450	.21	74162	.88	75493	1.09	4072	.23	uA733CA	.75
7451	.21	74163	.88	75494	1.19	4073	.23	uA741CV	.44
7453	.21	74164	.96	82S25	2.19	4075	.23	uA747CA	.70
7454	.21	74165	1.15	4000	.23	4081	.23	uA748CV	.49
7459	.21	74166	1.26	4001	.23	4082	.23	uA7805CU	1.25
7460	.21	74170	2.64	4002	.23	4502	.79	uA7806CU	1.25
7470	.30	74173	1.42	4006	1.23	4510	1.14	uA7808CU	1.25
7472	.30	74174	.98	4007	.23	4511	1.05	uA7812CU	1.25
7473	.30	74175	.93	4008	.79	4514	2.80	uA7815CU	1.25
7474	.30	74176	.79	4009	.44	4515	2.80	uA7818CU	1.25
7475	.49	74177	.79	4010	.44	4516	1.23	uA7824CU	1.25
		74180	.70	4011	.23	4518	1.14		

WIRE WRAPPING WIRE IN BULK
Red or Black 30 ga. Kynar

100' $2.00 500' $8.50 1000' $15.00

SILICON DIODES

1N4001	.64/10	5.50/C	$49/M
1N4002	.66/10	5.60/C	$51/M
1N4003	.68/10	5.80/C	$52/M
1N4004	.70/10	5.95/C	$54/M
1N4005	.82/10	7.05/C	$63/M
1N4006	.90/10	7.75/C	$69/M
1N4007	.99/10	8.60/C	$77/M
1N4148	.40/10	3.50/C	$29/M

Double Digit Discounts Save You Even More!

½ WATT ZENER DIODES

1N5226B	3.3v	.15	$11/C	1N5236B	7.5v	.15	$11/C
1N5227B	3.6v	.15	$11/C	1N5237B	8.2v	.15	$11/C
1N5228B	3.9v	.15	$11/C	1N5238B	8.7v	.15	$11/C
1N5229B	4.3v	.15	$11/C	1N5239B	9.1v	.15	$11/C
1N5230B	4.7v	.15	$11/C	1N5240B	10v	.15	$11/C
1N5231B	5.1v	.15	$11/C	1N5241B	11v	.15	$11/C
1N5232B	5.6v	.15	$11/C	1N5242B	12v	.15	$11/C
1N5233B	6.0v	.15	$11/C	1N5243B	13v	.15	$11/C
1N5234B	6.2v	.15	$11/C	1N5244B	14v	.15	$11/C
1N5235V	6.8v	.15	$11/C	1N5245B	15v	.15	$11/C

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PLESSEY SAMPLER
An Assortment of Metalized Polyester Capacitors

300 Caps 18 Values $26.00

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NSL5053 T-1¾	.18	$15/C
NSL5056 T-1¾	.18	$15/C

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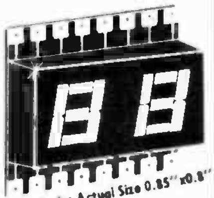
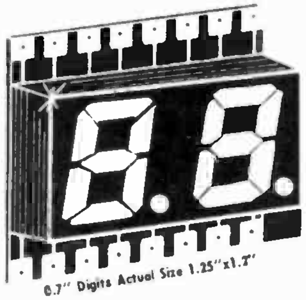
PRICED PER PAIR OF 2 DIGITS

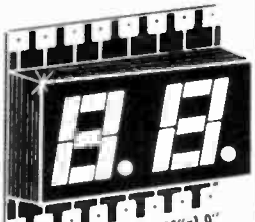
NEW!

- NSN373 0.3" CC . $2.20/Pair
- NSN374 0.3" CA . $2.20/Pair
- NSN584 0.5" CC . $2.60/Pair
- NSN584 0.5" CA . $2.60/Pair
- NSN783 0.7" CC . $3.00/Pair
- NSN784 0.7" CA . $3.00/Pair

ALL LEADS BROUGHT OUT FOR EASE OF APPLICATION


0.3" Digits Actual Size 0.85"x0.8"


0.7" Digits Actual Size 1.25"x1.7"


0.5" Digits Actual Size 1.05"x1.0"

NEW!

MA1003 CAR CLOCK
- 12 Hour Only
- 12 Volt DC
- Crystal Time Base
- Bright Green Digits
- Assembled and Tested

NEW!

NEW — FOR CAR OR BOAT!

The MA1003 bright green flourescent display offers a brilliance that cannot be achieved by LED displays, a feature that sold Detroit!

0.3" Digits Actual Size 1.75"x3.05"

MA1003 ..... $24.95
Includes 3 Push Button Switches

NEW!

MA1002 0.5" High Digits

Actual Size: 1.375"x3.05"

MA1002A 12 Hour AM-PM	$10.50
MA1002C 24 Hour	$10.50
SPECIAL TRANSFORMER & SWITCHES	$3.45

ABOUT OUR CLOCKS

The MA1002 and MA1010 series clock modules by National Semiconductor are fully assembled and tested clocks using a 4 digit LED display and an MOS integrated circuit on the same board. Simply connect switches and our special transofmer and you have a fully functioning clock.

The MA1003 clock module is a fully assembled and tested 12 hour clock using a high brilliance green flouresent display and crystal time base making it perfect for car, boat or other portable use. It operates directly from 12 volts DC so no transformer is needed. Our price includes three push button switches for setting the time.

MA1002A	.5" LED 12 Hour AM-PM Clock Module	$10.50
MA1002A SET	Module with Transformer & Switches	$13.95
MA1002C	.5" LED 24 Hour Clock Module	$10.50
MA1002C SET	Module with Transformer & Switches	$13.95
MA1003	12 Volt Car Clock with Switches	$24.95
MA1010A	.84" LED 12 Hour AM-PM Clock Module	$13.00
MA1010A SET	Module with Transformer & Switches	$16.45
MA1010C	.84" LED 24 Hour Clock Module	$13.00
MA1010C SET	Module with Transformer & Switches	$16.45

RADIAL ELECTROLYTICS

.47/50V	.08	.65/10	22/50V	.12	1.00/10	330/25V	.23	1.86/10
1/50V	.08	.65/10	100/6.3V	.09	.75/10	470/10R	.21	1.71/10
2.2/50V	.08	.65/10	100/10V	.10	.77/10	470/16V	.23	1.81/10
3.3/50V	.08	.65/10	100/16V	.11	.85/10	470/25V	.29	2.35/10
4.7/35V	.08	.65/10	100/25V	.13	1.10/10	1000/10V	.24	1.96/10
4.7/50V	.08	.68/10	100/50V	.21	1.71/10	1000/16V	.29	2.35/10
10/16V	.08	.65/10	220/10V	.13	1.08/10	1000/25V	.42	3.33/10
10/25V	.08	.65/10	220/16V	.15	1.16/10	2200/10V	.42	3.33/10
10/50V	.10	.75/10	220/25V	.21	1.71/10	2200/16V	.54	4.30/10
22/16V	.08	.67/10	220/50V	.29	2.35/10	2200/25V	.58	4.67/10
22/25V	.09	.70/10	330/10V	.15	1.16/10	3300/16V	.89	7.14/10
			330/16V	.21	1.66/10			

AXIAL ELECTROLYTICS

.47/10V	.11	.90/10	33/25V	.14	1.15/10	330/16V	.29	2.35/10
1/30V	.11	.90/10	33/50V	.19	1.52/10	330/25V	.32	2.54/10
3.3/35V	.12	.95/10	47/16V	.14	1.15/10	470/16V	.32	2.55/10
3.3/50V	.12	1.00/10	47/25V	.17	1.30/10	470/25V	.37	3.00/10
4.7/25V	.11	.90/10	47/50V	.21	1.17/10	1000/10V	.33	2.65/10
4.7/35V	.12	.95/10	100/10V	.14	1.13/10	1000/16V	.39	3.15/10
4.7/50V	.12	1.00/10	100/16V	.17	1.30/10	1000/25V	.56	4.50/10
10/25V	.12	1.00/10	100/25V	.20	1.55/10	2200/10V	.50	3.96/10
10/50V	.14	1.15/10	100/50V	.29	2.30/10	2200/16V	.62	4.95/10
22/16V	.12	1.00/10	220/10V	.18	1.42/10	2200/25V	.79	6.36/10
22/25V	.13	1.05/10	220/16V	.20	1.55/10	3300/16V	.95	7.63/10
22/50V	.17	1.32/10	220/25V	.29	2.35/10	4700/16V	1.09	8.70/10
33/16V	.12	1.00/10	220/50V	.40	3.23/10	10000/10V	1.15	9.19/10
			330/10V	.14	1.16/10			

Double Digit Discounts Save You Even More!

MA1010 0.84" High Digits

Actual size: 1.75"x3.75"

MA1010A 12 Hour AM-PM	$13.00
MA1010C 24 Hour	$13.00
SPECIAL TRANSFORMER & SWITCHES	$3.45

SEND FOR OUR FREE CATALOG
WE STOCK A WIDE VARIETY OF PARTS NOT IN THIS AD PLUS MANY SPECIALLY PRICED BARGAINS!

DATA BOOKS

TTL IC's 595 p	$4.00
Linear IC's 957 p	$5.00
CMOS 74C 256 p	$3.00
Memory IC's 592 p	$3.00
Interface IC's 464 p	$4.00
Volt. Regs. 126 p	$3.00
Linear Appl. 1 632 p	$4.00
Linear Appl. 2 246 p	$3.00
Audio 196 p	$3.00
MOS/LSI IC's 713 p	$4.00
CMOS 4000 276 p	$3.25
Analog Manual 637 p	$5.95

SLIDE SWITCHES

SPST	.15	1.20/10	10.00/C
SPDT	.19	1.70/10	13.00/C
DPDT	.23	2.00/10	19.00/C

STRANDED HOOK UP WIRE

20 ga PVC	2.50/100'	10.00/500'
22 ga PVC	2.80/100'	11.25/500'
24 ga PVC	2.10/100'	8.50/500'
26 ga PVC	2.10/100'	8.50/500'

50 VOLT DISCS

100 pf	.40/10	3.50/C
220 pf	.40/10	3.50/C
470 pf	.40/10	3.50/C
.001 uf	.40/10	3.50/C
.0022 uf	.40/10	3.50/C
.0047 uf	.40/10	3.50/C
.01 uf	.45/10	3.65/C
.022 uf	.50/10	4.00/C
.047 uf	.70/10	5.60/C
.1 uf	1.35/10	11.50/C

WIRE-WRAPPING TOOL
$5.95
Wraps, Unwraps & Strips 30 ga. Wire

¼ & ½ WATT 5% CARBON FILM RESISTORS
5c each in multiples of 5 per value
$1.70/100 & $12.00/1000 of same value

1 ohm thru 1.0 megohm

I.C. SOCKETS

8 Pin Solder	.17	1.60/10
14 Pin Solder	.20	1.90/10
16 Pin Solder	.22	2.10/10
18 Pin Solder	.29	2.75/10
24 Pin Solder	.38	3.60/10
28 Pin Solder	.45	4.25/10
40 Pin Solder	.63	6.00/10
8 Pin W-W	.24	2.30/10
14 Pin W-W	.26	2.50/10
16 Pin W-W	.30	2.85/10
18 Pin W-W	.60	5.70/10
24 Pin W-W	.96	9.10/10
28 Pin W-W	1.12	10.00/10
40 Pin W-W	.92	8.75/10

HARDWARE

2-56 1/4 Screw	.99/C	7.20/M
2-56 1/2 Screw	.99/C	7.65/M
4-40 1/4 Screw	.55/C	3.60/M
4-40 1/2 Screw	.60/C	4.05/M
6-32 1/4 Screw	.65/C	4.40/M
6-32 1/2 Screw	.75/C	4.85/M
8-32 3/8 Screw	.90/C	5.85/M
8-32 5/8 Screw	.99/C	7.00/M
2-56 Hex Nut	.55/C	3.60/M
4-40 Hex Nut	.55/C	3.75/M
6-32 Hex Nut	.60/C	4.00/M
3-32 Hex Nut	.60/C	4.15/M
No. 2 Lockwasher	.85/C	5.75/M
No. 4 Lockwasher	.45/C	3.00/M
No. 6 Lockwasher	.45/C	3.00/M
No. 8 Lockwasher	.45/C	3.00/M

DOUBLE-DIGIT DISCOUNT SCHEDULE

Merchandise	Discount	Merchandise	Discount
$ 0.00-$24.99	NET	$100.00-$499.99	Less 15%
		$500.00-$999.99	Less 20%
$25.99-$99.99	Less 10%	$1000.00 & Up	Less 25%

Then Add the Standard Charge Below

STANDARD SHIPPING/HANDLING CHARGE

If your merchandise total after discount is between

$ 0.00-$ 4.99	add $2.00	$ 50.00-$99.99	add $0.25
$ 5.00-$24.99	add $0.75	$100.00 & up	No Charge
$25.00-$49.99	add $0.50		

Includes shipping and insurance to USA & Canada

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"Only Quality Components Sold!"

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DIGI-KEY CORPORATION
Box 677, Thief River Falls, MN 56701 218-681-6674

7400N TTL

SN7400N	.16	SN7459A	25		
SN7401N	.16	SN7460N	22	SN74154N	1.00
SN7402N	21	SN7470N	.45	SN74155N	99
SN7403N	.16	SN7472N	39	SN74156N	99
SN7404N	.18	SN7473N	.37	SN74157N	99
SN7405N	24	SN7474N	32	SN74160N	1.25
SN7406N	20	SN7475N	50	SN74161N	99
SN7407N	29	SN7476N	.32	SN74163N	.99
SN7408N	.25	SN7479N	5.00	SN74164N	1.10
SN7409N	.25	SN7480N	.50	SN74165N	1.10
SN7410N	.18	SN7482N	98	SN74166N	1.25
SN7411N	.30	SN7483N	70	SN74167N	5.50
SN7412N	33	SN7485N	89	SN74170N	2.10
SN7413N	.45	SN7486N	39	SN74172N	8.95
SN7414N	70	SN7488N	3.50	SN74173N	1 50
SN7416N	35	SN7489N	2.49	SN74174N	1 25
SN7417N	.35	SN7490N	.45	SN74175N	99
SN7420N	.21	SN7491N	75	SN74176N	90
SN7421N	.33	SN7492N	.49	SN74177N	90
SN7422N	.49	SN7493N	.49	SN74180N	99
SN7423N	37	SN7494N	.79	SN74181N	2.49
SN7425N	29	SN7495N	79	SN74182N	95
SN7426N	29	SN7496N	.89	SN74184N	1 95
SN7427N	.37	SN7497N	4.00	SN74185N	2 20
SN7429N	42	SN74100N	1.00	SN74186N	15.00
SN7430N	.26	SN74107N	39	SN74187N	6 00
SN7432N	.31	SN74121N	39	SN74188N	3 95
SN7437N	27	SN74122N	39	SN74190N	1 19
SN7438N	.27	SN74123N	.50	SN74191N	1.25
SN7439N	.25	SN74125N	60	SN74192N	.89
SN7440N	15	SN74126N	.60	SN74193N	.89
SN7441N	.89	SN74132N	1.09	SN74194N	1.25
SN7442N	.59	SN74136N	.95	SN74195N	.75
SN7443N	75	SN74141N	1.15	SN74196N	1 25
SN7444N	75	SN74142N	4.00	SN74197N	75
SN7445N	75	SN74143N	4.50	SN74198N	1 75
SN7446N	.81	SN74144N	4.50	SN74199N	1 75
SN7447N	.69	SN74145N	1.15	SN74200N	5 59
SN7448N	79	SN74147N	2 35	SN74279N	90
SN7450N	26	SN74148N	2 00	SN74251N	1 79
SN7451N	.27	SN74150N	1.00	SN74284N	6.00
SN7453N	.27	SN74151N	.79	SN74285N	6 00
SN7454N	20	SN74153N	.89	SN74367N	75

MANY OTHERS AVAILABLE ON REQUEST
20% Discount for 100 Combined 7400's

CMOS

CD4000	25			74C04N	.75
CD4001	25			74C10N	65
CD4002	25	CD4035	1 85	74C20N	65
CD4006	2.50	CD4040	2.45	74C30N	65
CD4007	25	CD4042	1.90	74C42N	2 15
CD4009	59	CD4044	1.50	74C73N	1 50
CD4010	59	CD4046	2.51	74C74	1 15
CD4011	25	CD4047	2.75	74C90N	3.00
CD4012	25	CD4049	79	74C95N	2 00
CD4013	47	CD4050	79	74C107N	1 25
CD4016	56	CD4051	2 95	74C151	2 90
CD4017	1.35	CD4053	2.95	74C154	3 00
CD4019	55	CD4060	3.25	74C157	2 15
CD4020	1.49	CD4066	1.75	74C160	3 25
CD4022	1 25	CD4069	45	74C161	3.25
CD4023	25	CD4071	45	74C163	3 00
CD4024	1.50	CD4081	45	74C164	3 25
CD4025	25	CD4511	2 50	74C173	2 60
CD4027	69	CD4518	2 50	74C193	2 75
CD4028	1 65	MC14566	3.00	74C195	2 75
CD4029	2 90	74C00N	39	MC4044	4 50
CD4030	65	74C02N	55	MC14016	56

LINEAR

LM300H	80			LM1351N	1 65
LM301H	35			LM1414N	1 75
LM301CN	35	78MG	1 75	LM1458C	65
LM302H	75	LM370N	1 15	LM1496N	95
LM304H	1.00	LM373N	3 25	LM1556V	1.85
LM305H	1.00	LM377N	4 00	LM2111N	1.95
LM307CN	35	LM380N	1 39	LM2901N	2 95
LM308H	1.00	LM380CN	1.05	LM3065N	69
LM308CN	1.00	LM381N	1.79	LM3900N	55
LM309H	1.10	LM382N	1 79	LM3905N	60
LM309K	99	NE501K	8 00	LM3909	1.25
LM310CN	1.15	NE510A	6.00	LM5556N	1 85
LM311H	90	NE531H	3.00	MC5558V	1.00
LM311N	90	NE536T	6 00	LM7525N	.90
LM318CN	1.50	NE540L	6 00	LM7535N	1.25
LM319N	1.30	NE550N	79	8038B	4 95
LM320K-5	1 35	NE555V	39	LM75450	.49
LM320K-5.2	1 35	NE560B	5 00	75451CN	39
LM320K-12	1 35	NE561B	5 00	75452CN	39
LM320K-15	1.35	NE562B	5 00	75453CN	.39
LM320T-5	1.75	NE565H	1 25	75454CN	39
LM320T-5.2	1.75	NE565N	1 75	75491CN	79
LM320T-8	1.75	NE566CN	1 25	75492CN	.89
LM320T-12	1.75	NE567H	1 95	75494CN	.89
LM320T-15	1.75	NE567V	1.50	RCA LINEAR	
LM320T-18	1.75	LM703CN	45	CA3013	2 15
LM320T-24	1.75	LM709H	29	CA3023	2.56
LM323K-5	9.95	LM709N	29	CA3035	2.48
LM324N	1.80	LM710N	79	CA3039	1 35
LM339N	1.70	LM711N	39	CA3046	1.30
LM340K-5	1 95	LM723H	55	CA3059	3 25
LM340K-6	1 95	LM723N	55	CA3060	3 25
LM340K-8	1.95	LM733N	1.00	CA3080	85
LM340K-12	1 95	LM739N	1.00	CA3081	2.00
LM340K-15	1.95	LM741CH	35	CA3082	2.00
LM340K-18	1.95	LM741CN	35	CA3083	1 60
LM340K-24	1.95	LM741-14N	39	CA3086	85
LM340T-5	1.75	LM747H	79	CA3089	3 75
LM340T-6	1.75	LM747N	79	CA3091	10 20
LM340T-8	1.75	LM748H	39	CA3102	2 95
LM340T-12	1.75	LM748N	39	CA3123	2.15
LM340T-15	1.75	LM1303N	90	CA3130	1 39
LM340T-18	1.75	LM1304N	1.19	CA3140	1 25
LM340T-24	1.75	LM1305N	1.40	CA3600	1 75
LM350N	1.00	LM1307N	85	RC4194	5.95
LM351CN	65	LM1310N	2.95	RC4195	3 25

74LS00 TTL

74LS00	29			74LS139	1.95
74LS02	29			74LS151	1 55
74LS03	29	74LS74	49	74LS153	1 89
74LS04	35	74LS75	69	74LS157	1 55
74LS05	35	74LS76	39	74LS162	2 25
74LS08	29	74LS83	1 75	74LS163	2 25
74LS10	29	74LS85	2 49	74LS164	1 95
74LS13	69	74LS86	49	74LS175	1.95
74LS14	1 75	74LS90	1 25	74LS181	3 69
74LS20	29	74LS92	1 25	74LS190	2 85
74LS26	39	74LS93	1 25	74LS191	2 85
74LS27	39	74LS95	1 95	74LS192	2 85
74LS28	39	74LS96	1 89	74LS193	2 85
74LS30	29	74LS107	59	74LS194	1 89
74LS32	39	74LS109	59	74LS195	1 89
74LS40	39	74LS112	59	74LS257	1 75
74LS51	29	74LS132	1 25	74LS260	55
74LS55	29	74LS136	59	74LS279	79
74LS73	49	74LS138	1 89	74LS670	3 95

CLOCK CHIPS

MM5309	6 Digit, BCD Outputs, Reset PIN	$9 95
MM5311	6 Digit, BCD Outputs, 12 or 24 Hour	4 95
MM5312	4 Digit, BCD Outputs, 1 PPS Output	4 95
MM5314	6 Digit, 12 or 24 Hour, 50 or 60 Hz	4 95
MM5316	4 Digit, Alarm, 1 PPS Output	6 95
MM5318	Video Clock Chip, For Use With (MM5841 - $9 95)	9 95
CT7001	6 Digit, Calendar, Alarm, 12 or 24 Hour	5 95

DATA HANDBOOKS

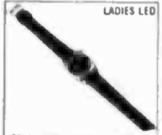
7400	Pin out & Description of 5400/7400 ICS	$2.95
CMOS	Pin out & Description of 4000 Series ICS	$2.95
Linear	Pin out & Functional Description	$2.95

ALL THREE HANDBOOKS $6.95

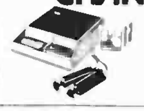
Timeband by FAIRCHILD — Watches —

Men's & Ladies

- Solid State
- Displays hour, minute, second, month & day
- Snap-out battery replacement
- Free set of replacement batteries
- Choose LED or LCD styles
- One year factory warranty



CHANNEL F™ FAIRCHILD VIDEO ENTERTAINMENT SYSTEM



$159.95

- Freeze Action • Speed Option
- Automatic time and scorekeeping
- Battery-free AC operation
- Dual controls with 8-way action
- Built-in Pro Hockey and Tennis games
- Easy hook-up on any B/W or Color TV
- Factory warranty

Channel F — additional cartridges — $19.95 ea.

#8112 - Desert Fox/Shooting Gallery
#8113 - Blackjack (1 or 2 players)
#8114 - Spitfire (1 or 2 players)
#8115 - Space War
#8111 - Tic-Tac-Toe/Shooting Gallery/Doodle/Quadra-Doodle

DISCRETE LEDS

.125" dia			.190" dia		
XC209	Red	10/$1	XC111	Red	10/$1
XC209	Green	4/$1	XC111	Green	4/$1
XC209	Orange	4/$1	XC111	Yellow	4/$1
XC209	Yellow	4/$1	XC111	Orange	4/$1

.200" dia			.185" dia			.200" dia			.085" dia		
XC22	Red	10/$1	XC526	Red	5/$1	XC556	Red	10/$1	ME50	Red	6/$1
XC22	Green	4/$1	XC526	Green	4/$1	XC556	Green	4/$1	INFRA-RED LED		
XC22	Yellow	4/$1	XC526	Yellow	4/$1	XC556	Yellow	4/$1			
XC22	Orange	4/$1	XC526	Orange	4/$1	XC556	Orange	4/$1			
SSL-22	RT	4/$1	XC526	Clear	4/$1	XC556	Clear	7/$1			

SPECIAL * — XC556 Red 100/$8.00 1000/$60.00 — SPECIAL *

DISPLAY LEDS

DL707 UL338

TYPE	POLARITY	HT		TYPE	POLARITY	HT	
MAN 1	Common Anode	270	2 95	MAN 3640	Common Cathode-orange	300	1 75
MAN 2	5 x 7 Dot Matrix	300	4 95	MAN 4710	Common Anode-Red	400	1 95
MAN 3	Common Cathode	125	3/1 00	DL701	Common Anode-red	300	99
MAN 4	Common Cathode	187	1 95	DL704	Common Cathode	300	99
MAN 7	Common Anode	300	1 25	DL707	Common Anode	300	99
MAN 7G	Common Anode-green	300	1 95	MAN 4740	Common Anode Red	400	99
MAN 7Y	Common Anode yellow	300	1 95	DL741	Common Anode	600	1 50
MAN 52	Common Anode-green	300	99	DL 747	Common Anode	600	2 25
MAN 64	Common Anode-red	400	99	DL 750	Common Cathode	600	2 49
MAN 74	Common Cathode	300	1 50	DL 338	Common Cathode	110	50
MAN 82	Common Anode yellow	300	99	FND70	Common Cathode	250	75
MAN 84	Common Cathode yellow	300	99	FND503	Common Cathode	500	1 00
MAN 3620	Common Anode orange	300	1 75	FND507	Common Anode	500	1 00

FACTORY REJECTS ATARI GAME BOARDS

BOARD A — 8½" x 16" $6.95 ea.
Over 60 each reusable IC's
Misc. Transistors, Resistors, Diodes, Caps, Crystals, Switch, etc
ONLY 500 EA AVAILABLE

DELUXE BOARD B — 11½" x 18" $9.95 ea.
Over 100 each reusable IC's
Misc. Transistors, Resistors, Diodes, Caps, Crystals, Switches, LEDS, etc
ONLY 500 EA AVAILABLE

HP 5082-7300 Multi-Digit Series

- ⅛" Ht. • Common Cathode • Dip Package
- 3 to 5 volts @ 5 mils per segment
- 7 segment Monolithic • Red Display

2 Digit	$ .79
3 Digit	.89
4 Digit	.99
5 Digit	1.19

IC SOLOERTAIL — LOW PROFILE (TIN) SOCKETS

	1-24	25-49	50-100		1-24	25-49	50-100
8 pin	$ 17	16	15	24 pin	$ 38	37	36
14 pin	20	19	18	28 pin	45	44	43
16 pin	22	21	20	36 pin	60	59	58
18 pin	29	28	27	40 pin	63	62	61
22 pin	37	36	35				

SOLOERTAIL STANOARD (TIN)

14 pin	$ 27	25	24	28 pin	$ 99	90	81
16 pin	30	27	25	36 pin	1 39	1 26	1 15
18 pin	35	32	30	40 pin	1 59	1 45	1 30
24 pin	49	45	42				

SOLOERTAIL STANOARO (GOLO)

8 pin	$ 30	27	24	24 pin	$ 70	63	57
14 pin	35	32	29	28 pin	1 10	1 00	90
16 pin	38	35	32	36 pin	1 75	1 40	1 26
18 pin	52	47	43	40 pin	1 75	1 59	1 45

WIRE WRAP SOCKETS (GOLD) LEVEL #3

10 pin	$ 45	41	37	24 pin	$1 05	95	85
14 pin	39	38	37	28 pin	1 40	1 25	1 10
16 pin	43	42	41	36 pin	1 59	1 45	1 30
18 pin	75	68	62	40 pin	1 75	1 55	1 40

50 PCS. RESISTOR ASSORTMENTS $1.25 PER ASST.

SPECIAL

ASST. 1	5 ea.	10 OHM 27 OHM	12 OHM 33 OHM	15 OHM 39 OHM	18 OHM 47 OHM	22 OHM 56 OHM	1/4 WATT 5%	50 PCS
ASST. 2	5 ea.	68 OHM 180 OHM	82 OHM 220 OHM	100 OHM 270 OHM	120 OHM 330 OHM	150 OHM 390 OHM	1/4 WATT 5%	50 PCS.
ASST. 3	5 ea.	470 OHM 1 2K	560 OHM 1 5K	680 OHM 1 8K	820 OHM 2 2K	1K 2 7K	1/4 WATT 5%	50 PCS.
ASST. 4	5 ea.	3 3K 8 2K	3 9K 10K	4 7K 12K	5 6K 15K	6.8K 18K	1/4 WATT 5%	50 PCS.
ASST. 5	5 ea.	22K 56K	27K 68K	33K 82K	39K 100K	47K 120K	1/4 WATT 5%	50 PCS
ASST. 6	5 ea	150K 390K	180K 470K	220K 560K	270K 680K	330K 820K	1/4 WATT 5%	50 PCS.
ASST. 7	5 ea.	1M 2 7M	1 2M 3 3M	1 5M 3 9M	1 8M 4 7M	2 2M 5 6M	1/4 WATT 5%	50 PCS.

ASST. 8R Includes Resistor Assortments 1-7 (350 PCS.) $7.49 ea.

SPECIAL

$5.00 Minimum Order — U.S. Funds Only
California Residents — Add 6% Sales Tax

Spec Sheets - 25¢ — Send 35¢ Stamp for 1977A Catalog
Dealer Discount Available — Request Pricing

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All Advertised Prices Good Thru July

WIRE WRAP CENTER

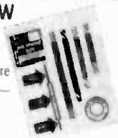
HOBBY-WRAP TOOL-BW-630

- Battery Operated (Size C)
- Weighs ONLY 11 Ounces
- Wraps 30 AWG Wire onto Standard DIP Sockets (.025 inch)
- Complete with built-in bit and sleeve

$34.95
(batteries not included)

WIRE-WRAP KIT — WK-2-W

WRAP • STRIP • UNWRAP



- Tool for 30 AWG Wire
- Roll of 50 Ft. White or Blue 30 AWG Wire
- 50 pcs. each 1", 2", 3" & 4" lengths — pre-stripped wire

$11.95

WIRE WRAP TOOL WSU-30

WRAP • STRIP • UNWRAP - $5.95

WIRE WRAP WIRE — 30 AWG

25 ft. min. $1.25 50 ft. $1.95 100 ft. $2.95 1000 ft. $15.00
SPECIFY COLOR — White - Yellow - Red - Green - Blue - Black

Plastic Push Button Switch

* 18 AWG Solid Wire - 5" Long
* .50 (wide) X .60 (high) ⅜-27 Thread
* 8 AMP @ 14 Volt - 1 AMP @ .10 Volt

		1-9	10-Up
J-188-1	Push On-Push Off	59	49
J-188-2	Normally Open	59	49
J-188-3	Normally Closed	59	49

DIP SWITCHES

SPST Slide Action

#206-4	(8 pin dip)	4 switch unit	$1.75 ea.
#206-7	(14 pin dip)	7 switch unit	$1.95 ea.
#206-8	(16 pin dip)	8 switch unit	$2.25 ea.

TV GAME CHIP SET — $18.50

Includes AY-3-8500-1 chip and 2 010 mhz crystal — if purchased separately would cost $21 90

ZENERS — DIODES — RECTIFIERS

TYPE	VOLTS	W	PRICE	TYPE	VOLTS	W	PRICE
1N746	3.3	400mm	4/1 00	1N4005	600 PIV	1 AMP	10/1 00
1N751A	5 1	400m	4/1 00	1N4006	800 PIV	1 AMP	10/1.00
1N752	5 6	400m	4/1 00	1N4007	1000 PIV	1 AMP	10/1.00
1N753	6 2	400m	4/1.00	1N3600	50	200m	6/1 00
1N754	6 8	400m	4/1 00	1N4148	75	10m	15/1.00
1N959	8 2	400m	8/1 00	1N4154	35	10m	12/1 00
1N965B	15	400m	4/1 00	1N4305	75	25m	20/1 00
1N5232	5 6	500m	28	1N4734	5 6	1w	28
1N5234	6.2	500m	28	1N4735	6 2	1w	28
1N5235	6.8	500m	28	1N4736	6.8	1w	28
1N5236	7.5	500m	28	1N4738	8.2	1w	28
1N456	25	40m	6/1 00	1N4742	12	1w	28
1N458	150	7m	6/1 00	1N4744	15	1w	28
1N485A	180	10m	6/1.00	1N1183	50 PIV	35 AMP	1.60
1N4001	50 PIV	1 AMP	12/1 00	1N1184	100 PIV	35 AMP	1.70
1N4002	100 PIV	1 AMP	12/1 00	1N1185	150 PIV	35 AMP	1.50
1N4003	200 PIV	1 AMP	12/1 00	1N1186	200 PIV	35 AMP	1.80
1N4004	400 PIV	1 AMP	12/1.00	1N1188	400 PIV	35 AMP	3 00

SCR AND FW BRIDGE RECTIFIERS

C36D	15A @ 400V	SCR	$1.95
C38M	35A @ 200V	SCR	1 95
2N2328	1 6A @ 200V	SCR	50
MDA 980-1	12A @ 50V	FW BRIDGE REC	1 95
MDA 980-3	12A @ 200V	FW BRIDGE REC	1 95

TRANSISTORS

MPS A05	5/$1 00			PN4249	4/$1 00
MPS A06	5/$1 00			PN4250	4/$1 00
2N2219A	3/$1 00	PN3567	3/$1 00	2N4400	4/$1 00
2N2221	4/$1 00	PN3568	4/$1 00	2N4401	4/$1 00
2N2222A	5/$1 00	PN3569	4/$1 00	2N4402	4/$1 00
2N2369	5/$1 00	2N3704	5/$1 00	2N4403	4/$1 00
2N2369A	4/$1 00	2N3705	5/$1 00	2N4409	5/$1 00
2N2484	4/$1 00	2N3706	5/$1 00	2N5086	4/$1 00
2N2906A	4/$1 00	2N3707	5/$1 00	2N5087	4/$1 00
2N2907A	5/$1 00	2N3711	5/$1 00	2N5088	4/$1 00
2N2925	5/$1 00	2N3724	$ 65	2N5089	4/$1 00
2N3053	2/$1 00	2N3725	$1 00	2N5129	5/$1 00
2N3055	$ 89	2N3903	5/$1 00	2N5138	5/$1 00
MJE3055	$1 00	2N3904	4/$1 00	2N5139	5/$1 00
MJE2955	$1 25	2N3905	4/$1 00	2N5209	5/$1 00
2N3392	5/$1 00	2N3906	4/$1 00	2N5951	5/$1 00
2N3398	5/$1 00	2N4013	3/$1 00	C106B1SCR	2/$1 00
		2N4014	3/$1 00	2N5432	$2 00
		2N4123	10/$1 00		

CAPACITOR CORNER

50 VOLT CERAMIC DISC CAPACITORS

	1-9	10-49	50-100		1-9	10-49	50-100
10 pf	.05	04	03	.001µF	.05	04	.035
22 pf	05	.04	03	.0047µF	05	04	.035
47 pf	05	04	.03	01µF	.05	.04	.035
100 pf	05	.04	.03	022µF	.06	.05	.04
220 pf	05	.04	03	047µF	06	.05	.04
470 pf	05	04	035	1µF	12	09	.075

100 VOLT MYLAR FILM CAPACITORS

001mf	.12	.10	07	022mf	13	11	.08
.0022	.12	.10	07	047mf	.21	17	13
0047mf	12	10	07	1mf	27	.23	.17
01mf	.12	10	.07	.22mf	33	.27	22

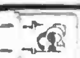
+20% DIPPED TANTALUMS (SOLID) CAPACITORS

.1/35V	28	23	17	1.5/35V	30	26	21
15/35V	28	23	.17	2 2/25V	31	.27	22
22/35V	.28	23	17	3.3/25V	.31	.27	22
33/35V	28	23	17	4 7/25V	32	28	23
.47/35V	.28	23	17	6 8/25V	36	31	.25
.68/35V	28	.23	.17	10/25V	.40	.35	29
1 0/35V	28	23	.17	15/25V	63	50	.40

MINIATURE ALUMINUM ELECTROLYTIC CAPACITORS

Axial Lead				Radial Lead			
47/50V	15	13	.10	.47/25V	.15	.13	10
1 0/50V	16	14	11	.47/50V	16	14	.11
3.3/50V	15	13	.10	1.0/16V	15	13	10
4.7/25V	16	14	12	1.0/25V	.16	14	11
10/25V	15	13	10	1 0/50V	.16	.14	.11
10/50V	16	14	12	4 7/16V	15	13	10
22/25V	17	15	12	4.7/25V	.15	.13	.10
22/50V	.24	20	18	4 7/50V	.16	.14	11
47/25V	.19	17	15	10/16V	14	.12	09
47/50V	25	21	19	10/25V	15	13	10
100/25V	.24	20	.18	10/50V	16	14	12
100/50V	.35	30	28	47/50V	24	21	19
220/25V	32	.28	25	100/16V	19	15	14
220/50V	.45	.41	.38	100/25V	24	20	18
470/25V	.33	.29	.27	100/50V	.35	30	28
1000/16V	55	.50	.45	220/16V	23	17	16
2200/16V	.70	.62	55	470/25V	.31	28	26

CIRCLE 12 ON FREE INFORMATION CARD



CRYSTALS

THESE FREQUENCIES ONLY

Part #	Frequency	Case Style	Price
CY1A	1 000 MHz	HC33/U	$5.95
CY2A	2 000 MHz	HC33/U	$5.95
CY3A	4 000 MHz	HC18/U	$4.95
CY7A	5 000 MHz	HC18/U	$4.95
CY12A	10 000 MHz	HC18/U	$4 95
CY14A	14 31818 MHz	HC18U	$4 95
CY19A	18 000 MHz	HC18/U	$4 95
CY22A	20 000 MHz	HC18/U	$4 95
CY30B	32 000 MHz	HC18/U	$4.95

XR-2206KB Kit $29.95 **Special** XR-2206KA Kit $19.95

EXAR

WAVEFORM GENERATORS		MISCELLANEOUS		TIMERS	
XR 205	$8 40	XR-2211CP	$6 70	XR-555CP	$ 39
XR 2206CP	4.49	XR-4136	99	XR-320P	1 55
XR 2207CP	3 85	XR-1468	3 85	XR-556CP	1 85
STEREO DECODERS		XR-1488	5 80	XR-2556CP	3 20
XR 1310CP	$3 20	XR-1489	4.80	XR-2240CP	3 25
XR 1310EP	3 20	XR-2208	5 20	**PHASE LOCKED LOOPS**	
XR-1800P	3 20			XR-210	5 20
XR 2567	2 99			XR-215	6 60
				XR-567CP	1 95
				XR-567CT	1 70

CONNECTORS

PRINTED CIRCUIT EDGE-CARD

156 Spacing-Tin-Double Read-Out

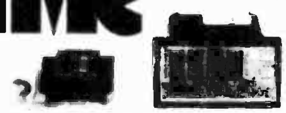
Bifurcated Contacts — Fits 054 to .070 P.C Cards

15/30	PINS (Solder Eyelet)	$1.95
18/36	PINS (Solder Eyelet)	$2.49
22/44	PINS (Solder Eyelet)	$2.95
50/100 (.100 Spacing)	PINS (Solder Eyelet)	$6.95

25 PIN-D SUBMINATURE

DB25P	PLUG	$3.25
DB25S	SOCKET	$4.95

3½ DIGIT DVM KIT



This 0-2 VDC 05 per cent digital voltmeter features the Motorola 3½ digit DVM chip set. It has a .4" LED display and operates from a single +5V power supply. The unit is provided complete with an injection molded black plastic case complete with Bezel. An optional power supply is available which fits into the same case as the 0-2V DVM allowing 117 VAC operation.

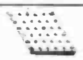
A. 0-2V DVM with Case $49.95

B. 5V Power Supply $14.95

Vector

Etching Kits 32 X A-1	P C Etch Materials Kit enough for 5 circuit boards	$29.95 ea.
27 X A-1	Etched Circuit Kit Complete kit — only add water	$ 9.95 ea.
Plugboards 3662	6.5 X 4.5 X 1/16 Epoxy glass P-Pattern-44 P C Tabs-spaced 156"	$ 6.95 ea.
8800V	Universal Microcomputer Processor plugboard — Epoxy Glass — complete with heatsink and mounting hardware 5 313 X 10 X 1/16 copper clad	$19.95 ea.

1/16 VECTOR BOARD



	0.1" Hole Spacing Part No	P-Pattern L	W	Price 1	2-Up
PHENOLIC	64P44 062XXXP	4 50	6 50	1 72	1 54
	169P44 062XXXP	4 50	17 00	3 69	3 32
EPOXY GLASS	64P44 062	4 50	6 50	2 07	1 86
	84P44 062	4 50	8 50	2 56	2 31
	169P44 062	4 50	17 00	5 04	4 53
	169P84 062	8 50	17 00	9 23	8 26
EPOXY GLASS COPPER CLAD	169P44 062C1	4 50	17 00	6 80	6 12

HEAT SINKS

205-CB	Beryllium Copper Heat Sink with Black Finish for TO 5	$ .25
291-.36H	Aluminum Heat Sink for TO-220 Transistors & Regulators	$ .25
680-.75A	Black Anodized Aluminum	$1.60

HEXADECIMAL ENCODER 19-KEY PAD

- 1 - 0
- ABCDEF
- Return Key
- Optional Key (Period)
- — Key

$10.95 each

63 KEY KEYBOARD

This keyboard features 63 unencoded SPST keys, unattached to any kind of P.C.B. A very solid molded plastic 13 × 4 base suits most applications

$19.95

HD0165 16 LINE TO FOUR BIT PARALLEL KEYBOARD ENCODER $7 95

JOYSTICK

These joysticks feature four * potentiometers, that vary resistance proportional to the angle of the stick. Sturdy metal construction with plastics components only at the movable joint. Perfect for electronic games and instrumentation.

Special *5K Pots $4.95

*100K Pots $7.95

MICROPROCESSOR COMPONENTS

8080A	CPU	$19.95	8228	System Controller - Bus Driver	$10.95
8212	8 Bit Input/Output	4 95	MC6800L	8 Bit MPU	35.00
8214	Priority Interrupt Control	15.95	MC6820L	Periph. Interface Adapter	15.00
8216	Bi-Directional Bus Driver	6.95	MC6810AP1	128 x 8 Static RAM	6.00
8224	Clock Generator/Driver	10.95	MC6830L7	1024 x 8 Bit ROM	18.00
CDP1802	- with user manual	39.95	Z80	CPU	49.95

CPU S

8080	Super 8008	24 95
8080A	Super 8008	19 95

SR S

2504	1024 Dynamic	$ 3 95
2518	Hex 32 BIT	7 00
2519	Hex 40 BIT	4 00
2524	512 Dynamic	2 49
2525	1024 Dynamic	6 00
2527	Dual 256 BIT	3 95
2529	Dual 512 BIT	4 00
2532	Quad 80 BIT	3 95
2533	1024 Static	Special $.95
3341	Fifo	6 95
74LS670	16 x 4 Reg	3 95

UART'S

AY-5-1013	30K Baud	$5 95

ROM S

2513(2140)	Char. Gen upper case	$ 9 95
2513(3021)	Char Gen lower case	9 95
2516	Char Gen	10.95

RAM'S

1101	256 x 1	Static	$ 1 49
2101	256 x 4	Static	5 95
2102	1024 x 1	Static	1 75
2107 5280	4096 x 1	Dynamic	4 95
2111	256 x 4	Static	6 95
7489	16 x 4	Static	2 49
8101	256 x 4	Static	6 95
8111	256 x 4	Static	6 95
8599	16 x 4	Static	3 49
91L02	1024 x 1	Static	2 25
74200	256 x 1	Static	6 95
93421	256 x 1	Static	2 95
MM5262	2K x 1	Dynamic	2 for 1 00

PROMS

1702A	2048	Famos	$ 9.95
5203	2048	Famos	14 95
82S23	32 x 8	Open C	5 00
82S123	32 x 8	Tristate	5 00
74S287	1024	Static	7 95
3601	256 x 4	Fast	3 95
2708	8K	Eprom	29 95
6301-1	1024	Tri-State Bipolar	3 49
6330-1	256	Open Collector Bipolar	2 95
6331 1	256	Tri-State Bipolar	2 95

SPECIAL REQUESTED ITEMS

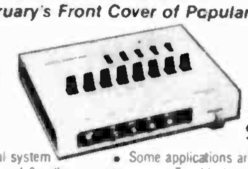
AY-3-8500-1	$16 95					8T97	2 00
MC3061P	3 50	CD4508	6.75	82S115	25 00	3341	6 95
MC4016P (74416)	7 50	CD4515	6 50	5841	9 95	9368	3 95
MC14583	3 50	CD4520	2 70	MK50240	17 50	MC1408L7	9 95
MC14562	14 50	MCM6571	17 50	11C90	19 95	LD110 LD111	25 00 set
CD4059	9 95	MCM6574	17 50	DS0026CH	3 75	AY 5-9100	17 50 ea
CD4070	95	MCM6575	17 50	TIL308	10 50	95H90	13 95

PARATRONICS

ALLOW 1 TO 3 WEEKS DELIVERY

Featured on February's Front Cover of Popular Electronics

Logic Analyzer Kit



MODEL 100A

$189.00/Kit

- Analyzes any type of digital system
- Checks data rates in excess of 8 million words per second
- Trouble shoot TTL, CMOS, DTL, RTL, Schottky and MOS families
- Displays 16 logic states up to 8 digits wide
- See ones and zeros displayed on your CRT, octal or hexadecimal format
- Tests circuits under actual operating conditions
- Easy to assemble — comes with step-by-step construction manual which includes 80 pages on logic analyzer operation
- Some applications are:
  - — Troubleshooting microprocessor address, instruction, and data flow
  - — Examine contents of ROMS
  - — Tracing operation of control logic
  - — Checking counter and shift register operation
  - — Monitoring I/O sequences
  - — Verifying proper system operations during testing

BUGBOOK ®

Continuing Education Series

BUGBOOK I & II - Basic concepts of TTL Logic — over 90 experiments		$17.00/set
BUGBOOK IIa - Introduces UART — recommended for RTTY enthusiast		$5.00/book
BUGBOOK III - Explores 8080 chip — Introduces Mark 80 Microcomputer		$15.00/book
555 TIMER APPLICATIONS SOURCEBOOK WITH EXPERIMENTS — over 100 design techniques		$6.95/book
CMOS-M-DESIGNERS PRIMER AND HANDBOOK a complete CMOS instruction manual		$6.00

Introductory Offer — all 5 books (worth $49 95)

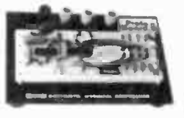
SPECIAL - $42.95

CONTINENTAL SPECIALTIES

PROTO BOARD 6

$15.95

(6" long X 4" wide)



Other CS Proto Boards

PB100 - 4.5" x 6"	$ 19 95
PB101 - 5.8" x 4.5"	29 95
PB102 - 7" x 4.5"	39 95
PB103 - 9" x 6"	59 95
PB104 - 9.5" x 8"	79 95
PB203 - 9.75 x 6½ x 2¾	75 00
PB203A - 9.75 x 6½ x 2¾ (Includes power supply)	120 00

Logic Monitor $84.95
for DTL, HTL, TTL or CMOS Devices

PROTO CLIPS

14 PIN	$4.50
16 PIN	4.75
24 PIN	8.50

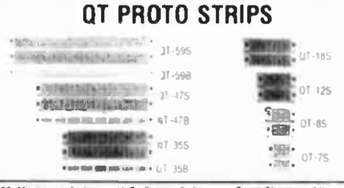
DESIGN MATES

DM1 - Circuit Designer 54.95

DM2 - Function Generator 69.95

DM3 - RC Bridge 59.95

QT PROTO STRIPS



QT type	# holes	price
QT-59S	590	12 50
QT-59B	bus strip	2 50
QT-47S	470	10 00
QT-47B	bus strip	2.25
QT-35S	350	8 50
QT-35B	bus strip	2 00
QT-18S	180	4.75
QT-12S	120	1.75
QT-8S	80	3 25
QT-7S	70	3 00

Experimentor 300	$ 9 95
Experimentor 600	$10 95

$5.00 Minimum Order — U.S. Funds Only
California Residents — Add 6% Sales Tax

Spec Sheets - 25¢ — Send 35¢ Stamp for 1977A Catalog
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All Advertised Prices Good Thru July

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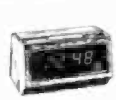
Digital Alarm Clocks

C-500 - Ivory Case
C-500B - Ebony Case
$16.95

- 24-hour alarm
- Doze Button
- 100% Solid State
- Large Red Led Display (.8" high)
- AM PM indicator
- Seconds display at touch of button
- Power failure indicator
- One year factory warranty



C-8211
Woodgrain Case
$19.95

DIGITAL AUTO INSTRUMENT

SEVEN DIFFERENT INSTRUMENTS!

MEETS OR EXCEEDS ORIGINAL AUTOMOTIVE SPECS

Please specify which one of the seven models you want when ordering — these do not all come in one unit. Each model must be bought separately

1 TACHOMETER 0-9900 RPM 4, 6 or 8 Cylinders

2 WATER TEMP 100-250° F

3 FUEL LEVEL Percentage Low Fuel Indicator

4 SPEEDOMETER* 0-99 MPH

5 OIL PRESSURE 0-80 PSI

6 OIL TEMP 200-350° F

7 BATTERY MONITOR ±1 Volts From 11-15 VDC

BRIGHT YELLOW ORANGE 3" LED DISPLAY!

Kit includes case, bracket and all components — complete. Nothing else to buy! 12 Volt NEG GRD

DIMENSIONS 4½ x 4 x 2 **KIT: $49.95**

* Add $10.00 for required speed transducer **ASSEMBLED: $59.95**

DIGITAL STOPWATCH

- Bright 6 Digit LED Display
- Times to 59 minutes 59.59 seconds
- Crystal Controlled Time Base
- Three Stopwatches in One
  Times Single Event — Split & Taylor
- Size 4.5" x 2.15" x .90" (4½ ounces)
- Uses 3 Penlite Cells

Kit — $39.95
Assembled — $49.95
Heavy Duty Carry Case $5.95

Stop Watch Chip Only (7205) $19.95

ELECTRONIC 'PENDULUM' CLOCK

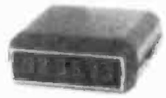
- Swing Pendulum
- .7" Hours and Minutes Display
- 12 or 24 Hour Mode
- Time Set Push Buttons
- Alarm Feature

Kit-unfinished (case unassembled) **$59.95**

Assembled-stained (case assembled) **$69.95**

QUARTZ DIGITAL AUTO CLOCK OR ELAPSED TIMER!

Elapsed Timer: Hrs, Mins and Secs
12 or 24 Hr Capacity
Simple Reset - Start Pushbutton Control



Complete kit includes mounting bracket, case and all components, nothing else to buy. Features MM5314 chip. Large .4" LED's. Accuracy better than ± min per mo. internal battery backup. 12 volt non-polar operation

DIMENSIONS 4½ x 4 x 2
12 or 24 HOUR MODE

Kit: $29.95
Assembled: $39.95

CASE ONLY (includes hardware, mounting bracket and bezel) **$6.50**

JE700 CLOCK

12 or 24 Hour

115 VAC

The JE700 is a low cost digital clock but is a very high quality unit. The unit features a simulated walnut case with dimensions of 6" x 2½" x 1". It utilizes a MAN72 high brightness readout, and the MM5314 clock chip

$17.95

DIGITAL CLOCK KIT — 3½ INCH DIGITS

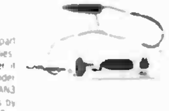
4 DIGIT KIT $49.95 **4 DIGIT ASSEMBLED $59.95**

6 DIGIT KIT $69.95 **6 DIGIT ASSEMBLED $79.95**

This clock features big 3½" high digits for viewing in offices, auditoriums, etc. Each digit is formed by 31 bright 0.2" LED's. The clock operates from 117 VAC, has either 12 or 24 hr. operation. The 6 digit version is 27" x 3½" x 1½" and the 4 digit is 18" x 3½" x 1½". Kits come complete with all components, case and transformer.

Specify 12 or 24 Hour When Ordering

JE803 PROBE

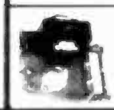


The Logic Probe is a unit which is for the most part indespensible in trouble shooting logic families TTL, DTL, RTL, CMOS. It derives the power it needs to operate directly off of the circuit under test drawing a scant 10 mA max. It uses a MAN3 readout to indicate any of the following states by these symbols (HI) 1 (LOW) 0 (PULSE) P. The Probe can detect high frequency pulses to 45 MHz. It can't be used at MOS levels or circuit damage will result

$9.95 Per Kit

printed circuit board

T²L 5V 1A Supply



This is a standard TTL power supply using the well known LM309K regulator IC to provide a solid 1 AMP of current at 5 volts. We try to make things easy for you by providing everything you need in one package, including the hardware for only

$9.95 Per Kit

SPECIAL PRICING!

PRIME - HIGH SPEED RAM

21L02-3 400 NS

LOW POWER - FACTORY FRESH

1-24	$1.95 ea	100-199	$1.60 ea
25-99	1.75 ea	200-499	1.45 ea

OVER 500 PCS. **1.39** ea.

PRINTED CIRCUIT BOARDS for CT-7001 Kits sold separately with assembly info. PC Boards are drilled Fiberglass, solder plated and screened with component layout.
Specify for 7001 *B, C or X - $7.95*

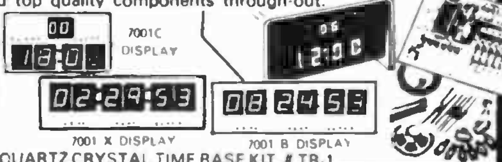
6-DIGIT LED CLOCK CALENDAR KIT

DATE-TIME-SNOOZE ALARM & MORE... KIT 7001

FOR THE BUILDER THAT WANTS THE BEST. FEATURING 12 OR 24 HOUR TIME — 29-30-31 DAY CALENDAR. ALARM. SNOOZE AND AUX. TIMER CIRCUITS

Will alternate time (8 seconds) and date (2 seconds) or may be wired for time or date display only, with other functions on demand. Has built-in oscillator for battery back-up. A loud 24 hour alarm with a repeatable 10 minute snooze alarm, alarm set & timer set indicators. Includes 110 VAC/60Hz power pack with cord and top quality components through-out.

KIT 7001B WITH 6 .5" DIGITS $39.95
KIT - 7001C WITH 4 - .6" DIGITS & 2 - .3" DIGITS FOR SECONDS $42.95
KIT - 7001X WITH 6 .6" DIGITS $45.95



KITS ARE COMPLETE (LESS CABINET)
ALL 7001 KITS FIT CABINET I AND ACCEPT QUARTZ CRYSTAL TIME BASE KIT # TB-1

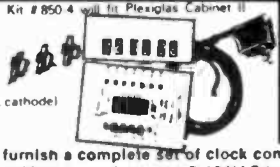
6 DIGIT LED CLOCK KIT #850-4

12/24 HR. OPERATION BIG .4" DIGITS - 50/60 HZ OPERATION.

KIT INCLUDES
- INSTRUCTIONS
- QUALITY COMPONENTS
- 50 or 60 Hz OPERATION
- 12 or 24 HR OPERATION

6 LED Readouts (FND-359 Red, com. cathode)
1 MM5314 Clock Chip (24 pin)
13 Transistors
3 Switches
6 Capacitors
5 Diodes
9 Resistors
24 Molex pins

Kit # 850-4 will fit Plexiglas Cabinet II



$11.95 ea. QTY. 1-5
$10.95 ea. QTY. 6-11
$9.95 ea QTY. 12 OR MORE

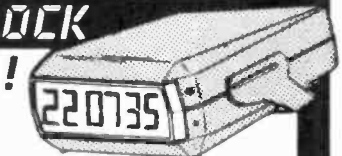
"Kit #850-4 will furnish a complete set of clock components as listed. The only additional items required are a 7-12 VAC transformer, a circuit board and a cabinet, if desired."

PRINTED CIRCUIT BOARD FOR KIT # 850-4, SCREEN PRINTED DRILLED AND SOLDER PLATED FIBERGLASS $2.95
MINI-BRITE RED LED'S (FOR COLON IN CLOCK DISPLAY) ... Pkg. of 5-$1.00
MOLDED PLUG TRANSFORMER 115/10 VAC (WITH CORD) $2.50
NOTE: Entire Clock may be assembled on one PC Board or Board may be cut to remote display.

MOBILE LED CLOCK

12/24 HR .4" DIGITS!

MODEL #2001 — 12 VOLT AC or DC POWERED



- 6 JUMBO .4" RED LED'S BEHIND RED FILTER LENS WITH CHROME RIM
- SET TIME FROM FRONT VIA HIDDEN SWITCHES • 12/24-Hr. TIME FORMAT
- STYLISH CHARCOAL GRAY CASE OF MOLDED HIGH TEMP. PLASTIC
- BRIDGE POWER INPUT CIRCUITRY — TWO WIRE NO POLARITY HOOK-UP
- OPTIONAL CONNECTION TO BLANK DISPLAY (Use When Key Off In Car, Etc.)
- TOP QUALITY PC BOARDS & COMPONENTS - EXCELLENT INSTRUCTIONS
- MOUNTING BRACKET INCLUDED

KIT # 2001 COMPLETE KIT (Less 9V. Battery) 29.95 EA — 3 OR MORE $27.95 EA. — 115 VAC Power Pack #AC-1 $2.60 EA

ASSEMBLED UNITS ORDER # 2001 WT — WIRED & TESTED (LESS 9V BATTERY) $39.95 EA. — 3 OR MORE $37.95 EA
WIRED FOR 12 HR OP # NOT SPECIFIED OTHERWISE

60 HZ. XTAL TIME BASE

Will enable Digital Clock Kits or Clock-Calendar Kits to operate from 12V DC. 1"x2" PC Board Power Req. 5-15V (2.5 MA. TYP.) Easy 3 wire hookup Accuracy ± 2PPM
#TB-1 (Adjustable)
Complete Kit $4.95 ea
Wir & Cal $9.95

PLEXIGLAS CABINETS

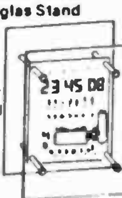
Great for Clocks or any LED Digital project. Clear-Red Chassis serves as Bezel to increase contrast of digital displays.

CABINET I — 3"H, 6¼"W, 5½"D
CABINET II — 2½"H, 5"W, 4"D
Black, White or Clear Cover — $6.50 ea

RED OR GREY PLEXIGLAS FOR DIGITAL BEZELS
3"x6"x1/8" 95¢ ea. 4/$3

SEE THE WORKS Clock Kit
Clear Plexiglas Stand

- 6 Big .4" digits
- 12 or 24 hr. time
- 3 set switches
- Plug transformer
- all parts included



Plexiglas is Pre-cut & drilled
Kit #850-4 CP
Size: 6"H, 4½"W, 3"D
$23.50 ea. 2/$45.
A SUPER CLOCK!

JUMBO DIGIT CLOCK

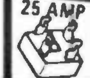
A complete Kit (less Cabinet) featuring: six .5" digits, MM5314 IC 12/24 Hr. time, 50/60 HZ., Plug-Transformer, Line Cord, Switches, and all Parts. (Ideal Fit in Cabinet II)
Kit # 5314-5 $19.95 2/$38.
WITH PC Boards

JUMBO DIGIT CONVERSION KIT $9.95 ea.
Convert small digit LED clock to large .5" displays. Kit includes 6 LED's, Multiplex PC Board & easy hook-up info.
Kit # JD-1CC For common Cathode
Kit # JD-1CA for common Anode

TELEPHONE FORMAT KEYBOARD
BY Chomerics
EF-21360
2-1/4"x3"

5/32 thick
$4.95
6/$28.

25 AMP BRIDGE



$1.95 ea.
3/$5.00

NEW LSI TECHNOLOGY

FREQUENCY COUNTER KIT

8 LARGE .4" RED LED DIGITS

Kit #FC-50 • 8 IC's • XTAL TIME BASE

A truly "State of the Art" counter using quality components throughout.
KIT INCLUDES: DETAILED INSTRUCTIONS, XTAL, TOP QUALITY FIBERGLASS DOUBLE SIDED PC BOARD, IC'S WITH SOCKETS AND ALL PARTS LESS POWER SUPPLY AND CABINET.

50 MHZ COUNTER KIT	#FC-50	$69.95
5 VOLT REGULATED 1 AMP POWER SUPPLY KIT	#PS-02	$9.95
350 MHZ PRESCALER KIT	#PSL-350	23.95
650 MHZ PRESCALER KIT	#PSL-650	$29.95
CABINET [& MTG HARDWARE]	#CAB III	$19.95

[CABINET WILL HOUSE #FC-50, #PS-02, AND A PRESCALER]

Fairchild Super Digit FND-359

.4" Char. Ht. 7 segment LED RED Com. Cath. Direct pin replacement for popular FND-70.

95¢ ea, 10/$8.50
100/$79.00

SET OF 6 FND-359 WITH MULTIPLEX PC BOARD $6.95

NYLON WIRE TIES
8" TIE-WRAP 100/$1.95
4" TIE-WRAP 100/$1.75

PLUG TRANSFORMERS
12VAC at 150 MA $2.50
12VAC at 500 MA 3.50
7VAC at 1.75 VA $3.50

SCHOTTKY TTL

74S00	$ .35
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74S04	.55
74S05	.60
74S09	.55
74S10	.40
74S20	.50
74S22	.45
74S40	.45
74S50	.45
74S51	.55
74S60	.85
74S64	.55
74S74	.85
74S75	1.75
74S78	1.50
74S86	.95
74S107	.95
74S112	.95
74S113	1.40
74S114	.95
74S133	.75
74S134	.75
74S138	1.75
74S139	1.50
74S151	1.95
74S153	1.95
74S155	1.95
74S156	1.95
74S157	1.80
74S158	2.50
74S174	2.50
74S175	2.50
74S181	2.95
74S182	1.95
74S251	2.75

DIGITAL CLOCK IC's

MM5312	$ 4.95
MM5314	3.95
MM5375AB	3.95
CT-7001	7.95
CT-7002	13.95
MM5369	2.50

LED DRIVERS

7447	$ .95
7448	.95
75491	.65
75492	.65
9368	2.50

PRESCALE

11C90DC	$15.95
95H90	9.95

VOLTAGE REGULATORS

LM 309 H	TO-5	$ .95
LM 309 K	TO-3	1.25
7805	TAB	.95
7812	TAB	1.25
7812	TO-3	1.50
7815	TO-3	1.25
7815	TAB	1.25
78L15	TO-5	.75
7824	TO-3	1.25
723	DIP	.75
723	TO-5	.75

PROM

1702	E Prom	$8.95
5203	E Prom	$8.95

SPECIAL IC'S

7207A	INTERSIL	
7208	INTERSIL	
MC14553	MOT	$ 9.95
MC14410	MOT	$12.50
2513	SIG	$ 9.95

IC SOCKETS

PINS	1-24	25	100
8	$ .25	$ .22	$ .20
14	.25	.22	.20
16	.28	.25	.23
18	.31	.28	.26
24	.50	.45	.40
28	.60	.55	.50
40	.75	.70	.65

XTAL

5.242880 MHZ.	$4.95
3.579545 MHZ.	$1.95

MOLEX PINS

$9.95 Reel of 1000
100 for $1.25

TRANSISTORS

2N2222 A	TO 18	3/$1.00
2N2712	TO-98	5/$1.00
2N3415	TO-9	5/$1.00
2N3704	TO-92	5/$1.00
2N4400	TO-92	5/$1.00
2N4125	TO-92	5/$1.00
2N4249	TO-92	5/$1.00
2N4437	TO-92	5/$1.00
2N6027	PUT	2/$1.00
2N5457	N J-Fet	2/$1.00

DIODES

IN 4002	1A. 100 PIV	12/$1.00
IN 4005	1A. 600 PIV	11/$1.00
IN 4007	1A. 1000 PIV	10/$1.00
RECTIFIER	2.5A. 1000 PIV	4/$1.00
IN 914	SIL. SIGNAL	20/$1.00
IN 4148	SIL. SIGNAL	20/$1.00
DYAC	28V.	4/$1.00

LINEAR

555	TIMER	2/$1.00
556	DUAL TIMER	.95
565	PLL	.95
566	FUNCTION GEN.	1.75
567	TONE DECODER	1.75

TRANSISTOR SOCKET
TO-5/18 GOLD PINS
5/$1.00

7-SEG LED

COMMON CATHODE

	COLOR	HT	DEC PT	PR EA
FND 359	RED	.4"	RHDP	$ .95
FND 503	RED	.5"	RHDP	$1.35
DL 750	RED	.6"	LHDP	$2.95
XAN 654	GREEN	.6"	NDP	$1.95
XAN 664	RED	.6"	NDP	$1.95

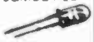
COMMON ANODE

	COLOR	HT	DEC PT	PR EA
DL 747	RED	.6"	LHDP	$1.95
XAN-72	RED	.3"	LHDP	$1.25
MAN 72	RED	.3"	LHDP	$1.25
XAN 81	YELLOW	.3"	RHDP	$1.75
XAN 351	GREEN	.3"	RHDP	$1.50
XAN-362	ORANGE	.3"	LHDP	$1.50
XAN-662	RED	.6"	NDP	$1.95
XAN 692	RED	.6"	NDP	$1.95

OP AMPS
3/$1.00

301	TO-5
709	DIP
709	TO 5
741	DIP
741	M-DIP
741	TO-5
747	TO 5

DISCRETE LED's
JUMBO RED



10 FOR $1.00
100 FOR $9.50

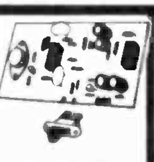
PC TRIM POTS
25K 6/$1.00
4.7K 6/$1.00

SPECTROL 10K 10 TURN
95¢
4/$3.00

CMOS

	ea.
4001	$ .20
4002	.20
4010	.40
4011	.20
4013	.40
4015	.95
4016	.40
4023	.20
4025	.20
4027	.40
4028	.85
4030	.35
4042	.75
4044	.60
4046	1.75
4049	.40
4050	.40

AUTO BURGLAR ALARM KIT



AN EASY TO ASSEMBLE AND EASY TO INSTALL ALARM PROVIDING MANY FEATURES NOT NORMALLY FOUND. KEYLESS ALARM HAS PROVISION FOR POS & GROUNDING SWITCHES OR SENSORS. WILL PULSE HORN RELAY AT 1HZ RATE OR DRIVE SIREN. KIT PROVIDES PROGRAMMABLE TIME DELAYS FOR EXIT, ENTRY & ALARM PERIOD. UNIT MOUNTS UNDER DASH - REMOTE SWITCH CAN BE MOUNTED WHERE DESIRED. CMOS RELIABILITY RESISTS FALSE ALARMS & PROVIDES FOR ULTRA DEPENDABLE ALARM. DO NOT BE FOOLED BY LOW PRICES! THIS IS A TOP QUALITY COMPLETE KIT WITH ALL PARTS INCLUDING DETAILED DRAWINGS AND INSTRUCTIONS OR AVAILABLE WIRED AND TESTED

KIT #ALR-1 $9.95
#ALR-1WT WIRED & TESTED $19.95

VARIABLE REGULATED 1 AMP POWER SUPPLY KIT

- VARIABLE FROM 4 to 14V
- SHORT CIRCUIT PROOF
- 723 IC REGULATOR
- 2N3055 PASS TRANSISTOR
- CURRENT LIMITING AT 1 Amp

KIT IS COMPLETE INCLUDING DRILLED & SOLDER PLATED FIBERGLASS PC BOARD AND ALL PARTS (Less TRANSFORMER) KIT #PS-01 $8.95

TRANSFORMER 24V CT will provide 300MA at 12V and 1 Amp at 5V. $3.50

OPTOELECTRONICS, INC.

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WE PAY ALL SHIPPING IN CONTINENTAL USA — OTHERS ADD 5% (10% FOR AIRMAIL)
SEE OUR BOOTHS AT THE ATLANTA HAMFESTIVAL - JUNE 18-19, 1977

CIRCLE 33 ON FREE INFORMATION CARD

CARBON FILM RESISTORS

IN STOCK- A FULL LINE OF QUALITY ¼W 5% RESISTORS
STANDARD VALUES FROM 2.7 ohm to 4.7Mohm

5 for .25 10 for .40 100 for $1.60 1000 for $14.
(no mix of values) 100 per value for 1000 price

free intel data catalog
new 77 928 page
WITH $25. PREPAID ORDER

RESISTOR ASSORTMENTS
100 assorted values of ¼W or ½W most 5% w/PCB cut leads.. specify ¼or½W $1.00

25K Trimmer

Printed Circuit Board Type
Each $.20
10 for $1.50

SUPER LED's

This family of LED's are mounted on a TO-5 header with a 6/32 threaded stud to secure to a heat sink.. TWO AMPERES max. continuous current rating (with heat sink). LED's can be pulsed at up to 25A with low duty cycle. Data supplied w/order.

ME2 Infra Red w/low lens
ME5 Infra Red w/high lens
MV4 Visible Red with low lens
MV4H Visible Red with high lens

$2.99 ea.

HP

5082-4557
Bright Yellow
LEDs W/panel clips 3 / $1.00

150Mhz PRESCALER

Use your low frequency counter to measure VHF or UHF frequencies. This kit will divide the input signal by ten (10 or 100 with 650MHz option) Kit contains drilled circuit board, 2 MC10131 IC's, all parts needed and instructions.

150/170MHz KIT $12.95

650MHz option W/11C90 IC........$29.95

-requires 5v at app. .2A, power supply and case are not part of kit---

SPECIALS

747 dual 741 OP-AMPS $.65
14 pin DIP 10/$5

NE2 Neon Lamps 10¢

2N3773

TO-3 power transistors removed from computer boards, 160V NPN 16A, full leads $1 ea. 10/$9

Diode Array

10-1N914 SILICON SIGNAL DIODES IN ONE PACKAGE. 20 LEADS ALTERNATELY SPACED .1"! NO COMMON CONNECTIONS.

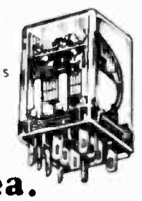
25¢ ea.
Ten for $2.25

Transistor Sale!

MPSU56	PNP	PWR.	80V	2A TAB	$.40	10/3.50
TIP31A	NPN	PWR.	60V	3A TAB	$.40	10/3.50
D41D1	PNP	PWR.	30V	1A TAB	$.30	10/2.50
*D40C1	NPN	PWR.	DARL.	TAB	$.40	10/3.50
2N2222	NPN	SW.	40V	TO-92	$.20	10/1.75
2N3565	NPN	GP	30V	TO106	$.15	10/1.25
*2N3640	PNP	SW	12V	TO106	$.15	10/1.35
*2N3646	NPN	SW	15V	TO106	$.15	10/1.35
2N3440	NPN	GP	250V	TO-5	$.60	10/5.00
2N4400	NPN	GP	50V	TO-92	$.20	10/1.75
2N4248	PNP	GP	40V	TO-92	.15	10/1.35
2N5964	NPN	SW	150V	TO-92	.20	10/1.75

*leads cut for PCB. All transistors are full spec. and guaranteed.....

POTTER BRUMFIELD



Type KHP Relay
4 PDT 3A Contacts
24VDC COIL
650 ohms
120VAC
10.5MA

$1.60 ea.

5 WATT AUDIO AMPLIFIER

IC audio power amplifier kit. A complete kit including a drilled circuit board, 706 Fairchild IC with heat sink, and all parts to make a complete high gain (46db) power amplifier. Kit operates from single power source of 6-16VDC and drives a 4 ohm spkr.

$8.95 each. ---- 2 (stereo) for $16.50

does not include a case or power supply

High Quality PCB Mounting IC Sockets

8 pin	$ .19
14 pin	.19
16 pin	.21
24 pin	.55
28 pin	.70
40 pin	1.10

wire wrap sockets
14 pin WW $.36
16 pin WW .41

MOLEX

500 $4.75 1k $8.50
2k $16.50 5k 37.50

ONE AMP OP-AMP

General purpose operational amplifier in an eight pin TO-3 package. Similar to the National LH0021. Ideal for servo drive or power supply etc. use.. Data included

$4.50 each five for $20.

FULL WAVE BRIDGE RECTIFIERS

FULLY TESTED
COSMETIC REJECTS
(SCRATCHES)

500V 25A
$1.75 ea
10/$15.

100V 25A
$1.35 ea
10/$12

DIP TRIM POT

12 turn trimpots in a DIP package. ¼" x ¼" x ¼". 5k and 200k only.... (DALE)

$.65 ea. 10/$4.95

Special
20¢ ea.
10 $1.50
$12.50/c
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.25 ea

TRIACs

RCA 8A 500+ V house marked.
59¢ each

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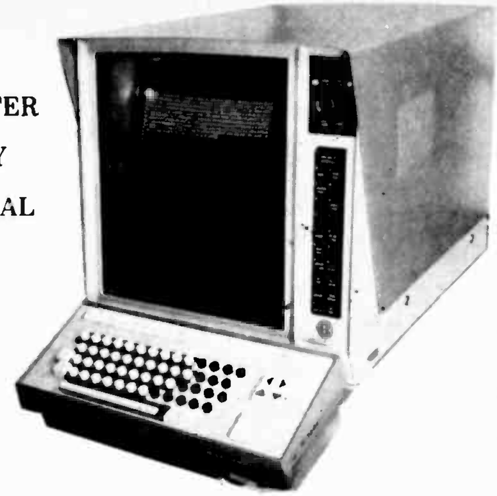
BANKAMERICARD

CIRCLE 34 ON FREE INFORMATION CARD

COMPUTER DISPLAY TERMINAL

$180.00



Unused computer terminals in original factory boxes. Made for airline ticketing & seating reservations. 17 inch B/W CRT in modernistic housing. 41 lines of data, 52 characters per line, generated by diode matrix (graphic) technique. Self contained power supply. Keyboard, free standing, reed switches, 54 data keys, 28 special keys. Logic unit (not shown) 1024 by 6 bit core memory, printer I/O interface, communications I/O interface. Due to several years storage, though unused, you may have to tinker, clean contacts on circuit boards, etc. We furnish free with each, one operational manual, one book of schematics. Sold "as is", all sales final. The price is a give-a-way. Check with order please (for immediate shipping certify your check. Shipped truck (238 lbs) you pay shipping on arrival. These have been interfaced by local customers with KIM-1 and IMSAI (no doubt can be interfaced with many others.

$180.00

JOHN MESHNA JR, PO BOX 62, E.LYNN MASS 01904

CIRCLE 52 ON FREE INFORMATION CARD

4 or 6 Digit Alarm Clock Kit

Features:
A. Fairchild 0.5" FND500 Series Display
B. Display Board may be remote
C. P.C. Boards, Transformer, Speaker and all the parts needed (less case).
D. Detailed Instructions
12 Hr. 6 Digit $16.50, with 10 min. timer $25.50 with timer and crystal time base $29.50
4 Digit $14.95 6 Digit-24 Hr. $14.95 (no alarm)

MINIATURE SLIDE SWITCH

DPDT .20 each
10 for $1.75
100 for $15.00

BOWMAR SLIDE RULE CALCULATOR

Features:
A. 8-Digit Display C. Comes with Batt. Charger
B. Build-in NI Cad Batt. D. One full year warr.
ONLY $32.00 (Limited Quantity)

0.8" 4 Digit Jumbo Display Alarm Clock Kit

Features:
A. Fairchild 0.8" FSC8000 Display Array
B. Fairchild Super-Chip – F-3817PC
C. P.C. Board, Transformer, Speaker and all parts included (less case)
D. Detailed Instructions $19.50

POWER SUPPLY KITS

5V 10A with OVP (Less Case, X'former, $7.95
Rect.&Cap)—with X'former, Rect.&Cap $16.50
2-20V 1.3A continuously adjustable with current limiting. Includes Transformer, P.C. Board, 2N3055, Heat sink, and everything but the case $10.95

BOURNS MINIATURE TRIMMERS

3292X 2K 55¢ ea. or 10 for $5.00
330PP 2K 75¢ ea. or 10 for $6.75

4" MUFFIN FAN—Slightly Used—$5.00

All in perfect Condition. Satisfaction Guaranteed

INTER-COM BOARD

Fully assembled.
Works on 9~15V D.C.
2 speakers make it work.
With Schematic
ONLY $3.00

TRANSFORMERS

All inputs 110 V AC

40 V C.T. 10A	$14.50
30V C.T. 20A	$13.50
20V C.T. 10A	$8.00
24V 1.3A	$3.50
2.4.6.3.9.12V 1A 4 in 1	$3.50
28V C.T. 0.6A	$2.00

THIS MONTH'S SPECIALS!

SN7400	$ .12
LM741 CH - To-5	.30
MH0026C (5 MHZ Clock Driver)	2.95
AY-5-3600(Keyboard Encoder by G.I.)with Spec. Sheet	10.50
LM340T-12	.80
LM340T-5	.80
AN214 4.5W Power I.C. with Spec.	2.95

ZENER DIODES

	5V	½W	.12
	14V	½W	.12
	15V	¼W	.10
IN2979	15V	10W	2.50
IN3029	24V	1W	1.25
IN3002	75V	10W	2.50

WIRE-WRAP TOOLS from OK

Hobby Wrap - 30 $5.45
Hobby Wrap—Model BW 630 Battery Op. (less batt.) $32.95

PANEL METERS

2¼" X 2¼"

50µA	$3.50	150µA	$3.00
100µA	$3.00	300µA	$3.00

1¾" X 1¾" – 50µA $4.00

OPEN FRAME POWER SUPP.

12V @ 1.8A with OVP 115V AC input $7.50
5V @ 3A with OVP 115V AC input $17.50

COMPUTER GRADE CAPACITORS

18,500µF	80V	$4.50
91,000µF	20V	$4.00
100,000µF	5V	$2.50
1,000µ+200	50V	$1.00

L.E.D.

0.25"	Red	25¢	10 for $2.00
0.25"	Green	30¢	10 for $2.50
0.125"	Red	20¢	10 for $1.75
0.5"	FND503 C.C.		$1.00
0.5"	FND507 C.A.		$1.00
0.8"	FSC8000 C.C.		$7.50

MODULAR POWER SUPPLY

5V @ 32A 115V AC Input with OVP (New) $69.50
24V @ 12A 115V AC input (used) $37.95
28V 3A (used) $19.95

TANTALUM CAPACITORS

1µ 35V	.15
1µ 10V	.15
3.3µ 35V	.20
10µ 50V	.35
22µ 35V	.25

RECTIFIERS RCA House Mark.

IN4001	.06	1000V 3A	.40
IN4002	.07	600V 5A	.75
IN4003	.08	**MOTOROLA**	
IN4004	.09	IN1202A	.65
IN4005	.10	IN1612	.75
IN4006	.12	MDA962-2	1.80
IN4007	.14	Bridge 100V 12A	

I.C. SOCKETS

14 Pin	Lo Pro	$ .30
14 Pin	Standard Gold	.35
14 Pin	Wire Wrap Gold	.45
16 Pin	Lo pro	.35
16 Pin	Wire Wrap-Gold	.50
22 Pin	Lo pro	.45
24 Pin	Lo pro Open Frame	.45
24 Pin	Standard-Gold	1.00
40 Pin	Lo pro Open Frame	.55

MINIATURE TOGGLE SWITCH

SPDT	$1.00
DPDT	$1.25
DPDT Center off	$1.25

PUSH BUTTON SWITCH

Red, White, green and yellow 30¢ ea. 4/$1.00

TERMS: Money Back Guarantee
CALIF. RESIDENTS ADD 6% SALES TAX
Please add $1.00 for postage inside Calif., $2.00 for Out of State, Overseas add 10% of order.
Minimum Order $5.00 C.O.D. $20.00 ($1.00 handling)
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CIRCLE 16 ON FREE INFORMATION CARD

CB SPECIALS—R.F. DRIVERS—R.F. POWER OUTPUTS—FETS

2SC481	1.85	2SC767	15.75	2SC866	5.85	2SC1449-1	1.60	40081	1.50
2SC482	1.75	2SC773	.85	2SC1013	1.50	2SC1475	1.50	40082	3.00
2SC495	1.10	2SC774	1.75	2SC1014	1.50	2SC1678	5.50	2SC608	4.85
2SC502	3.75	2SC775	2.75	2SC1017	1.50	2SC1679	4.75	SK3046	2.15
2SC517	4.75	2SC776	3.00	2SC1018	1.50	2SC1728	2.15	SK3047	3.75
2SC614	3.80	2SC777	4.75	2SC1173	1.25	2SC1760	2.15	SJ2095	3.50
2SC615	3.90	2SC778	3.25	2SC1226A	1.25	2SC1816	5.50	SK3048	3.25
2SC616	4.15	2SC797	2.50	2SC1237	4.50	2SC1908	.70	SK3054	1.25
2SC617	4.25	2SC798	3.10	2SC1239	3.50	2SC1957	1.50		
2SC699	4.75	2SC781	3.00	2SC1243	1.50	2SF8	3.00	2SK19	1.75
2SC710	.70	2SC789	1.00	2SC1306	4.75	HEP-S 3001	3.25	2SK30	1.00
2SC711	.70	2SC796	3.15	2SC1306-1	4.90	2SD235	1.00	2SK33	1.20
2SC735	.70	2SC799	4.25	2SC1307	5.75	MRF8004	3.00		
2SC756	3.00	2SC802	3.75	2SC1307-1	6.00	4004	3.00	3SK40	2.75
2SC765	9.50	2SC803	4.00	2SC1377	5.50	4005	3.00	3SK45	2.75
2SC766	10.15	2SC839	.85	2SC1449	1.30	40080	1.25	3SK49	2.75

JAPANESE TRANSISTORS

2SA52	.60	2SB187	.60	2SC458	.70	2SC815	.75	2SC1569	1.25
2SA316	.75	2SB235	1.75	2SC460	.70	2SC828	.75	2SC1756	1.25
2SA473	.75	2SB303	.65	2SC478	.80	2SC829	.75		
2SA483	1.95	2SB324	1.00	2SC491	2.50	2SC830	1.60	2SD30	.95
2SA489	.80	2SB337	2.10	2SC497	1.60	2SC839	.85	2SD45	2.00
2SA490	.70	2SB367	1.60	2SC515	.80	2SC945	.65	2SD65	.75
2SA505	.70	2SB370	.65	2SC535	.75	2SC1010	.80	2SD68	.90
2SA564	.50	2SB405	.85	2SC536	.65	2SC1012	.80	2SD72	1.00
2SA628	.65	2SB407	1.65	2SC537	.70	2SC1051	2.50	2SD88	1.50
2SA643	.85	2SB415	.85	2SC563	2.50	2SC1061	1.65	2SD151	2.25
2SA647	2.75	2SB461	1.25	2SC605	1.00	2SC1079	3.75	2SD170	2.00
2SA673	.85	2SB463	1.65	2SC620	.80	2SC1096	1.20	2SD180	2.75
2SA679	3.75	2SB471	1.75	2SC627	1.75	2SC1098	1.15	2SD201	1.95
2SA682	.85	2SB474	1.50	2SC642	3.50	2SC1115	2.75	2SD218	4.75
2SA699	1.30	2SB476	1.25	2SC643	3.75	2SC1166	.70	2SD300	2.50
2SA699A	1.75	2SB481	2.10	2SC644	.70	2SC1170	4.00	2SD313	1.10
2SA705	.55	2SB492	1.25	2SC681	2.50	2SC1172B	4.25	2SD315	.75
2SA815	.85	2SB495	.95	2SC684	2.10	2SC1209	.55	2SD318	.95
2SA816	.85	2SB507	.90	2SC687	2.50	2SC1213	.75	2SD341	.95
		2SB511	.70	2SC696	2.35	2SC1226	1.25	2SD350	3.25
2SB22	.65			2SC712	.70	2SC1243	1.50	2SD352	.80
2SB54	.70	2SC206	1.00	2SC713	.70	2SC1293	.85	2SD380	5.70
2SB56	.70	2SC240	1.10	2SC732	.70	2SC1308	4.75	2SD389	.90
2SB77	.70	2SC261	.65	2SC733	.70	2SC1347	.80	2SD-390	.75
2SB128	2.25	2SC291	.65	2SC739	.70	2SC1383	.75	2SD437	5.50
2SB135	.95	2SC320	2.00	2SC715	1.75	2SC1409	1.25		
2SB152	4.50	2SC352	.75	2SC762	1.90	2SC1410	1.25	MPS-U31	4.00
2SB173	.55	2SC353	.75	2SC783	1.00	2SC1447	1.25	MPS8000	1.25
2SB175	.55	2SC371	.70	2SC784	.70	2SC1448	1.25		
2SB178	1.00	2SC372	.70	2SC785	1.00	2SC1507	1.25		
2SB186	.60	2SC394	.70	2SC793	2.50	2SC1509	1.25		

POWER-TRANSISTORS HIGH-VOLT. TV. TYPE

BU204	1300V	3.90	BU207	1300V	5.40	2SC1172B	1100V	4.25
BU205	1500V	4.70	BU208	1500V	6.25	2SC1308	1100V	4.95
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OEM SPECIALS

1N270	.10	2N960	.55	2N2219A	.30	2N2913	.75	2N3740	1.00	2N4401	.20
1N914	.10	2N962	.40	2N2221	.25	2N2914	1.20	2N3771	1.75	2N4402	.20
		2N967	.50	2N2221A	.30	2N2916A	3.65	2N3772	1.90	2N4403	.20
2N173	1.75	2N1136	1.35	2N2222	.25	2N3019	.50	2N3773	3.00	2N4409	.20
2N178	.90	2N1142	2.25	2N2222A	.30	2N3053	.30	2N3819	.32	2N4410	.25
2N327A	1.15	2N1302	1.25	2N2270	.40	2N3054	.70	2N3823	.70	2N4416	.75
2N334	1.20	2N1305	.75	2N2322	1.00	2N3055	.75	2N3856	.20	2N4441	.85
2N336	.90	2N1377	.75	2N2323	1.00	2N3227	1.00	2N3866	.85	2N4442	.90
2N338A	1.05	2N1420	.20	2N2324	1.35	2N3247	3.40	2N3903	.20	2N4443	1.20
2N398B	.90	2N1483	.95	2N2325	2.00	2N3250	.50	2N3904	.20	2N4852	.55
2N404	.75	2N1540	.90	2N2326	2.85	2N3375	6.50	2N3905	.20	2N5061	.30
2N443	1.75	2N1543	2.70	2N2327	3.80	2N3393	.20	2N3906	.25	2N5064	.50
2N456	1.10	2N1544	.80	2N2328	4.20	2N3394	.17	2N3925	3.75	2N5130	.20
2N501A	3.00	2N1549	1.25	2N2329	4.75	2N3414	.17	2N3954	3.50	2N5133	.15
2N508A	.45	2N1551	2.50	2N2368	.25	2N3415	.18	2N3954A	3.75	2N5138	.15
2N555	.45	2N1552	3.25	2N2369	.25	2N3416	.19	2N3955	2.45	2N5198	3.75
2N652A	.85	2N1554	1.25	2N2484	.32	2N3417	.20	2N3957	1.25	2N5294	.50
2N677C	6.00	2N1557	1.15	2N2712	.18	2N3442	1.85	2N3958	1.20	2N5296	.50
2N706	.25	2N1560	2.80	2N2894	.40	2N3553	1.50	2N4037	.60	2N5306	.20
2N706B	.40	2N1605	.35	2N2903	3.30	2N3563	.20	2N4093	.85	2N5354	.20
2N711	.50	2N1613	.30	2N2904	.25	2N3565	.20	2N4124	.20	2N5369	.20
2N711B	.60	2N1711	.30	2N2904A	.30	2N3638	.20	2N4126	.20	2N5400	.40
2N718	.25	2N1907	4.10	2N2905	.25	2N3642	.20	2N4141	.20	2N5401	.50
2N718A	.30	2N2060	1.85	2N2905A	.30	2N3643	.15	2N4142	.20	2N5457	.35
2N720A	.50	2N2102	.40	2N2906	.25	2N3645	.15	2N4143	.20	2N5458	.30
2N918	.35	2N2218	.25	2N2906A	.30	2N3646	.14	2N4220A	.45	C103y	.25
2N930	.25	2N2218A	.30	2N2907	.25	2N3730	1.50	2N4234	.95	C103d	.40
2N956	.30	2N2219	.25	2N2907A	.30	2N3731	2.75	2N4400	.20	C106b1	.50
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2N4870	.50		

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7413	.39	7486	.30	74176	.75
7414	.63	7489	1.85	74177	.75
7416	.25	7490	42	74180	.65
7417	.25	7491	58	74181	1.90
7420	.14	7492	.43	74190	1.00
7425	25	7493	.45	74191	1.00
7426	.22	7494	.70	74192	.83
7427	.25	7495	.65	74193	.83
7430	.14	7496	.65	74194	.85
7432	.25	74107	.28	74195	.52
7437	.21	74121	.33	74257	1.25
7438	.21	74123	.65	74279	.87
7440	.14	74125	40	75324	1 75
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74LS37	.37	74LS191	1.75	LM 553	2.50
74LS38	.37	74LS192	1.75	LM 555	.44
74LS74	.49	74LS193	1.75	LM 556	.85
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74LS74	.45	74LS257	1.35	566	1 50
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7420	.16	7490	.43	74175	.97
7422	.30	7491	.75	74176	.89
7423	.29	7492	.48	74171	.84
7425	.27	7493	.48	74180	.90
7426	.26	7494	.78	74181	2.45
7427	.29	7495	.79	74182	.79
7430	.20	7496	.79	74184	1.90
7432	.23	74100	.90	74185	2.20
7437	.25	74105	.44	74187	5.75
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7441	.89	74122	.38	74192	.95
7442	.59	74123	.65	74193	.85
7443	.73	74125	.54	74194	1.25
7444	.73	74126	.58	74195	.74
7445	.73	74132	.89	74916	1.25
7446	.81	74141	1.04	74197	.73
7447	.79	74145	1.04	74198	1.73
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74H01	.25	74H30	.25	74H62	.25
74H04	.25	74H40	.25	74H74	.39
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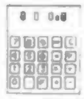

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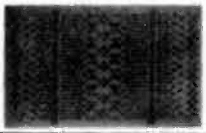

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INFRARED CLEAR DOME	.170"	.29
MV10B		
CLEAR DOME	.170"	.25
MV50		
CLEAR — AXIAL	.09"	.12
RED — AXIAL	.09"	.12
NSL100		
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RED DIFF. SUBMINIATURE	.12"	.12
RLT-T1-03		
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6.8	5	270	5	3.3K	10	47K	10	680K	10
10	10	330	10	3.9K	10	68K	10	2.2M	5
15	5	470	20	4.7K	20	100K	20	3.3M	5
22	5	680	10	6.8K	10	150K	10	4.7M	5
33	5	1.0K	20	22K	10	220K	10		
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4007A	.26	4023A	.25	4072A	.35
4008A	1.52	4024A	.89	4073A	.39
4009A	.57	4025A	.25	4075A	.39
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4012A	.25	4030A	.44	4518A	1.56
4013A	.45	4035A	1.27	4528A	1.56
4014A	1.27	4040A	1.39	4585A	2.10
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74C00	.19	74C74	1.04	74C162	2.49
74C02	.26	74C76	1.34	74C163	2.66
74C04	.44	74C107	1.13	74C164	2.66
74C08	.68	74C151	2.62	74C173	2.22
74C10	.35	74C154	3.15	74C195	2.26
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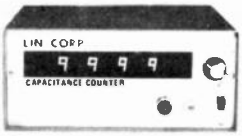

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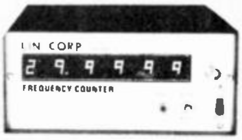

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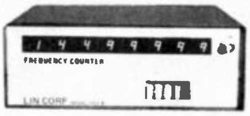

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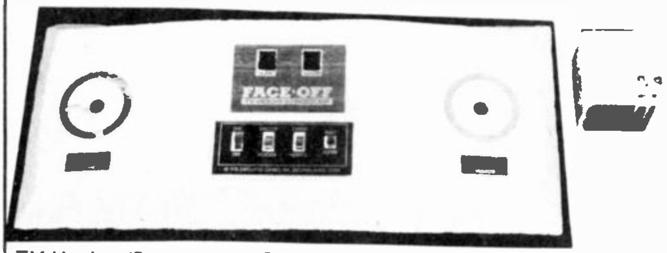

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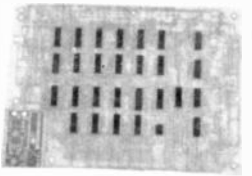

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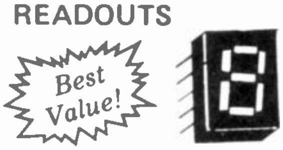

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7409	17	7490	71
7410	17	7491	71
7411	25	7492	.71
7413	.45	7493	.67
7420	17	7494	.90
7421	17	7495	71
7423	35	7496	.85
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7426	25	74121	31
7427	17	74123	61
7430	.25	74125	44
7432	.30	74141	71
7437	35	74145	97
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