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Radio-Electronics

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LEN FELDMAN REPORTS—
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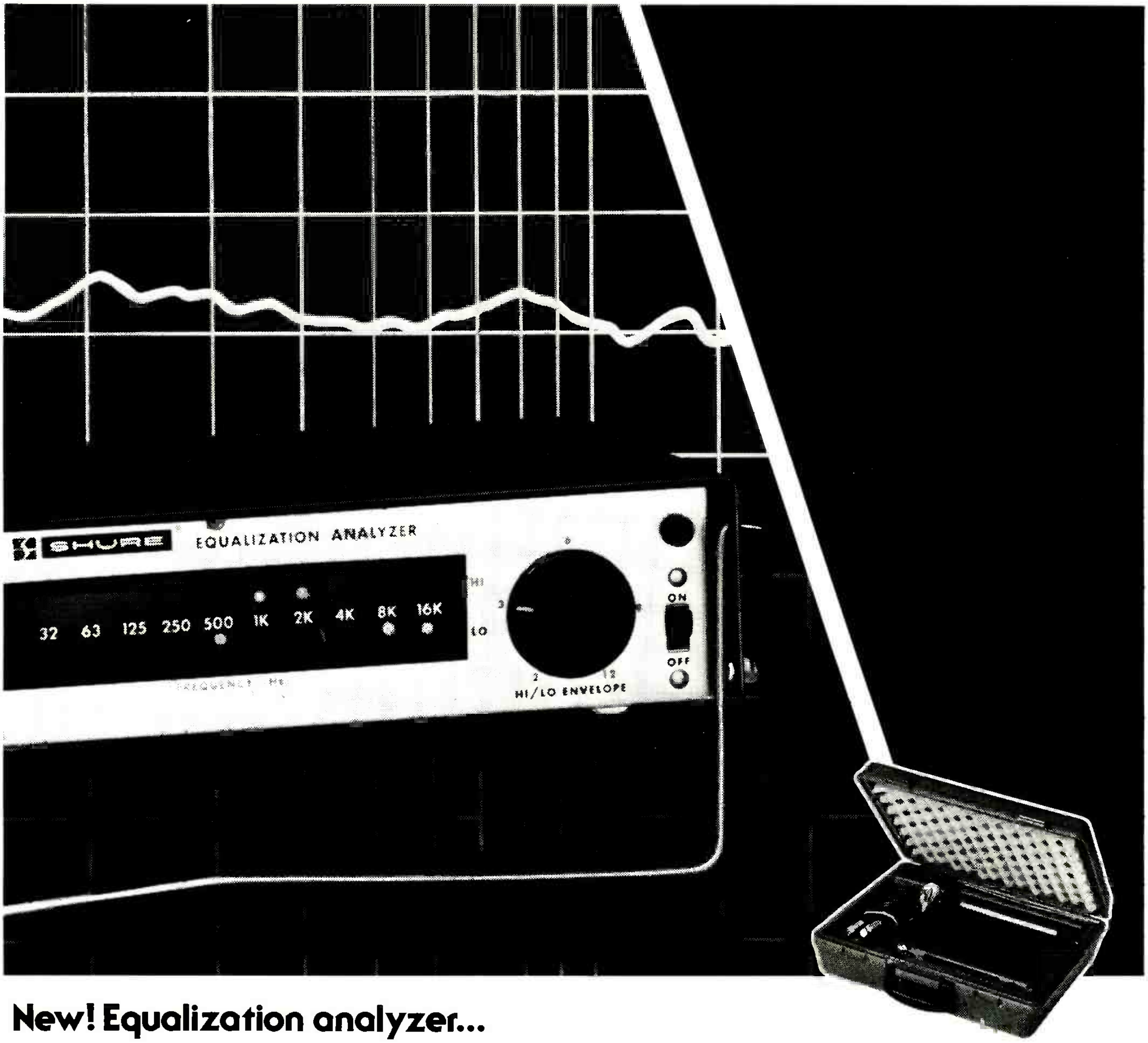

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HI-FI STEREO

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CB RADIO

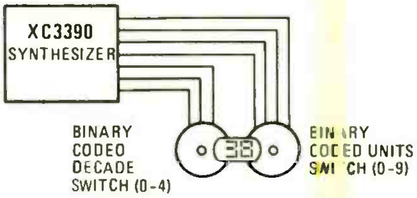
GENERAL ELECTRONICS

TELEVISION

DEPARTMENTS

ON THE COVER

That's Len Feldman sitting in JVC's special biphonic chair. If you want to know what he is hearing, see our special story starting on page 40.



PLL FREQUENCY SYNTHESIZERS are hot. Here's how BCD switches deliver binary signals to the synthesizer IC...................... see page 58

INFRARED SIGNALS link these headphones to the amplifier. For the story behind them and other new equipment ......see story on page 40

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looking ahead

Video horserace is on: The Japanese government, prodded by parliament, has urged videocassette recorder manufacturers to establish a single standard system. Although four separate, and incompatible, systems have already been introduced on the Japan home market, the race seems to be narrowing down to two somewhat similar—but, once again, incompatible—systems. These are the Sony Betamax, which has a large lead in terms of number of machines produced, and the Japan Victor Corporation (JVC) VHS, or Video Home System. The VHS currently offers two-hour recording and playing time on a single cassette, compared with one hour for the Betamax, but it's known that Sony is preparing a new version of Betamax that will double the playing time of its standard cassette.

Japanese manufacturers are choosing up sides, and since no American manufacturers are known to be preparing their own entries in the field, this should set the pace for this country. In addition to JVC, the VHS system now has been chosen by Hitachi and Sharp. Matsushita, Japan's No. 1 television set maker and JVC's parent company, has its own system (VX-2000), but it has indicated that it may add VHS. Mitsubishi is also believed to be in the VHS camp. Toshiba and Sanyo are pushing another system (V-Cord II), but Toshiba is waivering and presumably will decide between VHS and Betamax. The question in many minds is whether Sony has enough momentum going for its Betamax to offset a massive challenge from VHS. How important are these Japanese maneuvers to us? Well, one major American manufacturer (which asks not to be identified) has told us that it will manufacture videotape decks to the specifications of the format that wins in Japan.

VTR turn-off: Three home videocassette recorders are now on sale in the United States—Sony's Betamax, Sanyo's V-Cord II and Quasar's "Time Machine" VR-1000. The strong success of Betamax, whose sales last year totaled 25,000 to 30,000 units and exhausted virtually all supplies, is worrying the movie makers, as evidenced by the suit filed by Universal Pictures and Walt Disney Studios against Sony (**Radio-Electronics,** February, 1977). Now the Motion Picture Association of America is looking into the situation, seeking a technological—rather than legal—solution to the problem. The MPAA has signed a contract with Bell & Howell for the development of a system that would make it impossible for consumers to tape certain copyrighted programs.

The idea would be to transmit along with the program (probably in the vertical interval between pictures) a signal which would prevent home videotape machines from recording. This would be a lock-and-key situation, requiring special equipment at both the transmitting and receiving ends, and appears to pose some legal as well as technical problems. The electronics work may be the simplest part. After technical specs are developed, it would be necessary to get FCC approval for the transmission of the special anti-taping signal and Congressional legislation to require all VTR manufacturers to include in their products circuits which would automatically make it impossible to record programs which are transmitted with "no-no" signals. Or MPAA could try to get VTR manufacturers to agree to include such circuitry voluntarily. Fat chance.

Warwick becomes Sanyo: Sanyo Electric of Japan has purchased Warwick Electronics, which manufactures television sets, mainly for Sears Roebuck. This latest purchase of an American television manufacturer by foreign interests leaves only seven American-owned TV makers in a field which once had more than 100. The remaining U.S.-owned manufacturers are Admiral Group (part of Rockwell International), General Electric, Curtis Mathes, RCA, Sylvania, Wells-Gardner and Zenith. There are actually 10 if you include Andrea Radio Corp., which is principally a regional manufacturer in New York; Heath Co., which makes TV kits, and Advent, manufacturer of consumer projection TV.

Other acquisitions of American TV companies by foreign-controlled organizations in recent years have been Matsushita Electric's purchase of Motorola's TV business (now Quasar) and North American Philips' acquisition of the Magnavox Co. The television-manufacturing portion of Warwick, which was controlled by Whirlpool Corp., has been re-named Sanyo Manufacturing Corp. What is left of Warwick, unaffected by the sale, is now Thomas International, manufacturer of Thomas electronic organs. Sanyo plans to continue the manufacture of color TV consoles in the former Warwick Forrest City, Ark. plant. The purchase puts Sanyo into contention for the title of third-largest supplier in the American television market (Sanyo also markets here under its own brandname and various private labels). Other contenders for the No. 3 spot are Magnavox, Sony and Matsushita (the latter selling under Panasonic, Quasar and private labels).

LCD TV projection: Television manufacturers are watching with interest a project by Hughes Aircraft, that could conquer one of the major problems of home projection TV—lack of brightness. Hughes' Dr. Alex Jacobson heads a team which has developed a breadboarded color TV projector using a liquid-crystal light valve to modulate the beam of an external light source, such as a xenon arc lamp. (Existing home projectors use cathode-ray tubes as light sources.) The color projector has three LCD's—one for each color—and uses dichroic mirrors to converge the picture into a single lens system. There are still some technical problems, but the Hughes engineers are confident they'll have a pre-production prototype of a reasonably priced super-bright projector within a year.

continued on page 101

new & timely

Sun's magnetic field determined by Pioneer 11

Scientists studying data returned by Pioneer 11—now on its way to Saturn—have been able for the first time to determine the structure of the sun's magnetic field. According to the data, it's roughly spherical, envelops the entire solar system (probably as far out as the orbit of the planet Pluto), extends several billion miles above the sun's north and south poles and is split into northern and southern hemispheres by a thin sheet of electric current.

Previous data, from spacecraft traveling in or near the earth's orbit, had recorded confusing and apparently contradictory data. Pioneer 11 was able to make its discoveries because it traversed a hitherto unknown region of space high above the earth's orbit. On its way to Saturn, the spacecraft had been thrown 100 million miles above the earth's plane by Jupiter's gravity while flying by that planet.

The northern and southern magnetic fields of the sun, explained Dr. Edward J. Smith of the Jet Propulsion Laboratory, Pasadena, CA, to a meeting of the American Geophysical Union, are separated by a warped sheet of electric current. The currents tend to circle the sun in the inner solar system, but gradually turn and flow outward in the outer part of the system. As the sun rotates, the warped sheet appears to move up and down, above and below the plane of the earth's orbit. Thus, a spacecraft might at different times see a field in one direction, no field or one in the opposite direction depending on whether it was below, in, or above the sheet of current.

QUAD INCREASES MUSIC APPRECIATION

BOOKER T. GIBSON, teacher at the Valley Stream South High School, NY, after "some discouraging moments in teaching" seventh- and eighth-grade students music appreciation by traditional methods, decided that he "had to use some new ways. . . . So," he says, "I started to bring my own SQ full-logic equipment to school."

The students reacted to the modern approach and their enthusiasm spread to parents and eventually to the school administration, who finally bought a permanent SQ quad system for the classroom. Mr. Gibson, a former jazz pianist who is a lover of classical music, says, "I think it's helped tremendously in increasing the enthusiasm of my students for all types of music."

Mysterious source jams radios

Amateur and commercial radio stations have been troubled during the late summer and fall months of 1976, by a powerful pulse transmission. This appeared on several frequencies, and was heard in both the United States and Europe. It was not clear whether the source was one station operating on different frequencies, or several stations. One educated guess is that three stations were involved.

One New Jersey amateur reported an unmodulated pulse signal on about 14.2 MHz. It spread out enough to be audible over about 300 kHz. Severe interference (as an amateur understands the word) was confined to a few kilohertz on each side of the peak. (He had also heard of the same type of interference on the 7-MHz band.)

Using a directional antenna and checking with a California friend who also had a directional antenna, the source was located roughly in the northern part of European Russia, possibly in the Leningrad area. Purpose of the transmission was not clear. "It sounded like an ionosphere sounder," he said. Power was high and the signal was strong, though few other signals were heard from the same direction.

Commercial and maritime stations also reported the same type of transmission. One East Coast station measured the signals at different times on 12.393, 16.523, 22.080 and 22.032 MHz. Interference was strong on the peak frequencies, dropping off to each side. This type of thing, the informant pointed out, was not uncommon—signals were often encountered where they apparently had no business being. The usual procedure in such cases was to inform the FCC, who would track down the interference and take any necessary steps.

Inquiries made around the middle of November indicated that at that time the interference had not been heard for a week or two. It was suggested that the station or stations may have shut down or been shifted to a non-interfering frequency after the publication of articles on the subject by the Washington *Star* and the *New York Times*.

CB workshops begin operation in 1977

A series of training workshops in CB servicing (including the second class radiotelephone license) will be conducted by Forest Belt in various parts of the country during 1977. Mr. Belt is a leading teacher and writer on electronic subjects, and a former editor of **Radio-Electronics.**

The workshops are divided into two parts:

Section A devotes three days to fundamentals of CB communication, AM and single-sideband transmitters and receivers, 40-channel phase-locked-loop circuits, frequency synthesizers, etc. Trouble-shooting techniques, performance measurements, alignment, and tran-

continued on page 12

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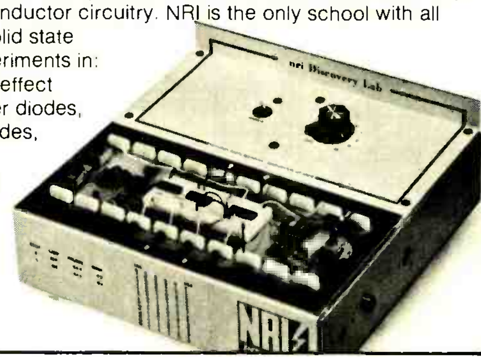

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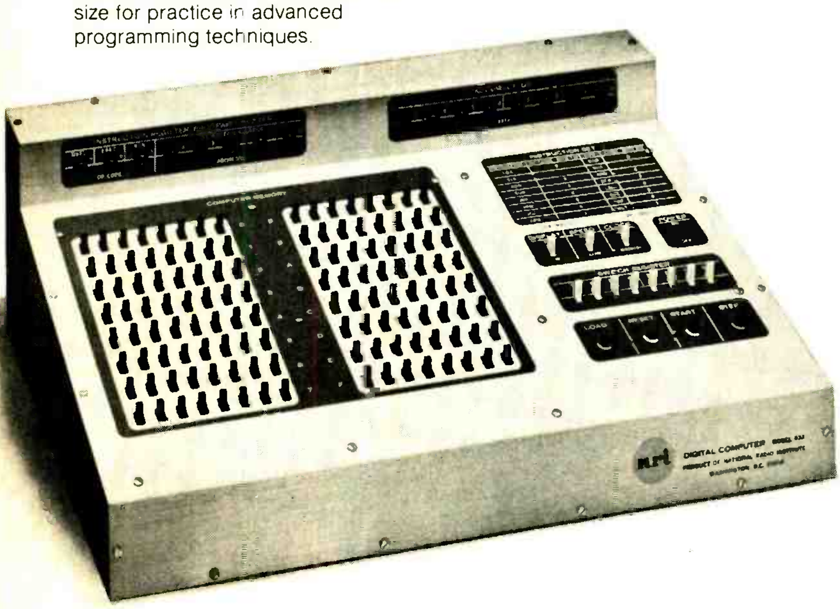

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new & timely continued from page 6

sistor and integrated circuit testing will also be covered.

Section B, an advanced two-day workshop, covers FM communications and equipment as used in marine, police, taxi and other two-way mobile systems. A Second Class Radiotelephone option is offered. The radiotelephone license is necessary for any technician who services CB or other transmitting equipment.

Workshops will be held in Indianapolis, IN, January 24–28; in Oakland, CA, February 28–March 4; San Diego, CA, March 7–11; Phoenix, AZ, April 4–8; Denver, CO, April 11–15, and San Antonio, TX, April 25–29.

For further details, schedule of locations, rates, enrollment applications, etc., write Forest Belt's Training Workshops, Box 69120, Indianapolis, IN 46268.

Sharon Penix, Samuel Ford are Gernsback Award winners

This month's first-prize winner of the Gernsback Award, a check for $150 sent to an outstanding student in each of eight leading electronics home study schools, is Samuel R. Ford. He enrolled in the National Technical Schools' Master Course in Color-TV Servicing in March 1975 and had finished three quarters of the course by the middle of 1976. Ms. Penix, this month's second-prize winner, and Mr. Ford, the school says, have "received excellent grades on all lessons completed."

SAMUEL R. FORD

Samuel R. Ford was born and has lived all his life in Hagerstown, MD, with the exception of four years with the Navy in the Orient. In high school, he was "fortunate enough to complete three years of a four-year electronics course," and has had a year and a half of a college physics major. He started his course with National Schools in March, 1975.

Mr. Ford has been working for the Burroughs Corp. for the last four years, and is now a senior field engineer responsible for the maintenance of about 70 computer terminals and a like number of minicomputers and peripheral adjuncts. The most pleasing thing about his career, he says, is being "constantly challenged by the diversity of the electronic/mechanical repairs I am called on to make."

Mr. Ford has been married 10 years and has an 8-year-old son. Besides electronics, he is interested in astronomy, classical music and guitar.

SHARON ROSE PENIX

Sharon Rose Penix is not professionally in the electronics field, but lives on an Indiana farm, occasionally engaging in the farm work by driving trucks for her father during the harvest season. Her husband works on construction as an operating engineer. She started the course in December, 1975, and had finished three-fourths of it by June, 1976.

A CB'er, her call is KPJ 8579. She uses the CB equipment on the farm and when camping (the Penix's designed and built their own recreational vehicle, "which is difficult to distinguish from a factory model"). Other hobbies, furthered by the rural environment, are flower gardening and attracting wild life to the property. She also collects antique clocks.

Ms. Penix's object in studying radio and television is threefold: First, she is interested in learning more of the "magical world" of electronics. Her second object is to learn a skill that could be an aid to employment; and last—and more immediately important—she wants to keep her own TV and electronic equipment in working order.

Ms. Penix receives a model 280 digital multimeter donated for the purpose by B & K. **R-E**

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CIRCLE 72 ON FREE INFORMATION CARD

letters

NEW BRAINWAVE APPLICATION

Brainwave detection ("Mindpower: Alpha"; July, August, September and October, 1976, issues) has one unexplored area of great usefullness. Alpha and certain other brainwaves tend to signal a lack of concentration on the senses. This can be dangerous when one is driving or operating complex machinery. Using such brainwave detectors in an *opposite* direction to sound a jolting alarm for possible lack of attention could be a great safety innovation.

Some readers may like to look into developing a simple, portable, lack-of-attention or sleep alarm based on brainwave techniques. This should be welcomed by long-distance truck drivers, guards and workers operating almost automatic (and thus boring) machinery—all of which represent danger due to a lack of attention or sleep.

PETER LEFFERTS
Electro-Audio Research Labs
San Martin, CA

SR-51 CALCULATOR

I am another one of the many owners of the Texas Instruments SR-51 calculator. While reading the September 1976 issue of **Radio-Electronics,** I noticed the letter from E. G. Lemmon in the "Letters" column. I had also read Thomas Cox's letter earlier.

As with many calculator owners, I have been exploring the hidden capabilities of my calculator. It may be true that the memory capability of this calculator is as stated in the owner's manual, but I have discovered that there are several uses for the second function key that were not mentioned in my owner's manual.

I found that after pressing the following keys; "2nd", "1", "cos", the display showed an unfamiliar number without a decimal point. After some experimentation, I determined that the display was the same number that was being displayed as before except that it was justified to the least significant digit, or the right hand-digit, instead of the most significant digit. This means that the last three digits that are not normally displayed can be seen. (The calculator calculates to thirteen decimal places, but can accommodate only ten digits in the display.)

A way to demonstrate this is to press the "pi" key. The display should read 3.141592654. After pressing the "*2nd*", "1", "cos" keys, the number 1592653590 is on the display. These numbers are recognized as pi with the first three digits removed. To return the calculator to its normal operation, press any function key. As far as I can tell, no data is lost in the process, except from operator malfunction.

Some other interesting functions are; "*2nd*", "1", summation; "*2nd*", "1", exchange; "*2nd*", "1", "tan". These all turn off the display for various amounts of time. The first for about one minute-ten seconds; the second, as far as I can tell, indefinitely; and the third for about four seconds. If the operator wishes to return his calculator back to normal operation, just turn the calculator off and then back on again.

The SR-51 may have limited memory, but for me it is an unlimited source of entertainment.

STEVEN L. BUCHHOLZ
Davis, CA

DIODE POLARITY WRONG?

When I built the Electronic Stopwatch (from the November 1975 and February 1976 issues) I found that all diodes (D1—D7) on the printed-circuit board layout have the wrong polarity indicated. The diodes must be reversed in order for the stopwatch to function properly. I completed the stopwatch and am very pleased with the way that it operates. Keep up the good work.

GABRIEL ROTTER
Roseville, MI

We are happy that you were able to troubleshoot the stopwatch and correct the problem. It appears that you are confused about the accepted method of marking diode elements on schematics and parts placement diagrams. On schematics and any other places where the symbol is used, the arrowhead indicates the anode and the bar indicates the cathode. In addition, the cathode terminal may be marked with a plus sign. This indicates the terminal of the diode that will show a positive voltage or polarity when an alternating voltage is applied to the other terminal.—Editor

COUNTDOWN TIMER QUERIES

(A number of readers questioned apparent discrepancies between the schematic diagrams and board layouts for the Digital Countdown Timer in the August and September 1976 issues. Most of the questions were among those included in letter below. Answers—supplied by author George R. Baumgras—appear in italics.—*Editor*)

The following errors were noted in the Digital Countdown Timer articles in the August and September issues:

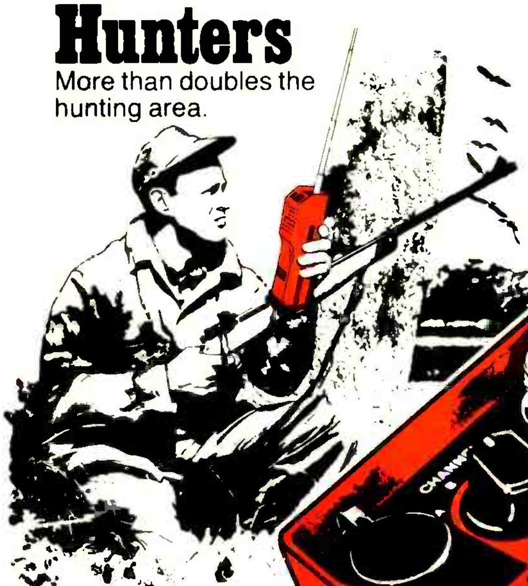
1—IC8. Bottom layout shows pins 2 and 3 tied together but not on the schematic.

2—IC9 has the same function as IC8 but pins 2 and 3 are not tied together in the bottom layout. Is one of these wrong?

The 7490 and 7492 can be reset with either pin. Rather than leave an unused floating input to an active circuit, the two

continued on page 16

A new stay-in-touch system for all outdoorsmen.



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LETTERS

continued from page 14

inputs should be tied together. This is done during the circuit-board layout.

3—IC9. Bottom layout shows a wire going from pin 4 to pin 13 of IC10. Actually pin 4 is not connected to anything inside the IC. So why the hookup?

"No-function" pins are often used to simplify board layout but are not shown on the schematic. In this case, IC9 pin 4 should go across to IC9 pin 12.

4—The terminal of IC2-b that connects to IC9 pin 1 is not numbered.

Should be pin 6.

5—IC9. On the bottom layout, pin 4 goes to pin 13 of IC10. Since pin 4 is not used internally in IC9, I believe that the whole connection is wrong and pin 12 of IC9 should have been used. Is this correct?

The connection is correct as noted in question 3.

6—IC5, pin 3 goes to pin 2 of IC4 in the bottom layout. I think it should have been pin 2. Is this correct?

IC5 pins 2 and 3 go to IC4 pins 2 and 6. Also refer to question 1.

7—IC5. Pin 5 on the schematic is going to pin 13 of IC6. Pin 5 is the V_{cc} connection so this is not correct. I think it should have been pin 8, not pin 5.

Correct.

8—IC14 has pins 6 and 7 tied together on the bottom layout but not on the schematic?

9—IC16 has pins 2 and 3 tied together on the bottom layout but not on the schematic?

Refer to answer to questions 1 and 2.

10—IC 16. Pin 4 on the schematic goes to ground. Actually, it is not connected inside the IC. Is this necessary?

Should be IC16 pins 6 and 7.

11—IC17. Pins 6 and 7 tied together on bottom layout but not in the schematic?

Refer to answer to questions 1 and 2.

12—IC17. Pin 3 goes to ground on bottom layout but not in schematic?

Refer to answer to question 3. IC17 pin 3 connects to ground on the other side of the board.

13—IC15. R6 is marked 11K on the schematic and 1K in the parts list. Which is correct?

Should be 1K.

14—IC15. Pins 6 and 7 tied together to ground on bottom layout but not in the schematic. Which is correct?

IC15 pin 6 is not connected to pin 7. It goes to IC16 pins 1 and 14.

15—IC15. Pin 11 is tied to pins 1 and 2 on the schematic but pin 10 is tied to 1 and 2 on the bottom layout. Which is correct?

16—IC15. Pins 10 and 11 are tied together on the schematic but not on the bottom layout?

IC15 pin 11 connects to IC15 pins 1, 2 and 10. Add this connection to bottom layout.

17—IC4. Schematic shows pins 2 and 6 tied together and then to pin 2 of IC5. Bottom layout has the connection made to pin 3 of IC5. Which is correct?

Either is correct. Refer to answers to questions 1 and 2.

18—IC6. The resistor connected to pin 6 should be R27, not R20.

Correct. Should be R27, 3.3K.

19—Capacitor C4 is listed as 2.2 μF in the parts list and 22 μF on the schematic. Which is correct?

The correct value is 2.2 μF as in the parts list.

20—Top view of the control board. The EN and ADD labels are reversed on the left side of the board.

OK as shown.

21—On the alarm board we have three 1N4000 diodes. The outlines indicate axial-lead types. Actually, a 1N4000 is a 10-watt, stud-mount 7.5-volt Zener. Shouldn't these diodes be 1N4001's?

Yes. They should be 1N4001's or similar.

WILLIAM L. SCHREIBER
Fullerton, CA

R-E

Rural fire departments using scanning monitors

The fire department of Wicasset, ME, has recently purchased 11 scanning monitors, and a department in Whitefish, MT, bought 21 units, reports RCA's Distributor and Special Products Division, which makes the units in portable, base and mobile models. Scanners are also being used by fire departments in Markleville, IN; Lakewood, NJ; Auburn, VA and Kingston, PA.

The scanners tune continuously over several emergency frequencies and then lock in on any one that is transmitting. They are especially useful on mobile units, alerting the crew to an emergency immediately without having to wait for a message from headquarters.

Fire Chief Gordon Merry of Wicasset reports that members of his department are now able to keep in much better contact with all local fire, police and ambulance calls. In three recent emergencies, he says, the scanners were especially useful. Calls for an ambulance came in on the wrong frequency. Had it not been for the scanners, he said, the calls would have been missed.

240,000 telephone calls an hour switched in new central office

With its 1,000th local-service electronic switching system (ESS), the Bell System initiated its first large-capacity central office switching system, the 1A ESS. The new system went into action last October in Chicago.

The system operates around a new information-processing control unit, the 1A Processor, which operates at more than twice the speed of the earlier No. 1 ESS machines. With its maximum speed of 240,000 calls an hour, the No. 1A ESS becomes the highest-capacity local switching system in the world. The processor is also used in the No. 4 ESS for long-distance switching.

The new processor is so designed and constructed that it can easily replace the No. 1 processor used in No. 1 ESS exchanges, wherever the call-handling capacity needs to be increased. It can even be switched in without interruption to the telephone service.

Decimal computations abandoned by new sexagesimal calculator

A sexagesimal calculator (one that counts by sixties instead of by tens) has

THE BABYLONIAN MATHEMATICIANS would have welcomed the new Canon calculator.

been introduced by Chafitz, Inc., of Rockville, MD. The instrument, called the *Time Machine,* was designed to automatically add, subtract, multiply and divide hours, minutes, seconds and tenths of seconds without the cumbersome conversions required with a decimal calculator. In the numerous applications where time is calculated, the instrument reduces calculating time by 50 percent or more. It is, of course, equally useful in other applications requiring circular measurement by degrees, minutes and seconds.

The instrument has both manual and automatic modes, and also converts hours, minutes, etc., to decimal form and vice-versa. A calculator that handles sexagesimal computations as one of its functions has been announced previously (from Casio), but this is the first instrument to make such calculations its primary feature. It sells for about $50. **R-E**

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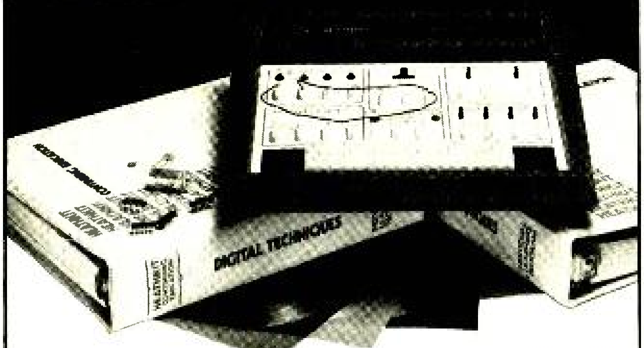

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Stacks—what they are and how they're used

TIM BARRY

MICROCOMPUTER USERS THESE DAYS ARE CONstantly bombarded with a bewildering supply of new jargon. In addition to the normal proliferation of new hardware terms, we now have to cope with words from software design, systems analysis, and a whole herd of other less well defined disciplines. One of the most commonly used (and abused) terms these days is *stack*. The hardware represented by this picturesque term is often endowed with rather mysterious qualities. Vague utterances about "pushing" and "popping" blend together with questions about "balancing" and "nesting" to create an ample atmosphere of confusion. In this article we will look at two principal types of stacks and how they operate. In doing this we will hopefully dispel some of the myths surrounding these extremely versatile devices.

What is a stack?

In the most general terms, a stack can be considered to be any serial storage system. A stack will have an input end and an output end. All data placed into the stack must pass one element at a time through the input end of the stack. Once an individual data element is in the stack, it can only be accessed by removing preceding or succeeding data elements until it reaches the output end of the stack. The order in which data is placed into and removed from the stack differentiates between two different types. Figure 1 illustrates the two different types.

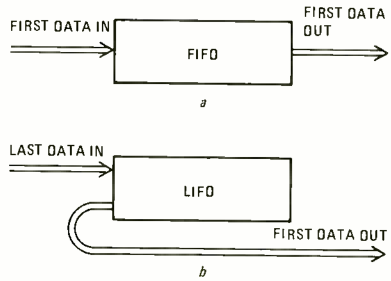

FIG 1

The first type we will discuss is probably the easiest to understand. In these days of crowded facilities and long lines, we, as people, all spend plenty of time in FIFO (*F*irst *In*, *F*irst *Out*) stacks. The data entered into the input end of a FIFO emerges from the output end in the same order in which it was entered. (See Fig. 1-a.) The principal use of FIFO's is to store arriving data for later use. The next time you are waiting in line, you can reflect on the fact that you are participating in a genuine computer buzz word.

The second type of stack is less commonly encountered in our day to day experiences. A LIFO (*L*ast *In*, *F*irst *Out*) stack returns data in the opposite order from which it was entered. (See Fig. 1-b.) This means that all the data in the LIFO must be removed before the first data element entered can be recovered. For example, consider an empty bus. Assume that each passenger who gets on the bus goes to the back and no one gets off enroute. When the bus unloads, it should behave like a LIFO, with the last passenger that entered being the first one off. LIFO's are most commonly used in computer programming to save program data and subroutine return addresses.

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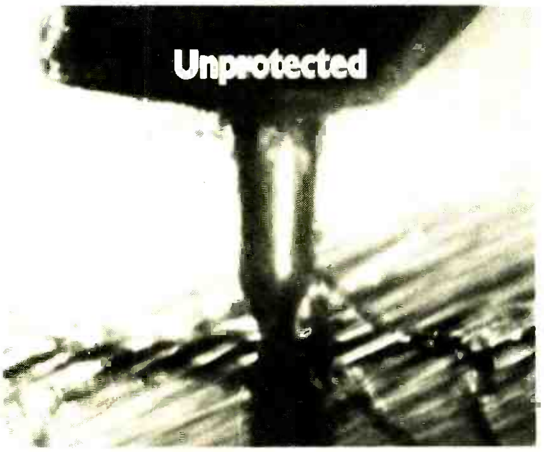

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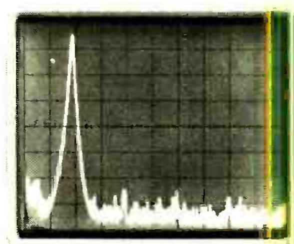
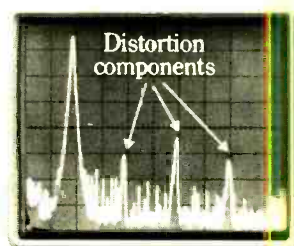
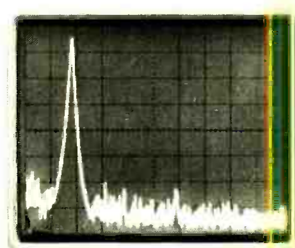


Test record played first time.



After 100 plays without Sound Guard.



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FIFO operation

FIFO stacks are most commonly encountered in computer I/O systems and data acquisition systems. They are used to match the data transfer rates between two systems. In this type of application they are often referred to as *storage buffers*. The need for these devices arises when data is transmitted in bursts which are to fast for the receiving device to process. The FIFO is used to store the data in the order in which it arrives during the entire burst. The receiver (usually a computer) can then process the data from the FIFO at its own rate. A common FIFO application of this type is found in computer disk systems. Data to be transferred to or from a disk must be transferred at a higher rate than most computers can manage. To solve this problem, a FIFO buffer is used. The disk transfers a block of data into the FIFO at high speed. The computer can then use the data at its own rate.

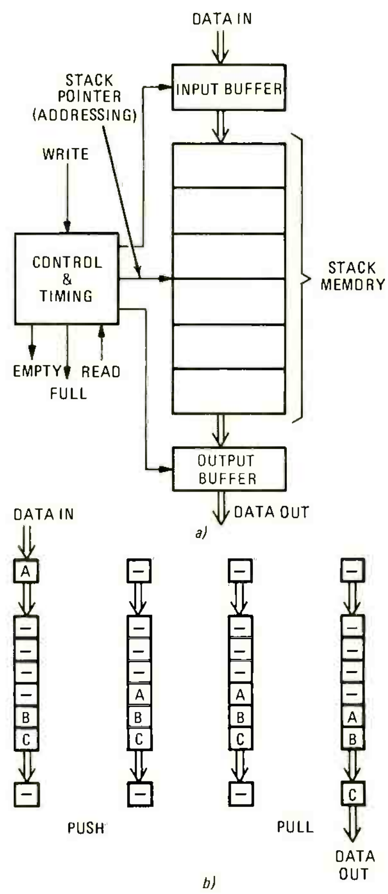

FIG 2

FIFO's can be implemented in either hardware or software. Hardware FIFO's are actually available as LSI integrated circuits from several semiconductor manufacturers. They contain data buffers, registers, a memory, and all required control logic. The block diagram of a typical FIFO (simplified to 6 locations) is shown in Fig. 2-a. In operation, the FIFO accepts data into the input buffer. It then *pushes* the data down in memory until it rests in the first empty location in the memory. When data is read

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from the FIFO, the first data element in the memory is *pulled* into the output buffer. All other data in the memory is then moved down one. If the FIFO becomes full or empty, it sets flags to indicate these conditions. A graphical illustration of a FIFO operation is shown in Figure 2-b.

A FIFO can be implemented using software instead of hardware. In this case subroutines are used to perform the push and pull operations. The flow chart for the push subroutine is shown in Fig. 3-a and the pull subroutine is shown in Fig. 3-b. In actual use, these two programs will both share a common block of the computer's main memory for the FIFO stack. They will keep track of where the data in the FIFO is by using a *stack pointer*. A stack pointer always indicates the memory address of the most recent data element entered into the stack. (This is true of both FIFO's and LIFO's.)

When the push subroutine is executed, the stack pointer is incremented by one and the new value returned to the memory. The data passed to the subroutine is then transferred into the stack memory at the address now indicated by the stack pointer. For a pull operation, the stack pointer is first tested to see if the stack is empty. If it is, an error flag is set and the subroutine returns. If it is not empty, the data at the first memory address of the stack is obtained. The stack pointer is then decremented by one and re-stored in the memory. All the data in the FIFO is moved down one in the memory. The routine then returns to the calling program with the data.

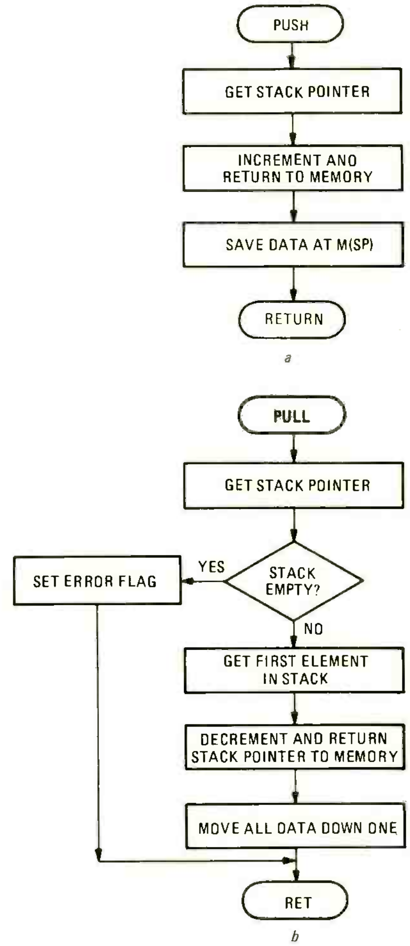

FIG 3

LIFO operation

The LIFO stack is most commonly encountered in systems programming and microcomputer subroutine systems. In systems programming (particularly language processors), the LIFO is used to store data and operands during the evaluation of arithmetic and algebraic expressions. In microcomputer subroutine systems, the LIFO is used to hold program data and subroutine return addresses.

The hardware required to implement a LIFO consists of the same basic hardware we saw used in the FIFO. It is simply connected together in a different configuration. (See Fig. 4-a.) In operation, the data is received into the input buffer just as before. However, all the other data in the LIFO is now pushed down one to make room at the top for the new element. For an output operation, the top element of the stack is *popped* into the output register and all the other data is then moved up in the memory. These LIFO operations are illustrated in Fig. 4-b.

Implementing the LIFO can also be done in software. The flowchart for the push subroutine is shown in Fig. 5-a and the pop subroutine is shown in Fig. 5-b. As with our software FIFO, the software LIFO routines will share a common memory area and stack pointer. When the push subroutine is called,

continued on page 32

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continued from page 26

the stack pointer is incremented by one and the new value returned to the memory. The data passed to the subroutine is then transferred into memory at the address indicated by the stack pointer. For a pop operation. the stack pointer is first tested to see if the stack

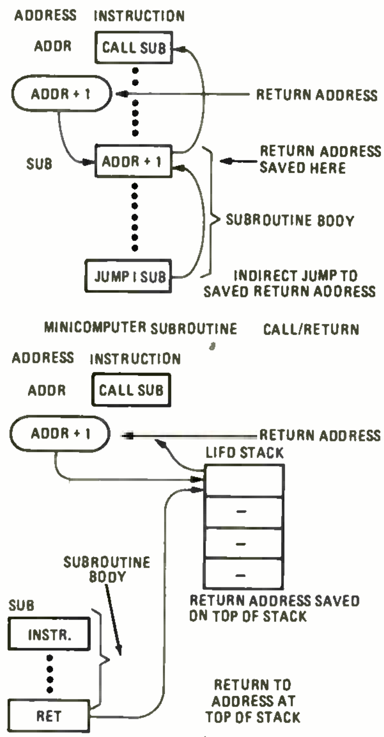

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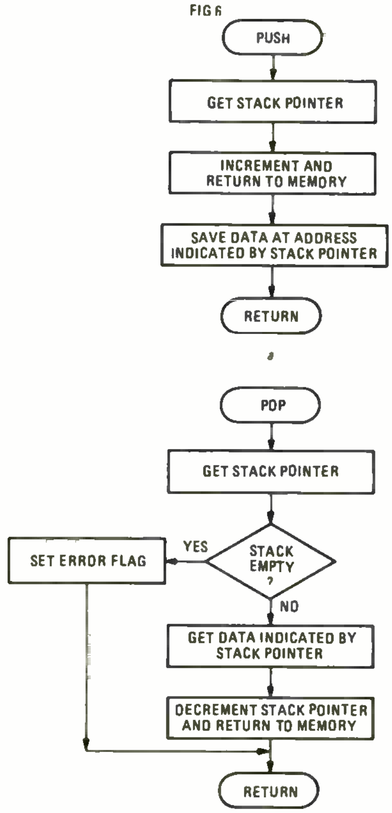
FIG 6



b

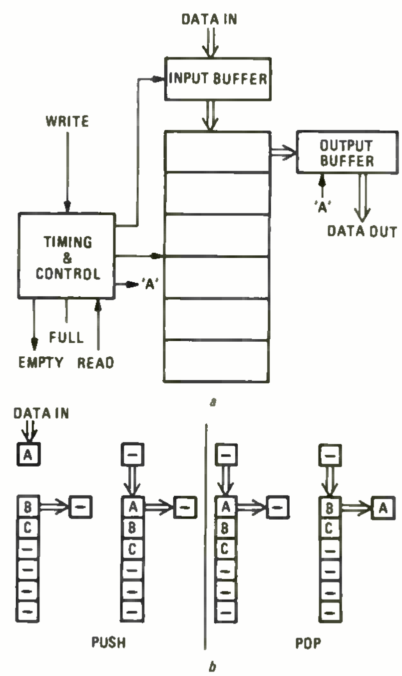
FIG 5

is empty. If it is, an error indicator flag is set and the routine returns. If the stack is not empty, the data at the address indicated by the stack pointer is obtained. The stack pointer is then decremented by one and the new value stored in the memory. The routine then returns to the calling program with the data.

Stacks and microcomputers

As mentioned earlier, many microcomputers use stacks to implement their subroutine systems. This arose because of the unsuitability of the normal minicomputer way of saving return addresses. When a subroutine is called, most minicomputers save the return address of the calling program in the top location of the subroutine called. A return can then be executed by performing an indirect jump to the first location in the subroutine. (See Fig. 6-a.) This works great in systems where the subroutines are located in read/write memory. It's not so hot when the subroutines are to be located in read only memory. Since most microcomputers make extensive use of ROM, something had to be done. Enter the LIFO.

When a LIFO is used for the subroutine structure everytime a subroutine is called, its return address is pushed onto the stack. When a subroutine return is executed, the top address in the stack is popped into the program counter, thus transferring control to that location. (See Fig. 6-b.) Now this means that all subroutines must be returned in the



b

FIG 4

opposite order in which they were called if proper program operation is to be maintained. The number of subroutine calls executed before a return is executed is called *nesting*. Thus the phrase, "My program is nested five deep", means that the program has called five subroutines before the first return has been executed.

Microcomputer designers took two basic approaches to implementing the LIFO stack for return addresses. The first way was to build the LIFO in as part of the CPU hardware. This method required no special

continued on page 86

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equipment reports

Data Precision Model 175 Digital Multimeter

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There are only the two controls and the switch on the front panel. The rest is taken up by the LED readout. The test leads plug into miniature banana jacks at the right side of the case, near the back. The whole thing is so compact that you can easily hold the instrument and the common test-lead in one hand, and the hot test-lead in the other. They have thoughtfully provided a wrist strap with a pivoted ring, to slip over your arm so that you won't drop it. This makes it very nice for getting readings in dark places. You don't have to shine your penlight on the meter to read it! (Where do you get the third hand to

continued on page 87

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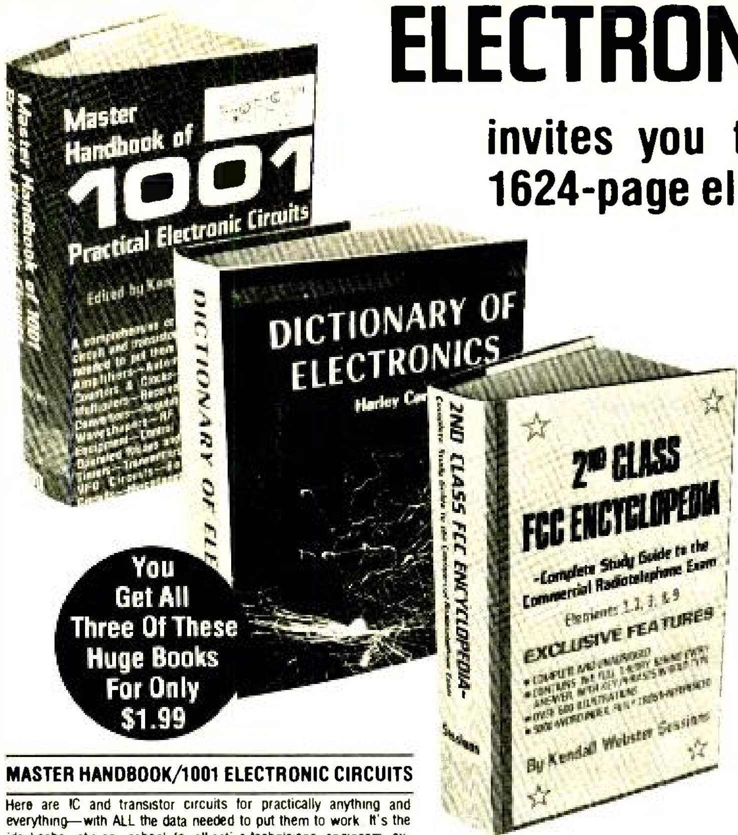

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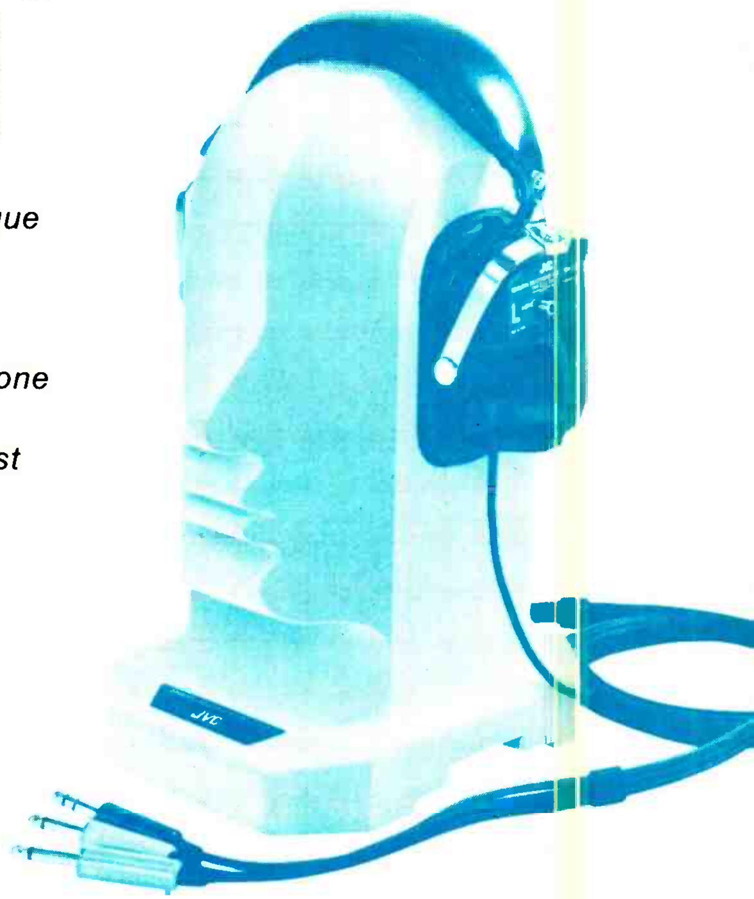
ADD DIMENSION TO STEREO

Binaural/Biphonic Sound

A recent revival of an old technique that provides precise spatial localization of sound sources. JVC's recent introduction of a combination headphone/microphone brings this technique within easy grasp of the home recordist

LEN FELDMAN
CONTRIBUTING HI-FI EDITOR



BACK IN THE EARLY 1930'S, BELL LABORATORIES performed extensive research into the nature of human hearing and, more specifically, the "binaural" effect. As most readers are probably aware, the reason that we can localize or perceive the direction of sounds is that we have two ears. Until recently, it was thought that two factors help us to determine angular directions from which sounds reach us—the difference in time of arrival of a sound to our two ears, and the difference in amplitude of the sound reaching our left and right ears. These factors are illustrated in Fig. 1. Sound waves approaching us from the left arrive at the left ear first, with sound reaching the right ear a small fraction of a second later. Since the sound has also travelled a greater distance to reach the right ear, it will be somewhat diminished in intensity as well.

More recent studies have shown that a third factor influences our ability to localize sounds. When the early Bell Lab studies were being performed, the question arose as to why we are able to detect the difference between a sound coming from directly in front of us and one coming from directly behind. It was at first supposed that since both kinds of sounds arrive at both ears simultaneously, and with equal intensity, that we must subconsciously be turning our heads ever so slightly to establish an angular difference (and hence a different time of arrival) that then gives us the final clue as to the source of the sound. More recently, studies have shown that there is another factor involved. Because of the construction of our outer-ear (the auricle, or pinna), the frequency response of our overall hearing is "poorer" for sounds reaching us from behind, compared with sounds reaching us from in front. The "baffle" formed by the outer ear attenuates "highs" reaching us from behind.

Dummy-head microphones

In those early Bell Lab experiments, a dummyhead was fitted with two microphones, each located where the ears would normally be. Sounds picked up by each microphone were amplified by a separate amplifier and reproduced over a pair of headphones, as shown in Fig. 2. The sensation was very much as though the listener wearing the headphones was "transported" to the position in space occupied by the dummy head. Not only were angular directions of sounds clearly discernible, but listeners were able to determine, quite accurately, the *distances* to the sound source. In other words, there was a total and complete sound field perceived by listeners wearing the headphones.

Years passed and, as we know, binaural sound reproduction was given little or no attention. In the early 1950's, attention was turned to stereophonic sound. The chief reason why binaural sound was regarded as impractical as a home entertainment music system was its need for headphone listening. Most people preferred listening to music reproduced over free-standing loudspeakers. If a binaural recording (using a dummy-head microphone arrangement) were to be played back over a stereo system, one would lose almost all perception of sound localization. The reason for this is obvious. The sounds originally intended for *only* the left ear are heard in both ears when reproduced via speaker systems, and the same is true of those sounds intended for only the right ear.

In order to synthesize a feeling of spread or separation, stereo recordings intended for reproduction over two loudspeakers had to be made with microphones widely separated. In this way, the sounds picked up by the left-channel microphone would be substantially different from those picked up by the right microphone.

As stereo recording technology advanced, all attempts to recreate a true "sound field" have just about vanished. Most stereo recordings today contain a mixture of multi-channel monophonic recordings (often, combined from 16, 24 or even more microphone channels). Such recordings can "fool" the listener into visualizing a two-dimensional sound plane, with musical instruments or vocalists "positioned" across a wall of sound. But the typical stereo recording, reproduced over conventional stereo hi-fi equipment cannot offer sound in three dimensions. The sense of distance is lacking.

Recent interest in 4-channel sound reproduction arose because of this deficiency in conventional stereo reproduction. But even 4-channel recordings, however carefully engineered, fail to provide true 360-degree sound fields with total realism and with distances from the listener to the sound source that are still difficult to ascertain with any precision. The ability to perceive sound sources, even in a discrete 4-channel system, is limited. (See Fig. 3.)

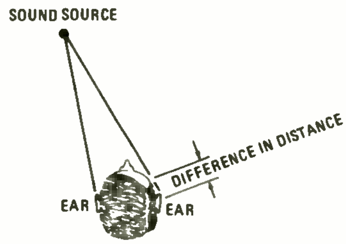


FIG. 1—SOUND SOURCES are localized by the time difference between sound waves reaching the left and right ears.

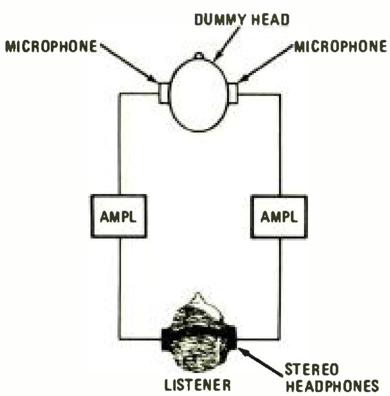


FIG. 2—BINAURAL REPRODUCTION requires microphones to be located where the human ears would normally be.

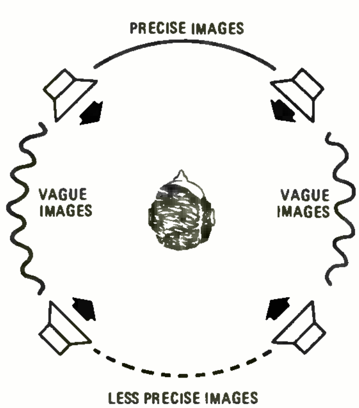


FIG. 3—QUADRIPHONIC SYSTEM is incapable of providing precise localization of sound sources.

Renewed interest in binaural

Several factors have recently contributed to renewed interest in binaural sound recording and reproduction. For one thing, headphone listening has become quite popular and many audiophiles listen to stereo programming via headphones a good deal of the time. Also, compact high-performance microphones have been developed which facilitate the construction of "dummy head" dual-microphone systems that more nearly duplicate the physical dimensions and shape of the human head and ear. Finally, there has been a growing interest in live recording both in Japan and in the United States as more and more audiophiles take to the field with high-quality portable stereo cassette decks to record live events, musical or otherwise. As anyone who has tried to do a live stereo recording in the field is well aware, the problem of microphone placement, monitoring of the recording as it is being made, and the like, can discourage even the most enthusiastic of recordists.

After extensive research, JVC (Japan Victor Company) developed and is marketing an unusual headphone/microphone combination they call the *model HM-200E*. A close-up view of this product is shown in Fig. 4. In addition to housing a dynamic-type air-tight headphone, each earpiece is also fitted with an omni-directional electret microphone that is surrounded by a plastic molded "outer ear" or pinna designed to provide much the same frequency response and attenuating characteristics as the human ear. A tiny battery compartment houses a penlight battery for powering the microphone in each earpiece. The cable terminates in three phono-plugs—the usual stereo headphone plug and one single-circuit plug for each microphone.

The robot-looking "head" shown in

FIG. 4—JVC *MODEL HM-200E* contains microphone and baffle combination with characteristics that approximate the human ear.

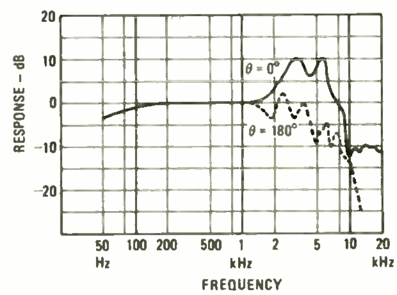


FIG. 5—MICROPHONE FREQUENCY RESPONSE at 0° and 180° with *HM-200E* fitted on human head.

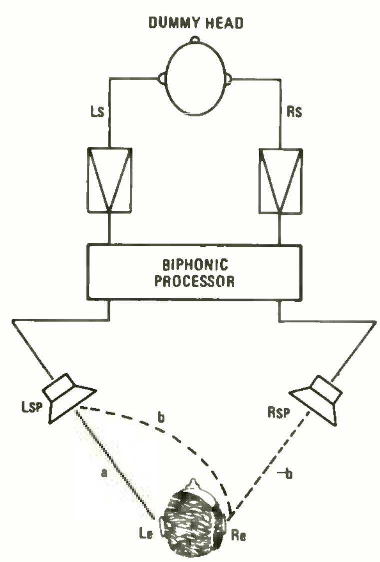


FIG. 6—BIPHONIC PROCESSOR permits binaural reproduction via speakers.

Fig. 4 is actually the microphone stand supplied with each *HM-200E*. It is made of a plastic material coated with a felt-like substance that is intended to approximate the density of a human head. The underside of the head is equipped with a variety of tapped screw-threads to fit any standard microphone stand (including the ⅝-inch standard used in the U.S.). So, the phone/microphone combination can be used to record either while wearing the combination on your *own* head or by mounting them on the supplied dummy head and pointing it in the right direction.

Because the headphones are the sealed or air-tight type, it is even possible to monitor sounds that are to be recorded while recording is taking place without inducing acoustic feedback between the microphones and the dynamic headphone transducers.

While the product may seem rather obvious and simple, a great deal of study went into its development. Primary considerations had to be given to the time difference between the arrival of sounds at each microphone for different incident angles, level–difference characteristics and frequency response. Comparisons had to be made between these characteristics observed on a scientifically accurate "dummy head", the same characteristics as observed when fitting the product on the listener's head, and those characteristics as observed when the product is fitted to the supplied "microphone stand" head. The frequency response at angles of 0 degrees and 180 degrees (the characteristic which enables us to distinguish between "front" and "rear" sounds) of the *model HM-200E* fitted on a human head is shown in Fig. 5.

Binaural sound from speakers

JVC's research into binaural sound has gone much beyond the development of the headphone/microphone system just described. Recognizing that it would be desirable if some of the spatial qualities of true binaural sound could be reproduced via a pair of stereo loudspeakers (or even a quadriphonic array of four speakers), they have developed an electronic processor that, under ideal listening conditions, can actually make it possible to enjoy the effects of binaural sound over a pair of loudspeakers.

As we stated earlier, the problem in listening to binaural sound over speakers is basically one of psychoacoustic crosstalk. *Both* ears end up hearing material intended for one ear alone, and in unprocessed form, binaural sound played over speakers sounds not much better than mono. If, however, precisely calculated amounts of out-of-phase, delayed and frequency-equalized left-channel information could be cross-coupled to the right-speaker channel and vice versa, it might be possible to create the binaural effect even when listening through speakers.

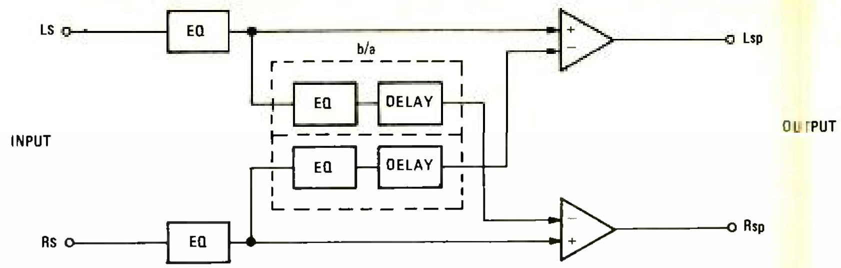


FIG. 7—BIPHONIC PROCESSOR is comprised of equalization and delay circuits.

The principle is shown in Fig. 6 and a simplified block diagram of the binaural-stereophonic processor is shown in Fig. 7. Although the processor does restrict listener position to a very small area in the listening room, we can attest to the fact that it really does work. For the first time in our own listening experience, we were actually conscious of distances from sounds heard, as well as of their angular relationship in space.

Another interesting effect of the binaural-stereophonic processor is the expanded sound field that it gives to conventional stereophonically recorded program sources. As illustrated in Fig. 8, a listener actually feels that sounds are coming from beyond the speakers themselves—an effect that may someday be quite useful, especially in situations where physical distance between speakers in a listening room is less than adequate because of limitations imposed by the room or its decor.

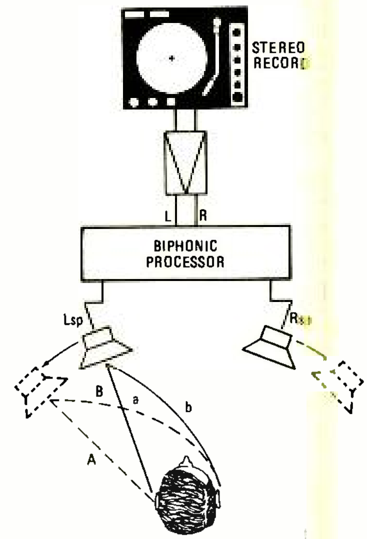


FIG. 8—SOUND FIELD of conventional stereophonic program material is expanded by biphonic processor.

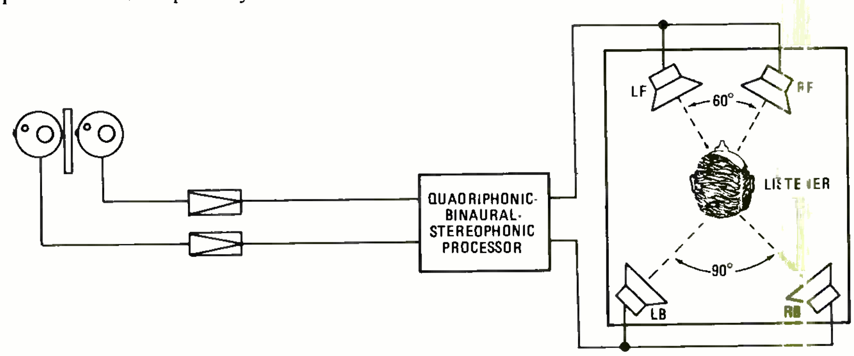


FIG. 9—4-CHANNEL BINAURAL reproduction via speakers is possible with quadriphonic-binaural-stereophonic processor.

Taking the idea a step further, JVC explored the possibility of processing quadriphonically recorded material to create a binaural–listening experience. They concluded that even when binaurally recorded material is played back via the processor over a pair of speakers, sound images that should be localized behind the listener are still localized in a rather vague manner and the listener senses sound images over little more than a 180-degree angle in front of him.

They proposed to solve this problem by what they call a quad-binaural-stereophonic system using dual artificial heads as shown in Fig. 9. Reproduced sounds "heard" by the microphones in the front head are reproduced from speakers placed in front of the listener, while those sounds picked up by the microphones in the rear head are reproduced over the speakers positioned at the rear of the listener. In this listening arrangement, they found that best results are obtained when the front speakers form an arc of 60 degrees with respect to the listener, while rear speakers are positioned at 90 degrees.

Neither of the two processors (the two–channel or four-channel version) is currently available to consumers, though that situation may, of course, change if the company feels that there is growing interest in such unique

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Tomorrow's HI-FI Gear

A look at future hi-fi equipment revealed at conventions in Tokyo and New York.

LEN FELDMAN
CONTRIBUTING HI-FI EDITOR

TRYING TO PREDICT WHAT TECHNOLOGICAL paths the high-fidelity industry will follow in the coming years is, at best, a risky business. An industry that has managed to triple its sales volume in less than half a decade is too dynamic and too diverse to lend itself to firm prophesies, as is evident if one examines the optimistic prognostications made for quadriphonic sound just a few years ago and compare them with the present state of apathy regarding 4-channel sound reproduction.

Nevertheless, two recent events took place within the audio industry that may serve as fairly good indicators of things to come in hi-fi. The first of these was a mammoth consumer high-fidelity show held at the giant Harumi convention center in Tokyo, Japan, that I was fortunate enough to attend, if only briefly. The second event was the annual Audio Engineering Society convention held in New York in the late autumn of 1976 that I also attended. These two events, as far apart geographically as any two happenings could be, had several things in common. Chiefly, they provided a glimpse of products and concepts that we are likely to see brought to commercial reality in the coming months and years. So, rather than devote this story to a single audio development, I would like to briefly discuss several innovative products and ideas that caught my fancy, either in Tokyo or in New York.

Headphones without wires

Popularity of stereo headphone listening has been growing ever since John Koss first introduced his somewhat crude looking stereophones in the late 1950's. One of the disadvantages of headphone listening has been the physical constraints that are imposed upon the listener who wears the phones. The long cable (neatly coiled as it may be) that connects the phones to the familiar front-panel phone jack confines the wearer to a limited area within the listening room (few cables are longer than 10 feet or so). Now, Sennheiser Electronics Corporation has developed a "wireless" set of stereophones that are shown in Fig. 1. While the company had earlier shown a monophonic version of the wireless phones, their introduction of a stereo version occurred at the AES convention mentioned earlier.

FIG. 1—SENNHEISER MODEL HDI-434 infrared stereo headphone.

The phones work on a completely invisible infrared light with a wavelength of 930 nanometers that is frequency modulated by a carrier of 95 kHz for one channel, 250 kHz for the other channel. Pre-emphasis of 50 micro-seconds is used. The transmitter, *model SI-434,* shown in Fig. 2, uses twelve light-emitting diodes to transform the audio signal into infrared light. These special GaAs diodes can be modulated up to several hundred kHz, but 50 kHz deviation has been standardized as the maximum frequency modulation swing for these units.

The audio signal to be transmitted is applied to the transmitter unit by connecting a plug to the normal stereo output jack of the amplifier or receiver. An audio output of 1.5 volts is required for a full 50-kHz deviation of the light carrier. The transmitter is powered by connection to a regular 120-VAC socket. An example of a working transmitter modulator circuit for an audio frequency modulated carrier set to 95 kHz is shown, schematically, in Fig. 3.

FIG. 2—SENNHEISER MODEL SI-434 infrared stereo transmitter.

At the receiver (headphone) end of the system, two dynamic transducers are driven by the built-in infrared light receiver. A switch allows the user to select both phones to be activated by the left channel, the right channel or in the stereo mode. This feature makes it possible for the phones (*model HDI-434*) to be used for two different programs. For example, the original and the translated sound track of a foreign language film could be "received" simultaneously and selectively assigned to both earpieces. One of the two

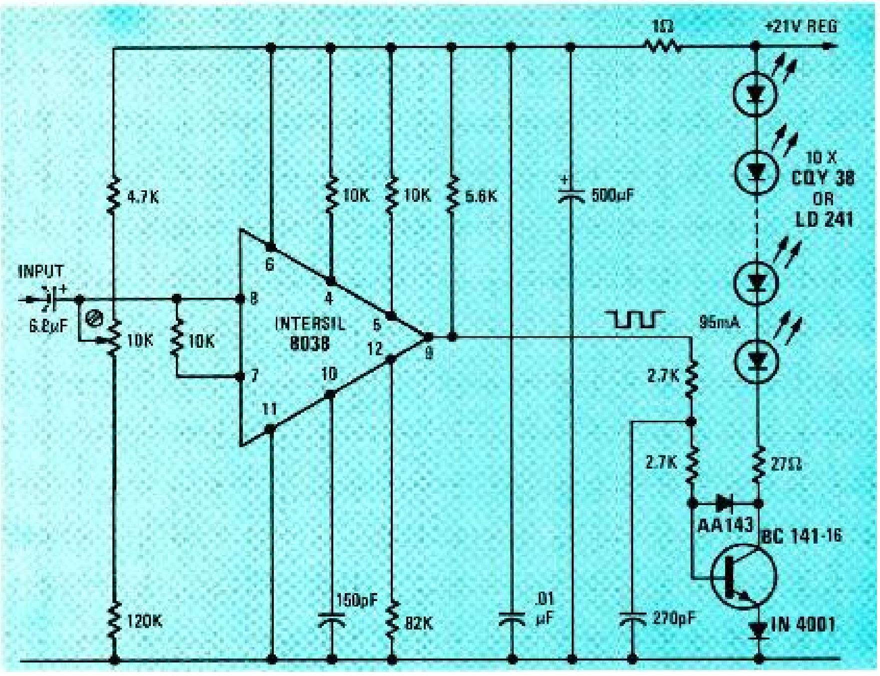

FIG. 3—INFRARED TRANSMITTER uses an IC function generator to frequency-modulate the LED's.

earpieces is also equipped with separate fader/volume controls for left-right channel balancing. A block diagram of the receiver setup for one channel of the headphones is shown in Fig. 4. Tentative pricing for the phones is $209.00 while the infrared transmitter module is expected to sell for around $184.00.

In our visit to Sennheiser's exhibit at the AES show we donned the phones and walked about the rather large room in which the units were being demonstrated. There was no fading whatsoever and, even more significant, unlike RF transmissions that have been attempted in the past for similar applications, there is no audible interference or multipath distortion no matter where one is situated in the room. We were informed that in very large listening areas, additional transmitters can be used in one room without creating problems. The power of the radiated light simply adds together for greater area coverage. A synchronizing jack on each transmitter permits connection of a second transmitter for such cascading of infrared light-emitting units.

Binaural and Bi-Phonic sound

Long before quadriphonic sound was introduced to audiophiles, experimenters (such as Bell Laboratories) had done considerable work with binaural sound reproducing systems. For those not familiar with the term "binaural", Fig. 5 shows the technique.

An artificial or "dummy" head, equipped with a pair of microphones located where our ears normally would be is used to record a live musical or other audible event in the standard two-channel format. When the recording is played back and listened to via headphones, spacial positioning of sounds is extremely precise. (After all, in real life we have only two ears with which to localize the sources of sound we hear and we manage to do so with pin-point accuracy.)

The reason why binaural recordings have not been more popular in the past is because most people prefer to listen to music via speakers rather than headphones and, in order to provide reasonable spatial information using speakers, stereophonic recordings employ microphones that are placed much further apart than the distance between our two ears. This is done to compensate for the fact that the speakers will also be placed far apart during listening and the fact that *both* of the listener's ears will be subjected to sounds from *both* speakers (as opposed to the binaural technique in which the listener hears only left-channel information via a headphone placed on his or her left ear and right-channel information via the right earphone).

One of the persistent problems in conventional stereophonic playback has been the inability to recreate sounds that have perceivable front-to-back localization. Stereo, in effect, creates two-dimensional sound rather than three dimensional sound, as might be the case with classical binaural recording and reproduction. It is this failing of stereo that prompted experiments with quadriphonic sound. But even 4-channel sound, using the usual two up-front, two-in-the-rear speaker placement suffers from an inability to create convincing side images and an inability to recreate accurately those sound images

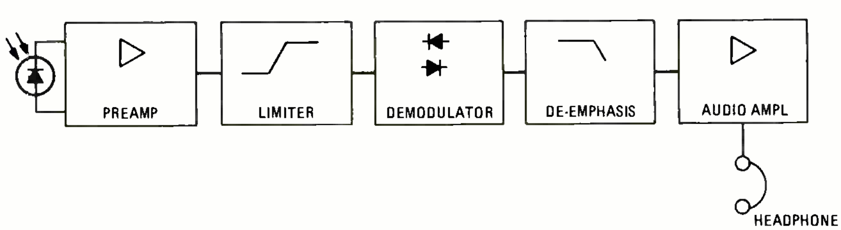

FIG. 4—INFRARED RECEIVER uses limiter and de-emphasis circuits in the same way as a standard FM receiver does.

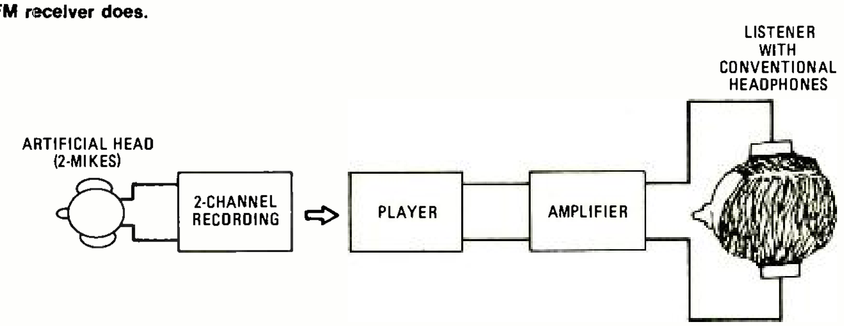

FIG. 5—BINAURAL SOUND SYSTEM provides precise spatial positioning of sounds.

that were intended to be close-in to the listener.

At the Tokyo high-fidelity show, a major portion of JVC's exhibit space was given over to demonstrations of two newly developed recording and reproducing systems. The first of these is known as Bi-Phonic (short for Binaural-Phonic) and involves the playing of tapes or discs that have been recorded in the classical binaural method (using dummy head equipped with microphones instead of ears). Interposed between the record or tape player and the amplifier which drives a pair of loudspeakers is a device called a "Bi-Phonic Processer". This processor transforms binaural signals into stereophonic signals by means of a complex equalizing and time delay system. The effect produces a convincing sound field from only a single pair of loudspeakers that actually "wraps" sound around the listener over at least a 180 degree arc. A simple block diagram of this approach is shown in Fig. 6.

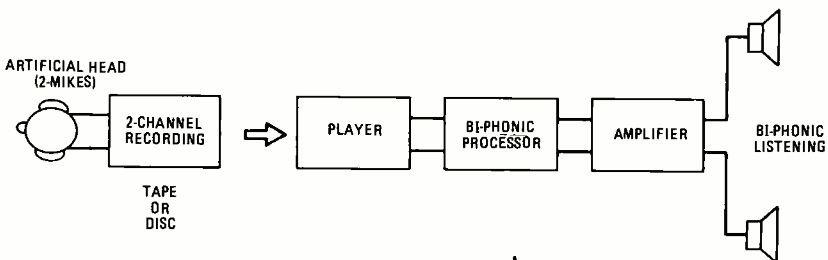

FIG. 6—BI-PHONIC SOUND SYSTEM is similar to binaural system except that speakers are used for playback rather than headphones.

Taking the binaural-to-stereo approach a step further, JVC also demonstrated a system they call Q-Bi-Phonic. In this system, two artificial heads are used. They are placed in close proximity—12 to 15 inches apart. Both face forward (towards the performance) and there is a special baffle between them. The front head is clearly forward oriented, while the rear head is less so, because of the interposed baffle. Each head produces a pair of binaural signals. Rather than being played back in binaural fashion, each pair of signals is fed through a special processing unit that again incorporates equalizing and time delay circuits to produce two pairs of signals. These signals are then suitable for quadriphonic loudspeaker presentation. This processor effectively produces a "binaural-to-quadriphonic" transformation, thus enabling the artificial head signals to be played back over loudspeakers set up in a normal 4-channel array. A block diagram of the Q-Bi-Phonic arrangement is shown in Fig. 7.

Bi-Phonic and Q-Bi-Phonic both represent elaborations on stereo and quadriphonic technology. Based upon our own listening tests, both systems require that the listener be located within a fairly small area along the axis of left-right symmetry. This is essential because the spatial phasors produced by either the Bi-Phonic or Q-Bi-Phonic processors cannot be accurately recreated over a wide lateral range. Listeners who are not located close to the axis of symmetry will, however, hear the traditional stereo or quadriphonic sound as they would normally be perceived.

Our experience with these two new approaches to sound recording and reproduction suggest that both offer considerable challenge in the recording studio for innovative record producers. We were treated to some very spectacular effects using these systems, particularly in the case of the Q-Bi-Phonic system, and, from all indications, JVC's American counterpart intends to promote this idea in the United States within the near future.

PWM audio amplifier

Switching back to this side of the world and the AES convention, we listened to a paper delivered by Mr. T. Suzuki, of the Sony Corporation, that concerned the development of a highly efficient audio amplifier using pulse-width modulation (PWM) instead of the conventional linear, analog signal amplification. If this sounds somewhat like the Class-D amplifier approach that was recently introduced in this country by Infinity Systems Corporation, it is, except that in Sony's version they have incorporated the new verticalfield-effect power transistors in this amplifier. Sony maintains that the vertical-FET, with its wide area of safe operation, excellent high-frequency response and good pulse-response due to absence of storage time in signal transfer, is particularly suited to the so-called Class-D amplifier design.

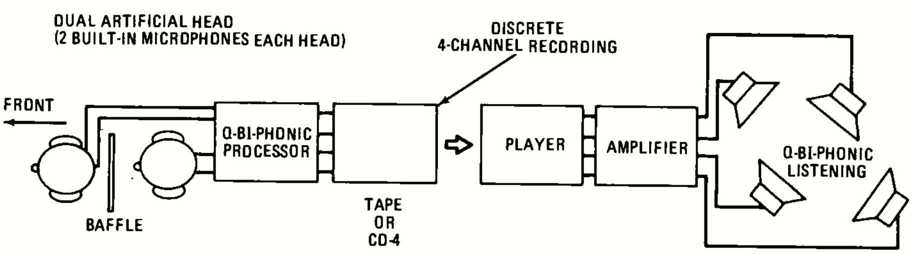

FIG. 7—Q-BI-PHONIC SYSTEM is the 4-channel version of the bi-phonic system.

The basic pulse-width modulation amplifier is shown in the simple block diagram of Fig. 8. The amplitude of the

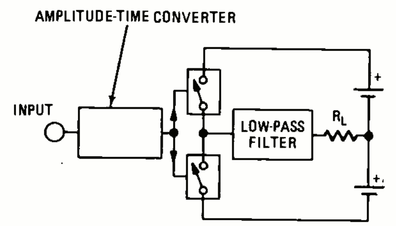

FIG. 8—PWM AMPLIFIER uses an amplitude-time converter to pulse-width modulate the output stage.

input audio signal varies the width of pulses by an amplitude-time converting circuit. The pulse signal then controls the switching elements of the power stage. The output of the power stage is passed through a low-pass filter to the load. Since the power stage is either the saturated or cut-off, there is, in theory, no loss of energy in its operation. Compared to a conventional linear amplifier, this system requires an additional amplitude-time conversion circuit and a low-pass network. In addition, since it is called upon to handle squarewave signals, suppression of unwanted RF radiation becomes necessary to make the amplifier commercially practical.

A more detailed block diagram and waveform diagram is shown in Fig. 9. A squarewave generator is used as the source of the high-frequency switching signal. The carrier is converted to a triangular waveform by means of an integrator circuit. This triangular-shaped carrier is added to the audio input signal and passed through a saturating high-gain amplifier to obtain a series of pulses whose time duration is directly proportional to the amplitude of the input audio signal. These pulse signals are then amplified by a pulse amplifier power stage and then demodulated by means of a low-pass filter. Suppression of the high-frequency switching carrier and its sideband components is also accomplished by the low-pass demodulating filter though, in a practical realization of the amplifier, extensive shielding of the entire amplifier was required to prevent RF radiation.

The particular prototype that was shown was no larger in size than a small preamplifier and yet was able to produce in excess of 100 watts-per-

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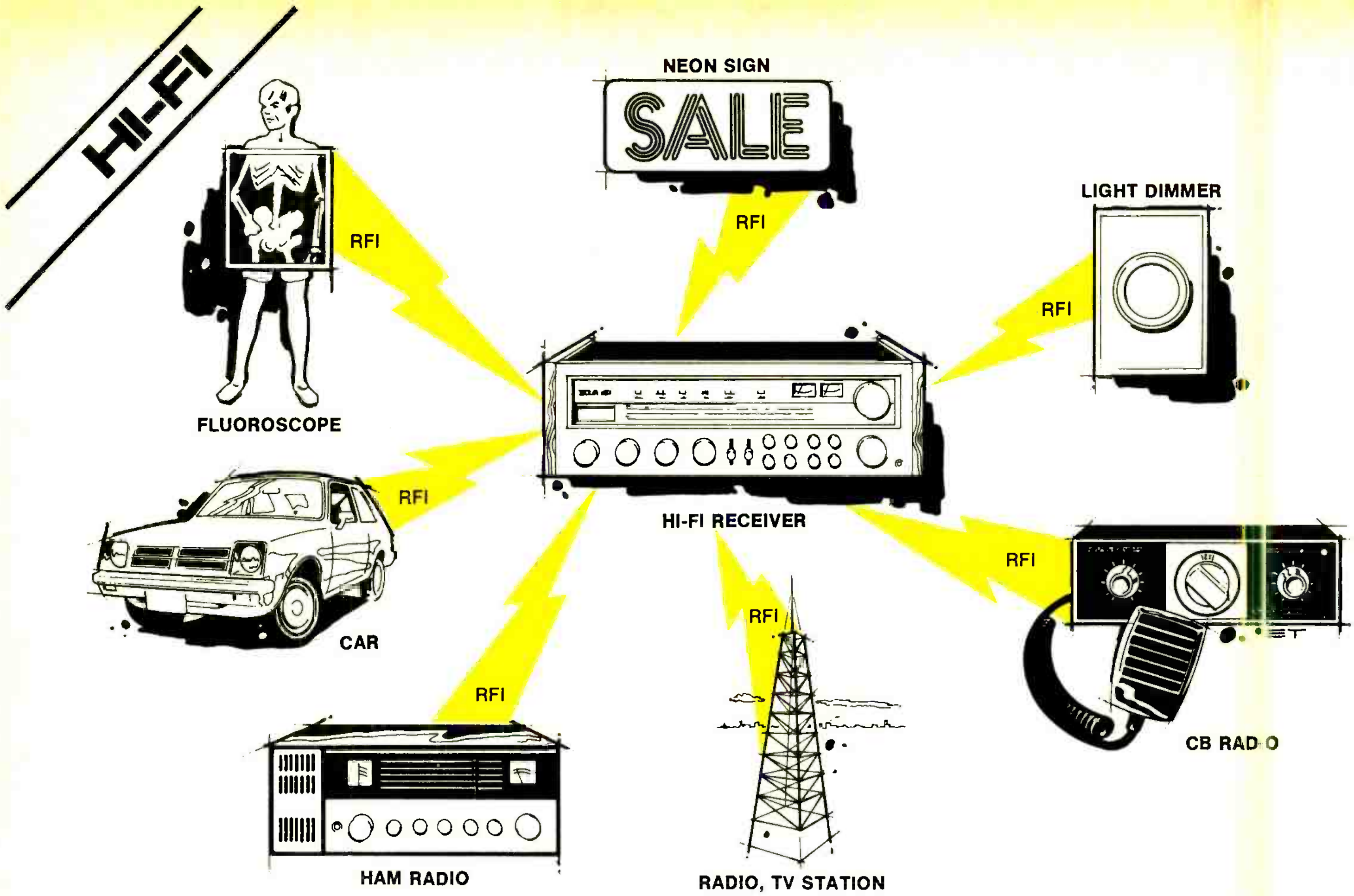


Getting Rid Of RFI

Don't despair when RF interference invades your hi-fi system. Here are some steps you can take to get rid of it.

LEN FELDMAN
CONTRIBUTING HI-FI EDITOR

IF YOU SUDDENLY HEAR A "GOOD BUDDY" warning of the imminent approach of Smokey over your expensive stereo hi-fi system while you are trying to audition a disc, don't get the idea that you are being singled out as a solitary victim by your neighborhood CB'er. You are just one of hundreds of thousands of victims of RFI (*R*adio *F*requency *I*nterference). In the last year alone, the FCC has received nearly 100,000 complaints regarding interference that degrades TV performance, intrudes upon the sounds of hi-fi and generally makes owners of home entertainment equipment miserable. In most cases, the FCC is powerless to do anything about the problem, especially since this sort of interference can and does take place even when the offending transmission equipment is operated within legal power limits. Even in cases where CB'ers use linear amplifiers to increase radiated power beyond authorized limits, the FCC is so understaffed (and CB usage has been proliferating at such a fast clip) that they would not be able to look into a specific complaint for months, if at all.

The Consumer Electronics Group of the Electronics Industry Association (EIA) has been considering this growing problem for some time and recently, they prepared a comprehensive booklet entitled *Electronic Technician's Interference Handbook, Audio Rectification.* Much of the material contained in this article is paraphrased from the final draft of that booklet, while some comes from personal experience with the problems of interference we have encountered over the past few years ourselves.

The most common type of audio interference encountered in hi-fi (and occasionally in TV) equipment found in the home is due to a phenomenon known as audio rectification. Audio rectification is the detection of modulated RF signals by an audio circuit of a radio, preamplifier, amplifier, or tape deck electronics that appear as unwanted or disturbing audio signals at the speaker output terminals. Since not all RF interference is created by RF transmitting equipment, the most common forms of interference can be divided into two groups: signals emanating from RF transmitting sources (radio or TV stations, amateur radio operators, CB operators, paging systems) and interference from electrical equipment or appliances (X-ray and diathermy equipment, neon signs, light dimmers, thermostats, commutators and switches).

The first category of equipment is usually not within direct reach of the "victim", and curing of interference problems from RF transmitting equipment is largely confined to working on the actual equipment experiencing the interference. The second category is more likely to be located within your house or apartment and, by turning off the suspected interfering source, it can at least be localized and identified.

Interference from the first group will prove more difficult to diagnose, because its point of entry into an audio device can be anywhere from the antenna to the speakers. Interference can be picked up by long connecting cables acting as antennas or a component acting as a detector, or it may be transmitted through the AC power lines, especially if the source of interference is in the same building as yours. Detection will then take place in the power-supply circuit of the audio equipment with the same disturbing effect on the listener.

Since the majority of interference problems occur because of nearby interfering equipment, there is little point in taking your receiver, amplifier or other equipment to a factory or authorized warranty service station. The technician at such service centers will be completely frustrated in trying to solve the problem remotely, because it would be impossible to duplicate the problem. Audio rectification happens with the best of equipment, and its absence is no indication that one piece or brand of equipment is better than another. In fact, equipment with higher sensitivity and gain is a better prospect than some inexpensive, low-gain audio equipment.

Correcting external interference

Before digging inside your receiver, amplifier or tape deck, there are several simple remedies you should try first. Check connecting audio (shielded) cables and replace overly long ones with shorter ones, wherever possible. If the interference is noticed only when the pick-up arm or the turntable is touched, a ground wire between the pick-up arm and preamplifier chassis ground is called for. If the phonograph pick-up headshell is bakelite or plastic, a small piece of foil or metal between the cartridge and headshell that is grounded to the metal portion of the pick-up arm or to the metal base of the turntable, may help. (See Fig. 1.) If the metal or

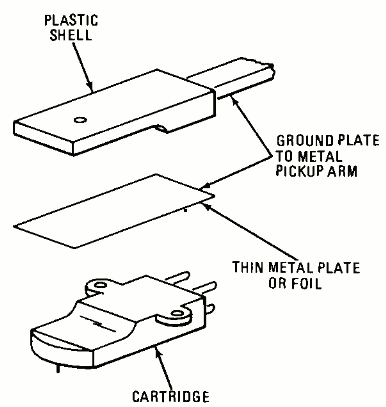


FIG. 1—GROUND PLATE between cartridge and pick-up arm may reduce interference.

foil alters the tracking force, this should be readjusted to maintain proper cartridge performance.

If the interference occurs when holding a microphone (but not when you place it on a table), a ground wire between the microphone shell and the preamplifier or amplifier chassis is called for. A "buzz" recorded on tape when using a hand-held microphone can also be caused by a defective or poorly shielded microphone, but this can be verified by making a recording in a location where the identified RFI is not present.

Interference is often caused by long speaker cables that can act as an antenna. In some extreme cases of strong RFI, the interference persisted (and was heard over the speakers) even after the entire system was turned off! Replacing unshielded speaker cables with shielded cable or installing a small capacitor across the speaker will often cure this problem. The audio purist will, of course, object to altering the load seen by the amplifier in this manner, but most modern amplifiers can tolerate fairly large values of capacitance across speaker terminals before oscillation occurs. Even so, it would be a good idea to check with a scope connected across the speaker terminals for any evidence

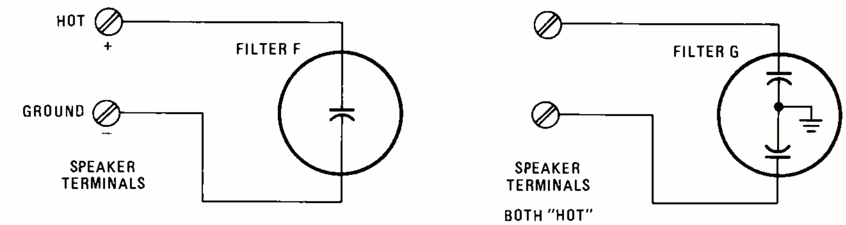


FIG. 2—LONG SPEAKER WIRES can act as a receiving antenna for RFI. Capacitors mounted across speaker terminals will eliminate this problem. Normal connection is shown as Filter F, and Filter G shows connection for strapped amplifiers.

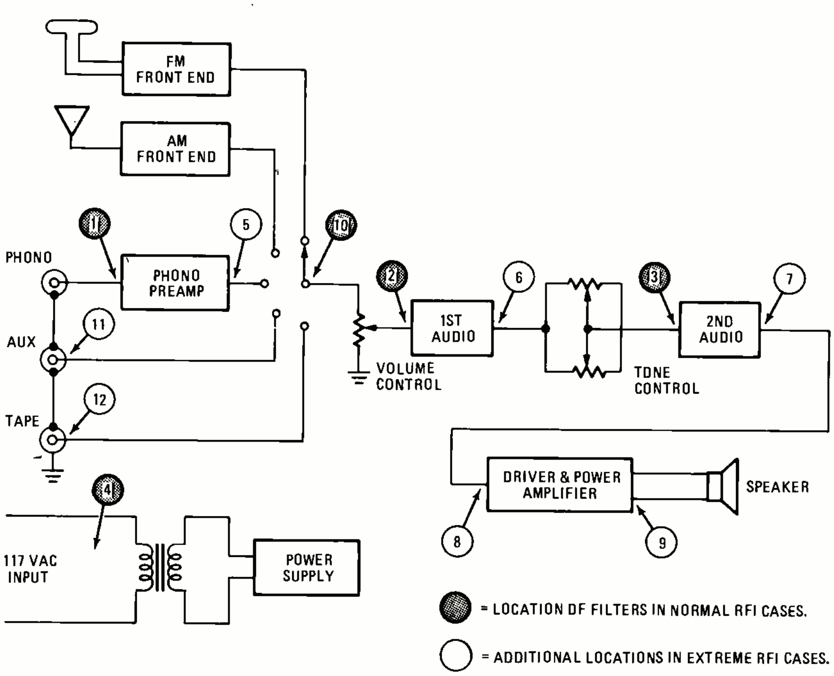


FIG. 3—FILTER LOCATIONS in AM/FM/phono equipment.

of oscillation before you run into a case of blown tweeter voice coils!

If you want to play things completely safe, you might try increasing the capacitance across the speaker terminals (while observing the scope trace) until evidence of high-frequency oscillation just begins. Final total capacitance should then be no more than half of the value required before oscillation takes place. Where speaker output terminals of the amplifier consist of a "hot" and a "ground" terminal, the capacitor should be connected as shown in Fig. 2-a. If both terminals at the output of the amplifier are "hot", use the configuration shown in Fig. 2-b, recalling that each of the two capacitors involved must be double the required value previously determined as needed to stop the interference. Such arrangements where both terminals are "hot" occur in some amplifiers that have been "strapped" for higher power (as in the case of some quadriphonic units that can be switched to 2-channel operation for increased output power.

Internal equipment modifications

If the few corrective steps enumerated above fail to eliminate or sufficiently reduce audio rectification, it's time to look inside your amplifier, receiver, preamp or tape equipment and to check for a few obvious causes. Check first for bad ground connections and poor solder joints. Sometimes, electrolytic capacitors that have been in service for many years develop a high internal-resistance. Paralleling a fresh capacitor across the suspected one will eliminate this as a possible source.

If the interference still persists at this

TABLE I—RFI TROUBLESHOOTING CHART FOR AM/FM/PHONO EQUIPMENT.

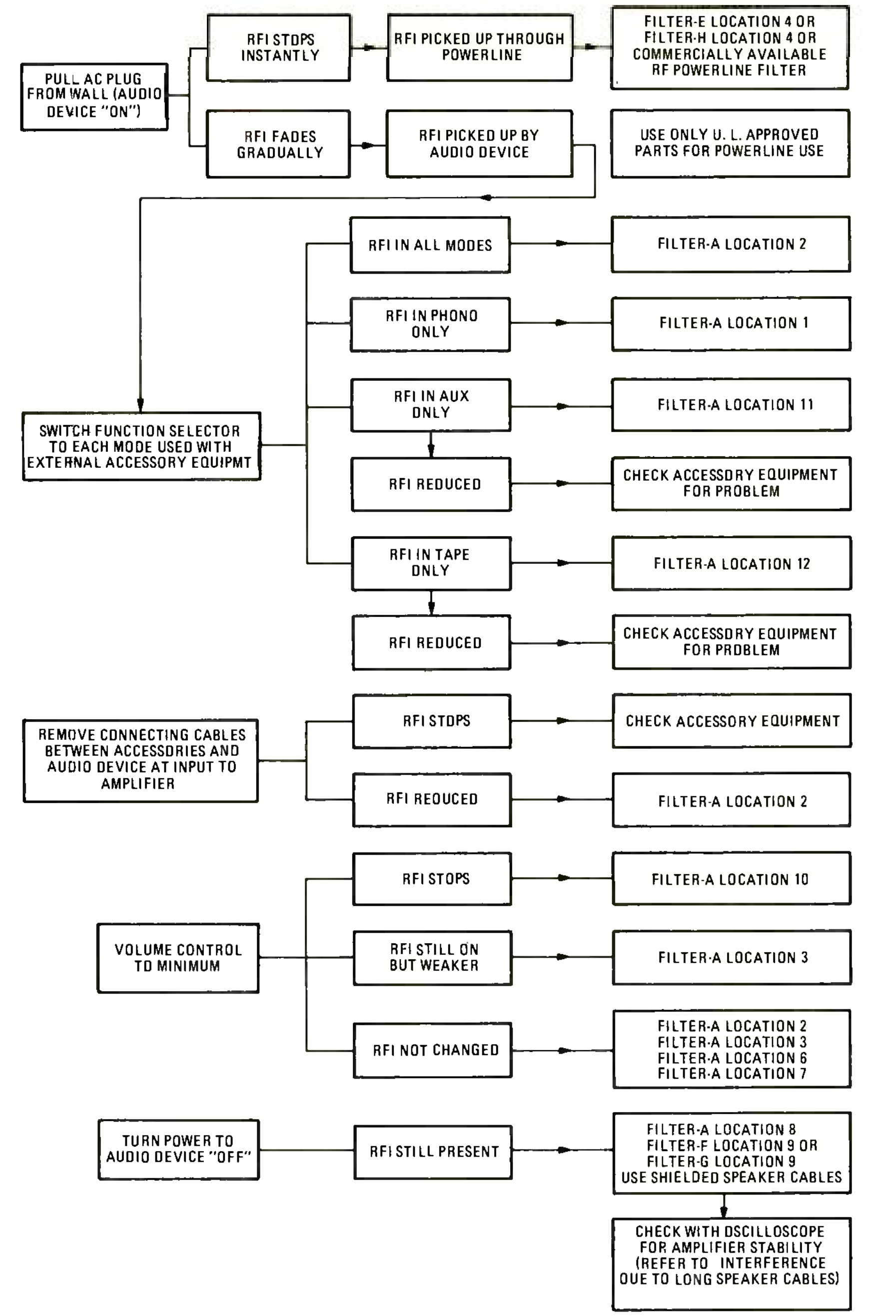
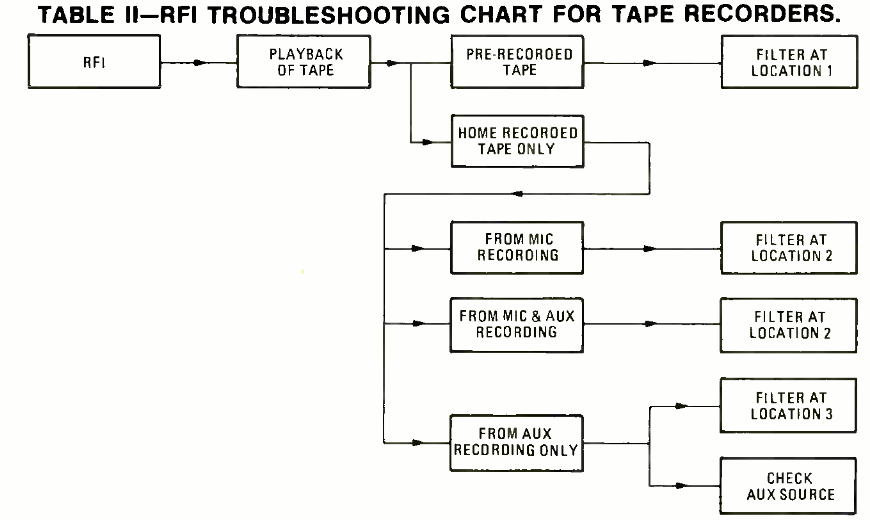


TABLE II—RFI TROUBLESHOOTING CHART FOR TAPE RECORDERS.



point, it's time to consider adding one or more filter networks. Table I is a troubleshooting chart that will help you to isolate AM, FM and phono interference-problems logically. Associated with Table I is Fig. 3, which is a simplified block diagram of a typical home hi-fi installation. The circled numerals indicate points of insertion of various filter circuits as called out in Table I. Filters are designated by the letters A through H.

Table II is a troubleshooting chart designed to help you analyze and correct RFI problems that occur in connection with the use of tape equipment, and Fig. 4 shows the location of possible corrective filters. The filter identified as "A" should be used for correcting tape RFI problems.

Filter networks

The most effective RFI filter from practical experience, is a "pi" filter-network consisting of a series RF-coil and two shunt capacitors. Suggested values for this filter, designated as Filter A in the troubleshooting chart of Table I, are shown in Fig. 5.

In mild cases of RFI, a single bypass capacitor between the base and emitter may be sufficient. This configuration is designated as Filter B in Fig. 6. Another fairly effective way to suppress RFI is through the installation of an L-type filter in the collector circuit, shown as Filter C in Fig. 6.

A coil inserted in series with the emitter leg of an audio input transistor, as shown in Fig. 7, may help in very mild cases of RFI. If such a remedy is used (Filter D), the coil should not be bypassed. This filter is the least desirable because of difficulty of installation in printed circuits and because of the possibility of oscillation that might take place in some circuits after it is installed.

Filters designated as E and H are generally used when it has been ascertained that RFI is coming in through AC power lines. Wiring diagrams for these two filters are shown in Fig. 8. In cases where the line cord is part of an indoor antenna system, there may already be a pair of coils wired in series with each side of the line cord. In that case, either Filter E or Filter F should be wired between these existing coils and the primary of the power transformer, as shown in Fig. 9.

Filters F and G have already been discussed and illustrated (see Fig. 2) in relation to speaker-cable pick up of RFI.

Filter installation

Several precautions should be observed whenever adding any of the filters illustrated. Install the filter network as close to the input of the audio stage that follows the so-called RFI

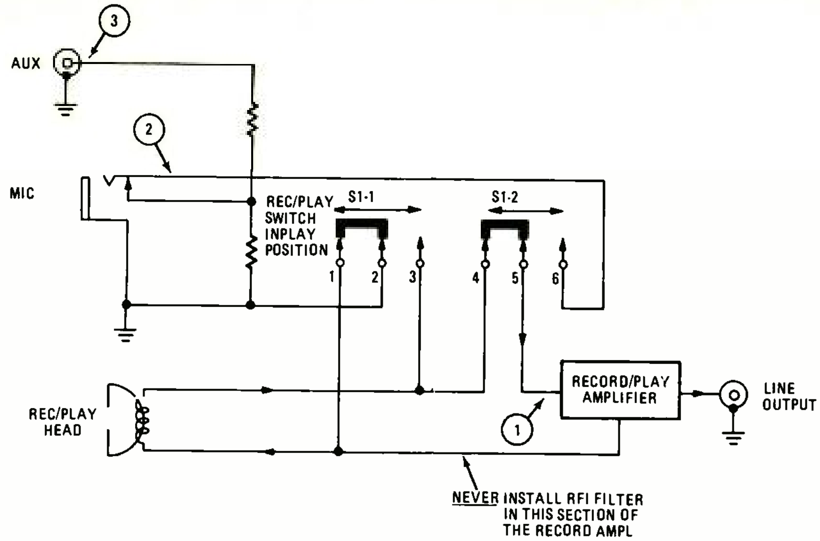


FIG. 4—FILTER LOCATIONS in tape recorders.

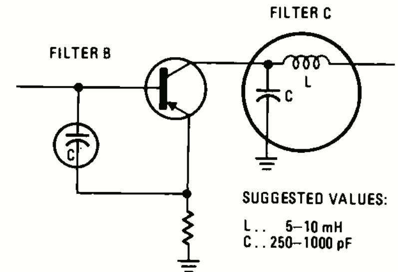


FIG. 6—FILTER B AND FILTER C. Filter B consists of single bypass capacitor between base and emitter. Filter C is an L-type filter in the collector circuit.

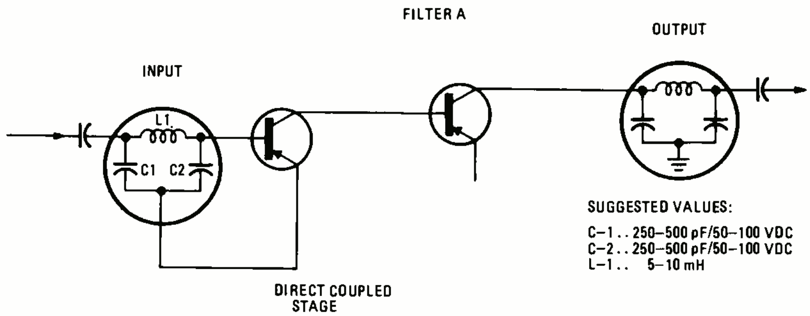


FIG. 5—FILTER A is a pi-filter network, which is very effective in the reduction of RFI. This network is usually inserted in the base and collector circuits.

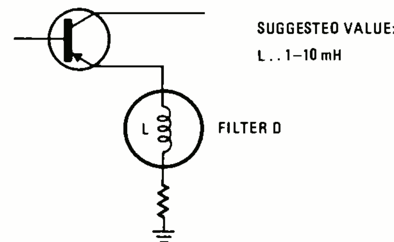


FIG. 7—FILTER D consists of a coil inserted in the emitter circuit.

pickup point (close to the base of the transistor or grid of a tube in the preamp of a receiver, for example). Use physically small components; small ceramic capacitors are preferable to paper capacitors. Keep all capacitor and coil leads (ground leads as well as "hot" leads) as short as possible. Long leads may compound the RFI problems instead of solving them. Install only as many filters as are found to be absolutely necessary. Too many filters may also do more harm than good.

It is advisable to run a frequency response check before and after filter installation to make sure that RFI filters have not changed gain or frequency response of the audio component significantly. A capacitor value that is suitable in a low-impedance circuit will not be a good choice in a high-impedance circuit.

IC's often pick up RF interference. Because of the feedback circuits incorporated in many IC applications, RFI filters should be installed both at the signal inputs and outputs of IC's, where they are suspect.

If RFI originates at the tape recorder source only, it must be determined whether it shows up only during playback of home recorded tapes or on commercially recorded tapes as well. In the former case, the RFI is actually recorded on the tape itself and will be heard whenever or wherever that tape is played back. A filter at the microphone preamp input will be necessary in such cases.

To avoid ground loops, shunt and bypass capacitors should be grounded to the emitter of the transistor when such filters are installed in the base circuit of a transistor stage.

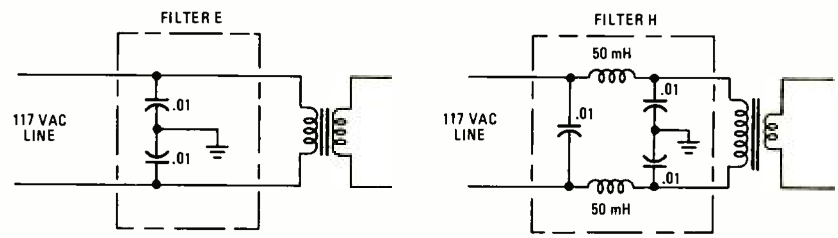


FIG. 8—FILTER E OR FILTER H should be used when the interference is coming through the AC power line.

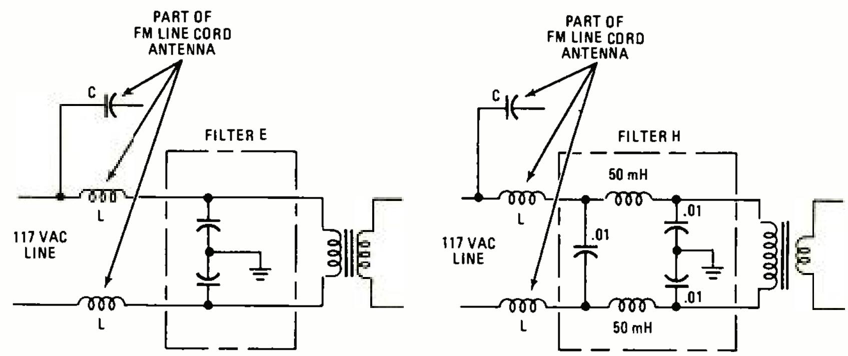


FIG. 9—CONNECTION OF FILTERS E AND H when coils are already attached to the AC power line, as is the case when the power line is also being used as an indoor antenna.

Safety comes first

In your eagerness to solve your RFI problems, don't overlook the importance of component safety. Use only U.L. approved components, especially when installing filters *across* the power-line input of the equipment. Capacitors rated at 400 VDC are *not* safe for 120 VAC. Capacitors must be rated specifically for line bypass applications and suitable for continuous operation at 125–150 VAC, RMS, 60 Hz. Mount components carefully to avoid possible shorts or arcing.

RF chokes are made by several

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Radio-Electronics Tests Garrard GT-55 Turntable

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CIRCLE 99 ON FREE INFORMATION CARD

LEN FELDMAN
CONTRIBUTING HI-FI EDITOR

IT IS NOW SOME SEVEN YEARS OR SO SINCE THE Garrard division of Plessey Incorporated first introduced their *model Zero-100* multiple-play turntable. That unit had the distinction of being the first model that provided true tangential tracking of the pickup arm as the arm was pivoted across the surface of a record. Tracking error of a cartridge's stylus had long been recognized as one of several distortion producing causes in record reproduction and Garrard sought to eliminate this source of distortion. The only other way to eliminate this form of distortion is by constructing a pickup arm that travels across the record while remaining parallel to the grooves, as is now the case for the Rabco (Harmon-Kardon) *model ST-7* and the Bang & Olufsen Beogram *model 4002*. Both of these models sell for considerably more than the new *GT-55*.

The new *GT-55* is shown in Fig. 1. It features a newly designed magnesium lightweight pickup arm that rides on jewelled vertical-pivot bearings and horizontal ball-bearings. While the headshell is a permanent part of this arm, a slide-in cartridge carrier, equipped with four slide-contacts, is removable and it is this carrier that retains the cartridge. A separate plastic stylus-alignment gauge is supplied for positioning the cartridge in the carrier to provide optimum stylus positioning and overhang.

Pickup arm balance is achieved by means of a counterweight that is screwed into the rear of the arm. When balance is achieved (with cartridge mounted), a rotatable indexing ring on the counterweight is set to zero. The entire counterweight is then screwed forward until the index reads desired downward tracking force, in grams.

A magnetic anti-skate control on the base of the turntable is completely free of mechanical linkage to any portion of the pickup arm and uses a magnet of varying diameter that is wrapped around the base of the arm. The anti-skate control has two calibration scales: one for use with elliptical stylus cartridges, the other for cartridges equipped with CD-4 (Shibata, etc.) stylus tips.

A cueing-speed control is located on the base, beneath the center of the arm, and permits the user to adjust the rate of descent or ascent of the pickup arm when the cueing lever is used. Further along the base is a lever that locks or releases the arm from its rest post.

Four lever operated controls are located at the right front of the turntable base. A detailed view of these controls is shown in Fig. 2. The leftmost lever is the CUE control.

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The second lever, labelled AUTO, is used to initiate the playing cycle and to reject a record at any time during play. The SIZE lever selects record sizes (7, 10 or 12 inches) so that the pickup arm is properly indexed. The rightmost MODE lever has an OFF position, as well as positions for MANUAL play, AUTOMATIC (multiple play) and REPEAT play. When repeat play is selected, a single record will be replayed so long as the MODE switch is left in this position or, in the case of a stack of records, the last record in the stack will be repeated until some other mode is chosen.

At the lower left of the turntable base is a SPEED lever that selects 33⅓ or 45 RPM, and a continuous control that varies the selected speed by ±3%. (See Fig. 3.) The speed and

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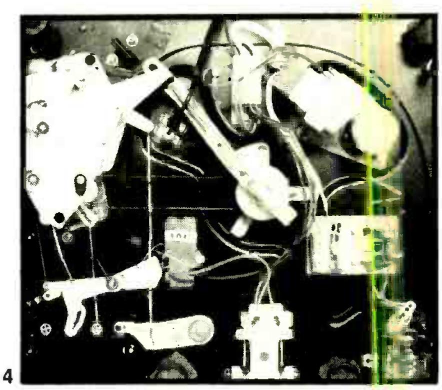
pitch controls are completely electronic. Unlike Garrard's earlier "zero-tracking" models, the *GT-55* is belt driven by a DC servo-controlled motor. The center front of the turntable base has a viewing window for strobe markings that can be seen for precise speed adjustment. Illumination of the strobe markings is provided for.

The underside view of the *GT-55* shown in Fig. 4 reveals that the designers of this unit have been able to considerably simplify the mechanism over previous models. The DC



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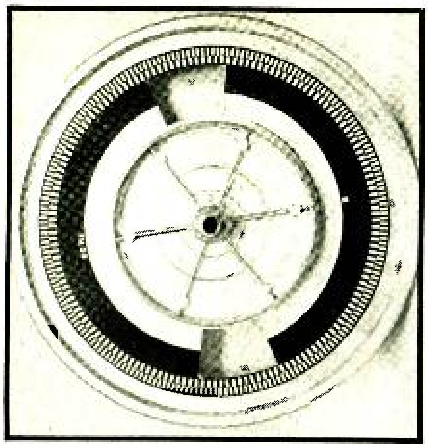
motor, near the upper right in the photo, is connected to an electronic circuit board that provides speed regulation. A secondary belt may be observed running from the turntable center-spindle leftward to the cycling and pickup arm linkages.

The platter itself, viewed from the underside in Fig. 5, is a dynamically balanced die-cast zinc-alloy unit. The two cutouts visible in

MANUFACTURER'S PUBLISHED SPECIFICATIONS:
Platter Diameter & Type: 11½-inches, die-cast, zinc-alloy, dynamically balanced. **Platter Weight:** 4.0 lbs. **Drive Motor:** 1000 RPM DC servo-controlled. **Drive System:** Belt. **Speeds:** 33⅓ and 45 RPM, with variable (±3%) pitch control. **Pickup Arm:** magnesium, with articulated (constant tangent) headshell. **Balance & Tracking Force:** adjustable counterweight. **Anti-skating Adjustment:** magnetic, with settings for elliptical and CD-4 stylus shapes. **Pickup Arm Friction:** Vertical: 20 milligrams; Horizontal: 30 milligrams. **Effective Pickup Arm Mass:** 19 grams (assuming 5 gram cartridge). **Minimum Tracking Force:** 0.75 grams. **Tracking Force Range:** 0 to 3.0 grams. **Wow and Flutter:** 0.05%. **Rumble:** –66 dB (DIN "B"). **Cueing:** adjustable speed, damped in both directions. **Maximum Record Stack:** 6. **Dimensions:** (chassis) 15 5/16 W × 14⅛-inches D. **Height Above Motor Board:** 4⅜-inches. **Clearance Below Motor Board:** 1⅞-inches. **Weight:** 16 lbs. **Suggested Retail Price:** $249.95. (Optional Base BW-40: $15.95; Dust Cover D-40: $9.95. Optional Combination Base & Dust Cover, BDC-8: $39.95).



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the photo permit relatively simple installation of the flexible rubber drive-belt after the turntable has been mounted on the center spindle. Multiple-play as well as single-play spindles are supplied with the unit, as is a 45 RPM adaptor. A rear support post combines with the multiple-play center spindle to provide two-point support when stacking records.

Laboratory measurements

There are really only three measurements that are significant when measuring performance of a turntable. These are speed accuracy, signal-to-noise, and wow-and-flutter. Although Garrard does not specifically say so, we presume that their wow-and-flutter specification was measured on the basis of a WRMS (Weighted, Root-Mean-Square) measurement, and our measurements were made accordingly. On that basis, we did a bit better than Garrard claimed, measuring 0.04% as opposed to the claimed 0.05%.

As for rumble, using the DIN "B" weighting curve, we read an excellent –68 dB as opposed to the –66 dB claimed. By way of comparison, we should note that the best readings we have ever obtained for rumble (with the most expensive, single-play direct-drive turntable systems around) were just above –70 dB.

Once the 33⅓ RPM speed was adjusted by means of the PITCH control, we detected absolutely no drift in speed over a test period of one hour. Line-voltage variations of ± 10% (from 120 volts) similarly had no effect on speed accuracy. The PITCH control on our sample provided +3.5% and –4.0% variation, somewhat greater than that specified. A complete listing of our laboratory measurements appears in Table I.

Use and listening tests

We used the Garrard *GT-55* with a variety of phono cartridges, ranging from a CD-4 type that required 2.0 grams of downward tracking force to a moving-coil type that normally is intended to track at less than 1.0 gram. Each of these cartridges was accommodated with no problem and tracked very well at recommended forces. The record changing cycle of the *GT-55* is extremely smooth and noise free and we noted that there was considerably less "drag" on the drive mechanism during the cycling than we were accustomed to seeing with other multiple-play machines. Cueing-lever action is precise and we were able to interrupt play of records and resume playing with a maximum error of no more than one groove width.

It is difficult to ascribe the low distortion reproduction we heard to any one feature of the *GT-55*, and we must take the company's word for it that tangential tracking is an important factor here. But, whatever the contributing design factors, we must complement the designers of this "second generation" Garrard turntable system for having succeeded in a total redesign that seems trouble free and, in our opinion, is capable of providing years of reliable record playing service.

Our overall product evaluation will be found in Table II, together with summary comments regarding our reaction to the GT-55. **R-E**

TABLE I

RADIO-ELECTRONICS PRODUCT TEST REPORT

Manufacturer: **GARRARD** Model: **GT-55**

TURNTABLE SYSTEM MEASUREMENTS

PERFORMANCE CHARACTERISTICS	R-E Measurement	R-E Evaluation
Wow-and-flutter (% WRMS)	0.04	**Excellent**
Rumble, unweighted (dB)	50	**Very good**
Rumble, (DIN weighted "B") (dB)	68	**Very good**
Speed adjustment range (±%)	+3.5, –4.0	**Useful**
Speed build-up time (rotations)	<1.0	**Excellent**
COMPONENT MATCHING CHARACTERISTICS		
Tracking Force Range (__ to __ grams)	0-3	
Anti-skating Force Range (__ to __ grams)	0-3	
Available speeds (RPM)	33⅓, 45	
Drive System	Belt	
Motor Type	DC servo	
Power Requirements	<10(watts)	
Pick-up arm wiring capacitance (per channel) (pF)	23	
MISCELLANEOUS EVALUATIONS		
Adequacy of Controls		**Excellent**
Automatic features, performance		**Very good**
Speed stability		**Superb**
Vertical pickup arm friction		**Good**
Lateral pickup arm friction		**Good**
Quality of Construction		**Excellent**
OVERALL TURNTABLE SYSTEM RATING		**Very good**

TABLE II

RADIO-ELECTRONICS PRODUCT TEST REPORT

Manufacturer: **Garrard** Model: **GT-55**

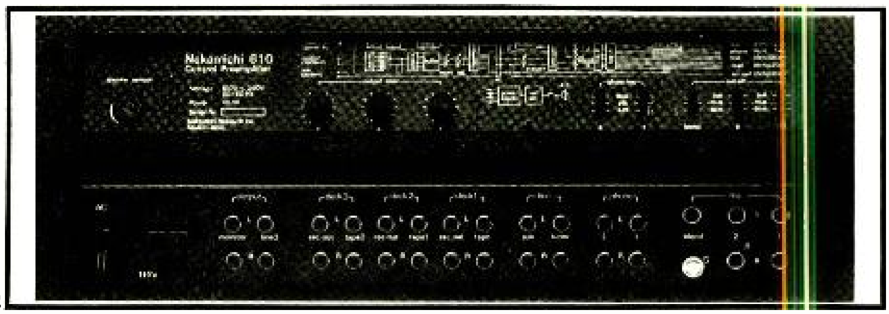
OVERALL PRODUCT ANALYSIS

Retail price	**$249.95** (Base and dust cover are extra.)
Price category	**High**
Price performance ratio	**Very Good**
Styling and appearance	**Excellent**
Sound quality	**Excellent**
Mechanical performance	**Excellent**

Comments: Garrard's emphasis of their articulated pickup-arm head is, perhaps, unfortunate, for there is so much else going for this totally redesigned unit that readers of their literature may lose sight of its other virtues. The departure from a synchronous motor (however many poles it might have) to a DC servo motor that is electronically controlled is, to us, a more significant breakthrough. The low mass magnesium pickup-arm is another significant breakthrough that would be important even if it did not include the "true-tangent" feature. Belt drive for a multiple-play turntable system is no longer unique, but Garrard's excellent execution of this principle, plus their use of a second belt to actuate the pick-up arm cycling and motion, is an improvement over earlier linkages and results in one of the smoothest changing cycles we have ever seen. Truly, their claim that the pickup arm is handled more gently than could be done by the steadiest of hands is well founded. The one thing we wish Garrard had been able to achieve with their new design is somewhat simpler installation. The typical purchaser of a multiple play turntable is, perhaps, not as sophisticated or mechanically inclined as is the purchaser of a single-play machine and confrontation with the many "loose parts" (including the platter, the C-ring that must be removed and replaced, the belt which must be properly installed and the center-spindle which must be pre-lubricated) may be discouraging to some. Once the installation has been accomplished, however, the GT-55 performs extremely well, has fewer parts that can go wrong than did its predecessor, and measures well in all the major areas that determine ultimate turntable performance.

Nakamichi 610 Preamplifier


1



2

NAKAMICHI RESEARCH, INC., IS BEST KNOWN IN this country for their high-performance stereo cassette decks. The foremost deck in their line is the *model 1000*—a three-headed deck that has, in the few years since its introduction, become the standard machine against which all others are compared. More recently, the company has begun to produce other audio products such as monitor loudspeakers, microphones, phono pickups and now, wholly electronic components such as a power amplifier and the preamplifier control unit that we tested for this report.

The *model 610*, shown in Fig. 1, is a sloped unit that provides excellent visibility and accessibility to its operating controls and switches when positioned on a table-top. Centered at the top of the unit are two peak level meters that are calibrated over a wide range, from −40 dB to +10 dB. Fast attack time (120 milliseconds) and slow decay (1.5 seconds) make these meters particularly suited to indicate program peaks. Three OUTPUT switches to the left of the meters, when used in conjunction with an available remote control box *(model RM-610)*, permit instant comparisons and selection of three speaker systems or of three associated power amplifiers.

Since circuitry is divided into line-A and line-B switching, as well as left-right stereo channels, inputs may be assigned to the line-A or line-B busses or may be mixed by means of the pushbuttons just below the OUTPUT switches. This cluster of eight buttons at the left also introduces a series of test tones at frequencies of 1 kHz, 3.16 kHz and 10 kHz and, by simultaneously depressing more than 1 button, frequencies of 4.16 kHz, 11 kHz and 14.16 kHz are also available. The last button activates a pink-noise generator that can be directed to the outputs for a variety of system checks and tests.

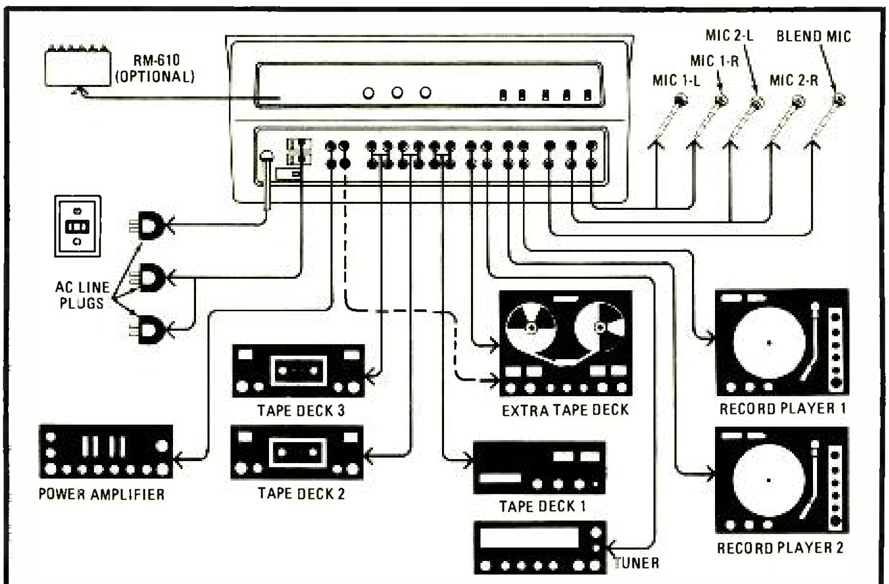
The TONE LEVEL control just below this cluster of buttons adjusts the amplitude of test tones or pink noise while the large MASTER control just below sets overall output level and is equipped with a reference marker that can be set to any dB level for quickly resetting the MASTER control. A headphone jack is located to the left of the MASTER control, since a self contained headphone amplifier is included in the *model 610*.

Two rows of buttons below the meters assign inputs to the line-A or line-B bus. Provision is made for two phono inputs, a pair of mikes, tuner, aux and three tape decks for each line bus. Below the input selectors are five microphone level controls (in addition to the mike 1 and mike 2 input, a fifth "blend" microphone can be connected for L+R assignment), and each microphone can be phase-inverted (since microphone wiring is not standardized) by a pushbutton located above each microphone level control.

A power on/off button is located at the upper right, while below are four buttons for SOURCE or any of the three tape monitor settings. Four more buttons just below the source-monitor switches are used in conjunction with the phase-check buttons to provide L-only, L−R, L+R and R-only phase checks. A balance control is located below these buttons, and below it is a separate MONITOR control that alters signal levels at the separate monitor output jacks (independent from the line outputs).

The rear panel, shown in Fig. 2 has a vertically oriented surface that contains the line and monitor outputs, the previously listed inputs and tape outputs, the five microphone inputs, a ground terminal and two convenience AC outlets. The tape and line output terminals are completely unaffected by the BALANCE, MONITOR level, and MASTER level controls. These controls are simply there to control monitoring sound systems during recording.

The sloped section above contains three output-level matching controls, phono input-impedance switches (200, 50,000 and 100,000 ohms), and microphone attenuator switches with positions for 15 or 30 dB attenuation in case all microphones used do not have equal sensitivities.



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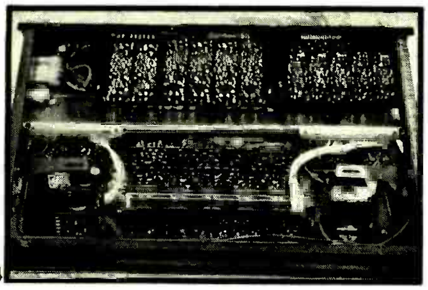
MANUFACTURERS PUBLISHED SPECIFICATIONS:

Frequency Response: Mike: 30 Hz—100 kHz, +0, −1.5 dB; Phono: 30 Hz—15 kHz, ±0.3 dB; High Level: 20 Hz—100 kHz, +0, −1.5 dB. **Input Sensitivity:** Mike: 0.2 mV; Phono: 1 mV; High Level: 75 mV. **Maximum Input Level:** Mike: 1 volt; Phono: 250 mV; High Level: 50 volts. **Signal-To-Noise Ratio:** (IHF A-weighting): Mike: Better than 53 dB, referenced to 0dB; Phono: Better than 80 dB, referenced to 1 mV. **Distortion:** Mike: Less than .01% at all frequencies up to 10 kHz; Phono: less than .005% at all frequencies up to 10 kHz; High Level: Less than .005%. **Dimensions:** 15.75 wide × 6.70 high × 9.33-inches deep (400 × 170 × 237 mm). **Weight:** 15½ pounds (7 kg).

Some idea of the variety of components that may be used with the *model 610* is illustrated in Fig. 3.

Circuit configuration

As can be seen from the photo of the internal layout of the 610 (Fig. 4), Nakamichi has managed to incorporate a vast amount of circuitry into a relatively small space while retaining reasonable access to the many circuit boards involved in the assembly of the product.



4

A particularly interesting circuit section is the phono preamplifier/equalizer. First, its rated sensitivity is a low 1.0 mV, which means that there is enough gain so that it can be used with many of the moving coil cartridges that have been gaining in popularity in recent years. A basic schematic layout of the phono-preamp section is shown in Fig. 5. The first stage employs a unique "triple transistor" circuit. The three transistors are arranged in a parallel configuration that provides a signal-to-noise improvement of around 5 dB above that of conventional designs. Selected low-noise silicon units are used for these "first stage" transistors, which act as a single transistor with very low internal impedance in a common-emitter configuration. A second common-emitter stage, Q4, with current supplied by constant current source Q6, establishes a low distortion current drive for the final stage. The output stage of the phono section is a complimentary Class A circuit with bias set by the Q5 collector to emitter voltage. Proper RIAA equalization is provided via the negative feedback loop, which ties the output signal to the emitter of the first triple-transistor stage.

Laboratory measurements

Table I summarizes measurements and lists reference levels applicable to the Nakamichi 610. Microphone input sensitivity (without attenuation) was measured as 0.2 mV for a 0-dB meter reading, exactly as specified. It should be noted that the phono preamplifier signal-to-noise ratio recorded (−83 dB, IHF A-weighted) was measured with respect to a 1-mV input sensitivity. Most other preamplifiers have an input sensitivity of around 2.0 to 2.5 mV, so that if the S/N were specified with respect to that higher input level (typical of moving magnet cartridge nominal outputs), the figure would be between 89 and 91 dB! Carrying this still further, if a 10 mV input signal reference were used (many manufacturers quote S/N with respect to this high input figure), S/N would be an incredible 103 dB!

The few distortion figures listed in Table I are actually residual distortion contained in our source signal.

Use and listening tests

Since there are nineteen different inputs to the *model 610*, attempting to describe everything you can do with this preamp would require more space than a single test report warrants. Here are just a few of them. You can do live recording with up to five microphones on as many as three separate tape decks simultaneously with independent monitoring capability. You can combine live and prerecorded inputs, such as three mikes and a tape deck or a phono input source. You can mix two stereo sources, such as a pair of phonos, a tuner plus a tape deck, or any combination of these. A-B comparison of any two sources, such as tape versus disc, tape

TABLE I

RADIO-ELECTRONICS PRODUCT TEST REPORT

Manufacturer: **Nakamichi** Model: **610**

PREAMPLIFIER/CONTROL PERFORMANCE MEASUREMENTS

	R-E Measurement	R-E Evaluation
OUTPUT LEVELS		
Monitor out at 0-dB (volts)	1.0	
Line out at 0 dB (volts)	0.316	
Record out at 0 dB (volts)	0.316	
Headphone out at 0 dB (mW/8-ohms)	40.0	
Maximum monitor out at clipping (volts)	6.0	Very good
Maximum line out at clipping (volts)	6.0	Very good
Maximum record out at clipping (volts)	6.0	Very good
Maximum phones out at clipping (mW/8 ohms)	320	Good
DISTORTION MEASUREMENTS		
(Master volume @ −20dB, line out @ 2 volts, 1kHz)		
Mike inputs (%)	0.0025*	Superb
Phono inputs	0.0025*	Superb
High level inputs	0.0025*	Superb
	*Limit of test equipment	
PHONO PREAMPLIFIER MEASUREMENTS		
Frequency response (RIAA ±dB)	0.2	Excellent
Maximum input before overload (mV)	270	Excellent
Hum/noise referred to full output (dB) (at rated input sensitivity)	83 (IHF "A")	Superb
HIGH LEVEL INPUT MEASUREMENTS		
Frequency response (Hz-kHz, ±dB)	20-80, 1 dB	Excellent
Hum/noise referred to full output (dB)	88	Very good
Residual hum/noise (min. volume) (dB)	95	Excellent
COMPONENT MATCHING MEASUREMENTS		
Input sensitivity, phono 1/phono 2 (mV)	1.0/1.0	
Input sensitivity, auxiliary input(s) (mV)	75	
Input sensitivity, tape input(s) (mV)	230	
Output level, tape output(s) (mV)	316	
Output level, headphone jack(s) (V or mW)	40 mW	
EVALUATION OF CONTROLS, CONSTRUCTION AND DESIGN		
Adequacy of program source and monitor switching		Superb
Adequacy of input facilities		Superb
Arrangement of controls (panel layout)		Excellent
Action of controls and switches		Excellent
Design and construction		Superb
Ease of servicing		Good
OVERALL PREAMPLIFIER/CONTROL PERFORMANCE RATING		Superb

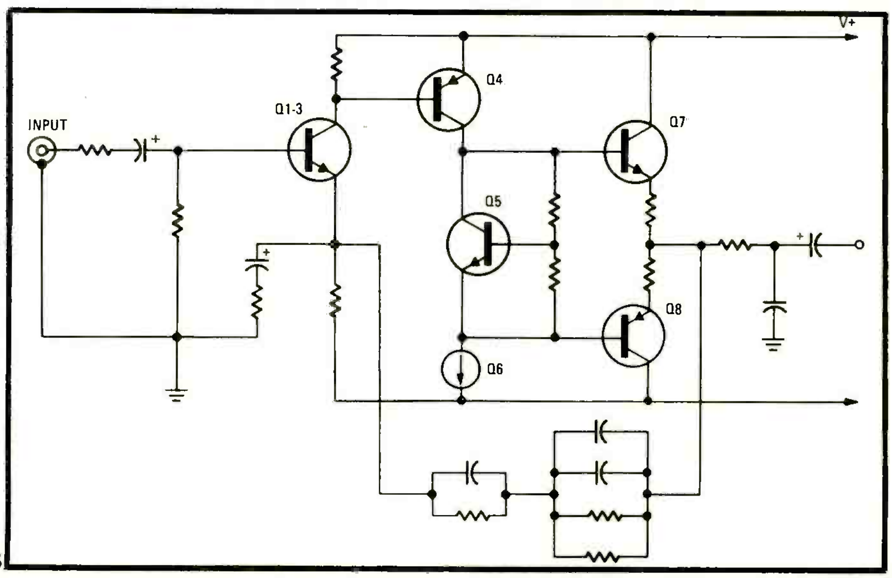


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TABLE II

RADIO-ELECTRONICS PRODUCT TEST REPORT

Manufacturer: **Nakamichi** Model: **610**

OVERALL PRODUCT ANALYSIS

Retail price	**$570 ($550 in silver finish)**
Price category	**Medium-high**
Price/performance ratio	**Excellent**
Styling and appearance	**Superb**
Sound quality	**Superb**
Mechanical performance	**Excellent**

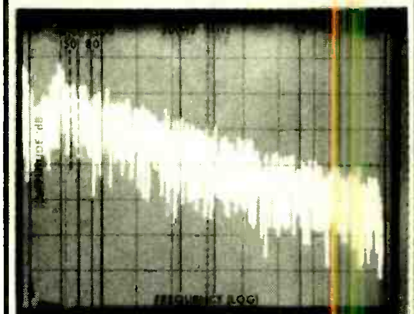
Comments: As you might gather from glancing at our Evaluation column above and in Table I, we were tremendously impressed with the design, construction and performance of the Nakamichi *610*. We hasten to point out, however, that the emphasis on this unit is understandably towards the serious tape recordist, rather than to the passive audiophile. If you crave elaborate tone controls, filters, loudness controls and the like, this is *not* the preamp/control unit for you. But if you normally play your music flat, own a tape deck or two, and like to do some live recording, the *610* can well serve not only as your basic preamp but as your mixing console as well. The incorporation of the test tones and the pink noise generator was truly an inspiration as far as we are concerned. Comparing the sound of "pink noise" in an A-B test is still one of the best methods we know for evaluating the response of a component system by ear and even the few frequencies from 1 kHz to 14.6 kHz supplied by the test-tone circuitry are enough to help you calibrate or align tape heads and the rest of your tape recording circuitry should that become necessary. The tones serve as a ready means of comparing different tape formulations and their performance on your given machine, too.

Considered strictly as a preamplifier, the performance of the *610* is as close to that of a "straight wire with gain" as anything we have ever measured. Our test equipment, as good as it is, was simply not able to indicate meaningful distortion figures, since its own signal distortion is known to be around 0.0025% and that reading was obtained using any of the input terminals of the *610*.

Controls are logically arranged on the sloped front panel, though a few minutes of familiarization are needed to operate the unit with assurance. Nakamichi recently introduced a matching power amplifier, *model 620*, and had previously introduced their *model 600* stereo cassette deck. These three items, placed side by side or mounted in a special rack available from the company, represent a flexible home recording system that any serious recordist would be proud to own and use.

WHAT IS PINK NOISE?

Pink noise, for those unfamiliar with the term, is random-frequency noise that contains equal energy in each octave in the audio spectrum, from 20 Hz to 20 kHz. So-called white noise is also random-frequency noise, but it contains equal amplitudes of all audio frequencies. To modify white noise so that it contains equal energy in each octave, the random noise must have its amplitude attenuated at a constant rate of 3-dB per octave. Such a noise signal is extremely useful in comparing sound qualities of different components and loudspeakers. When listening to pink noise through an audio system, even minute changes in overall response can be detected by a clear change in the overall character of the noise heard. In the photo shown, a spectrum analyzer was swept



from 20 Hz to 20 kHz while a pink-noise signal was applied to the vertical input. The results clearly show the 3 dB-per-octave slope of the frequencies contained in the pink-noise signal from the Nakamichi *610* preamplifier.

versus FM and so forth becomes simple and meaningful, with the aid of the independent level matching controls at the monitor outputs. All of these intricate interconnection schemes are accomplished by the push of a few buttons—no juggling of patch cords, cables and the like.

Used alone, with a pair of good quality headphones (in remote recording situations where the balance of a stereo monitoring system is not available), we were able to do on-location monitoring of a recording and, unlike the headphone outlets supplied on some lesser preamps, there was plenty of gain and power available to drive our 8-ohm phones so that we could hear the full dynamic range of the sound sources we were mixing during that session. While we did not have the optional *RM-610* remote control box available for our tests, we can easily see that its addition (for around $75.00) would add even more versatility to this "dream" preamp.

As for sonic qualities of program sources fed through it strictly for musical listening purposes, we compared FM signals received from one of the few "clean signal" stations in our area by feeding them directly to our high quality power-amp and to that same power amp via the line inputs and outputs of the *model 610* preamp. With levels adjusted carefully, we, as well as several other listeners subjected to the same test, could not detect any audible difference between the two setups. If a preamp control unit is intended to process signals with absolutely no coloration or alteration, this one comes as close to doing so as anything we have ever heard. If, on the other hand, you insist upon a variety of equalizing and tone controlling functions, you can always buy a separate graphic equalizer which could be outboard-connected to the *model 610* via one of the tape monitor circuits. You would still have two such circuits available for two tape decks.

Our summary comments regarding the Nakamichi *model 610* will be found together with our overall product analysis in Table II. **R-E**

Higher hi-fi recording group goes back to direct-on-disc

A Canadian record company, Nimbus 9 Productions Ltd., has abandoned the tape-recording stage of disc production. The new direct-on-disc albums, bearing the Umbrella trademark, will be sold in the United States by Audio-Technica, the phono cartridge firm.

According to Jon Kelly, general manager of Audio-Technica, bypassing the tape recording stage eliminates problems of distortion, limited dynamic range, and of course, tape noise. Because engineers mix and record the studio performances direct onto a master disc, Kelly points out: "Musicians and engineers must display a high degree of professionalism. There is no room for error.

Records were expected to be available early this winter. Discs will cost $12.95 at retail. Umbrella's first release through Audia-Technica will be a rock album by the Toronto group "Rough Trade," a six-piece ensemble. Later releases will include classical and percussion offerings.

Large-screen TV viewers now have stereo vision

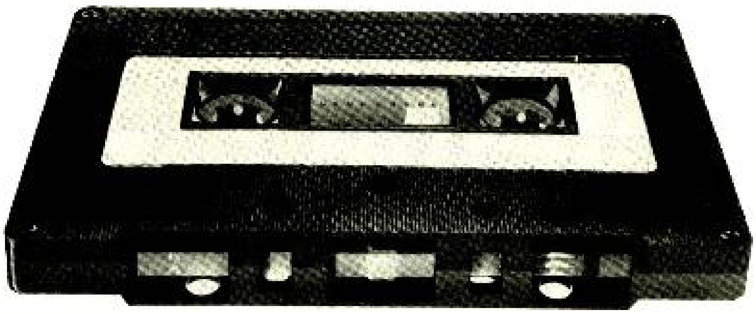
Three-dimensional wide-screen projection television was demonstrated to the Society of Motion Picture and Television Engineers at their conference in New York recently. The demonstration was accompanied by a technical paper by television consultant and video experimenter Bruce D. Stephens.

Mr. Stephens' technique combines two well known devices, the General Electric single-lens *Light Valve* color television projector and the Marks Polarized Corp. 3-D film projection *Polarator*, to produce a new effect.

The two slightly differing left-eye and right-eye images, positioned one above the other in a single film or video frame, are projected through the Light Valve projector and the Polarator, then redirected toward the screen so that they are superimposed.

One of the superimposed pictures is horizontally, the other vertically, polarized. The viewer wears a pair of inexpensive viewing spectacles of the type used in 3-D movies. These act as a decoder, allowing each eye to see only the picture intended for it. **R-E**

New For Cassettes



Automatic Program Search

New system for cassette decks automatically switches deck from fast forward or rewind mode to play at the beginning of recorded passages

KARL SAVON
SEMICONDUCTOR EDITOR

GETTING CLOSE TO THE SELECTION YOU want is not too difficult using the footage indicator on a cassette tape. But then there is the annoying trial and error hunting to first find the precise selection, and then to locate its opening bars. A turns-counter works providing you have the number of turns written down, that you remembered to reset it at the beginning of the tape and, of course, that your machine has one.

Sharp Electronics has an interesting alternative in their GF-6000 Cassette Recorder and MW/SW/FM Receiver combination. It incorporates the APSS (*A*utomatic *P*rogram *S*earch *S*ystem) that is designed to quickly get you to the beginning of the next tape selection or back to the beginning of the one in progress.

What identifier can be found on most tapes that would serve as a beginning-of-selection marker? Sharp's answer is the blank interval between recorded segments. APSS looks for these blank segments in either the fast forward or rewind modes and switches back to the normal playback mode when it finds one.

Pushing the FWD-APSS button starts a fast-forward operation in the conventional way by retracting the pinch roller from the capstan and engaging the fast-forward gear with the take-up reel. The only mechanical difference is that the function is latched by the APSS lock-plate that can be released by applying power to a solenoid-type plunger. The system runs at 10 to 30 times normal playback speed until the electronics senses a blank interval in the tape. When this occurs, the plunger is activated and the fast-forward gear is disengaged. The action is identical when the fast-rewind mode is selected.

How it works

The circuit details are shown in the schematic in Fig. 1 and the waveforms in Fig. 2. In the playback mode, equalizer amplifier IC2 is fed from the record/playback head. Part of its output signal drives the APSS preamp IC4. Power is applied to the preamp only during APSS operations. Amplified signals from the tape are coupled to the base of Q111 through C177. Both the base and emitter of the transistor are connected to the +12-volt (+B1) supply so that when the output of IC4 exceeds 1 V_{be} (one base-to-emitter junction potential of approximately 0.6 volt), transistor Q111 turns on. Each time Q111 conducts, it supplies a relatively high-current pulse into its collector load—the R177-C179 network. In effect, C179 is charged through the 33-ohm emitter resistor R176, but discharges through the 8.2K resistor R177.

Very much like a diode peak detector rectifies a signal, transistor Q111 peak detects and amplifies the signal from the tape. Whenever a signal is present, the collector of Q111 is very close to 12 volts. The output of this transistor drives the base of Q112. Transistors Q112 and Q113 form a regeneratively-switched schmitt trigger. An input sufficient to start Q112 into conduction quickly causes it to go fully on while Q113 turns off. As the collector of Q112 is lowered, the emitter voltage of Q113 and Q112 is reduced. Transistor Q112 then conducts more heavily because of its increased base-to-emitter potential, and things spiral or rather regenerate so that the circuit latches.

Notice the way the collector of Q113 feeds the emitter of the following Q114 stage through capacitor C180. The emitter and base of this device are both referenced from the positive supply so it is biased off. Further, the positive pulse coupled to its emitter when Q113 goes off is in a direction to keep it off, so nothing happens here yet. As long as

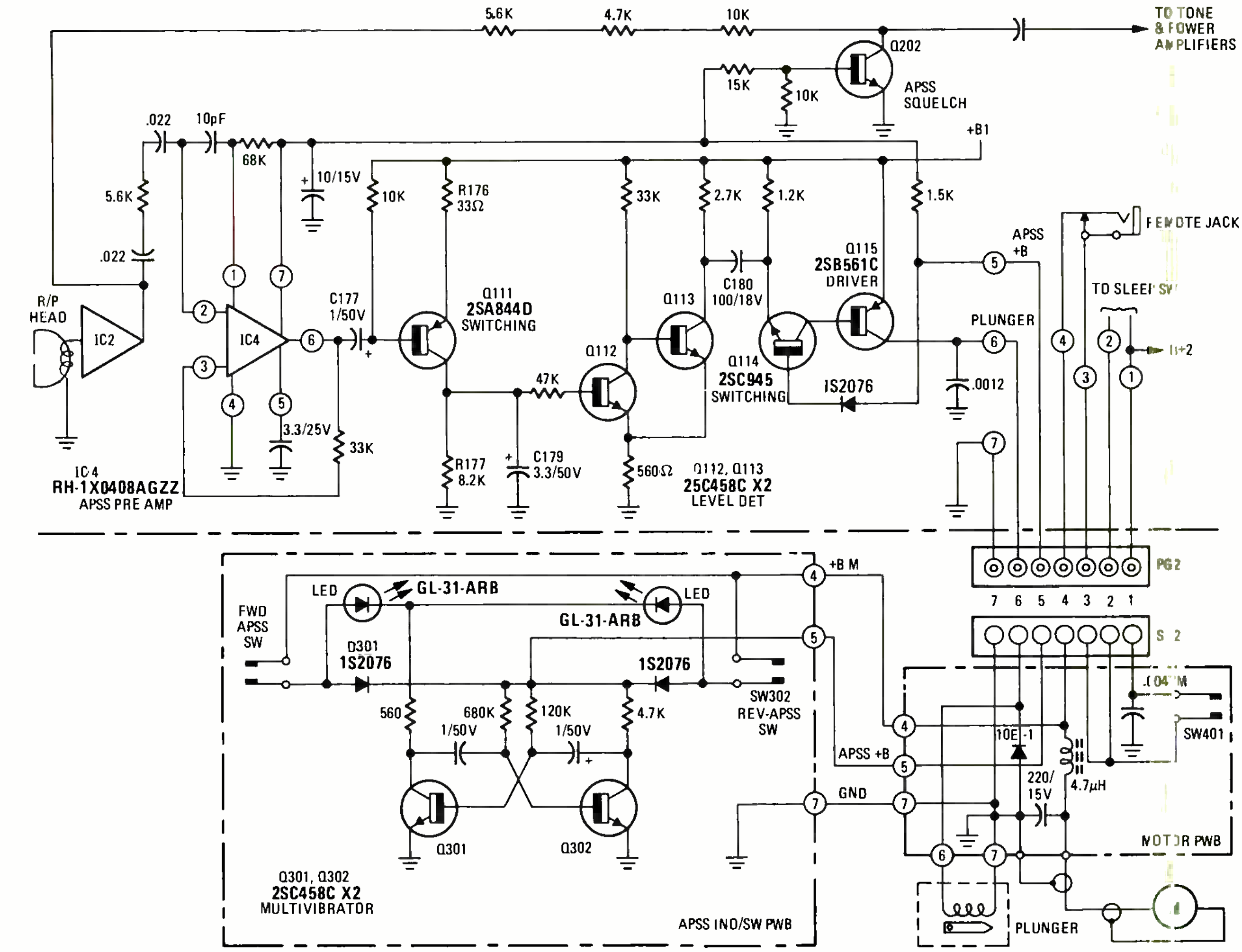


FIG. 1—APSS CIRCUIT detects blank intervals in program material and switches cassette deck from fast forward to play mode.

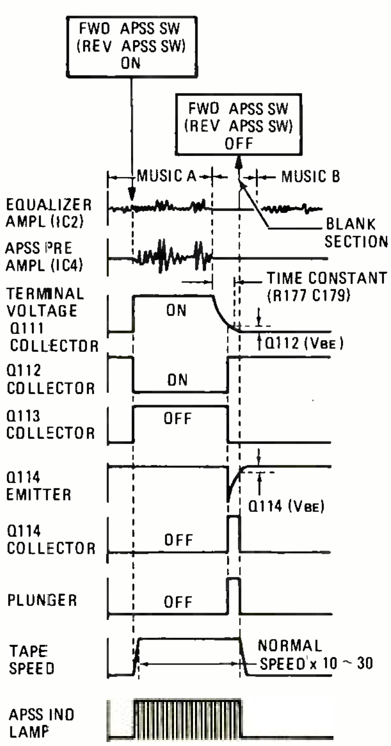


FIG. 2—WAVEFORMS of the APSS circuit. Circuit detects blank interval between recorded passages.

Q114 is off, driver transistor Q115 is also off. Transistor Q115 drives the solenoid that disengages the fast-forward gear.

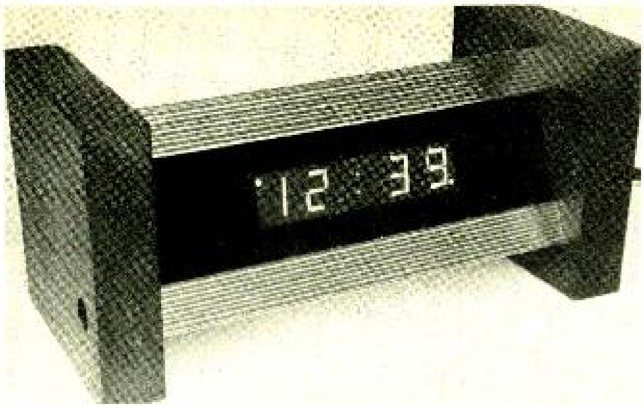
As the high-speed search continues, a drive current is sent to squelch transistor Q202 (not shown). The base current of transistor Q202 is derived simply by a resistor from the APSS +B supply. Signals are blocked from reaching the speaker by Q202 whenever an APSS search is in progress.

Assuming that a blank segment of tape has been reached, let's retrace the circuit operation: The signal from the playback head is amplified by IC4 and it now consists only of low-level noise of insufficient amplitude to overcome the base-to-emitter threshold of Q111. This transistor no longer provides current pulses to the R–C network in its collector circuit. The network discharges as shown in the waveforms of Fig. 2. Discrimination against temporary nulls in program material is provided by the time constant of the R–C network. A minimum of a one-to-three second blank interval at normal playback-speed is necessary for the APSS circuit to detect. The range in time is because of the three-to-one variation in fast tape speed.

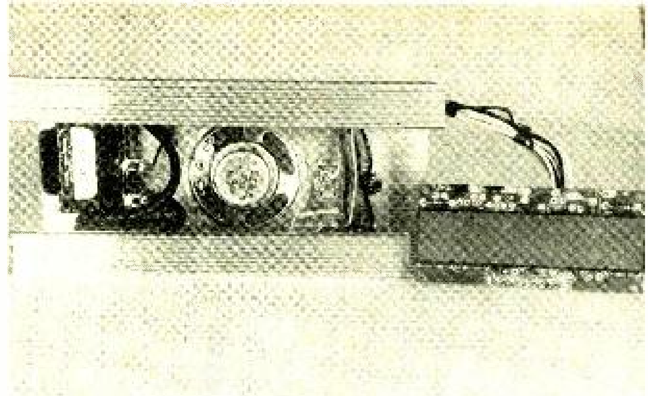
Base drive to transistor Q112 falls below its conduction level and Q112-Q113 switches to its opposite state with Q113 on. The negative pulse generated at the collector of Q113 turns on Q114 for a time interval determined by the coupling network. During the time it takes to charge C180, Q114 and Q115 remain on.

The circuit can be fooled by a prolonged soft music or blank passages. A second or third operation of the button may be required in such cases. Complete misses of the blank leader occur if the button is pressed when the tape happens to be less than 10 playing seconds away from the leader.

Two LED's indicate operation of the circuit, one for each tap direction. Switch contacts S301 are closed by the FWD-APSS button. Power to IC4 and the squelch transistor is supplied through the switch contacts and diode D301. Transistors Q301 and Q302 are an astable multivibrator that flashes the LED indicator. The bottom waveform in Fig. 2 represents the pulsing of the LED during the search time. R-E



THE INTERFAB DC-60 CLOCK comes complete with chassis and end blocks, which make a case of excellent appearance.



INTERIOR VIEW, INTERFAB DC-60N. Speaker comes mounted to the case. Transformer is a Signal model 241-3-16, supplied with the kit. Alarm circuit is not installed.

Easy-to-Build Digital Clocks

Preassembled clock modules are the heart of these full-featured LED clocks. They are built by simply adding switches and a transformer

FRED BLECHMAN

FIFTEEN YEARS AGO, IF YOU WANTED TO BUILD AN ELECTRONIC digital clock to display hours, minutes and seconds, it took hundreds of parts, a hopeless maze of wiring and would have cost at least $150 for parts. In the early '60's, when the first IC's became popular, you could build the same clock with 12 IC's and about 70 additional discrete parts—still a lot of wiring—at a cost of about $75. Then along came LSI (*L*arge *S*cale *I*ntegration), and its application resulted in IC's designed specifically for clocks and watches.

From a large stable of contenders, a few thoroughbreds emerged, among them the National Semiconductor MM5314 and MM5316. These IC's contained various clock functions, but they still needed a variety of parts for signal and display conditioning to end up with a clock. Kits appeared on the market in abundance for $12 and up, with a wide spectrum of digit sizes and features—but most of them still required a lot of careful soldering and hours to assemble and troubleshoot. (See "Digital Clock Kit Roundup", **Radio-Electronics**, August and September 1976 issues.)

The latest advance in electronic digital clock design is the full-featured, pre-tested "clock module" with almost all the electronic parts preassembled on a common board. All you need to add is a transformer and switches for a complete clock!

The first three clock modules to appear on the market are the National Semiconductor MA1001 and MA1002 (both with 0.5-inch-high digits) and the Fairchild FCS8100 (with 0.8-inch-high digits). The MA1001 series, released in December 1975, is already obsolete and has been replaced by the slightly smaller MA1002 series. Some MA1001A's are still available at a reduced price (see parts list). Functionally, the MA1001A and the MA1002A are identical—the physical difference is that the large 40-pin MM5385 IC package has been removed from the display side of the board and now appears as a small circular black "blob" on the back. Figures 1 and 2 show the physical dimensions of these two modules. The Fairchild FCS8100, recently released, is roughly a half-inch wider and higher, since it has digits 60 percent higher. See Fig. 3 for its physical dimensions and pin connections.

Features and assembly

The MA1001A and MA1002A have the same features: 1. Bright 3½-digit 0.5 inch red LED 12-hour display showing

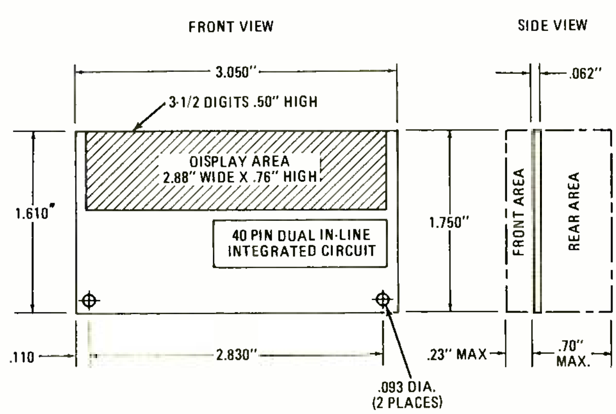
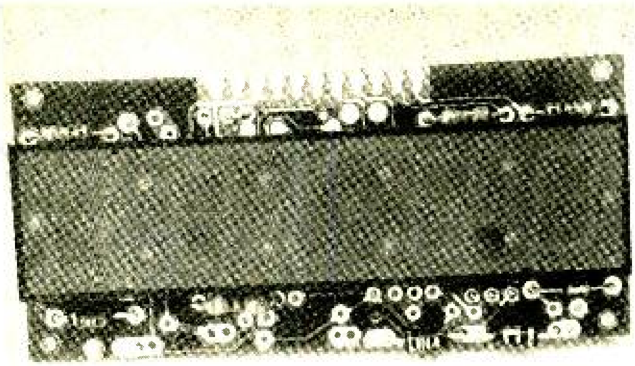
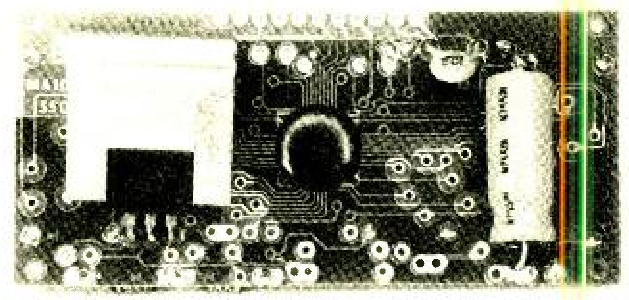


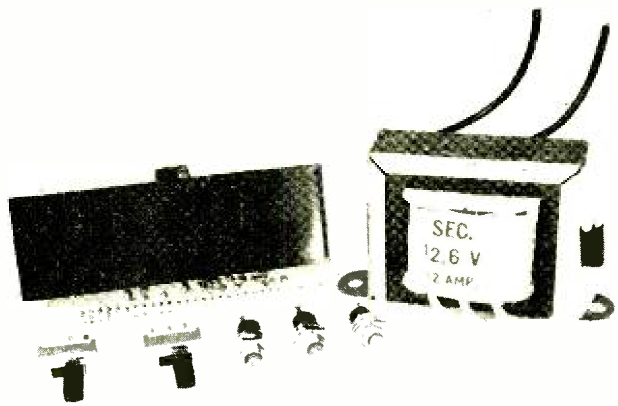
FIG. 1—PHYSICAL DIMENSIONS of the MA1001A.



MA1002A DIGITAL CLOCK MODULE.



THE MA1002A MODULE, REAR VIEW. The "black blob" seen in the center is the IC.



FAIRCHILD FCS8100 MODULE with transformer and switches.

FAIRCHILD FCS8100 clock with the controls mounted on top.

hours and minutes, but with seconds displayed on demand. 2. Alarm and 9-minute "snooze". 3. Alarm-on indicator. 4. PM indicator allows setting alarm for 24-hour repeat. 5. External radio can be controlled with 59-minute "sleep" function. 6. Direct drive of display—no radio interference. 7. Brightness control capability. 8. A 1-second flashing colon. 9. Power failure indication—the entire display flashes on and off.

Other versions of the MA1001 and MA1002 (identified by the suffix letters B,C,D,E,F,G & H) offer a variety of built-in options, such as 24-hour display, 50-Hz input, and alarm tone output (requiring a special earphone). For simplicity, only the MA1001A and the MA1002A full-feature clock-radio 12-hour 60-Hz modules are covered in this article.

Figure 4 shows the external wiring to the MA1001A or MA1002A, and the connection points on the modules are shown in Figs. 5 and 6. The HOLD function is not shown wired, since it is also available by closing the SECONDS display switch and holding down the SLOW SET switch until you want counting to resume. Wiring is shown for maximum brightness; a 50K potentiometer wired to vary the resistance from MA1001A pin-6 or MA1002A pin-4 to V_{DD} will cause the

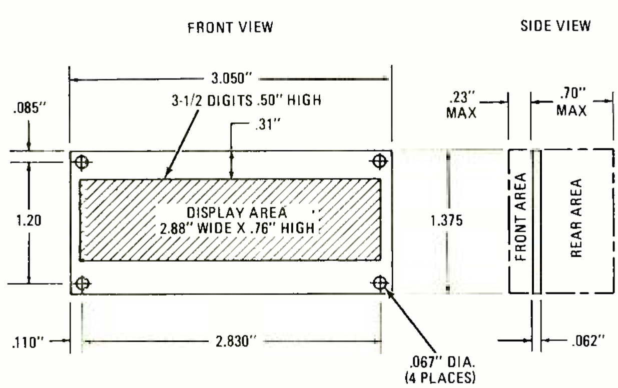
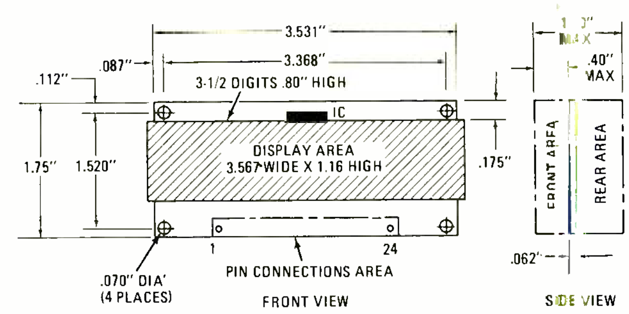


FIG. 2—THE MA1002A is smaller than the MA1001A.



PIN	FUNCTION	PIN	FUNCTION
1	SLEEP DISPLAY INPUT	13	SNOOZE INPUT
2	ALARM DISPLAY INPUT	14	ALARM OUTPUT
3	SECONDS DISPLAY INPUT	15	ALARM OFF INPUT
4	SLOW SET INPUT	16	SLEEP OUTPUT
5	FAST SET INPUT	17	NO CONNECTION
6	50 OR 60 Hz SELECT	18	V_{DD} (MINUS TEST POINT)
7	12 OR 24 HOUR SELECT	19	NO CONNECTION
8	CENTER TAP (LED COMMON)	20	NO CONNECTION
9	CENTER TAP (LED COMMON)	21	NO CONNECTION
10	12.6 VAC (V_{DD})	22	OUTPUT (MINUS)
11	12.6 VAC (V_{SS})	23	ALARM SET INDICATOR—ANODE
12	12.6 VAC (V_{SS})	24	ALARM SET INDICATOR—CATHODE

FIG. 3—THE FAIRCHILD FCS8100. Physical dimensions and pin connections.

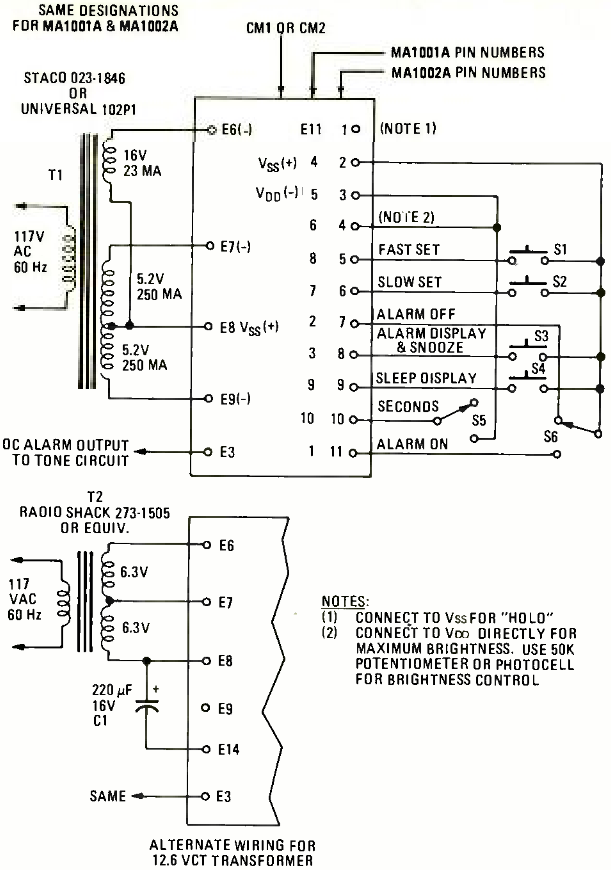


FIG. 4—THE WIRING DIAGRAM for either the MA1001A or MA1002A, showing how to substitute for the special transformer specified.

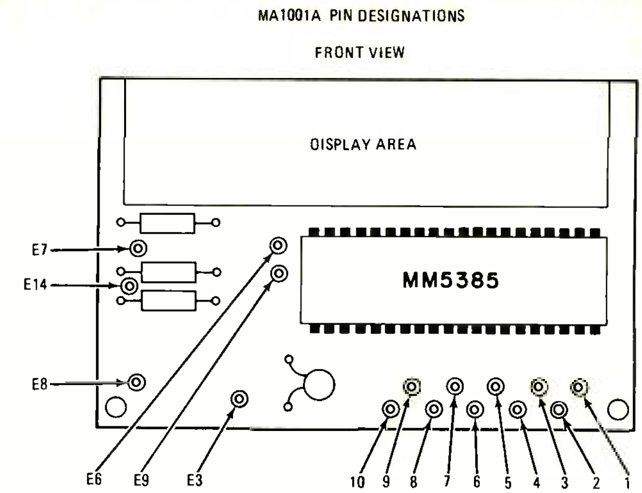


FIG. 5—PIN CONNECTIONS of the MA1001A.

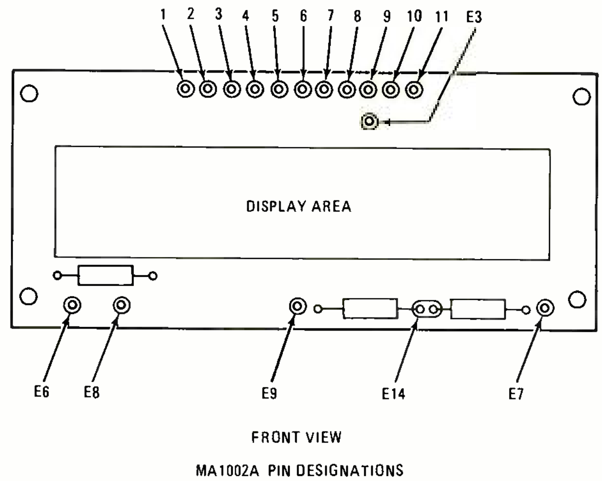


FIG. 6—PIN CONNECTIONS for the MA1002A.

brightness to vary from dark (high resistance) to bright (no resistance). This suggests the use of a photocell to automatically dim the display at night—but be careful! The photocell must have specific light response to give you the proper brightness variation. The photocell shown in the parts list has been selected for this use.

The transformer specified in the National Semiconductor data sheet for these modules is a special model. Two sources are given in the parts list. However, a standard 12.6-volt center-tapped transformer (less expensive, but larger than the specified special transformer) can be used if wired as shown in Fig. 4. By adding C1 (220 µF 16V) electrolytic capacitor as shown, the brightness is increased to the level obtained with the special transformer, and without any sacrifice in performance.

Unfortunately, some of the pin connections are scattered around on the board, so be very careful in using the drawings as a guide; some discrete components near the connection points have been shown to help you. Although only the front of these modules are shown, they have a printed circuit on both sides, with plated-through holes, so you can solder to either the front or back side of the connection holes.

The Fairchild FCS8100 12-hour clock radio module is built around the FCM 3817A digital clock IC. It features: 1. 3½-digit 0.8-inch LED red display showing hours and minutes, with seconds on command. 2. Operation from 50 or 60-Hz line using a standard 12.6-volt center-tapped transformer. 3. Built-in alarm tone. 4. Alarm on indicator. 5. AM and PM indicators that permits setting the alarm for 24-hour repeat operation. 6. 9-minute "snooze". 7. External radio can be controlled with 59-minute "sleep" function. 8. Direct drive—no RFI. 9. Power failure protection for 10 seconds. 10. Power failure indication after 10 seconds—AM indicator blinks, and display reads 12:00. 11. 1-second flashing colon.

Figure 7 shows the external wiring to the FCS8100 module. A transistor driver is built into this module, and the jumper between pins 14 and 16 is necessary to operate the transistor for the alarm function (the sleep-output pin is internally connected to the driver-transistor input). Since this module has a built-in tone oscillator connected to the alarm circuitry, all you need to do to hear the alarm is connect a small speaker and 33-ohm resistor in series between pins 9 and 22. Now, whenever the alarm switch S6 is placed in the ON position and the alarm-set time and real time coincide, you'll hear a 700-Hz (approximate) tone from the speaker.

The MA1001A or MA1002A modules have only direct current at their alarm outputs (E3). Therefore, a tone oscillator is required to drive a small speaker. Figure 8 shows such a circuit. Power for this oscillator is derived from the transformer (E8 and E9), using D1 and C2 as a rectifier and filter. This isolates the power supply of this circuit from the clock IC, which is a problem if power is taken directly from the alarm output pin. Instead, the alarm output (pin E3) only provides control voltage to the oscillator, with very little current drain (less than 0.5 mA). The speaker emits a loud, pleasant tone when the alarm is activated.

Although you can make an operating clock from one of these modules by wiring just the transformer and switches to the appropriate module points with a small-tip soldering iron in about 30 minutes (once you've identified the module terminals), the real "rub" is the packaging—mounting the various switches and the transformer and speaker in some kind of enclosure. Since this can take considerably more time than building the clock, the modern-style case offered in the parts list is highly recommended. It is made from an anodized aluminum and walnut end-blocks, held together with one long screw. All necessary mounting and speaker grille holes are punched and tapped, and even a red plastic bezel is included.

PARTS LIST

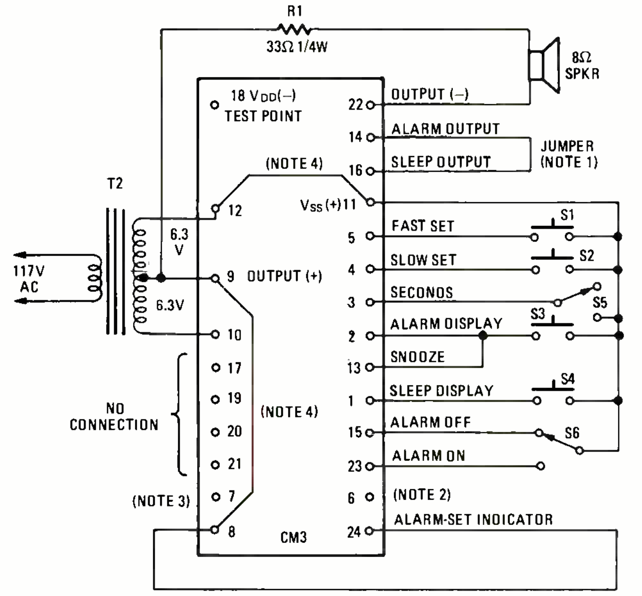
CM1—National Semiconductor MA1001A Clock Module. (Jade Co., 2007 West Carson, Torrance, CA 90501. $9.95 each plus $1.00 shipping and handling per order. California residents add 60¢ tax for each module.)
CM2—National Semiconductor MA1002A Clock Module. (Interfab, 27963 Cabot Road, Laguna Niguel, CA 92677. $12.50 each, plus $1.00 handling and shipping charge per order. California residents add 75¢ tax for each module. Order DC-60 MA1002A Clock Module.)
CM3—Fairchild FCS 8100 Clock Module. (Interfab. Order DC-60 FCS 8100 Clock Module. $18.00 each, plus $1.00 shipping and handling per order. California residents add $1.08 tax for each module.)
T1—Special transformer, Universal 102P1 (Universal Transformer Co., 4211 W. Lawrence Ave., Chicago, IL 60630, $5.00) or Staco 023-1846 (Staco, Inc., 2240 E. Third St., Dayton, OH 4421, $8.75). 117V, 60 Hz input.
T2—Transformer, 12.6V CT output, 117V 60 Hz input (Radio Shack 273-1505 or equal.)
S1, S2, S3, S4—Pushbutton switches, normally open. (Radio Shack 275-1547 or equal.)
S5, S6—SPDT switch (subminiature toggle, Radio Shack 275-613, or slide switch, Radio Shack 275-402 or equal.)
C1—220-μF, 16V electrolytic (used only with T2). (Radio Shack 272-1006 or equal.)

OPTIONAL ALARM PARTS

R1—33 ohms, ¼ watt
R2—6,800 ohms, ¼ watt
R3—1000 ohms ¼-watt,
C2—.470-μF, 16V electrolytic
C3—.047-μF, 16V disc
C4—1 μF, 16V electrolytic
D1—1N4001 silicon diode
IC—NE555 integrated circuit timer
SPKR—Minature 2-inch, 8-ohm speaker (Radio Shack 40-245 or equal.)
CASE—Black plastic, with aluminum faceplate 6¼ × 3¾ × 2 inches. (Radio Shack 270-627, or equal.)

COMPLETE KITS AND OPTIONS

Interfab Corp., 27963 Cabot Road, Laguna Biguel, CA 92677, offers the following: (California residents, add 6 percent sales tax on merchandise price. All orders, add $1.00 shipping and handling per total order.)
DC-60N—MA1002A *Complete Kit* Including decorator extruded aluminum case (Specify, gold, silver or black) with all holes drilled; walnut end blocks, finished, drilled and tapped; clock module; all switches; all alarm parts; transformer; pre-cut switch wires; solder; red plastic bezel, line cord and grommet, mounting hardware and instructions. $28.00 complete
DC-60F—Fairchild FCS 8100 Complete Kit. $31.00.
DC-60C—Case and endblocks, pre-drilled, with case assembly hardware. Includes bezel. Specify case color. $6.95.
RAC—60—Remote control appliance option. Operates from Sleep or Alarm outputs to control AC appliance. Plugs into 117 volt AC line. All parts, including box, line cord, plug, jack, relay, switch, diodes, transistor and cable. $7.00
TB-60—Timebase option for car use. All parts and printed circuit board. $4.95
DCD-60—Automatic dimmer option, Special photocell. $1.00



NOTES: (1) SIGNAL VOLTAGES USED TO ENABLE "ON-BOARD" DRIVER TRANSISTOR AT PIN 22 (OUTPUT MINUS).
(2) CONNECT TO V_{SS} FOR 50 Hz OPERATION.
(3) 24-HOUR FORMAT CONNECTION NOT USED WITH THIS 3-1/2 DIGIT DISPLAY.
(4) CONNECTED TOGETHER ON MODULE PRINTED CIRCUIT.

FIG. 7—THE FAIRCHILD FCS 8100 clock module. Wiring diagram and connections for speaker.

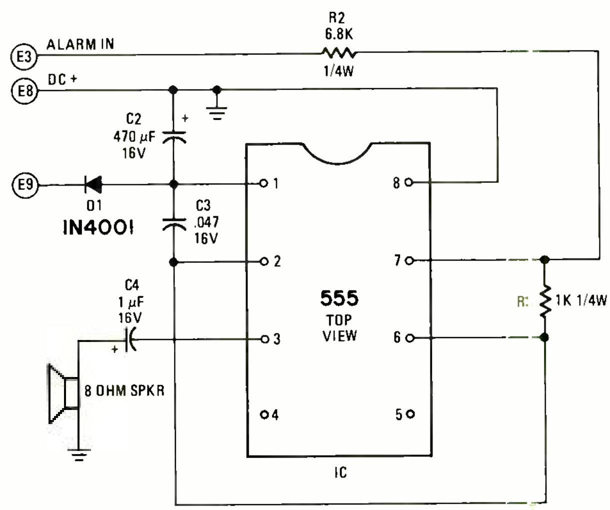


FIG. 8—AN ALARM TONE CIRCUIT for units using the MA1001A or the MA1002A.

With this case, the whole job from box to finished clock should take less than an hour!

A complete kit, including *everything* (even solder) for an MA1002A or FCS8100 clock, is also available at a saving over buying individual parts. Various options are also offered. The Appliance Option allows an AC device (such as a coffee maker) to be turned on by the sleep or alarm outputs from the clock. The Timebase Option allows you to operate your clock from a 12 volt DC source, such as in your car, van or dune-buggy—it generates a 60-Hz signal using an MM5369 IC and a 3.58 MHz crystal and feeds it to your clock. The dimmer option was mentioned previously.

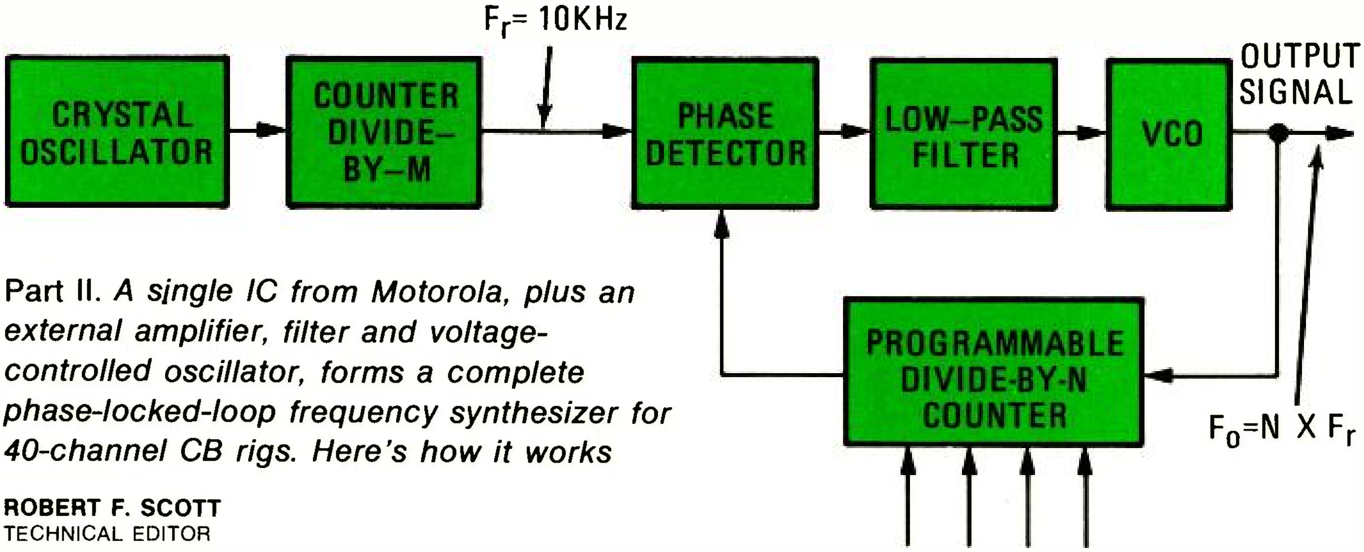
If you want to "customize", feel free. Several clocks shown in the photos may give you some ideas. The clear plastic cube-shaped clock was built by Peter Hillen, National Semiconductor field applications engineer, using an MA1001A module, as a demonstrator unit. He used the special transformer specified by National in their literature, and used toggle and pushbutton switches for display functions and time-setting. Very modern in appearance, the clear case (it's actually tinted red) shows all the interior parts making it a unique decorator conversation piece.

Using the controls

The switch and display functions of all the modules are essentially the same. The FAST switch moves the minutes ahead rapidly, while the SLOW switch moves the minutes ahead—you guessed it—slowly. The SECONDS switch "shifts" the display to show the last digit of the minutes, and the

continued on page 99

Using PLL for CB Frequency Synthesizers



Part II. *A single IC from Motorola, plus an external amplifier, filter and voltage-controlled oscillator, forms a complete phase-locked-loop frequency synthesizer for 40-channel CB rigs. Here's how it works*

ROBERT F. SCOTT
TECHNICAL EDITOR

LAST MONTH, WE REVIEWED THE BASIC phase-locked loop as applied to frequency synthesis and saw how the Nitron NC6402 digital PLL IC can be applied to a 40-channel CB rig. Now, as we promised, we'll take a look at the Motorola XC3390 phase-locked loop frequency synthesizer for CB radios.

The device is in a 24-pin plastic package with a 724 case configuration. It requires only one crystal to generate all transmit and receive frequencies in a 40-channel transceiver using a double-conversion superhet receiver. Channel selection can be by means of voltages from a binary-coded switch or from a 7-segment digital display. Figure 1 shows how the XC3390 fits into a typical CB transceiver.

When the transceiver is in the transmit mode, the synthesizer generates the channel carrier-frequency and feeds it to the exciter—a low-level RF voltage or power amplifier. In the receive mode, the synthesizer develops the oscillator injection frequencies for a double-superheterodyne receiver with first and second IF's of 10.695 MHz and 455 kHz, respectively. The first and second mixer injection frequencies are on the low side of the channel carrier and the first IF, respectively.

Figure 2 shows the sections of the XC3390 and how they are used to generate the carrier frequencies for the transmitter. The reference signal is developed by a precise and highly stable crystal oscillator. This is the signal that is rrocessed to provide the various precise signal frequencies needed in the transmit and receive processes. It is divided by 2 and by 3 to develop new precise signals on 15.36 and 10.24 MHz. The latter signal is divided by 2,048 to develop the 5-kHz reference that, as we saw last month, is needed as the reference for the frequency synthesizer as it develops signals for the 10-kHz spaced CB-channels.

Now, let's look at the VCO. It operates in the range of 16.725 to 17.165 MHz—10.695 MHz below the channel carrier frequency—to prevent birdies and spurious frequency modulation due to RF feedback when transmitting. The VCO output frequency f_v is summed in a balanced modulator with the 10.24-MHz output of the divide-by-3 circuit to develop the exciter drive signal f_e—a signal that ranges from 26.965 MHz for Channel 1 to 27.405 MHz for Channel 40.

The 15.36-MHz output of the divide-by-2 circuit is mixed with f_v to produce a *difference* frequency f_m ranging from 1.365 to 1.805 MHz, depending on the channel selected. This signal frequency is fed to a divide-by-n circuit where it is divided by a number between 273 and 361 to develop an output at precisely 5 kHz when the loop system is in lock. (The divide-by-n circuit is a programmable divider whose operation is controlled by the binary number (n_{pL}) appearing on the program lines.) It is this 5-kHz signal that is compared to the 5-kHz reference obtained by dividing the 30.720-MHz reference frequency by 3 and then by 2,048. Any frequency or phase error develops a correcting current that—after being filtered and amplified—pulls the VCO back on frequency.

If the PLL system is out-of-lock, the phase detector develops an auxiliary signal that gates off the exciter drive signal. This prevents the transmitter from radiating an off-channel signal;

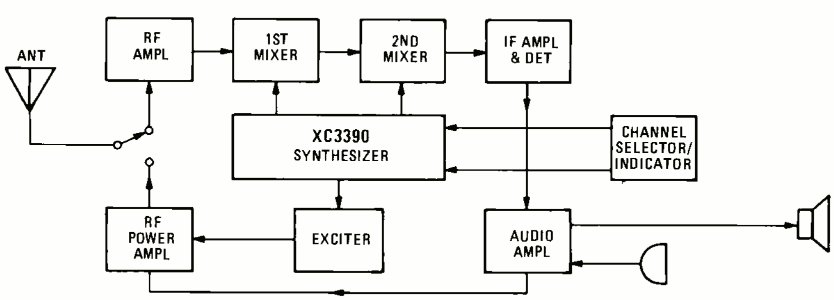


FIG. 1—CB TRANSCEIVER block diagram showing location of XC3390 phase-locked-loop.

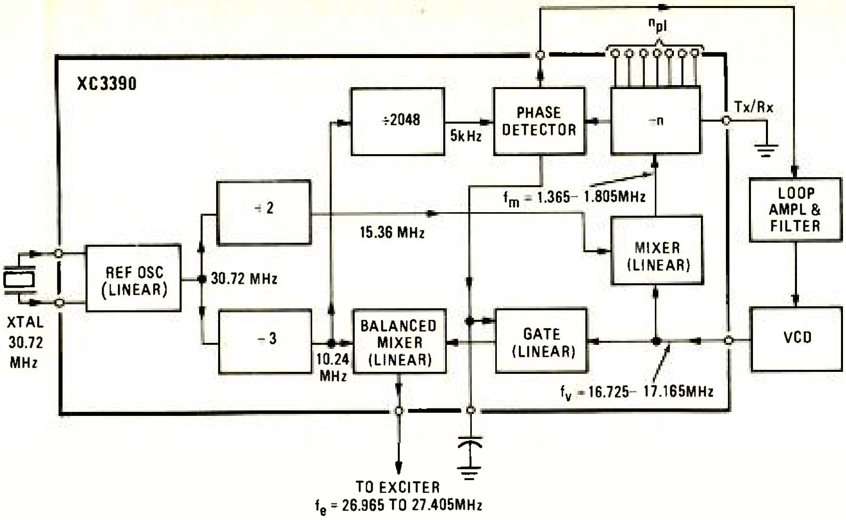


FIG. 2—MOTOROLA XC3390 phase-locked-loop IC requires external VCO, loop amplifier and filter. Frequencies are programmed via the ÷ n counter

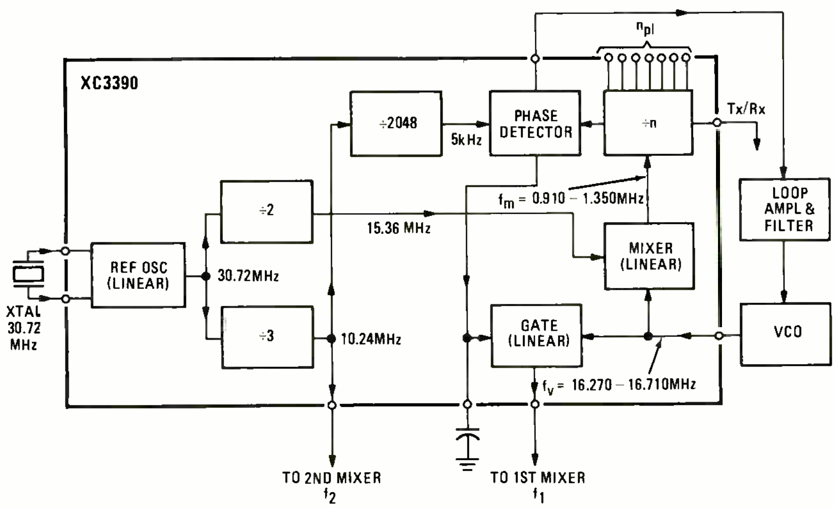


FIG. 3—RECEIVE FREQUENCIES generated by the phase-locked-loop synthesizer.

TABLE I

Channel Number	Decimal Equivalent (n_{pL})	Program Line Data Entries D6	D5	D4	D3	D2	D1	D0
1	0	0	0	0	0	0	0	0
2	2	0	0	0	0	0	1	0
3	4	0	0	0	0	1	0	0
4	8	0	0	0	1	0	0	0
5	10	0	0	0	1	0	1	0
6	12	0	0	0	1	1	0	0
7	14	0	0	0	1	1	1	0
8	18	0	0	1	0	0	1	0
9	20	0	0	1	0	1	0	0
10	22	0	0	1	0	1	1	0
I	I	I	I	I	I	I	I	I
22	52	0	1	1	0	1	0	0
24	54	0	1	1	0	1	1	0
25	56	0	1	1	1	0	0	0
23	58	0	1	1	1	0	1	0
26	60	0	1	1	1	1	0	0
27	62	0	1	1	1	1	1	0
I	I	I	I	I	I	I	I	I
30	68	1	0	0	0	1	0	0
I	I	I	I	I	I	I	I	I
35	78	1	0	0	1	1	1	0
I	I	I	I	I	I	I	I	I
40	88	1	0	0	1	1	0	0

either during the initial lock-up time or if the VCO should develop an output frequency that would result in a signal being developed on an unassigned frequency (as in the 20-kHz gap between Channels 3 and 4), or in the event of loop failure.

How the receiver works

During the receive mode, the synthesizer generates the frequencies shown in Fig. 3. The 5-kHz reference input to the phase detector, which remains constant during the transmit and receive modes, is obtained by dividing 30.72 MHz by 3 and then by 2,048. The output of the divide-by-2 is 10.24 MHz—455 kHz below the first IF.

When in the receive mode, the VCO operates between 16.270 and 16.710—10.965-MHz below the channel carrier fed to the first receiver mixer. A part of the VCO output is mixed with the 15.360-MHz output of the divide-by-2 to develop a mixer output frequency f_m ranging from 910 kHz to 1.350 MHz. The programmable divide-by-n operates over a range of 182 to 270 as determined by the binary-coded number on the program lines.

Binary channel selection

When in the transmit mode, the TRANSMIT-RECEIVE switch grounds the Tx/Rx terminal on the IC. The binary number on the synthesizer program-lines equals the program-line number (n_{pL}, a digital number) plus 273. Channel 1 requires a divide number of 273 so the binary number on the program line will be zero. Table 1 shows the relationship between channel numbers, n_{pL} and the binary equivalent as applied to the program lines.

When receiving, the Tx/Rx terminal is taken high and the divide-by-n number equals the program-line number plus 182. Thus n in the programmable divider varies from 182 for Channel 1 to 270 for Channel 40.

Figure 4 shows how the binary signals for the program lines can be developed.

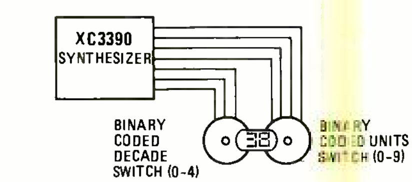


FIG. 4—BINARY SIGNALS for the program lines can be developed by either BCD switches.

There are two separate binary-coded rotary switches; one to develop a binary 0 through 4 for the decade portion of the channel number and the other to develop a binary 0 through 9 for the units portion.

In a future issue, we are going to take a look at the PLL frequency synthesizer in the General Electric model 3-5800A mobile CB transceiver. **R-E**

Build With IC's

Action Football Game

This portable game uses a random-chance circuit and a play chart with realistic odds. The key to playing this game is to pick the right offensive and defensive play strategy

RUDOLF F. GRAF AND
GEORGE J. WHALEN
CONTRIBUTING EDITORS

TO A TRUE FOOTBALL FAN, ANY MONTH having more than 27 days is a *great* time to enjoy football! Unfortunately, the real thing is available for just a few short months—barely enough to satisfy the pigskin addict's craving. Before you can say "Statue-of-Liberty play", the bowl games come and go, the goalposts are torn down and discussions with friends turn to rehashing events of the past season's games.

If you're tired of stale verbal "reruns" of past gridiron glories, invite your football buddies to join you for an evening in playing a fast-paced game of electronic football that pits your skill against that of your opponent, while bringing in the element of chance that so often means success or failure on the playing field!

The game is built around a unique random-chance "chaser" circuit using sixteen specially matched neon lamps and two integrated circuits. When in operation, a "count" is circulated through the chaser circuit so rapidly that all lamps appear to be flickering on and off at the same time. However, only one of the sixteen lamps is really on at any given millisecond. This means that if the count is stopped, just one lamp will remain glowing: the others will be extinguished. This is important because the lamps serve as indicators for reading the results of plays that you and your opponent select and run.

You, as the offense, for example, pick a play. There are sixteen possible outcomes for that play. Now, your opponent picks a defense and there are sixteen possible outcomes for his choice! The plays and results are all contained on a printed chart that fits under the 16-lamp line-up of the game. For any given play, the chart gives a statistically weighted ratio of risk-to-reward. That is, for plays that usually succeed, the chart gives better odds for success, although yardage gains will be smaller than in riskier plays. Conversely, for plays that are harder to pull off, yardage gains are greater and there's a chance of a touchdown, *but* the possibilities of failure are greater, too.

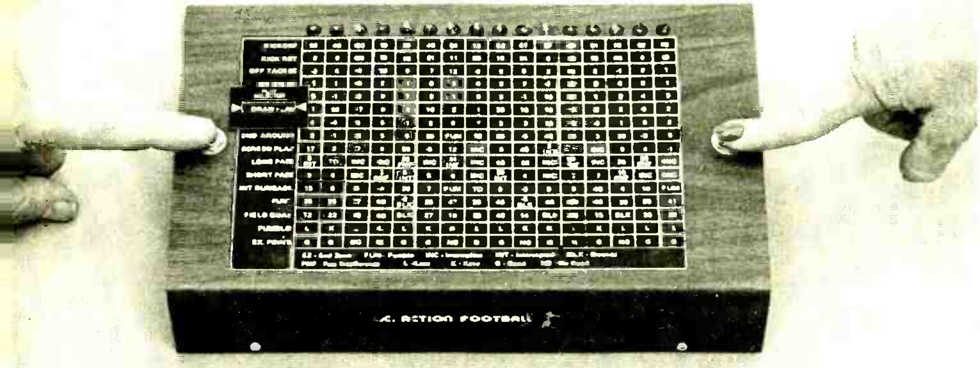
In devising the play chart, we consulted several football authorities (and we are particularly indebted to coach Curtis Blake of Colgate University for his expert assistance in setting up the play-chart odds). Of course, as in the real thing, there are possibilities of blocked kicks, interceptions and fumbles. That's why the element of skill in picking the *right* offensive or defensive play strategy is so strong in this game. While the circuitry may appear simple, the game is to be played by shrewd competitors who know the *right* plays to pick and who can stand the consequences. It's hot action for people who *really* know football!

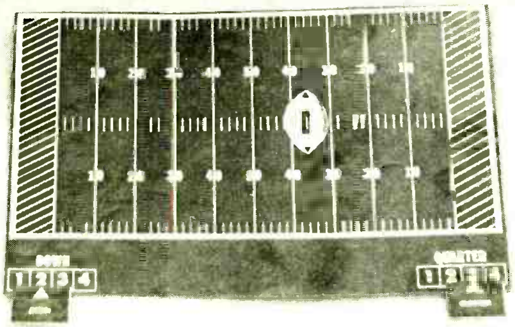
How it works

The random-chance "chaser" circuit shown in Fig. 1 uses sixteen neon lamps arranged so that they form a series of cascaded *neon lamp astable multivibrators*. Each astable has two lamps, two resistors and two coupling capacitors.

Figure 2 shows one such astable multivibrator stage. When the supply voltage is applied to the circuit, the voltage across lamps NE1 and NE2 begins to increase as the stray capacitance that is in parallel with the lamps charges up through R1 and R2. The *firing voltage* of one of the lamps will be reached first, since it is extremely unlikely that both will reach their trigger potentials at precisely the same time. Assuming that NE1 lights first, as that lamp goes into conduction, the voltage across it suddenly decreases to the *maintaining voltage*. Accordingly, a positive voltage pulse appears across R1, and this is coupled via capacitor C1 to the cathode of NE2. This pulse is approximately equal to the difference between the firing and maintaining voltages of lamp NE1. The pulse drives the cathode of NE2 positive, effectively reducing the potential difference across NE2 and preventing it from glowing. The voltage appearing across NE1, meanwhile, is approximately equal to its maintaining voltage so that it is glowing.

Shortly thereafter, however, capacitor C1 discharges permitting the voltage across NE2 to increase toward its firing potential. As this potential is reached, NE2 conducts and glows. When this happens, the voltage between its electrodes is reduced to the maintaining-voltage level. This causes a positive pulse to appear across R2, which is then coupled back to the junction of the NE1 cathode and R1. The pulse amplitude represents the difference between NE2's firing and maintaining voltages. However, since NE1 is only at its maintaining voltage, the sudden positive pulse at its cathode sharply decreases the potential difference between the lamp's electrodes, causing NE1 to extinguish. At this point, NE1 switches to the





high-resistence state and stops glowing, while NE2 is now at its maintaining voltage and is glowing. Note also that capacitor C2 has coupled the output pulse appearing across R2 to the next lamp in the chain. This means that this lamp will now go through the cycle of being inhibited from firing, then firing and extinguishing NE2 in the same sequence and manner as that just described.

As shown in Fig. 1, the identical stages of the circuit are connected as a "ring", with the output capacitor of the last stage feeding back into the first stage. This means that the "count" circulates rapidly through the ring causing the lamps to flicker in sequence, but giving the appearance that they're all flickering at the same rate.

PARTS LIST

All resistors are ¼ watt, 10%, unless noted.

R1—330,000 ohms
R2-R17—1.5 megohms, 5%
R18—1000 ohms
C1—10 μF, 150-volt electrolytic
C2-17—.05 μF, 50-volt radial-lead disc ceramic
D1—silicon rectifier, 200 PIV, 1 amp (International Rectifier 10D6, RCA SK3017A, or equal.)
NE1-NE16—miniature neon lamp (G-E 5AB-B, or equal.)
IC1, IC2—16-diode array (Fairchild FSA2510)
S1, S2—single-pole normally closed pushbutton switches
Misc.—PC board, playchart, game board, playing pieces, vinyl case.

The following parts are available from:
National Mentor Corp.
Box 53
Wykagyl Station
New Rochelle, NY 10804

A basic parts kit consisting of the neon lamps, IC's, woodgrain case and playchart for $29.00 postpaid. Order No. FBL-1.

A complete parts kit that includes everything in the FBL-1 kit, plus all resistors, capacitors, diode, PC board for the main game circuit, pushbutton switches, line cord, etc., for $39.00 postpaid. Order No. FBL-2.

NE1-NE16—16 neon lamps for $10.00
IC1, IC2—two 16-diode arrays for $7.50
PC board for main game circuit, $5.50
Walnut woodgrain predrilled case for $10.00
Playchart, game board and playing pieces on a pressure sensitive adhesive-backed stock for $2.75.

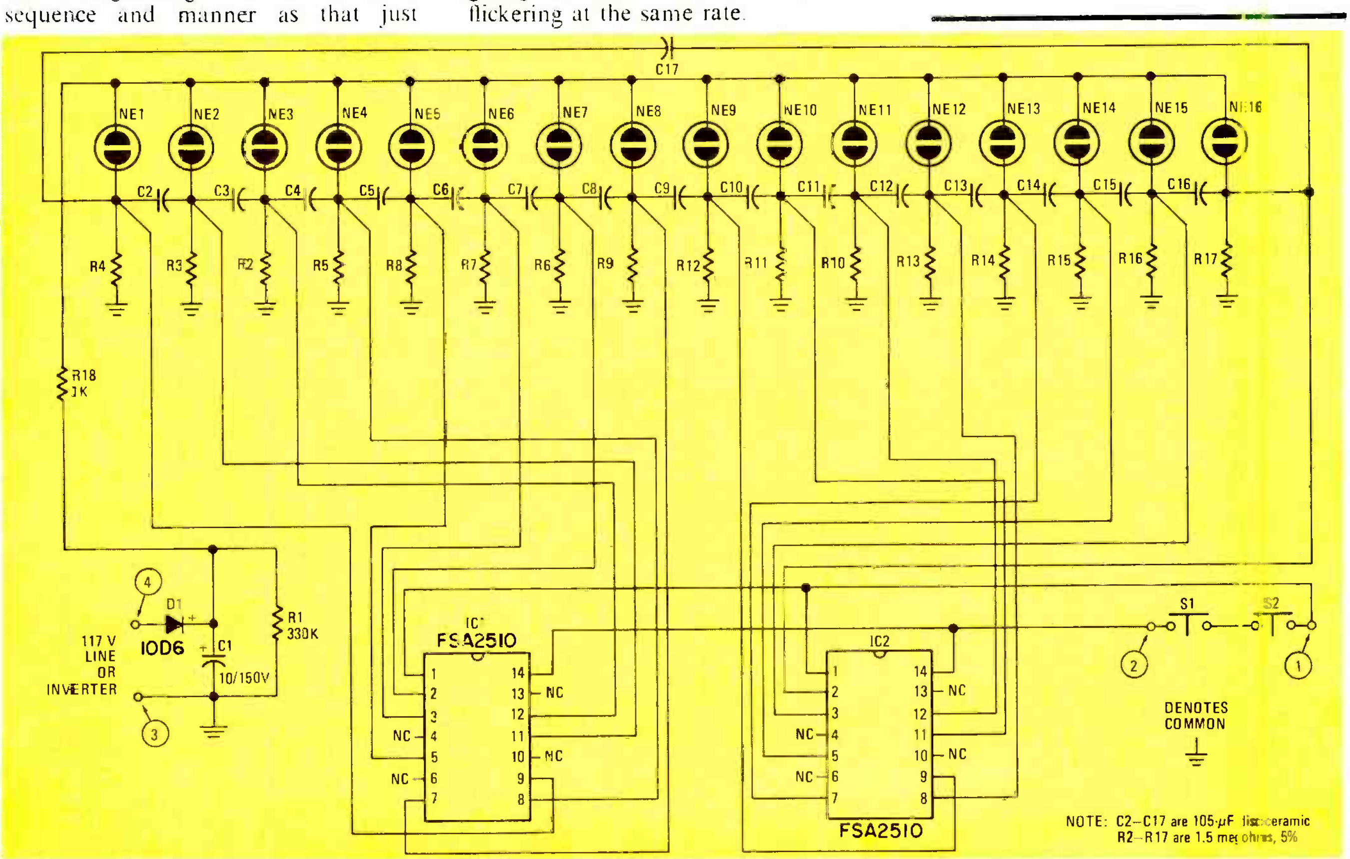


FIG. 1—GAME CIRCUIT uses neon lamps in astable multivibrator configuration. Switches S1 and S2 should have been shown as normally closed.

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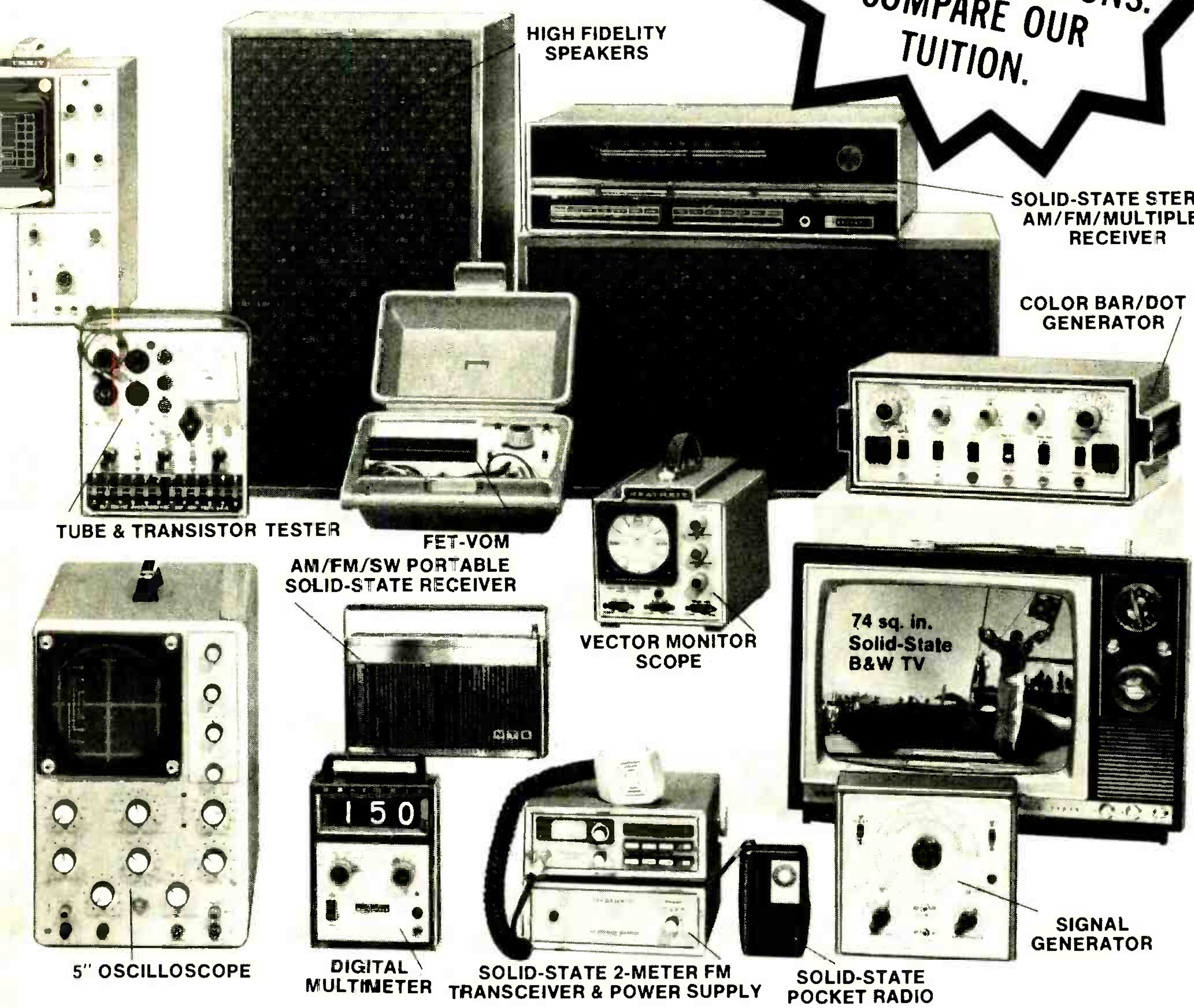

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This is only half the story, for now we must be able to stop the "count" at a random point so that only one lamp remains glowing while all the others are off. This is possible with the diode gating provided in the integrated circuits, IC1 and IC2.

There are a total of 16 series-connected diode-pairs with IC1 and IC2. Two diode-pairs are connected, as

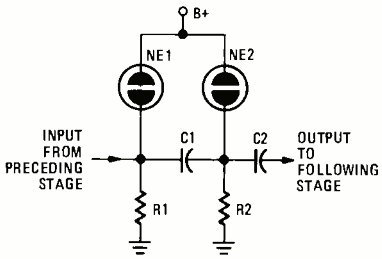


FIG. 2—BASIC ASTABLE MULTIVIBRATOR stage built around neon lamps.

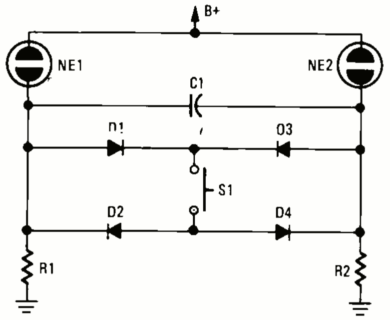


FIG. 3—DIODES are used to stop multivibrator operation.

shown in Fig. 3, to each astable stage of the chaser. The anode-cathode junction of D1 and D2 is connected to the junction of the NE1 cathode, R1 and C1, while the anode-cathode junction of D3 and D4 connects to the junction of C1, R2 and the cathode of NE2. The common anodes and cathodes of the diodes respectively connect to the terminals of switch S1. When switch S1 is open, no current flows through the diodes because the anodes are connected only to other anodes, and cathodes are connected only to other cathodes. During this time, the chaser is in the free-running "chase" mode described earlier.

However, if switch S1 is closed, all capacitors in the circuit are suddenly shorted because diodes D1-D4 and D2-D3 respectively and immediately appear in series across C1 (as well as across all the other capacitors in the circuit). In effect, *all* of the stages are suddenly inhibited so that only the lamp that is *on* at the time switch S1 is closed remains on. The count cannot be transferred until switch S1 is opened.

Referring back to Fig. 1, IC1 and IC2 provide a total of 32 diodes to interconnect the 16 lamp-stages. Switch S1 is actually an AND function formed by the series connection of two normally-closed pushbutton switches, S1 and S2. This means that to get the chaser to run, either you *or* your opponent must press a button. However, to get the chaser to *stop*, both you *and* your opponent must release. This "added extra" contributes to the randomness of the circuit.

The power supply of the game uses a conventional halfwave rectifier, D1 and filter capacitor C1. Resistor R18 serves only as a protective current-limiter to buffer the supply against inadvertent short-circuiting. Resistor R1 is a bleeder resistor for the filter capacitor.

Portable operation

There's no reason to stay indoors to play football, if the game is equipped with the accessory battery/inverter supply shown in Fig. 4. Using but a single

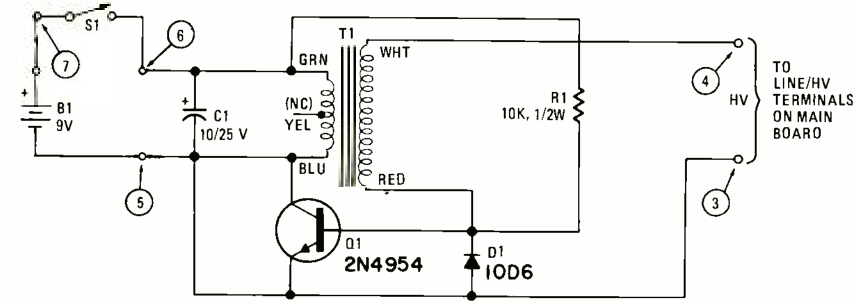


FIG. 4—OPTIONAL BATTERY INVERTER allows portable operation.

transistor, a 9-volt alkaline battery, a transformer and a few other parts, this supply delivers a high-frequency non-sinusoidal voltage of approximately 100 volts RMS. This input is applied to rectifier diode D1 and filter capacitor C1, providing adequate DC for several hours of operation.

The inverter circuit operates as follows: When toggle switch S1 is closed, current is supplied to the emitter-base junction of Q1, through R1. Transistor Q1 conducts a current pulse through its collector, storing energy in T1 and also inducing a voltage in the output winding that momentarily turns off Q1. The collapse of the magnetic field in T1 induces a voltage pulse across the output winding that is stepped-up by the turns ratio of the transformer. Diode D1 prevents the base of Q1 from going excessively negative, and also serves as the return path for the current to flow back to the transformer output winding. When the output pulse has passed, Q1 again conducts because of the bias supplied through R1, and another cycle commences.

NOTE

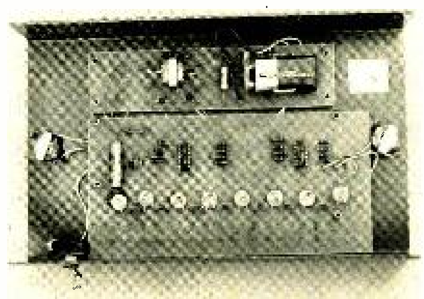
This game can be powered directly from the AC-line *only* if it is safely enclosed within a *completely insulated housing,* such as the woodgrain vinyl case shown in the accompanying photos. If you do not use an insulated case, a 1:1 power-line isolation transformer should be added to minimize shock hazard.

Construction

The Football Game circuit is contained on a 4 × 8-inch printed-circuit board that speeds and simplifies assembly. (See Fig. 5.) Importantly, the board also holds the sixteen indicator lamps in the correct physical alignment so that they will slip through holes in the case and be accurately aligned with the columns of the play chart that will later be affixed to the top of the case. Figure 6 shows the parts layout on the printed-circuit board. The 16 coupling/timing capacitors (C2 through C17), 16 resistors (R2 through R17), and the two IC diode arrays are mounted on the non-foil side of the board, as are the power-supply components (diode D1, filter capacitor C1 and resistors R1 and R18). The neon lamps are soldered to the foil side of the board, thus making it possible to install the board with the foil side facing the case. (This prevents accidental contact with components and conductors that operate at line voltage.) The two inte-

PARTS LIST
OPTIONAL BATTERY INVERTER

- R1—10,000 ohm, 1/2 watt, 5%
- C1—10μF, 25-volt electrolytic
- D1—silicon rectifier, 200 PIV, 1 amp (International Rectifier 10D6, RCA SK3017A, or equal.)
- Q1—2N4954 transistor
- S1—SPST toggle switch
- T1—miniature transformer; 1000-ohm CT primary, 200,000-ohm secondary (Radio-Shack No. 273-1376 or equal.)
- B1—9-volt alkaline battery
- Misc.—PC board, battery holder, battery terminal clips, etc.



MAIN CIRCUIT BOARD mounts next to battery inverter board.

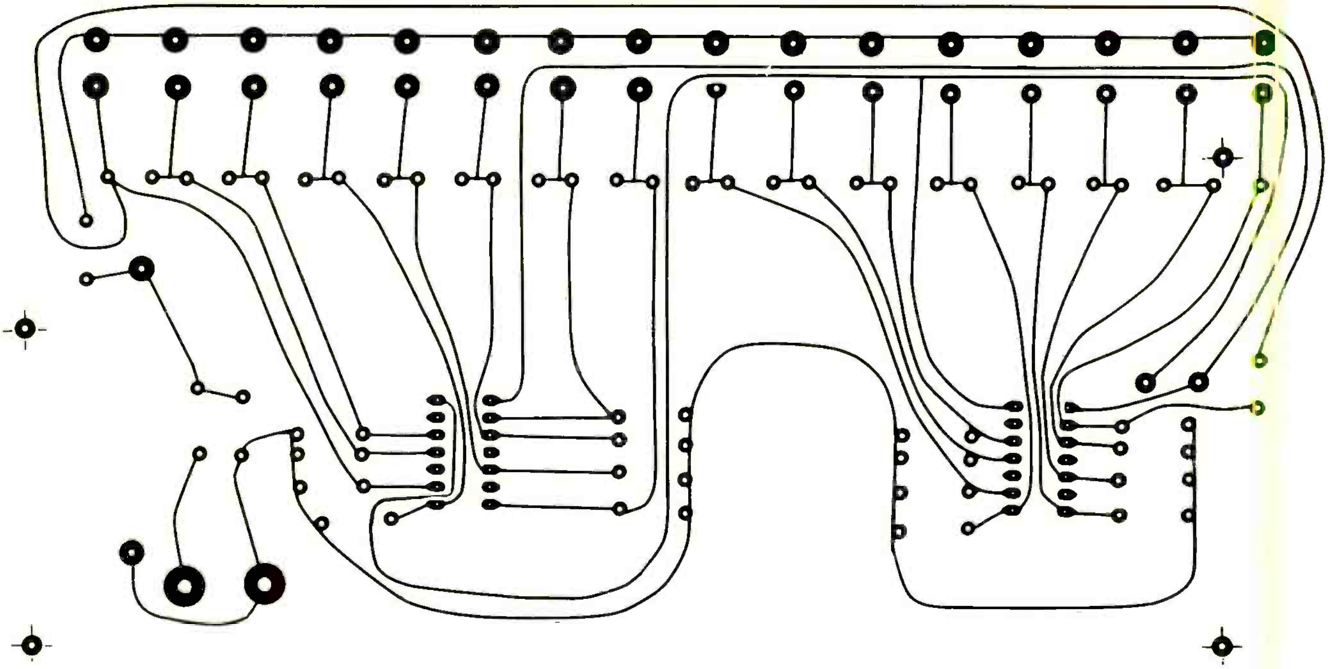
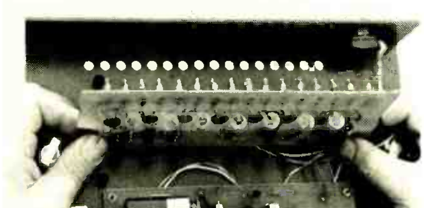


FIG. 5—FOIL PATTERN of game board shown full-size.

grated circuits (IC1 and IC2) are installed directly on the board, without sockets (although sockets may be used, if you prefer). A low-wattage soldering iron should be used to solder the components to the board.

To install the lamps, slide their lead wires through the board *from the foil side*, pressing gently but firmly until the point of maximum downward travel is reached. Board holes are spaced so that the lamps will be lead-supported about 3/16-inch above the foil side of the board. When the board is installed, only the topmost portion of each lamp will jut through the case holes. Switches S1 and S2 are installed on the case at either end and connected in series to the points 1 and 2 as shown in Fig. 6. The 117 VAC line-cord enters the case through a hole in the rear and solders directly to the board at points 2 and 3. The line is thus completely insulated from any components you touch. No on-off switch is included for AC-line operation, and so, the highest degree of isolation from the line is maintained. The unit is turned on by plugging it into an AC outlet and shut off by removing the plug. If you choose the inverter, its leads connect to the points 2 and 3 on the board instead of the line cord. Switch for the inverter then mounts in the case hole for the line cord.

The assembled board is supported in the case on four ½-inch screws fitted with ¼-inch insulated spacers. Flat-head screws are used, and holes in the case are counter-sunk so that no hardware protrudes above the case top surface. When the board has been mounted in the case and wiring has been completed, the play chart is installed on the case top. Next, prepare the playing field and game pieces. You can either cut these from a sheet of paper and use them as they are, or you can glue the sheet to a stiffening cardboard and cut the pieces out afterward. Be sure to cut out the center of the play selector and ball with a sharp knife or razor blade. The play chart, playing field and play pieces are shown in Fig. 7. A full-size pre-printed play chart, playing field and pieces with a self-adhesive backing is available (see parts list).



NEON LAMPS mount through holes drilled in front panel.

If portable operation is desired, assemble the optional battery inverter circuit. The foil pattern for this board is shown in Fig. 8, and the component placement diagram is shown in Fig. 9. The assembly procedure for this board is straightforward.

Playing the game

You start by flipping a coin to see who kicks off. The player winning the toss will receive. His opponent places the ball marker on his 40-yard line. The play selector is moved to the row labelled KICKOFF on the chart and the kicker's button is pressed. The light remaining on when the kicker releases his button indicates the kick's distance. If it went, say 48 yards, the ball marker is placed on the receiving team's 12-yard line. The play selector is now placed on KICK RET and the process is repeated to see how many yards the receiver, by pressing his button, makes on the runback. (If the kick goes into the end zone, the receiver takes the ball on his 20-yard line with no runback).

At this point, the offensive player has a first down with four tries to go 10-yards and make another first down. He

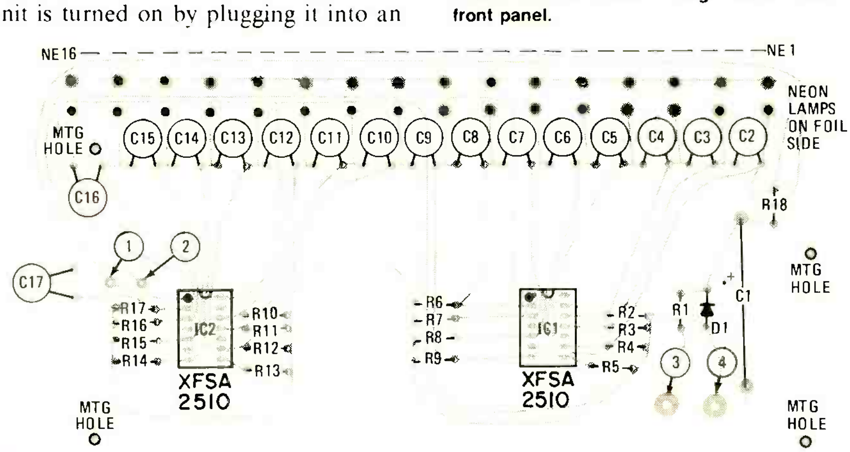
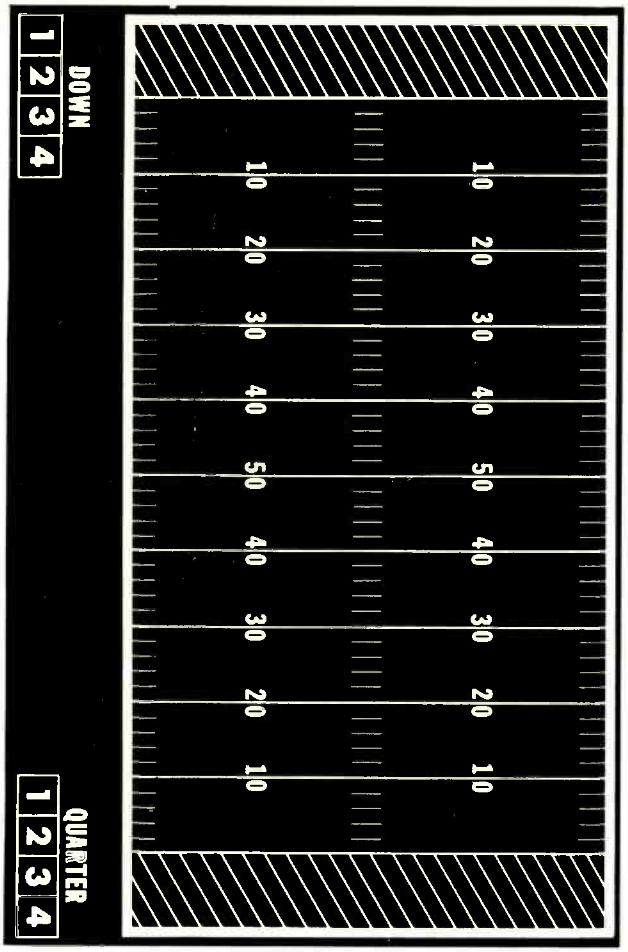


FIG. 6—COMPONENT PLACEMENT of main PC board.



KICKOFF	55	40	53	10	30	48	54	12	EZ	41	37	49	51	15	52	58
KICK RET	2	9	20	14	35	21	11	55	15	24	5	22	16	45	4	23
OFF TACKLE	-3	4	0	10	5	7	12	-2	6	0	2	15	3	-1	7	1
QB SNEAK	1	1	0	2	-1	0	3	0	2	7	-1	2	0	4	2	1
FB CENTER	5	-1	2	0	7	3	1	6	3	-1	10	2	1	2	4	3
DRAW PLAY	1	20	17	0	-2	16	2	1	20	15	18	1	-2	2	0	2
OFF GUARD	4	-4	1	5	-1	2	0	7	3	3	10	-1	4	1	8	2
END AROUND	3	-1	-2	5	0	30	FUM	12	25	-5	45	15	3	20	-3	5
SCREEN PLAY	17	3	-7	0	20	-5	12	INC	5	45	3 INT	7	INC	0	4	-1
LONG PASS	5 INT	TD	INC	INC	25 PNF	INC	20 INT	INC	45	30	INC	25 INT	INC	35	30 PNF	INC
SHORT PASS	3	4	INC	7 PNF	5 INT	5	6	INC	20 INT	-4	INC	7	7	10 PNF	INC	INC
INT RUNBACK	15	0	5	-4	20	7	FUM	TD	8	-3	0	5	40	4	10	FUM
PUNT	36	25	37	48	-8 BLK	35	47	38	45	-5 BLK	46	50	40	39	55	41
FIELD GOAL	12	23	20	29	BLK	27	18	28	40	14	BLK	35	15	BLK	38	30
FUMBLE	L	K	L	L	L	K	K	L	L	K	K	L	K	L	L	L
EX. POINT	G	G	NG	G	G	G	NG	G	G	NG	G	G	G	NG	G	G

EZ - End Zone FUM - Fumble INC - Incomplete INT - Intercepted BLK - Blocked
PNF - Pass Interference L - Lose K - Keep G - Good NG - No Good

FIG. 7—PLAY CHART, playing field and play pieces.

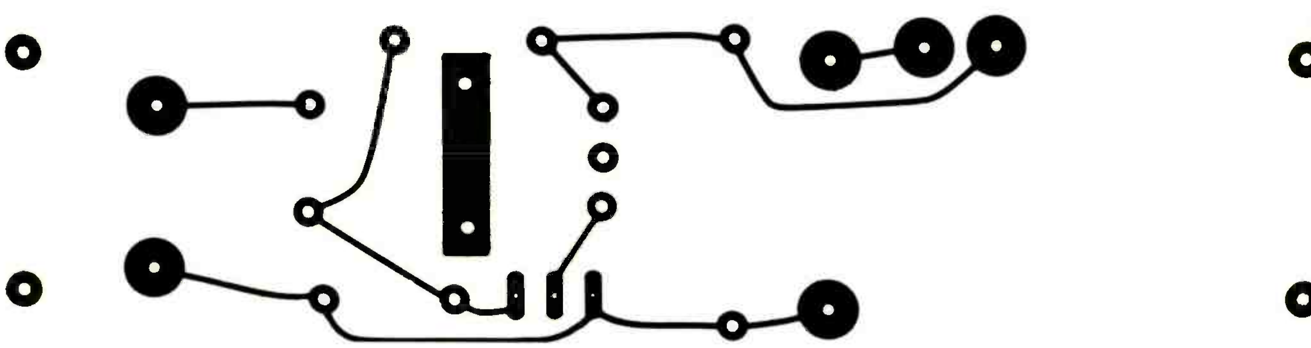


FIG. 8—FOIL PATTERN of optional battery inverter board shown half-size.

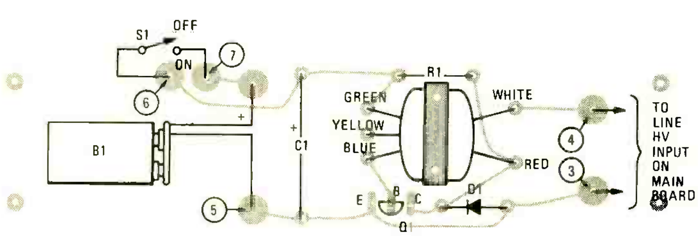


FIG. 9—COMPONENT PLACEMENT of battery inverter board.

may use any scrimmage play shown on the chart, moving the ball ahead the indicated yardage each time. Minus yardage means a player has been thrown for a loss and the ball must be moved back the distance shown. Note the position of the ball at each first down, the point the ball must reach for another first down and the line of scrimmage on each play.

A player may either kick on the fourth down or try for yardage. If he gambles and fails to make the first down, his opponent takes over the ball at that point. If he kicks, the play selector is moved to PUNT on the chart and the buttons are operated to determine the kick's distance. The opposing player then takes over the ball and uses the kick return play to determine how far he runs back the punt.

To score a touchdown on any play, the yardage indicated must be enough

continued on page 98

Analog Voltmeters

Part III. The analog voltmeter is alive and well. Here's a rundown of the different types currently available—their features, specifications and applications

CHARLES GILMORE*

THE FIRST TWO PARTS OF THIS ARTICLE discussed the different types of analog voltmeters and their features and specifications.

This concluding part of the article completes the discussion on specifications and introduces various applications.

Ohmmeter ranges

The TVM ohmmeter ranges are identical to those of the VTVM They have a 10-ohm center scale and have ranges from R × 1 ohms to R × 1 Meg. The TVM adds additional specifications to the ohmmeter. First, the maximum open circuit voltage of the ohmmeter is specified. This is especially true if the TVM has selection of HI and LOW ohms. A maximum open circuit voltage is then given for both high and low ohms operation. The ohmmeter specifications may also give the maximum source current. This specification is useful if there are critical components in the circuits that might be damaged by excessive currents. The common terminal of the TVM is usually negative, but if the manufacturer does not indicate this in the specifications or on the terminals of the meter itself, it is a good idea to check it out after purchase and note the information where it can easily be seen.

*Manager Design Engineering, Heath Co., Benton Harbor, MI.

Input impedance

In the DC function the input impedance of the TVM is most commonly 10 megohms. A few still have an input impedance of 11 megohms.

The AC input impedance of the TVM is composed of the same DC resistance used on the DC input with a shunt capacitance specified. The shunt capacitance ranges from a low of 30 to 40 pF on the very best of TVM's to 100 pF on the more common units. It should be noted this input capacitance does not disappear when the DC mode is used. When measuring the DC component of a signal, this capacitance may cause some disruption to the AC characteristics of the circuit. Unfortunately, few if any manufacturers specify the input capacitance of the DC voltmeter.

The ammeter

Specifications for both the AC and DC ammeter are very much alike. Not all TVM's have the ammeter function, and the lack of ammeter specifications indicates a lack of the function. Ammeter specifications indicate the insertion loss when the meter is placed in a circuit. This may be given in two ways. First, the manufacturer may note that the ammeter has a certain maximum voltage drop. Second, the manufacturer may indicate the insertion resistance and give the information necessary to calculate the voltage drop. Some manufacturers give both. The insertion resistance may be greater than expected in the high-ampere ranges, as the lead and connector resistances become appreciable.

Accuracy of the ammeter closely follows the accuracy of the lowest voltage scales of the meter. An additional error figure is often given for the lowest value of shunt resistance (highest current range), as high-accuracy shunts at low resistance are very difficult to make.

Frequency response of the AC ammeter closely follows the frequency response of the lowest range of the AC voltmeter. There may, however, be an additional derating for the high values of shunt resistance (lowest current ranges), as the distributed capacitance and the high value of the shunt resistance cause additional loss of high frequencies.

Ammeter ranges for TVM's run from $10\mu A$ to 1A full scale. A few TVM's offer wider ranges than this; however, they are not common. Up to 10-ampere ranges are offered on some TVOM's designed with *appliance service* in mind.

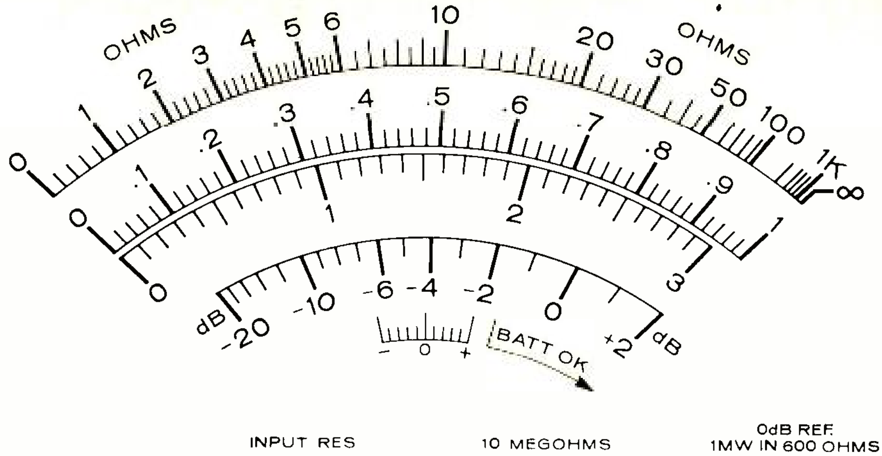


FIG. 12—THIS TYPICAL TVM SCALE is from the Heathkit IM-104 TVOM. Besides ohms and volts, it has a short zero-center scale and a battery check position.

Probes

Normally the probes provided with the TVM are not as exotic as those supplied with the VTVM. The most common one is the simple test probe with a test lead terminated in a banana plug, or sometimes in a tip plug. Occasionally some TVM's offer the VTVM probe. An 11-megohm input impedance is often a clue to a special probe.

AC rejection

A few TVM manufacturers specify the AC rejection of the DC ranges. This specification indicates the number of full scale overloads of a certain frequency AC (usually 60 Hz) which may be applied without affecting the DC reading.

Protection

As the TVM, especially TVOM's, are often used in situations where accidental contact with high voltages can occur (most commonly either the 120 or the 240 VAC power line), protection of the DC voltmeter and other functions is important. Protection is accomplished and specified in a number of ways. The manufacturer may simply state that the meter is protected from momentary overloads of 220 volts AC or DC on any range. This protection takes the form of back-to-back diodes at appropriate places in the circuit.

Additional instrument protection is given by a set of back-to-back diodes across the meter movement itself. These diodes prevent the movement from being destroyed by a continuous overload. Ohmmeters are protected by diodes, and a fuse may provide additional protection. Ammeter shunts are often fuse protected. These fuses may be difficult to obtain, and acquiring a few spares is wise.

Some of the TVM's, especially the TVOM's, have a ruggedized taut-band meter movement. Such an instrument will come through a fall onto a hard surface undamaged or at least with minor repairable damage, while conventional meters would be seriously damaged.

Scales

A typical TVM scale is shown in Fig. 12. Note the BATTERY TEST position. The dB scale is calibrated in dBm. (Zero dBm is one milliwatt on 600 ohms, or 0.774 volts). A small center-zero scale is given for null measurements.

Controls

The number of controls and the selection of functions are highly dependent on the functions offered by the particular TVM. Function selection is by rotary switch and/or push buttons. Range selection on the TVM frequency includes a battery test position.

A zero control is common to TVM's. The range of this control is sufficient to permit zero centering the meter as well as left-hand zeroing. An ohmmeter adjustment may not be included on a meter that utilizes internal constant current generators in its ohmmeter function.

The meter movement

As noted in the section on meter protection, some TVM's employ the taut-band meter movement. Those not indicating this type of meter movement use the regular moving-coil or D'Arsonval meter. Most manufacturers specify the size of the meter. A four- to five-inch meter is common and adequate for most laboratory and field service applications. Meter displays smaller than that become difficult to read, especially when there are a number of scales clustered on the face. Meters larger than five inches are useful in some shop or laboratory applications. A mirror-backed meter aids in resolution, but rarely does the TVM offer accuracy requiring a mirror-backed meter.

Amplifier outputs

Good laboratory TVM's have two different forms of outputs. There may be a DC voltage directly proportional to the meter movement. Such an output may be 100 mV, or 1 volt for a full-scale meter deflection. This type of output is handy for driving a strip-chart recorder or perhaps some form of limit detecting circuit. The second form of output is a signal taken from the meter amplifier prior to being applied to the rectifier. Such an output may be used to drive a set of headphones, for example, to listen to a circuit as well as to measure it. Such outputs usually have a few kilohms source impedance.

Floating inputs

A floating input is one not connected to the earth side of the power line. Generally this indicates the impedance to ground (usually a very high resistance with a small shunt capacitance) from both the high and the low (common) terminals of the voltmeter input is the same. Such a feature allows the voltmeter to be operated without one side of the voltmeter attached to ground. This is particularly handy for measuring voltage drops across circuit elements which have both terminals above ground. A maximum limit is given to this floating capability when the instrument is line operated. Battery operation automatically provides floating operation.

Accessory probes

Many manufacturers offer high-voltage probes to extend the useful DC voltage range of the meter, and RF probes to extend the useful frequency range of the AC voltmeter. These probes are often not interchangeable from one manufacturer to another. Close attention to the specifications of the voltmeter with which they are intended to be used is wise.

Battery operation

As noted in the section on floating inputs, battery operation is a useful feature when the instrument is operated with both inputs above ground. This feature is also used to eliminate unwanted signals present on a common ground system. This is desirable when the common input to the TVM is common to earth ground. Battery operation is also essential to field operation and is therefore a part of every TVOM. Batteries do tend to spoil after a time and can damage the instrument when they do. This feature also adds to the price.

Special current measurement

As noted in the theoretical discussion on ammeters, a few special types are available. These special ammeters are generally dictated by some special application. However, the ammeter in the Weston model 670, which does not require opening the circuit to make the current measurement, is especially useful for service work. Ammeters with special high current ranges are available for special applications. Generally such special scales come at the expense of some other feature or ranges.

Automatic polarity indication

Some of the more sophisticated TVM's have polarity indicators instead of a DC polarity reversal switch. Polarity reversal is indicated by the change of the polarity indicators from + to —or vice versa. Polarity indicators are disabled when AC measurements are being made.

Ohmmeter features

As noted before, many TVM ohmmeters offer both high and low resistance measurements. In addition to the high and low measurements, some TVM's offer an ohmmeter polarity reversal switch. The polarity reversal switch permits a quick check when forward biasing a semiconductor junction in a circuit, or when a semiconductor is being tested for shorts or opens.

The AC voltmeter

The ranges of the AC voltmeter cover a wider range than those of either the VTVM or the TVM. Ranges extend from the 0.1 to 10 mV area to the 300 to 1,000 volt area. The ranges of the AC voltmeter are also calibrated in decibels. Zero dB is 0.774 volt for zero dBm.

AC voltmeter accuracy is specified in one of two ways. First, the voltmeter may be given an accuracy specification at a single frequency and a frequency response specification to cover the operating band of frequencies for the instrument. The total operating range of the voltmeter may be subdivided into a number of ranges with a different response for each range. Second, the voltmeter may be given an accuracy specification for the entire range of operation. Usually this form of specification is reserved for the higher-priced meters. Accuracy may be specified as a percentage of reading plus a percentage of full scale for the AC voltmeter. Again the accuracy may be broken down by the frequency ranges of the meter.

The frequency response of the AC voltmeter is from the 10 to 20 Hz region to

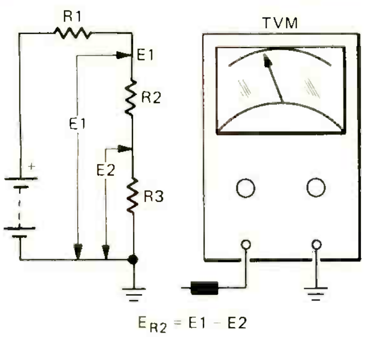


FIG. 13—IF THE METER IS GROUNDED, the voltage across "floating" resistor R2 cannot be measured directly, but voltage from ground at the two ends can be measured and the drop found by a simple subtraction.

the 1 to 4 MHz area. The exact extent of response may vary with the voltage range being discussed. The frequency response of the AC voltmeter is better than that either the TVM or the VTVM.

A 10-megohm input impedance shunted by 10 to 40 pF is common for the AC voltmeter. A few AC meters offer a lower input impedance. The input capacitance changes with the voltage ranges selected on some meters. This feature can cause a change in the circuit impedance when the meter is switched through its ranges, due to a change in capacitive loading.

The response time of the AC voltmeter indicates the time for the meter to settle within its rated accuracy. This specification indicates the time associated with the rectifier circuit. The response time indicates that the voltmeter may, or may not, be used as a VU meter, which requires a 0.3 second maximum response time.

AC voltmeters frequently feature amplifier outputs; the meter may also be used as a high-gain test amplifier. The output impedance of these amplifiers is either 50 or 600 ohms. Other features include an output proportional to the meter deflection (either 100 mV or 1V), filtering that may be switched in to eliminate high-frequency response, battery operation for portability and elimination of ground currents, linear dB scales, mirror-backed meters for ease in making high resolution measurements, and a true RMS converter. Generally, such options are available only on higher-priced units, and some, such as the true RMS converter, are expensive.

Regular and special applications

The electronic analog multimeter is used where it is necessary to measure a voltage, current, or resistance to an accuracy of two percent or less. This, in fact, is most of the time, especially for the home experimentor or the consumer products service shop. Some industrial service and laboratory situations require greater accuracy. The digital multimeter should be considered for those applications.

As noted previously, the analog meter is definitely the best display devise when the desired information is trend. Numerous situations exist in the alignment of an FM receiver/transmitter, for example, where the procedure calls for peaking the output of a stage. An analog meter proves its worth here and should always be carried for this purpose if for no other. Other examples of trend measurement are found in the same FM receiver/transmitter alignment procedure. For example, many oscillator circuits and some output stages require their supply current to the stage be reduced to a minimum, or "dipped." This too is a measurement of trend.

The DC output of the receiver discriminator is zero when the discriminator transformer is tuned to the center frequency of the IF strip. The zero offset capability of the TVM or VTVM is especially handy for this measurement, as the discriminator output voltage is of one polarity for frequencies above the IF center-frequency and of opposite polarity for frequencies below it. An analog voltmeter is needed to set the output of the discriminator at zero. This same "nulling" procedure is used in a number of bridge circuits, where an analog voltmeter with zero offset is also called for.

A common problem is the need to make a floating measurement when the meter's common terminal is connected to earth ground. A solution to this requires making two measurements, one at each end of the circuit, and subtracting the readings. When this technique is used, the difference between two large numbers is a small number with the same error as the large numbers. For example, the voltage drop across R2 of Fig. 13 is needed. E_1 is measured as 90 volts and E_2 is measured as 85 volts. The voltage drop across R2 is determined to be 5 volts. Examining the errors involved in the measurements, the 150-volt range of a 3% VTVM gave each of the high voltage measurements a ± 4.5 volt error. This error shifts the floating voltage of R2 by ± 4.5 volts. The accuracy of the difference between E_1 and E_2 depends on the linearity of the meter. Linearity is not often specified, but 1% of full scale is a good figure to use. The 5-volt drop across R2 can therefore vary by as much as ± 1.5 volts.

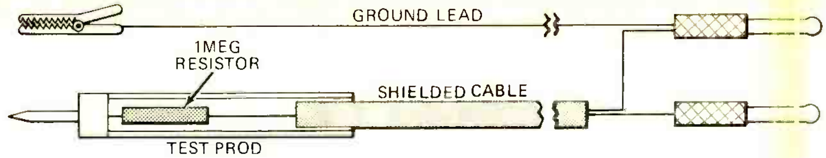


FIG. 14—AN ISOLATING TVM PROBE places a low-capacitance resistor in series, reducing the load on the circuit. Since, unlike the VTVM, the TVM is not calibrated to allow for a resistor in the probe, voltage readings will be low by 9 percent.

Many alignment and test procedures call for a specific type of voltmeter, frequently the VTVM. The 10-megohm TVM is a good substitute if the circuit is known not to need the isolation of the 1-megohm probe tip resistor of the VTVM. It is wise not to convert such measurements to digital multimeter measurements. Often the added resolution of the digital meter causes needless confusion. If a 10-megohm TVM is the only instrument available, a special probe can be made. This probe with the additional 1-megohm resistance at its tip reduces all measurements by 9%. However, the measurements are still valid with a *known* 9% error especially if these test points will not tolerate the capacitive loading of a 10-megohm 100-pF TVM. Fig. 14 depicts the construction of such a probe.

The in-circuit current meter is useful for troubleshooting. For example, presume one of ten integrated circuits soldered to a printed circuit board is shorted internally, enough to make the power supply enter current foldback. The normal method of servicing is to replace or disconnect each integrated circuit from the power rail until the power supply recovers. With the in-circuit current measurement, the current to each integrated circuit is measured. The shorted device is identified as the one drawing a large current. The defective component is replaced, saving considerable work. Needless to say, this technique is applicable to many other similar situations in both discrete and integrated designs.

Sources of error

The analog voltmeter, like any other instrument, is capable of introducing errors in the circuit being analyzed. These are fundamentally of two types, errors introduced by the operator and those caused by some characteristic of the instrument.

Errors in reading are the most common operator errors. Simple errors are often made from a misreading of scale

continued on page 104

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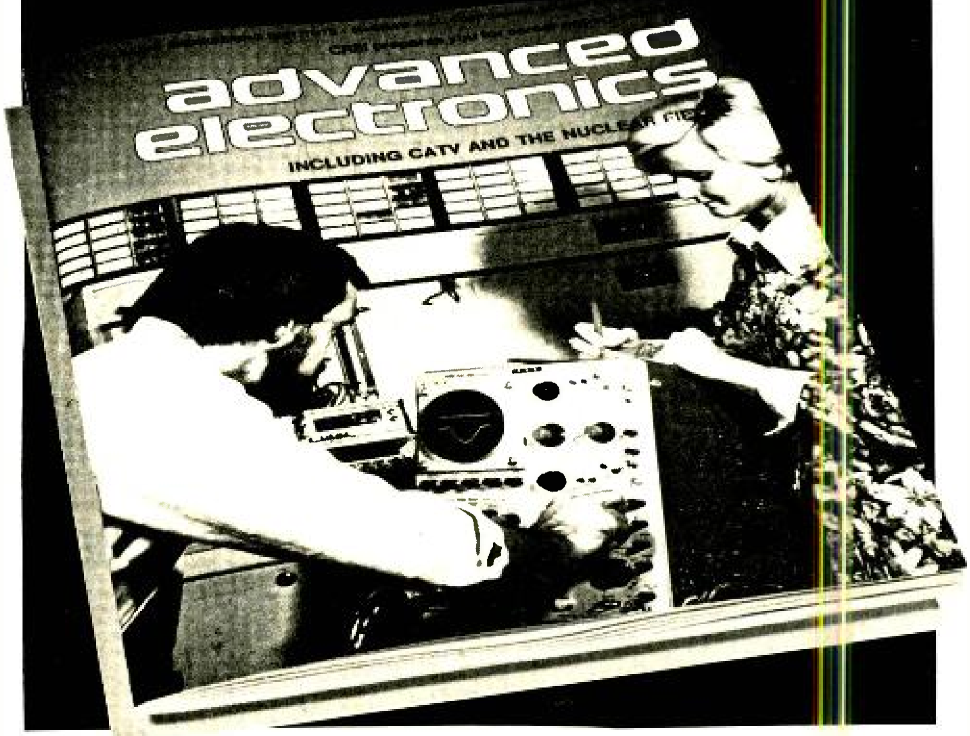

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BUILD

Tone Probe for Testing Digital IC's

This easy-to-build test instrument costs less than $16 and emits an audible tone to denote low and high logic-levels

LARRY FORT

HAVE YOU EVER COMPLETED A DIGITAL circuit project only to find that something is wrong? It's no problem if you have an oscilloscope, particularly one with a triggered sweep, but if your scope isn't too good, troubleshooting digital circuits will be difficult.

What if all you have is a voltmeter? They're fine for low-speed circuits where a signal stays at a given level long enough for the meter to react and settle at a reading, but fast pulses and high repetition rates make meters almost useless.

A logic probe then, is almost indispensable if you're building projects that use digital circuits, because you must be able to tell whether inputs and outputs are high, low or floating. Many probes are available today, but most of them use some kind of visual indication to tell the signal level. If your hands are steady and you have your wits about you, it's possible to look away from what you're probing to determine the signal level, then immediately return your attention to the probe and start again at the next lead. If not, you're in trouble unless you have a *tone probe*.

The tone probe described here uses sound to tell the status of the signal being probed. That means you can probe difficult points rapidly and know each signal level without any distractions. It has the added advantage of detecting intermittent problems just by the sound "pattern" changes that occur as you manipulate other components of the circuit.

There are really only three voltage levels of interest. A voltage level of less than 0.8 is considered *low* for almost all DTL and TTL families of digital IC's. Voltages greater than 2 volts are considered *high*, and any voltages between 0.8 volts and 2 volts are not guaranteed to be either high or low and can cause noise problems. The tone probe has an input circuit that senses the condition of the signal and produces either a low-pitched tone for low-level signals, or a high-pitched tone for high-level signals. Any signal between these two produces no tone.

An important consideration for all logic probes is that they must have a high input impedance so they will not load down the circuit under test. A low input-impedance can cause a good circuit to malfunction.

The tone probe is powered by the circuit-under-test rather than being self-powered, for two reasons: The supply voltage affects the switching points to some extent: and it is necessary to have a ground lead to all probes so the inconvenience of clipping one or more wires for B+ is insignificant.

How it works

Figure 1 shows the schematic diagram. Resistors R1 and R2 form a voltage divider that supplies about 1.5 V to resistors R3 and R4. Resistor R3 supplies some base drive to Q1, causing it to conduct. Transistor Q1's collector will be near ground and D1 is reverse-biased, thus no current flows through D1 to IC1.

Transistor Q1 is the low-level input detector. When the circuit-under-test forces the voltage at the junction of resistors R1 and R2 below approximately .5 V, Q1 stops conducting. Its collector rises toward +5 V through R7. This action forward-biases D1 and supplies current to IC1. IC1 is the popular 555 one-shot. It is connected to run in the astable mode. When R7 and D1 supply current to IC1 pin 7, IC1 oscillates at a low frequency.

Transistor Q2 is the high-level detector. Resistors R5 and R6 form a voltage divider that provides approximately 1.6

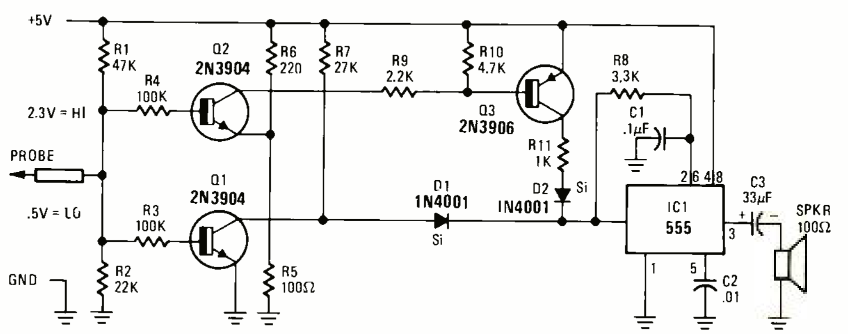
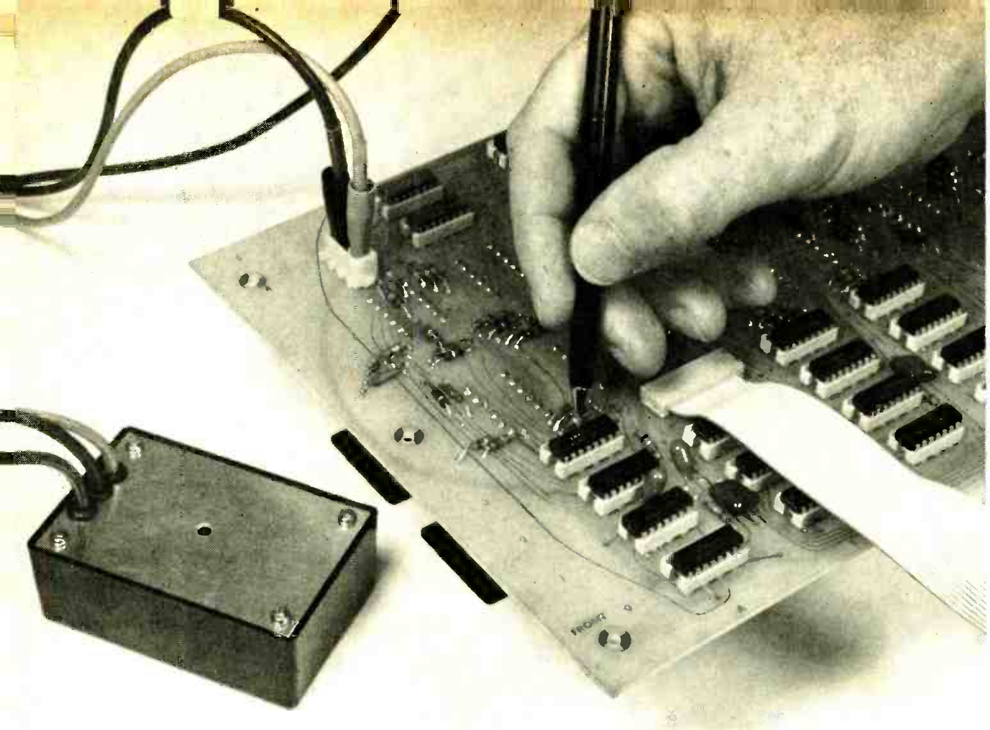


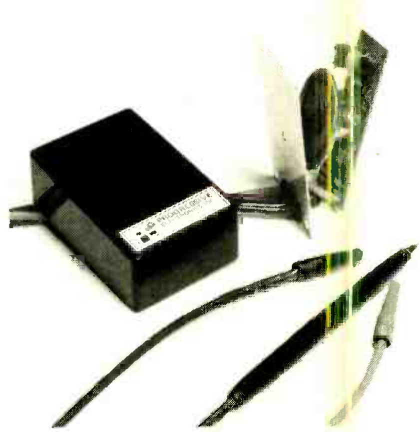
FIG. 1—THE TONE PROBE uses a 555 IC and three transistors.

PARTS LIST

All resistors are 1/4-watt, 10%.
R1—47,000 ohms
R2—22,000 ohms
R3,R4—100,000 ohmms
R5—100 ohms
R6—220 ohms
R7—27,000 ohms
R8—3300 ohms
R9—2200 ohms
R10—4700 ohms
R11—1000 ohms
C1—0.1 µF
C2—.01 µF
C3—33 µF
Q1,Q2—2N3904
Q3—2N3906
D1,D2—1N4001
IC1—555 timer
Misc.—5-volt power supply, 1 1/2-inch speaker (100-ohm), probe, circuit board or perforated board, 3 × 2 × 1-inch box.

The following items are available from Progressive Electronics, Inc., 432 South Extension, Mesa, AZ 85202. A pre-cut and pre-drilled printed-circuit board—$2.50. A complete kit of parts, including case—$15.75.





TONE PROBE shown removed from its case. Cover fits against speaker, holding assembly in place.

V for the emitter of Q2. With the probe low or floating, the base-emitter junction of Q2 is reverse-biased and no collector current flows. If the circuit-under-test changes state and goes high, Q2 begins to conduct at about 2.3 V. With Q2 conducting, R9 supplies base drive to Q3, causing it to conduct. The input signal causes Q1 to return to a conducting state and removes from IC1 the drive that causes it to oscillate at a low frequency. Transistor Q3 now supplies this drive current through R11 and D2. Resistor R11, being much smaller than R7, sends more current to IC1 and it oscillates at a much higher rate, producing a high-pitched tone.

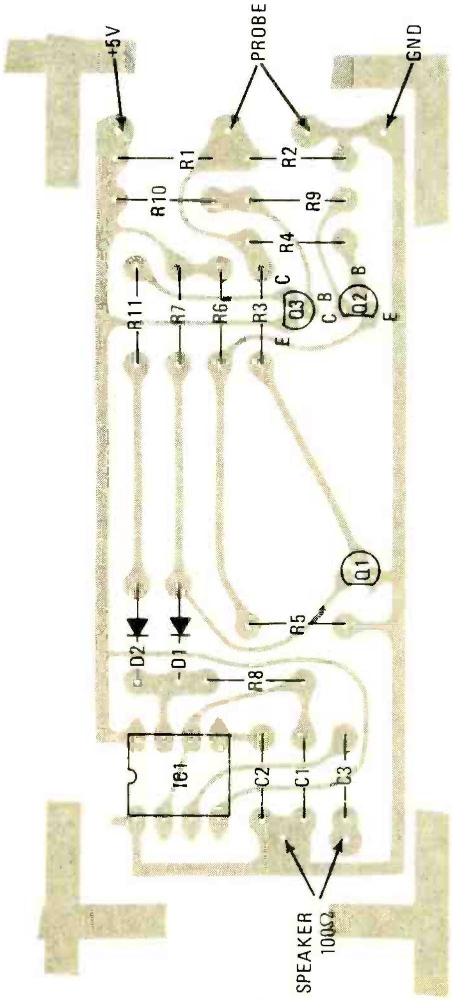


FIG. 2—PRINTED-CIRCUIT foil pattern. The board measures 6 × 2³/₈ in. (15.2 × 6.0 cm.)

Construction

The probe layout is not critical and may be built on perforated board or on a printed-circuit board made from the layout (Fig. 2) supplied.

All components, including the speaker, mount on the printed circuit board.

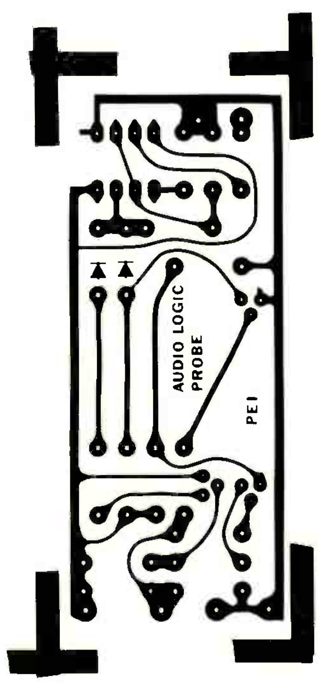


FIG. 3—COMPONENT PLACEMENT diagram.

A small amount of epoxy glue or silicon rubber sealant secures the rear of the speaker magnet to the component side of the board. When installed in the case, the cover is compression fit to the speaker.

The three leads have a knot just inside the cover of the box to act as a strain relief. The probe can be either a commercially available replacement probe or it can be made from a ball-point pen.

Checkout

To check the tone probe, a 5-volt supply is needed as well as a 1,000-ohm potentiometer. Connect the supply to the + and − leads of the probe. Connect the outside terminals of the pot across the power supply and rotate the pot so the center terminal is at ground (−). Connect the probe to the center terminal on the pot and check for a low-frequency tone. Turn the pot, increasing the voltage until the tone just quits. Measure this voltage. It should be between 0.4 and 0.6 V. Increase the voltage further until a high-pitched tone just starts. Measure this voltage. It should be between 1.7 and 2.0 V.

If your probe triggers within these limits it is functioning correctly. If it does not test correct, check for proper value resistors in R1, R2, R5 and R6.

If the probe does not make any sound, check IC1, Q1 and Q3. Also make sure D1 and D2 are connected in the right direction.

Using the probe

After attaching the tone probe to a power source, touch the probe to each of the leads of the integrated circuit being checked. A high-pitched tone will be heard if there is a high-level signal (2 volts); a low-pitched tone will be heard if there is a low-level signal (0.8 volt). No tone will be heard if the signal is between these two voltages. To check the tone probe, touch the end of the probe to the B+ source—a high-pitched tone should be heard. **R-E**

State of SOLID STATE

An in-depth look at two rhythm generators designed for electronic organs, new microcomputer boards and a programmable scientific calculator plug-in board are featured this month

KARL SAVON
SEMICONDUCTOR EDITOR

SOME YEARS AGO I PURCHASED A FAIRLY DELUXE SOLID-STATE ELECtronic organ. Solid-state meant that all the active devices in the instrument were transistors. The IC was not yet a reality. There was still a good crop of tube jobs around at the time. Oh boy! This was the epitome of home music making; it even had a little box in its innards that put an alternating-note xylophone into the percussion lineup! Press enough tabs and even a simple single-note melody line played in some semblance of cadence impressed the uninitiated.

With a couple of weeks or months of developmental ground work, you (or better still an organ manufacturer) can now take a handful of IC's and put together a tone and percussion generator that gives the older units a run for their money. The performance output per dollar of parts is unprecedented, even with continuing inflation.

The rhythm generator has always been an exciting add-on or add-in to the organ. Inability to play in time is a common fault of many amateur musicians. If they want to stop for a few beats to figure out that next chord, they simply do so and nothing much happens. Try to play with a group or listen to yourself on a tape recorder and you immediately know that you're doing something wrong. The rhythm generator is a big help in this situation. It acts as a metronome and forces you to learn to keep an even tempo. The first time you try to play along with one of these gadgets you may be in for a rude awakening.

At the time I bought my instrument, rhythm generators were expensive discrete multiple stage shift-register gizmos with slews of decoding diodes, switches, and wire.

Well, the IC rhythm generator has arrived. Ever-expanding memory products and technology have brought prices down to where consumer product makers are using them. The products will do new tricks and the manufacturer's costs are usually reduced. Toss the rhythm generator in with other music and standard monolithic devices and you can build an amazingly versatile wonder in a deceptively small container. Frequency dividers, flip-flops, and oscillator chips are natural additions to the mix.

Integrated rhythm generators

American Microsystems Inc. and more recently SGS-ATES Semiconductor Corporation have announced rhythm generators designed specifically for organs and other electronic instruments. These are not conglomerations of standard digital circuits but one-chip devices with only one application in mind.

Both manufacturers' devices are largely read-only-memories with the various rhythm patterns embedded in their cells. Supporting circuitry reacts to input controls and supplies the independent instrument outputs.

The AMI S9660 will drive seven rhythm instruments—that is, seven different, usually percussion simulation generators such as electronic versions of drums, cymbals, or bells. The rhythm pattern is 64 bits long—a unique nonrepeating 64-count sequence can be generated for each of seven selected rhythms, for each of the seven instrument outputs.

Figure 1 is the block diagram of the AMI S9660. One of the most fundamental things that must be done on the chip is to generate the 64 separately decoded beats for the maximum length rhythm pattern. That is done by a six-stage counter which is fed from a divide-by-two and an on-the-chip oscillator that is externally frequency controlled

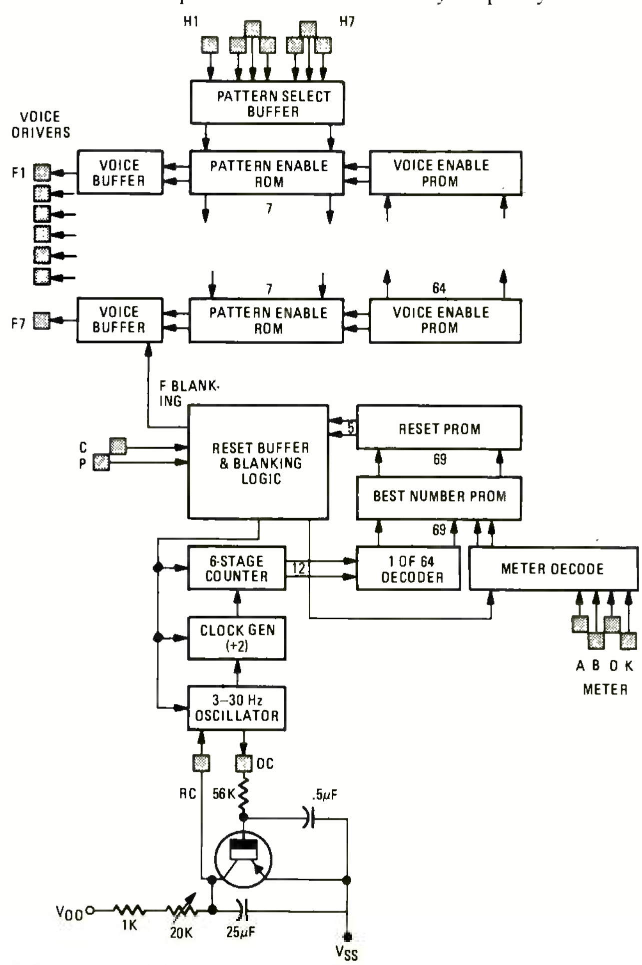


FIG. 1—AMI S9660 BLOCK DIAGRAM.

over a 3 to 30-Hz range. Terminal RC connects from the oscillator to the external resistor-capacitor frequency determining network. Base current to an external PNP transistor from terminal DC (dump charge) discharges the capacitor during the oscillator cycle. The six-stage counter steps through 64 independent states. (This maximum number of states is simply calculated as two to the sixth power.) There will be 64 different combinations of ones and zeros showing up in the counter's six stages. It is the job of the 1-of-64 decoder to detect and produce an independent output for each of these 64 counter states. The counter has 12 inputs, one for each complemented and uncomplemented stage of the counter, and 64 outputs. Each of the outputs activates one word in a 64-word read-only-memory. For this discussion, read-only-memory is synonymous with PROM. The memories are programmed during processing by using specially prepared masks.

Enough flexibility is built into the chip to generate all common rhythms. A 64-bit count is just not right for many of them, so the generator must be able to change the maximum sequence length. The S9660 has five mask programmable reset options. Normally the fifth one is reserved for the 64 unshortened count. These reset options are stored in a portion of the ROM. After programming, the five reset options are selected by the ABDK meter input terminals. V_{ss} (ground) is connected to one of the four terminals to select the first four meters. If none of the leads are activated the default 64-bit count is implemented.

Typically the timing could be programmed as follows: **A** might be $^3/_4$ time. A total of 36 bits can be broken into 9 bits for each of 4 measures. Three bits are assigned to each of the three beats per measure. The idea is to provide the maximum possible bits-per-beat for each meter within the 64-bit limit, consistent with the intricacies of the final rhythm. If **B** were set for $^5/_4$ time, 2 measures could be separated into 20 bits each. The number of bits in each measure must be a multiple of 5 in this case. This allows four bit divisions for each of the 5 beats, allowing timing outputs at $^1/_{16}$-note intervals. **D**, programmed for $^6/_8$ time, could have a total 48-bit count with again 4 bits assigned to each beat, in this case 6 beats per measure. **K** could also be $^3/_4$ time like **A** but with 4 bits/beat. A 48-bit sequence is required by 4 measures $\times$ 3 beats/measure $\times$ 4 bits/beat. And finally the full 64 count selected if all inputs are unconnected might be 4/4 time with 4 bits/beat, 4 measures, 4 beats/measure and 4 bits/beat: $4 \times 4 \times 4 = 64$.

At this point the decoded sequences have been generated and the device must be able to select the particular rhythms and generate the seven outputs.

Each of the 64 programmed words in the voice-enable PROM contains in its ones and zeroes the binary information as to which of the seven instrument outputs is to be activated at which of the maximum of 64 counts. Each of the seven instruments may contain an entirely different and independent rhythm as desired.

The seven H inputs address the pattern-enable portion of the ROM. A pattern is selected by applying V_{ss} to one of seven pins. The voice buffers are fed by the selected programmed ROM patterns. An interesting feature is that the rhythms may be combined by overlaying them by enabling more than one pin at a time. Overlayed outputs are logically OR'ed so that an output occurs when at least one of the overlapped patterns is enabled during a particular interval. The output voice drivers interface with transistors and provide low-resistance paths to V_{ss} when activated.

When held at V_{DD} the C reset input holds all outputs off. Applying the supply voltage starts the count at its beginning. This feature can be used as a synchronized trigger connected, say, to an organ-pedal sensing circuit.

The S9660 is built with AMI's ion-implant process. Starting out with the standard P-channel process, two ion implant steps are tacked on. Transistor thresholds are reduced to −1.5 volts by the first implant. Power consumption is reduced and TTL compatible input and outputs are the result. Constant-current load devices with +3.5 volt thresholds are selectively produced with the second implant. Higher speeds for the same current are possible with constant current loads. Accurately controlling threshold (the gate-to-source voltage at which the channel begins to turn on) increases the yield. Yield refers to how many of the pellets processed turn out to be good ones at the end of the line.

Internal pull-up resistors to V_{DD} are provided on all inputs except the oscillator input. The S9660 comes in a 28 pin dual-in-line package. The V_{DD} supply is operated between −8 and −13 volts.

A particular set of IC rhythm sequences is programmed by punching 54 IBM cards. Five cards are punched for the five reset short count inputs (N,K,D,B,A). Seven cards are punched for each H rhythm select input. Each of the seven cards for each H input contains the sequence (64 bits or less) for each instrument plus identification recognized by the programming machine. So these last cards total 7×7 plus the other five for the total 54.

Besides the S9660, AMI makes a number of other music-oriented products. The S2555 Music Frequency Synthesizer generates seven notes of the equally tempered scale, dividing down a 2.1 MHz input clock. The S2556 used with the S2555 supplies the other six notes of the scale. The equally tempered scale is the widely adopted harmonic compromise system. The same thirteen frequencies per octave can be used whatever the key.

American Microsystems Inc. is located at 3800 Homestead Road, Santa Clara, CA 95051.

An offering from SGS-ATES

The SGS-ATES M252 and M253 are similar monolithic circuits. The M252 has a 3840-bit PROM, which will store 15 rhythm patterns for eight instruments. Since the patterns may be up to 32 beats each, this calculates to $15 \times 32 \times 8 = 3840$ bits. The M252 will store 12 rhythm patterns for the same 8 instruments and 32 beats, and so uses a smaller 3072-bit memory.

The interesting thing is that the smaller memory device is packaged in the bigger DIP! The M252 comes in a 16-pin DIP but the M253 is mounted in a 24-pin package. The reason is that the M253 has its 12 patterns selected by connecting the input pin for the pattern to V_{SS}. Only one terminal is enabled at a time so 12 terminals are tied up in the process. This is simple for the user because all he does is provide an uncoded series of SPDT pushbuttons. Double-throw switches are needed to return the unused inputs to V_{GG}. The M252 with 15 rhythms uses binary coded 1-2-4-8 weighted select inputs. Four terminals then select the full 15 combinations. The difference between the 12 and 4-pin input terminal count is 8, precisely the difference in pins between the 16 and 24 pin packages.

Both devices are either purchased with standard patterns programmed in or are specially mask programmed to a user's preference. The standard version of the M252 includes the following rhythms: Waltz, Tango, March, Swing, Slow Rock, Rock Pop, Shuffle, Beguine, Cha Cha, Samba, Bossa Nova, Jazz Waltz, Foxtrot, Mambo, and Bajon. The 253 in its standards version leaves off the last four and adds the Rhumba.

Both the M252 and M253 use external clocks to feed a phase generator and a divided stage and then a 5-stage counter with its decoders. The general scheme is similar to the AMI chip. Five stages instead of six are adequate because the beat sequence is half as long. The decoder controls the read-only memory and the reset logic. Mask programming can shorten the 32 counts to 24 only. Other shorter counts are implemented by using output 8 to reset the counter. It will simultaneously generate a downbeat and reset signal, a single beat, which shortens the sequence to the number count at which it occurs.

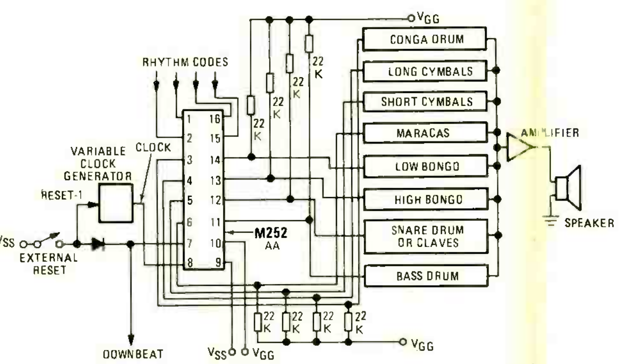


Fig. 2—SGS-ATES MODEL M252 rhythm generator.

Figure 2 shows a typical setup of the standard content M252 device with the suggested external instruments. If space separation for stereo effects is desired, the instruments can be split and summed differently into two or more amplifiers rather than the hookup shown. By combining two chips, the number of rhythms, the number of instruments, or the total number of beats can be extended.

Figure 3 shows the rhythm extension scheme. The 1-2-4-8 encoded inputs feed the corresponding terminals on the two chips in parallel. A coded 16-weight input is added to give the extended control. Thirty rhythms require five bits to control them since 2^4 is only 16. The added input simply selects which of the chips is to be activated. Both

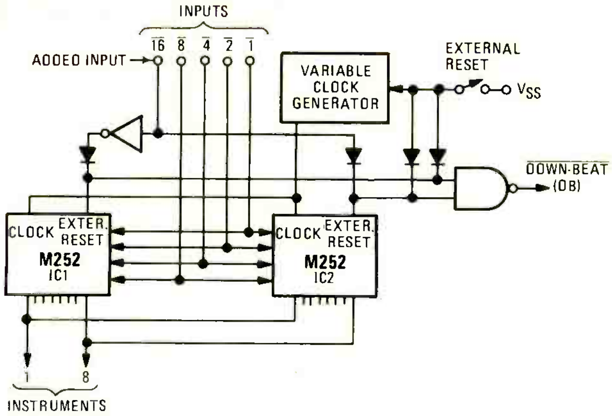
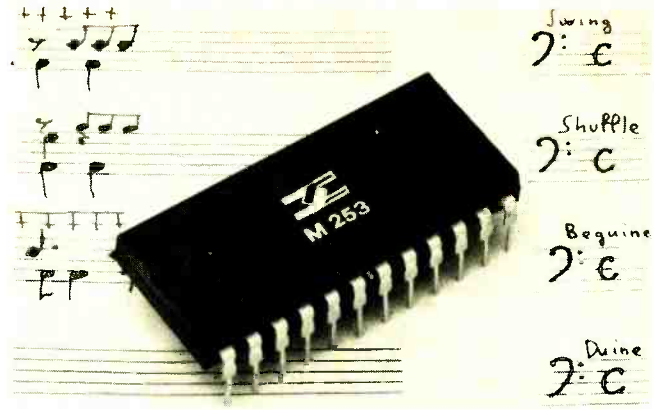


FIG. 3—RHYTHM DOUBLING SCHEME.



RHYTHM ON A CHIP—THE M253.

reset inputs are fed through diodes but chip-1 has an inverter in its reset path. This way one device is held at reset and the other allowed to operate, depending on whether the 16 input is high or low. To increase the number of rhythms with the M253, which is not binary coded, the two chips are operated with their outputs paralleled. The inputs are renumbered from 1 to 24 and no further select logic is needed.

The number of instruments can be increased by operating the two devices' clock inputs in parallel, resetting them at the same time and clocking them with the same generator, keeping them phase-locked. Rhythm programming is different for the two circuits so there are eight different instrument patterns from each chip for a total of 16 in all.

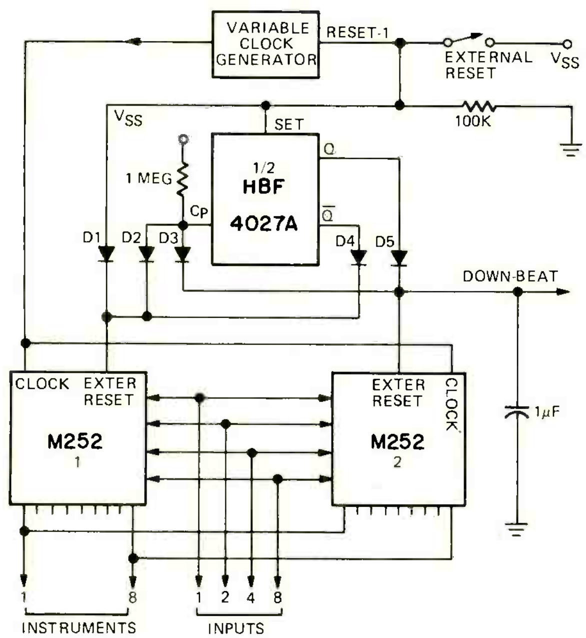


FIG. 4—LENGTHENING THE COUNT.

Figure 4 details the count lengthening scheme. A maximum of 64 beats is possible. The idea here is to let the two generators work sequentially. One-half of a 4027A dual J-K master-slave flip-flop is used to hold one generator reset while the other goes through its 32 counts. The flip-flop then changes state and the other rhythm generator takes over with its 32-bit sequence. Isolation diodes (D2 & D3) are connected to the flip-flop clock input from the reset terminals of each generator. It is the reset signal at the end of the 32nd pulse that signals the termination of one sequence and toggles the flip-flop. Since the output devices are open-drain and normally off, the eight instrument outputs on chip-1 can be wired directly in parallel with those on chip-2.

Mask programming information for the SGS-ATES circuits are written into a truth-table form. A table is filled out for each instrument, with 8 columns, one for each instrument.

Standard +5 and −12-volt supplies are used and maximum current drain is 15 mA. ON output resistance is less than 500 ohms. Down-beat trigger signals are available on the external reset/down-beat terminal. Driving a lamp from this signal gives visual indication at the start of each sequence.

P-channel silicon gate processing is used and both ceramic and plastic packages are available. Small-quantity prices for the M252 and M253 are $15 and $19.50 respectively. The prices drop by a third for quantities between 100 and 999. Further information is available from SGS-ATES Semiconductor Corp., 435 Newtonville Avenue, Newtonville, Mass. 02160.

Microprocessor news

Martin Research, authors of the book *Microcomputer Design*, offer a set of PC boards which form a bus-oriented system so that any board may be plugged into any position on the bus. If you want to expand the system you add the board at the next empty slot. This is the same sound philosophy used by some well-known minicomputer companies.

They have a *Mike 2-1* CPU Board, which holds the 8008 chip, a crystal-controlled oscillator, and the timing generation circuits. The *Mike 2-20* Console Board has six seven-segment displays and a twenty-key calculator-type keyboard. The output display can be read in octal, decimal, or hexidecimal (base 16). The *Mike 2-3* PROM/RAM board holds 1K of RAM and 2K of PROM.

MR's basic system uses 256 words of RAM and 256 words of PROM. It is preprogrammed with the *Mike 2* monitor that is used to write instructions into and read instructions from any location in memory using the keyboard.

The *Mike 203A*, which includes the 8008 microprocessor sells for $269.95 in kit form and $319.95 assembled (and tested). For details write to Martin Research, 1825 S. Halsted Street, Chicago, IL 60608.

Scorpia Laboratories SC-440

This is an externally programmable scientific calculator plug-in circuit board that interfaces with TTL. It works with ASCII inputs and has multiplexed BCD outputs. It can be used tied to instrumentation for data-reduction tasks that do not need the complexity of a microcomputer and the necessary software. In effect the software is built into the calculator chip. Or it can be a microcomputer satellite as a hard-wired data-reduction peripheral. Keyboards, accessory RAM/ROM memory cards, a low-cost cassette, a 3½ digit DVM/DMM and a 40-MHz frequency counter are being developed.

Scorpia's SC-441 is a 42-pin module designed to interface instruments with BCD outputs, such as digital voltmeters or clocks with microprocessors on 4, 8, or 16-bit data busses. It also allows retrofitting BCD instruments to become remotely controlled transmitters, using the recently standardized Universal Interface Bus.

It is useful in reading and storing in memory the time of the measurement as well as the readings of temperature, pressure, flow, liquid level or ph. The SC-440 is also useful in security alarm and payroll computing systems.

The SC-440 costs $300 in single units and drops a third over 50. The single unit price of the SC-441 is $100. Scorpia Laboratories Inc., 46 Liberty Street, Brainy Boro Station, Metuchen, N.J. 08840.

Calculator display drivers

National's DS8864 has nine independent LED digit drivers that will sink up to 50 mils from a common cathode display operating in a multiplexed mode. Drive current is typically 0.9 to 1.2 mA, which will interface with most MOS calculator chips. The LED to MOS interface chip also includes a battery-condition sense circuit that lights up the leftmost decimal point when the battery is low. **R-E**

R-E's Service Clinic

Lightning protection

Be safe rather than sorry

JACK DARR
SERVICE EDITOR

THERE'S AN OLD SAYING THAT GOES: "Lightning never strikes twice in the same place; because when it hits the second time, the place isn't there any more". Unfortunately, in solid-state circuitry, this isn't true. We're running into more repeated failures of the same parts due to lightning transients than ever before. This is the bane of designers' and technicians' lives. One harried technician wrote us a pitiful story of having replaced the same IC in a well-known make six times under warranty, and twice after the warranty ran out!

Unfortunately, there isn't any such thing as a true "lightning *arrester*". The only thing these gadgets can do is shunt the current off to ground through a small arc-gap, destroying themselves in the process. In the case of a direct hit, it's just too bad. The current is so tremendous that the place literally isn't there. I've seen a 6-inch square heavy ceramic fuse block, two big fuses, the brass holders, and everything except the ends of the wires completely disintegrated after a lick like this. (This occurred in a radio transmitter atop a mountain.) The cabinet looked as if someone had thrown about 5 pounds of flour in it!

However, for the smaller hits that cause sharp line-transients, we can help things a little. We can't stop them but we can hold the damage down quite a lot. There are devices that will help.

Chassis modifications

One of these is the super-fast action varistor, such as the GE-750 from General Electric, that is connected directly across the AC line where it comes into the chassis. These are specially designed metal-oxide devices and are called *GE-MOV* varistors. In normal operation, they have a very high resistance so that they have no effect on the circuit. When a transient spike comes along, they break down very quickly and become a short circuit across the line ("crowbar" effect). G-E's Application Note on these gives a response-time of less than 50 nanoseconds for the type V130LA1.

That's one; another method recommended by set-makers is the installation of chokes in the AC line. The idea of these is to offer a high resistance to very sudden changes of current, such as a transient spike. Bypass capacitors to ground are also used for the same reason; they provide a low-impedance path to ground for the spikes.

Zenith has a set of recommendations for problems like this. In their 19DC12 and 23DC14 chasses, they tell you to replace the original line chokes (95-2920) with one of higher inductance, 95-2964. In Issue 72-73 of *Tech-Topics*, they also recommend moving some of the low-level leads going to the 9-97 color module—one of the parts that have suffered repeated damage in areas where thunderstorms are frequent. It looks to me as if they are figuring on reducing the chance of the spikes being coupled into the module circuit by interlead capacitance.

Paraphrasing the instruction for this, several leads of the control plug and socket are changed. This requires the use of an 868-2 (Molex HT-1010-2B) pin-extraction tool. For the 19DC12 chassis, here are the changes (Fig. 1) that should be made:

(13)	(10)	(7)	(4)	(1)
(14)	(11)	(8)	(5)	(2)
(15)	(12)	(9)	(6)	(3)

19DC12 CHROMATIC CONTROL PLUG (LEAD END VIEW)

FIG 1

1. Remove the orange wire from pin 4 and place it in the empty pin-10 position.
2. Remove the black wire from pin 13 and place it in pin 4.
3. Remove the green wire from pin 5 and place it in pin 12.
4. Remove the blue wire from pin 6 and place it in pin 13.

(1 and 2 in the original layout are the leads to the AC switch. The leads on 5 and 6 go to the color circuits, and for goodness sake don't forget to change the leads in both plug *and* socket! It would also be a good idea to stick a note on the chassis saying that this modification had been made!)

(10)	(7)	(4)	(1)
(11)	(8)	(5)	(2)
(12)	(9)	(6)	(3)

23DC14 CONTROL PLUG (LEAD END VIEW)

FIG 2

In the 23DC14 control plug (Fig. 2) these changes should be made:
1. Remove the white-green wire from

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

pin 4 and place it in the empty pin 7 position.
2. Remove the black wire from pin 10 and place it in pin 4.
3. Remove the green wire from pin 5 and place it in pin 10.
4. Remove the white/black wire from pin 11 and place it in pin 5.
5. Remove the violet wire from pin 6 and place it in pin 11.

Be sure to get the right plug in the 23DC14. This is P203, which is the *12-pin* connector and not the 15-pin "Secondary Control Plug" P204.

Other manufacturers have similar "fixes" for these problems, for they've all run into them. If you have trouble, check with the nearest distributor for the brand and ask them what the factory recommends. If you can't get anything, you might go ahead and add the *GE-MOV* varistor and the bypass capacitors, as well as the chokes in the AC line. I've always been a "belt-plus-suspenders" man; a bit extra can't hurt.

Antennas

Cable systems are usually pretty well protected against lightning. The spikes have to travel through so many things that they dissipate before they get to you. However, if the set is used with an outside antenna, there are several things that must be done to make it as safe as possible from damage.

For the most important, the mast or tower must be well grounded. Drive at least a 4-foot ground rod and tie or bolt this to the mast. There is a very handy thing available that I wish I had when I was putting up antennas. This is a combined base and ground-rod. It's driven into the ground up to the flange, and the mast simply dropped over the stud on top. Since practically all antennas are well-grounded by the mounting bolts, a properly installed mast makes a very good lightning rod!

The other essential is a good UL approved lightning arrester, which should be mounted on the wall as close as possible to the place where the lead-in enters the house. If this is close to the bottom of the mast, you can use this ground. If it's more than a few feet away, drive *another* ground rod directly below the arrester and run a short heavy ground wire to it.

One more precaution. If a certain location seems to get more than its share of lightning damage, check the grounding of the *AC line* at the point where it enters the house. There should be an 8-foot ground-rod directly under the "service entrance" box. These ground rods are sometimes hard to drive all the way. Some careless workmen have been known to drive them only about 24-inches and hit a rock. Then they cut off the top of the rod and go away! This is *not* sufficient grounding for protection. (Ask me how I know. I did this, and lightning promptly hit the place and scattered the motor of my water-pump all over the basement! The well-casing made a good ground! There is now a full 8 feet of ground rod at my place; I had to drive three of them before I got one all the way in through the rocks but it's there and we haven't had any more of this kind of trouble.)

There is only one really effective way of eliminating lightning damage: pull the line plug and disconnect the antenna! This is quite safe, unless you take a direct hit on the house. If this happens, you will have so many other worries, you'll forget the TV set! **R-E**

reader questions

LOSS OF VERTICAL SWEEP

I've got a black-and-white portable with no vertical sweep at all. I want to make a quick-check of the vertical output transformer and yoke. Can I use a separate 6.3-volt filament transformer to feed a signal into the output tube? This set has a series heater string.—J.G., Arlington, VA.

If you feed the test signal into the grid of the vertical output tube. OK. If you feed it directly to the plate. either disconnect the plate voltage or use a good-sized blocking capacitor (0.25 or 0.5 μF.)

ALTERNATOR WHINE IN STEREO

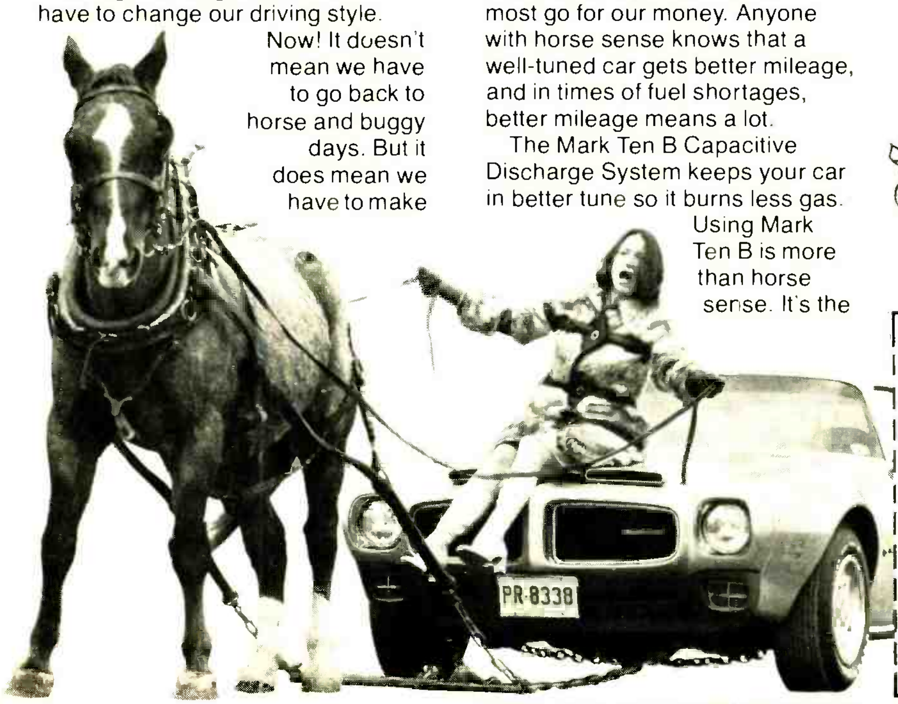
We're running into problems with stereo tape players, mainly in GM cars where the player is mounted on the left side of the dash. It seems to be a three-phase ripple loaded with harmonics, from the alternator, and coupling into the tape-player. Have you heard of this problem before?—J.H., Orangeburg, SC.

I've run into this a long time ago in two-way radio receivers. We just called it "alternator whine", and it *is* pretty hard to get out. We finally made up some L—C filters enclosed in metal boxes connected this in the line from the alternator output. This killed it.

You can get these filters all ready made now: J.W. Miller C-503-E. and others. I'm pretty sure these are L—C filters and not difficult to install.

LOSS OF WIDTH

The picture is perfect on this Zenith 16H27, but it isn't wide enough. I've checked all of the regular things; new tubes and so on. No go. The drive voltage



from the horizontal oscillator is low, and the oscillator plate voltage is too. B+ seems to be OK. In fact, the +265-volt source that feeds the horizontal oscillator reads +300 volts. This should be easy, but it isn't!—J.M., Marina del Rey, CA.

Old Saying: "Ought to be ain't is!". Sometimes I think there's no such thing as an easy one. Let's see.

Your grid drive to the 6DQ6 is low and this could cause it: low plate voltage on horizontal oscillator may be the cause. This stage is *not* fed from the B+ 265-volt source: it's fed from the boost, which should be +700 volts. Check the damper stage, particularly the boost capacitor. Also; there is a tricky one in this chassis. Check that 40-μF electrolitic capacitor on the *cathode* of the 6DQ6. If this is open, you'll get a degenerative feedback that will reduce the output. Scope it to make sure.

TOO MUCH RIPPLE IN PICTURE

I wrote you before about checking the excessive ripple in the picture of a Gambles TV2-3701 black-and-white TV. You suggested checking ripple on the power-supply filters. That was it! I had to add 80 μF of extra capacitance to get rid of it! Works now. Thanks.—J.W., Hastings, MI.

EXCESSIVE WIDTH

The raster in this Sylvania D05-14 is so wide that I can see only 8 vertical lines of a crosshatch pattern! All of the DC voltages seem to check out all right. I tried reducing the screen grid voltage of the horizontal output tube. That didn't work!—C.M., Diamond Bar, CA.

Well, there went one of my favorite ways of reducing excess width! So now what? In several cases this chassis has shown excessive width if that VDR from the pin-3 cathode of the 6CL8 high-voltage regulator tube to ground goes bad. This is part No. 38-15257-9. Replace with exact factory duplicate; couldn't find a listing on it.

120-HZ HUM BARS

If you see two hum-bars in the picture, you have a bad filter capacitor—right? Not Always! I had them in an old tube-type Sears color TV set. Checked all electrolytic capacitors by substitution revealed nothing. Scope showed the typical "writhing" ripple with one hump crawling up the other. The peak-to-peak amplitude of this ripple wasn't too bad, either.

So; what is it? The *filter choke* is *shorted.* Not to ground, but the windings were shorted. After finding this, I remembered that I had found the same thing in an RCA about a year ago! Watch for this.

Thanks to Leon Caldwell, Caldwell TV, Mena, AR.

HIGH-VOLTAGE FLUCTUATION

This RCA CTC-22 chassis has a 12CT3 damper tube instead of the solid-state device used in others. The high-voltage fluctuates oddly; it will be going good, then for no apparent reason it'll bloom and then go black. The high-voltage drops to about 4kV. Cathode current of output tube holds steady at about 180 mA. I suspect the pulse regulator. New tubes no help. Any ideas?—W.L., Fairmont, WV.

I believe I'll go with you. Check that little capacitor from the plate of the 17KV6 regulator to the screen. I don't know exactly what it's for but I suspect it somehow.

(Feedback: That was it! I took it out, checked it and it was bad. Seemed to have gone up in capacitance from 15 pF to about 28–30 pF. Replaced it and the thing works. How did you know?)

(I guessed!)

GREEN RASTER

This G-E CA chassis has all kinds of intermittents! Horizontal bars on the screen, the raster turns green and finally you lose focus, high-voltage and everything. If I pull the high-voltage lead to the picture tube, the high-voltage comes back. Found that when the problem shows up, the picture tube grid voltages

all jump up to about + 400 volts. Checked the blanker and other stages, no luck. I'm learning, and any help will be appreciated.—L.M., Hopatcong, NJ.

You'll learn, all right! This is kind of a tough one to start on, though. Now: you have *found* the cause of the symptom; now look for the cause of the cause. This will probably be one of two things. The basic cause is something that kills the plate current of the color-difference amplifier stages.

Check these: one, the 270-ohm cathode resistor of the difference-amplifier stages. This is common to all three and if one end has a bad solder joint, it opens the cathode circuits. Two: in these chassis, the *heater* supply for both difference-amplifier tubes goes through a wire jumper on top of the PC board. Check this for a bad solder joint.

WIDE SCANNING LINES

There are 5 or 6 horizontal lines in the center of the raster in this E0-2 Sylvania that are much wider-spaced than the rest. Vertical adjustments do nothing. Oddity: rolling the picture downward, the wide-spaced lines stay where they are! Could this be the deflection yoke?—G.D., San Juan Capistrano, CA.

Try turning the horizontal hold control on a blank raster. If this affects the position of these lines, suspect something in the pincushion circuitry. There is a resistor, R377, shunted across the pin-transformer that may be bad.

HALF A PICTURE

Here's a confusing one! I have the right half of the picture on the screen in this Magnavox T-940 chassis. The trouble is that the right half is on the left side of the screen and the right half is blank! Not blank, but black; no raster! Any suggestions?—H.S., Universal City, TX.

I have a silly cartoon over my desk on exactly the same problem! While the Professor is trying to figure out what's causing it, his wife pushes the *cabinet* to the left; this centers the picture! I don't think this is what's wrong here. (Did you try it, though? Never can tell!)

OK: Seriously. This chassis uses a pair of diodes in the horizontal centering circuit, with the centering control across them. This is in the horizontal deflection yoke circuitry. It sounds as if the raster is being deflected far too much to the left. Check the diodes, the bypass capacitors and the control itself for an open circuit. One of these has gone, I'd say.

MULTIPLE PROBLEMS

I changed the picture tube in this RCA CTC-16; now I've got several problems! Picture is dim when first turned on, but comes up to normal brightness after a few minutes. Contrast is poor; AGC has very little effect, color is odd, and for a last one, the horizontal hold is very touchy. It falls out of sync, but it can be restored by just touching the hold control. Give me some hints as to what's doing this!—J.C., Ft. Worth, TX.

You've got problems, and the problems have got problems! For openers, I believe I'd ignore the others and fix the horizontal hold problem. You just might clear up a whole lot of them when you do. All of the rest could be due to incorrect phase of the horizontal oscillator!

Suspect the AFC diode unit first. Replacement is the fastest way. If this doesn't get it, check the PC board conductors and that little 51-pF coupling capacitor from the sync separator to the AFC diode unit.

VERTICAL OUTPUT TRANSISTOR

I need a replacement for the vertical output transistor in a G-E UA-4104 WD. There was another type in it. Can't find a substitute. What will do this?—J.L., High Point, NC.

The original is a G-E ES15X91. An RCA SK-3104 or Motorola HEP S5015 should replace it. Same spec's and plenty of voltage rating. **R-E**

KOMPUTER KORNER

continued from page 32

user operations and solved most problems associated with the subroutine system. The main drawback of this method was imposed by the semiconductor processing technology. With the stack on the same chip as the processor, there wasn't a lot of room left. This meant that the number of elements in the LIFO had to be limited. The result was a limit on the amount of program nesting that could be performed without filling the stack and losing return addresses. On most processors the user was limited to seven unreturned subroutine calls. This limitation also meant that stack usage had to be limited to subroutine return addresses alone. This denied the user access to many of the other features a stack can provide.

To solve these two problems, some manufacturers decided to implement the LIFO as part of the system main memory. They provided the stack pointer and the automatic increment/decrement hardware. The user then supplied the address of the memory block to be used as the LIFO. This is accomplished by loading the top address of the selected memory block into the stack pointer. From then on the stack functions automatically.

This certainly solved the nesting problem. Most systems have far more memory than a properly functioning program will ever need for subroutine nesting. It also makes the stack available for other uses. This allows you to use the stack to save registers, pass data to and from subroutines, and lots of other useful functions. However, there is no such thing as a free lunch. If you are going to manipulate data in the stack you have to *balance* the stack pointer.

Balancing the stack pointer simply means that it must be pointing to the correct return address when a subroutine return is executed. Failure to do this can result in your program accidentally using the data you meant to pass back in the stack as the return address. This type of error can result in some really interesting program execution. Balancing the stack requires that you pay close attention to the order in which data is entered and removed from the stack. Under normal operations, the data must always be removed in the opposite order in which it was entered. You must also be certain that no programs accidentally write data into the area you have reserved as the stack. It is also a good idea to make sure the stack doesn't grow too large and encroach on other program storage. The easiest way to avoid most of these problems is to assign the stack to the top 100 bytes of your system memory and leave it alone. This will probably be far more stack than you ever need and it will save you a lot of time you would otherwise have to spend computing exact stack usage.

Summary

Stacks provide you with a convenient way to solve many design problems. The FIFO and LIFO offer different characteristics for use in different applications. They can both save you much time and make it easier to implement a variety of system functions. If your computer uses a memory LIFO stack for subroutine return addresses, with a little practice you will discover ways to use it to make your programs more efficient. Whether hardware or software, the stack is a useful new tool for the designer. **R-E**

1977 CB sales will exceed all previous years combined

More CB radios will be bought in the United States in 1977 than in all of CB's previous 28 years added together, says John Sodolski, vice president of the communications division of the Electronic Industries Association (EIA). He expects sales to approach the ten million mark for 1977, and estimates that retail sales of CB radios, antennas and accessories should top $2 billion for the year.

Only about three million CB radios were sold between 1958—when the FCC allocated 23 channels for Citizens radio—and 1973, when the sudden upsurge began. Sales exceeded a million in 1973, then doubled each succeeding year, hitting nearly five million in 1975.

Unlike some industry predictors, Mr. Sodolski believes that 23-channel radios will continue to be popular, especially during the earlier part of 1977, before the supply of 40–channel sets catches up with the demand. Favorable pricing and the realization that the 23-channel radio satisfies the needs of a majority of the people in many parts of the country are the important factors that will keep the 23-channel sets moving, he says. **R-E** hold the penlight? You don't; you hold it between your teeth just as you always did.)

The *model 175* is powered by self-contained rechargeable batteries. All of the very complex "works" are on only two boards, one for the logic, and the other for the display. A proprietary LSI/MOS IC performs all of the logic functions required by the A/D converter. Due to the extensive use of MOS circuitry, the total power consumption is less than 1.0 watt when used with the AC powered battery charger, and 0.6 watt on battery alone. The battery is good for up to 6 hours of normal operation with a full charge, and it can be recharged overnight; 12 hours. When the battery needs charging, the decimal point of the display *blinks* continuously!

The inherent high accuracy of the digital multimeter is taken full advantage of here. On DC volts, the accuracy is 0.1%. On AC volts between 50 Hz and 500 Hz, the accuracy 0.4%. To verify this, a complete set of the final test calibration readings is packed with every instrument. Specification limits are given and the actual test reading logged. On the 1,000 volt range of the one we reviewed, for example, the spec was +998 to +1002 volts. Anywhere between these limits, OK. The actual reading was 1,000 volts. Each instrument is given a burn-in test for 8 hours, and the calibration is then rechecked.

Everything else is automatic. The decimal point is automatically positioned correctly. On all DC measurements the polarity indicator is automatic. As is customary in DMM's, the resistance is read out in 1000 ohms, except for the very lowest range, 100 ohms. Overrange greater than 100% is indicated by a blanked display, leaving only the decimal point and polarity indicator lit.

Overload protection is provided as mentioned. If you accidentally go too far while reading AC or DC currents, they have provided a 2.0-ampere fuse located inside the handle of the red test prod! Just unscrew the black tip and the fuse pops out. Be sure to use only fast-blow type fuses for replacement. A spare fuse and push-on clips are also provided. The whole thing—meter, charger, test leads and all—can be stowed in a handy zipper carrying case.

There is a small pull-out stand on the underside of the case, to raise the front panel to an easier viewing angle. This folds for storage. A very detailed instruction manual comes with each instrument. This gives not only the correct method of operation, but a circuit description, parts lists, calibration data and a schematic with parts layout.

A very useful little instrument, and very reasonably priced for one with this kind of accuracy and reliability. **R-E**

Heath IP2718 Tri-Power Supply

THE HEATH COMPANY HAS INTRODUCED QUITE a range of power supplies for bench and experimental use. A typical example of these is their new *IP-2718* "Tri-Power" supply. This supply is intended for general experimental work in either analogue or digital circuitry. TTL and similar devices use a 5-volt DC power supply. The *IP-2718* has one;

CIRCLE 50 ON FREE INFORMATION CARD

regulated by an IC voltage regulator that also provides internal protection against overload, short-circuits and high-temperature conditions. Its current or voltage can be read on the panel meter.

For analogue circuits requiring a positive and negative DC voltage, there are two completely isolated 20-volt DC supplies. Each of these has a maximum output of 500 mA and can be continuously varied from 0 to 20 volts by the front-panel controls. Current or voltage in each supply can be read on the meter. These, too, are tightly regulated by transistor voltage regulators. The regulation is specified as less than 0.1% variation from full load to no load. Filtering is good; the maximum ripple level is only .005 V (5.0 millivolts RMS.)

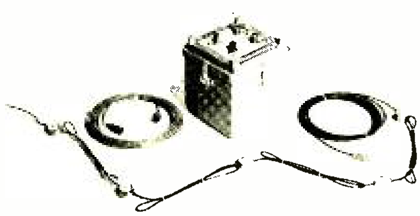
All three of the DC supplies (one 5-volt and two 20-volt supplies) are completely isolated from each other and from the instrument ground. They can be tied together in

continued on page 94

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 108.

INSTRUSION DETECTOR, *model T-10* buried-line unit protects an area up to 400 feet long and 10 feet wide. It is intended for direct burial in the ground of parking lots, driveways, sidewalks, or



any other surface for total concealment. It can be adjusted so it is not triggered by any weight of less than 50 pounds—**Mountain West Alarm Co.,** 4215 North 16th Street, Phoenix, AZ 85016

CIRCLE 84 ON FREE INFORMATION CARD

WIRE-WRAP TOOL, *Hobby Wrap model BW-630.* is a battery-powered tool for wire wrapping 30 AWG wire onto standard DIP socket terminals. The tool comes complete with a built-in bit and sleeve for producing the preferred "modified" style wrap. Weighs 11 ounces and

runs on any size "C" batteries. Price—$34.95—**OK Machine And Tool Corp.,** 3455 Conner St., Bronx, NY 10475

CIRCLE 85 ON FREE INFORMATION CARD

CB SERVICE MONITOR, *Measurements model CB-27E* is a low-cost instrument for trouble shooting and aligning CB transceivers. Used to check transceiver frequencies and offset from mid-channel frequencies measured by the front panel meter and calibrated against internal frequency standard by zero-beating with the built-in speaker. Additional channels in the 27-MHz spectrum can be added if assigned. When powered with optional NiCad battery, the *CB-27E* can check the transceiver without removing it from the vehicle. An incremental tuning range of ± 5 kHz is provided for simulated SSB receiver tests. Features include 455-kHz crystal IF output with modulation and output level control, and provision for two additional intermediate frequencies. Monitor and transmitter

are both protected against overloading if transmitter is accidently keyed; 1-kHz sinewave AM internal modulation and jack for external modulation covering speech frequencies; built-in transmitter meter. Price—$495.00—**Edison Electronics Div.,** Dept. 27E, Grenier Field, Manchester, NH 03103

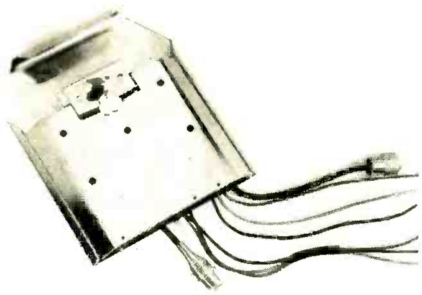
CIRCLE 86 ON FREE INFORMATION CARD

TVI FILTERS. *Trapper 45* is a compact low-pass TVI filter designed for average situations, eliminates CB-caused TVI on channels 2 and 5. Attenuation is 45 dB at 54 MHz, and 40 dB at 81 MHz. *Trapper 100,* super strength, low-pass TVI filter is intended for severe interference prob-

lems. Attenuates 100 dB at 54 MHz, and 75 dB at 81 Mhz—**Channel Master,** Div. of Avnet, Inc., Ellenville, NY 12428

CIRCLE 87 ON FREE INFORMATION CARD

SLIDE MOUNT. Universal key-lock unit, *model CBLM-520,* safe guards CB radios against theft. It is designed for use with all automobile CB transceivers, and mounts easily under the dashboard or on the floor. Both the mount and radio can be easily unlocked and removed when not in use. The unit comes complete with male and female coaxial cable connectors, 3-wires,



mounting hardware, screws and key. $14.50—**RMS Electronics, Inc.**, 50 Antin Place, Bronx, NY 10462

CIRCLE 88 ON FREE INFORMATION CARD

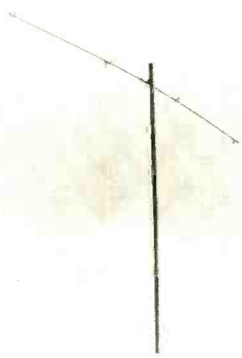
CB TRANSCEIVER, *Bobcat 23*, features a ceramic filter, a dual-conversion receiver, an S/RF meter, a front-panel switch to control the

public address system, automatic noise limiter with manual override, solid-state circuitry and crystals for all 23 CB channels.

Specifications include a power output of 4 watts, 100% modulation, sensitivity of 0.5-μV for a 10 dB signal-to-noise ratio, frequency tolerance within 0.005% and input voltage of 13.8 VDC positive or negative ground. The unit measures $2^3/_{16} \times 5^7/_8 \times 8^1/_4$-inches and weighs $3^1/_2$ lbs.—**Pearce Simpson,** Division of Gladding Corp., P.O. Box 520800, Biscayne Annex, Miami, FL 33152.

CIRCLE 89 ON FREE INFORMATION CARD

CB BEAM ANTENNA. The fiberglass *Mega-Beam style 4104*, resists the harshest environmental conditions, provides a low VSWR over the entire bandwidth. The fiberglass elements



exceed metal in reducing precipitation static.—**The Shakespeare Co.**—Antenna Group, 2805 Millwood Ave., Columbia, SC 29250

CIRCLE 90 ON FREE INFORMATION CARD

MICROCOMPUTER KIT, *model 80AI*. Designed around the *Z-80* microprocessor and runs at 2.5 MHz. The board provides a complete microcom-

puter, requiring only a power supply and terminal device, or the 100-pin edge connector may be plugged into an *Altair* or *IMSAI* bus in place of the 8080 based CPU board. The kit form retails for $450.00 and the assembled unit for $600.00—**Quay Corp.**, Box 386, Freehold, NJ 07728

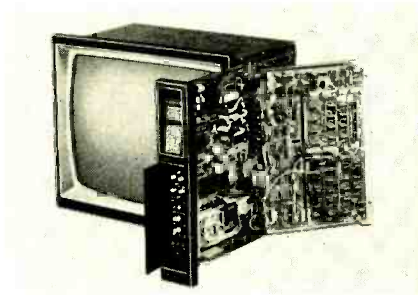
CIRCLE 91 ON FREE INFORMATION CARD

"COMPUTERIZED" COLOR TELEVISION SYSTEM, *Model GR-2001* lets you program your entire viewing schedule for two 12 or 24-hour periods, as it automatically switches to the right channel at the right time. If you have an outdoor antenna system, you can even program the *GR-2001* to rotate your antenna automatically for best reception on each channel.

Programming is done through a front panel keyboard that lets you select up to 32 channel changes and times during the two 12- or 24-hour periods, in any sequence—VHF to UHF, up or down—without tuning through in-between channels. An on-screen digital readout shows the times and channel numbers as you program them into the set, and flashes the time and

CIRCLE 57 ON FREE INFORMATION CARD

channel number whenever the channel changes. Other convenient features include a separate audio IF circuit which provides "hi-fi" quality sound and an audio output jack which



enables you to hook up the GR-2001 to your stereo system. The system is $849.95 in kit form and can be custom-installed or used with one of five optional furniture-quality cabinets in a variety of styles.—**Heath Co.,** Dept. 350-06, Benton Harbor, MI 49022

CIRCLE 93 ON FREE INFORMATION CARD

ANTENNA TUNER, *Model "Back Talk"* is said to tune up to four antennas and provide up to four times the talk power. Eliminates transceiver damage caused by excess power feedback, shorts or mismatched antennas. The tuner

tunes the antennas, not the coax. Thus, coax signal radiation is eliminated. The antenna is easily installed and recommended for multi-antenna installations, trucks, mobile homes, base stations. Measures $2\frac{1}{4} \times 4\frac{3}{8} \times 3\frac{1}{4}$ inches, weighs 12 ounces and comes with two PL-258 plugs, 9-inch coax and one PL-259 connector. Suggested retail $49.95—**Norcom Electronics Inc.,** P.O. Box 332, Northfield, OH 44067

CIRCLE 94 ON FREE INFORMATION CARD

PREAMPLIFIER, *Model PT-2* is a versatile, base station receiving preamplifier that tunes all ham and CB frequencies from 1.8 MHz through 54 MHz. It is meant to be used with a transceiver and provides full station control. Improves reception of weak signals by boosting sensitivity and signal-to-noise ratio while receiving.

Bypasses itself automatically when the transceiver is transmitting. FET amplifier gives superior cross-modulation protection. Provides master power control for station equipment. $69.95—**Ameco Equipment Co.,** 275 Hillside Ave., Williston Park, NY 11596 **R-E**

CIRCLE 95 ON FREE INFORMATION CARD

CIRCLE 92 ON FREE INFORMATION CARD

EQUIPMENT REPORTS

continued from page 87

series for higher voltage, or in parallel for a higher current rating. So, for the 20-volt supplies, you could have a +40-volt supply at 500 mA., a 20 volt supply at 1.0 amp or, by connecting in series and using the center tap as common, a ± 20-volt supply for CMOS and similar equipment. Voltage and current can be read in each "channel" with the selector switch for the meter.

All three supplies are current-limited at a point slightly above the maximum rated output, for protection against accidental shorts in the load.

A novel circuit is used with the two 20-volt supplies that allows the two supplies to operate either independently or to track each other. A selector switch is used for this purpose. In the INDEPENDENT position, the controls can be used to adjust the A or B supplies to any voltage between 0 and 20 volts. There is no interaction—each one is isolated from the other. If you want to make one supply "track" the other at a preset difference, move the switch to the TRACKING position. The control for the B supply is a dual concentric-type with a small red inner knob. To get a preset difference, say the B supply 5-volts greater than the A supply, set the switch to TRACKING and move the meter switch to read the voltage of A. Set the red knob to make this read say 10 volts. (You must hold the black outer knob to do this; this is intentional!) Now move the meter switch to read the voltage of the B supply and adjust the black control knob for the B supply to make the voltage read 15 volts. From this point on, both voltages will increase or decrease in step; the tracking error is claimed to be only 1%.

In the TRACKING position, the A control is disconnected; the red inner knob of the dual control sets A voltage. In the INDEPENDENT position, the red knob is disconnected and only the A control adjusts the A voltage. This is not as complicated as it sounds; in operation it's very easy!

The *IP-2718* is available in kit form, with the customary excellently-detailed Heathkit construction manual that tells you in detail just what to put where. It can also be purchased in fully assembled and tested form. For the serious experimenter, the versatility of this power supply will make things a lot easier. It has all of the necessary protective circuits to save the day in case of problems. It's easy to use; the terminals will accept banana plugs, terminal lugs or even old fashioned pieces of bare wire in emergencies. A very handy little instrument, that occupies only a little space on the bench. **R-E**

Switchcraft Q-Chek QC-1002 Cable Tester

CIRCLE 82 ON FREE INFORMATION CARD

THE SWITCHCRAFT COMPANY HAS LONG BEEN known for their comprehensive line of plugs, jacks, switches and many more useful things. Now they have brought out a very handy piece of specialized test equipment. This is the Q-Chek *model QC-1002* audio cable tester. (One suspects that this is a refinement of a production-line quality control test unit! It would be admirably suited for this.) It's a portable unit that will quickly check out practically all types of cables and plugs used in audio work. The unit is very compact, and battery-powered so that it can be used anywhere.

The *QC-1002* will check any kind of audio cable with up to 5 conductors plus a shield, for opens, shorts or even mis-wiring. The panel of the Q-Chek has eleven *sets* of jacks, divided into two sections and coded for fast identification. These are all numbered in pairs. The connectors range all the way from the miniature phone jacks up to the 5-pin DIN plugs used on many tape recorders, etc.

Testing is pretty simple: even I can do it. You plug one end of the cable into a matching jack in the INPUT section on the left, and the other end into the matching jack on the OUTPUT section. There are six pushbuttons across the bottom of the panel. All you do is puch one button for each conductor in the cable. Start with the one marked COM; this checks the shield for continuity. If it's good, the pushbutton lights up. If cable one has three conductors, depress the pushbuttons marked 1, 2 and 3. If they all light, the cable is good.

For finding an intermittent connection, just hold the pushbutton down and bend the cable back and forth. If the light blinks, you've found it. If you have a job that calls for making up a number of multi-lead cables, testing them is a breeze. It will catch any mis-wired plugs. If you push button 3 and button 2 lights up, something is wrong. If pushing 2 makes both 2 and 3 light, you have a short between these two leads or a jumper in the plug, which they warn you about in the instructions.)

If you run into a cable with a plug not included on the panel, the company has adapters available that will convert them to types which can be tested. If the cable has a male plug on one end a female on the other, conversion adapters for this are also on hand. The Switchcraft catalogue No. A-404D lists a great many of these adaptors. In the lid of the Q-Chek's case, spring clips are provided for holding up to 18 adapters.

If you do audio work, this unit can save a great deal of time and trouble. In specialized work such as language labs, that are now showing up in high schools as well as colleges, you may have to check a great number of cables. This unit will do it. The *model QC1002* comes complete with carrying case, instructions, 9-volt battery and seven separate audio adaptors; and is priced at $186.00. **R-E**

Electronic–communications contributors honored

The Radio Club of America, at its annual meeting and banquet in New York City last November, awarded its Armstrong Medal to Captain Wm. G.H. Finch, USN, retired, "for significant contributions to radio art and science." Captain Finch is the holder of more than 180 patents on facsimile, teleprinting and kindred subjects.

The Club's Sarnoff Citation, "for important contributions in electronic communications," was awarded to Fred Link, pioneer in mobile two-way radio communication and founder of Link Radio. A special Pioneer Award was presented to Harold Beverage for his early developments of the Beverage antenna and diversity reception; and Morgan McMahon, publisher of the Vintage Radio books, received the Ralph Batcher Memorial Award for his and his wife's work in preserving the history of radio.

Twenty–five members were elevated to the grade of Fellow in the Club. These included such well known figures as Lewis A. Bondon, founder and president of Prodelin, Inc.; Thomas A. Campobasso, vice president of the international sales division, Collins Radio; Francis T. Cassidy, Jr., general manager of ITT domestic communications operations; Richard E. Horner, president of E.F. Johnson Co.; Samuel McConoughey, chief of the mobile services division, FCC; R.D. Mignault, president of Pye Electronics, Canada; Charles E. Summers, manager, IBM private radio services; and William J. Weisz, president, Motorola, Inc.

The Radio Club of America, the world's oldest radio communications society, was founded in 1909, and has about 670 active members.

National Service Managers elect O'Shanna president

Robert J. O'Shanna, director of service of the Alemite Instrument Div., Stewart-Warner Corp., was elected president of the National Association of Service Managers at their annual conference last October. Mr. O'Shanna has held several offices in the Association, and as a member of the Education Committee, has been instrumental in having service management seminars set up at the University of Wisconsin and at Syracuse University in New York.

Edwin L. Penar, national service manager of Dole Refrigerating Co., Lewisburg, TN, was elected vice president. James Britton, service manager, Hartford Div., Stanadyne, Inc., of Hartford, CN, was named second vice president. Charles K. Lins, director of area service for Bell and Howell in Dallas, was named secretary, and William P. Zabler, Sears, Roebuck national service manager, was named treasurer.

Five-year warranty for new Sylvania picture tubes

GTE-Sylvania *Color Bright 85* picture tubes are now being sold with a five-year limited warranty. Sylvania is said to be the first manufacturer to offer a limited warranty of this extent on any grade of TV tube. **R-E**

TOMORROW'S HI-FI GEAR
continued from page 42

channel of audio power at approximately 0.1% total harmonic distortion while remaining comfortably cool to the touch. Figure 10 illustrates the output stage dissipation of the PWM amplifier the PWM approach only at maximum output, but since peak conditions (under musical listening conditions) are attained only for short periods of the total listening time, the PWM amplifier is seen to offer increased average efficiency or much lower average dissipation when used for music reproduction purposes.

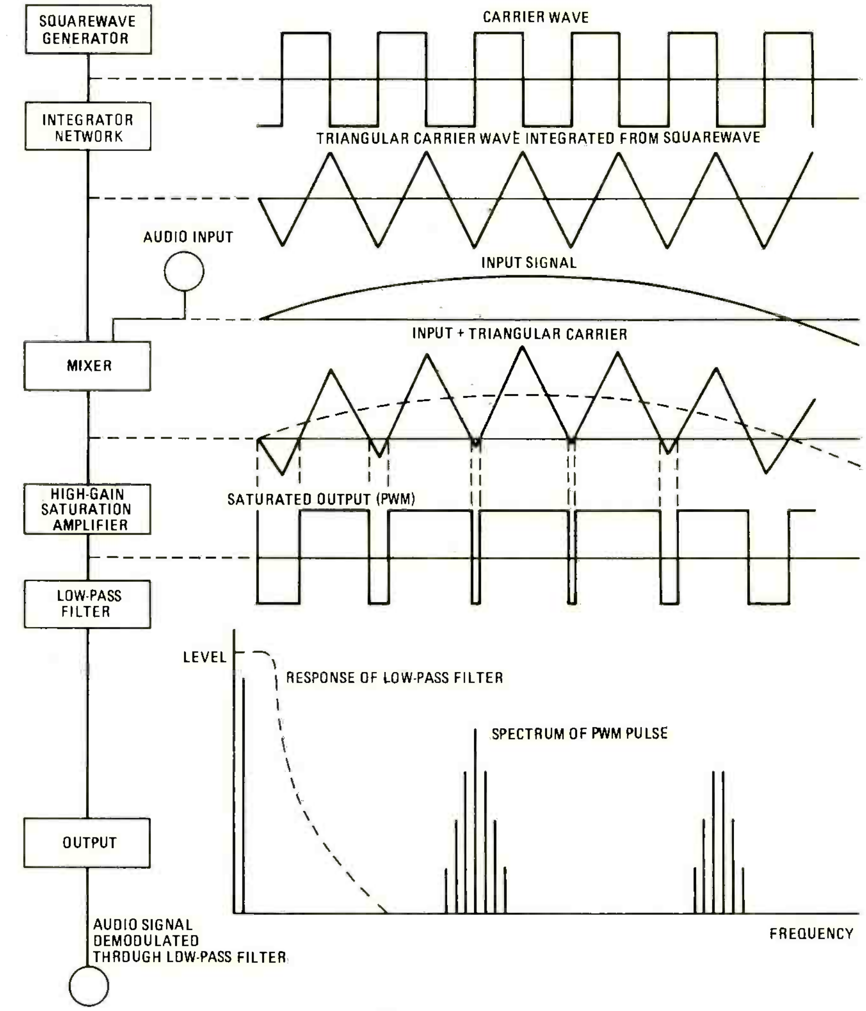


FIG. 9—WAVEFORMS at each stage of the PWM amplifier.

as compared with that of a conventional Class-B amplifier, each expressed or

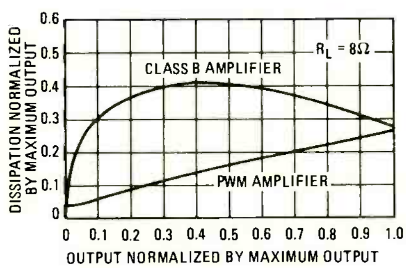


FIG. 10—POWER DISSIPATION of the PWM amplifier versus the conventional Class-B.

normalized in terms of maximum rated output. From this plot we see that the efficiency of the PWM amplifier is much higher than that of a Class-B amplifier operating in its ideal conditions over most of its power range. Class-B efficiency approaches that of

These are but a few of the innovative product ideas and circuit developments that I saw on opposite sides of the world and they suggest that the state of the audio art is hardly dormant. At that, we have only been able to skim the surface of the technology involved in each of these devices or products. As each reaches commercial reality in the marketplace, we hope to explore them in greater depth—either by devoting a full article to each, or by testing and reporting upon the resulting products themselves in future test reports. **R-E**

GET RID OF RFI
continued from page 46

manufacturers and are available from most electronic supply houses, especially those dealing in industrial electronic components. Because physical size is important, miniature or subminiature coils should be used. Capacitors should be disc ceramic types, of the HiK or TC type, and their size must be small, too.

Some final suggestions

If interference is known to originate from CB equipment, it might be a good idea to borrow a CB rig (unless you already own one) and operate it near the audio equipment while trying to cure the problem. By so doing, you won't have to wait for the interfering signal to come "on the air" to ascertain whether your attempts at a cure have been successful. If you are successful, record what parts you added to your equipment by adding them to the schematic diagram of your hi-fi component.

Remember, it is not always possible to cure RFI problems completely. In many cases only a reduction of interference may be possible, despite your best efforts, but reducing the problem is better than no solution at all. We know of at least one case in which just about all of the solutions we have outlined were attempted with no success. The listener was located directly across the street from a local FM transmitter tower. This frustrated audiophile had just about given up, and loved his hi-fi music enough to move to another location. Having disassembled his hi-fi in preparation for the move, he had stored all the components in his bedroom, which faced another exposure, away from the transmitter tower. Before packing the gear in shipping cartons, he decided to hook the units up for one last listen and, you guessed, the RFI was gone! **R-E**

"Now that you've built your TV Typewriter, your minicomputer, your digital clock, and your CB transmitter, do you think you're ready to tackle a broken toaster?"

ACTION FOOTBALL

continued from page 68

to reach, or go beyond, the goal line. The same holds true for a field goal attempt. If a field goal falls short, the ball is taken by the opposing player at his 20-yard line. If either a field goal or a punt is blocked, the opposing player takes possession at the line of scrimmage.

If the ball is fumbled, the play selector is moved to FUMBLE on the chart and the buttons are activated to see if the offensive team retains possession or not. If the result is LOSE, the opposing player takes over at the line of scrimmage. If it is KEEP, the offensive player loses the down but continues to play.

A pass can be complete with the yardage indicated, incomplete with no yardage or intercepted. If it is intercepted, the ball is first advanced to the point of interception according to the yardage shown in the chart. Then, the play selector is moved to INT RUNBACK and the buttons are actuated to determine how many yards the opposing player runs back the interception. If the intercepting player fumbles on the runback, the fumble play is used to tell whether he keeps possession at the point of interception, or loses the ball. If there is pass interference, the offensive team gets a first down at the point of the interference, which is indicated by the yardage shown on the chart.

As in actual football scoring, touchdowns count six points, field goals three and extra points one. Conversion attempts are determined by using the extra-point play to see if the kick is good or no good. You can, of course, vary the rules as you wish. You might decide, for instance, to permit two-point conversions.

Quarters can be determined by setting a kitchen timer to an agreed-on period or by limiting each player to a certain number of plays, say 16 or 20. In this case, only actual plays from scrimmage count. Kickoffs, kick returns, interception runbacks and conversion attempts are not included. At the start of the second half, the player who kicked off at the beginning of the game now receives the ball. **R-E**

DIGITAL CLOCKS

continued from page 57

seconds. When this switch is closed, the FAST switch becomes ZERO SECONDS AND HOLD and the SLOW switch becomes HOLD COUNT. If all three of these switches are closed at the same time, the display changes to 12:00 AM. This peculiar "programming" allows you to make any of these modules into a 24-hour "stopclock" that will count and display by the second, and can even be controlled and reset remotely! To do this, use toggle or slide switches instead of pushbutton switches. Hint: Small toggle switches will mount in the same ¼-inch diameter hole as miniature pushbutton switches.

The ALARM DISPLAY switch is also used as the SNOOZE switch. When this switch is closed, the alarm time is displayed, and is advanced by the FAST and SLOW switches to the desired time. (Be careful that you don't overlook AM or PM designation, or your alarm will be 12 hours off!). With the ALARM ON switch closed, when the real time matches the alarm-set time, the alarm will sound. By pressing the ALARM DISPLAY/SNOOZE switch, the alarm will stop for 9 minutes, then go on again. This can be repeated for up to one hour from the original alarm time. Of course, the ALARM OFF switch disables the alarm at any time. If this switch is turned off when the alarm sounds, and then turned right back on again, the alarm will automatically go on again in 24 hours! In other words, you can set the alarm for the next day when you get up, instead of before going to sleep . . . when you might forget.

Although all these modules are able to turn a radio on and off automatically, this requires a SLEEP TIMER display switch (shown in the wiring diagram, and included in the kit offered in the parts list), a MODE selector switch, and, in the case of the National modules, external driving circuitry. Also, because of the power requirements, this could mean a different power transformer, and you would need specific information on the radio circuit requirements. Therefore, these applications are not covered in this article. Although each of these modules is a versatile "brain" about which a lot more could be written, the main features and uses are covered. If you want more specific information, contact National Semiconductor Corp. (2900 Semiconductor Drive, Santa Clara, CA 95051), Fairchild Semiconductor Consumer Products Group (4001 Miranda Ave., Palo Alto, CA 94304) or Interfab Corp. (See parts list). **R-E**

THE UNFINISHED JOB

I asked you for some ideas on why I had several odd symptoms in an RCA CTC-38. You said "Check the electrolytic filter capacitors for any sign of signal." I did, and found that it was the one you said, on the + 140 volt line! However, the filter capacitor itself wasn't bad. It had been replaced but whoever did it just forgot to solder the lugs of the can to the chassis! Fixing this up stopped all the trouble. Thanks very much.—H.Y., Martinez, GA.

The moral of this is "Don't stop working on the a job until you're *through!*")

HALF A PICTURE MISSING!

I've got a real screwball in this Zenith 19EC45. The top half of the picture is perfect; no compression, no stretch. The whole bottom half is gone. It's just black! What the heck is this?—J.G., Crystal Springs, AR.

Real simple *after* you find out what it is! This set has an OTL (Output Transformer Less) two-transistor vertical output stage with dual-polarity DC power supply. (Just like the OTL circuits you find in transistor stereo amps, and so on.) So, there are two output transistors. Each one scans one half of the screen. If one should open or develop a bad contact in the socket, this is the reaction you'll see. If you lost the bottom half, go and check Q708. This is the transistor in the middle of the heat sink. That's it.

DISTORTION

The right channel sounds awful in this Truetone 4DC6325. Left channel OK. The scope shows a funny waveform in the right channel with a sinewave on the input. (See diagram.) I pulled

both transistors in that channel, checked them out of circuit and they were good! Help!—MDO, Ink., AR.

The output stages in this amplifier use small thermistors in the bias networks. It's very likely that one of these has been shorted out by a solder bridge! This has happened to me. Check the resistance across the terminals of each; should be a about 22 ohms. The waveform you drew shows a very bad case of crossover distortion and bad transistors are one cause of this; so, your test was correct.

VERTICAL RETRACE

I wrote you some time ago about a vertical retrace problem in a Sears TV set. I checked everything you suggested. Still had 'em. Finally, in desperation, I moved the vertical centering control. This raised the raster so that the retrace was hidden! I figured that I'd lose too much of the picture, so I ran the setup adjustment on the vertical size, linearity and shape controls. Much to my surprise, I found that I had a perfect raster—full, linear, and no retrace lines!

Do you think that the set came from the factory this way, or was it one of the Sears service technicians who had previously worked on it?—R.K., Middleburg Heights, OH.

Well, you've got one of two choices. Take your pick! **R-E**

LOOKING AHEAD
continued from page 4

AM stereo soon? The FCC could act to establish an AM stereo radio service as soon as the end of this year, in the opinion of Washington observers. An industry-wide National AM Stereo Radio Committee (NASRC) has studied a number of proposed systems and was scheduled to start field-testing them over radio stations in February.

Game problems: The hottest new electronic product since CB may be running into an unexpected problem: Are video games injurious to television sets? The first rumblings were heard from television dealers who found that after leaving games on the screen all day for many days, the outlines of the game perimeters were "burned" into the picture tube screen. They reported these problems to the set manufacturers, who immediately began to envision thousands of picture-tube warranty replacements due to the use of games, and got their engineers and lawyers working to figure out what to do about it.

The Federal Trade Commission got wind of the potential problem and quietly started an investigation, questioning TV set, game and picture tube manufacturers. The investigation has been inconclusive so far, but the Canadian government's Consumer and Corporate Affairs Department issued a public warning that "prolonged use of the games may cause the game pattern to remain as a ghost during regular TV viewing," explaining that this was the result of "phosphor exhaustion" caused by fixed lines on the screen. An American catalog house, Service Merchandise Corporation, is sending its game customers a letter telling them that the extent of the problem isn't known, but suggesting that games be turned off when play is completed and that normal viewing habits be maintained, to give the set a "rest."

Sounds like a regular epidemic of trouble—except that so far as we can determine there have been no complaints from consumers. The Electronic Industries Association (EIA), which is conducting its own investigation, has heard of none. The Council of Better Business Bureaus says it is aware of the potential for trouble but hasn't received any complaints, and game and TV makers say they've heard only scattered complaints, but these were from stores which leave the games on for protracted periods, and not from consumers.

*(**Radio-Electronics** is interested in this problem too. If you have had some personal experience with any instance of a TV game display damaging a picture tube, tell us about it. Send us full details, including manufacturer, model number, screen size, hours of use per day and room lighting. Send your data to Radio-Electronics Magazine, TV Games Data, 200 Park Avenue South, New York, NY 10003. Letters can not be acknowledged. We will publish the collected data in a future issue.*—Editor)

The biggest worry, of course, is that the big game sales started just last year and there hasn't been enough experience yet to determine the long-term effects, if any. Television set makers, increasingly nervous about thousands of potential claims, are preparing to put disclaimers in their warranties to indicate that the terms cover only the use of the sets to view programs. Until the problem is better defined, there's a simple precaution which probably will prevent any potential damage: Turn down the brightness and contrast.

DAVID LACHENBRUCH
CONTRIBUTING EDITOR

new books

CB UPDATE, by Mike Wendland. Sheed, Andrews & McMeel, Inc., 6700 Squibb Road, Mission, KS 66202. 5¼ × 8 in., 140 pp, $3.95 softcover.

Good Buddies and would be Good Buddies alike will find this up-to-now look at the hottest hobby in America intriguing. It contains valuable information for both longtime CB'ers and those with newly acquired ears. The author begins with a brief history of CB radio explaining how the Arab oil boycott and the double-nickels speed limit precipitated the CB mania. Once used only by a handful of businessmen and backroad coyote hunters, CB radios today are the truckers' best friend and a handy tool for thousands of motorists.

The book covers the ABC's of CB as well as the more technical aspects. The author explains AM and SSB operations, gives advice on operating etiquette, provides details of proper antenna mounts and the variety of useful tips. He also tells how to operate a unit from a home base, even in an apartment. Of particular interest will be the glossary of CB terms in the back of the book. Other helpful appendices include a guide to the 10-code and a copy of the FCC Rule and Regulations, Part 95.

CB RADIO, Tab Editorial staff. Tab Books, Blue Ridge Summit, PA 17214. 7 × 10-in., 210 pp, $5.95 softcover.

This is volume 4 in a series of CB Radio Schematic/Servicing Manuals. This one covers Pace, Fanon/Courier and Dynascan (Cobra). It's a complete rundown on servicing data on more than 30 CB transceivers. A valuable reference for any technician looking at the service and repair of CB radio equipment.

THE RADIO AMATEUR'S HANDBOOK. Fifty-third (1976) Edition. Edited by Bob Myers and The Headquarters Staff of the American Radio Relay League. Newington, CT 06111. 6½ × 9½ in., 705 pp including index. Softcover. $6.00 in U.S. and Possessions, $7.00 in Canada and $8.00 elsewhere. Hardcover clothbound $10.00 in U.S. and Possessions, $11.00 in Canada and $12.00 elsewhere.

Like the fifty-two previous editions, the ARRL Handbook is destined to be one of the most sought-after publications in the electronics field. It is chock full of material for beginners, advanced amateurs and electronics engineers alike. Readers of the Handbook will be pleasantly surprised at the number of new construction projects in this edition. Among them are a two-band solid-state transmitter, a 2-kW 2-meter amplifier and a communications receiver with digital readout. Hundreds of drawings, charts and photographs are used to present the material.

CB RADIO, Second Edition, Revised, by Leo G. Sands. A. S. Barnes & Co., Inc., Box 421, Cranbury, NJ 08512. 5½ × 8½-in., 192 pp, $8.95 hardcover.

This is a basic introduction to the fascinating world of CB updated and revised with all the latest rules, "lingo," and equipment. The following topics are covered fully: getting started; selecting equipment; cost of equipment; power sources for the house, vehicle, boat and walkie-talkie; antennas; installation; maintenance and repair; and efficient use of air time.

Special features include a license application form, official 10-code, CB operator lingo, trucker's CB lingo, abbreviations, and protecting yourself with CB radio.

CBer's HANDYBOOK OF SIMPLY HOBBY PROJECTS, by Robert M. Brown. Tab Books, Blue Ridge Summit, PA 17214. 5⅛ × 8¼-in., 168 pp. Softcover: $3.95.

This book contains 114 easy-to-build performance boosters for every CB'er including mobile and base station antennas, direction finders, modulation boosters, RF preamplifiers and converters, noise limiters, clippers, squelch switches, audio compressors and limiters plus 101 other useful and novel operating aids. Most of the projects can be built for under $5.00 using new parts. A soldering iron and normal hand tools are all that are needed to build any of these projects. **R-E**

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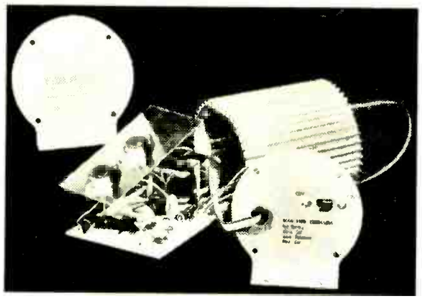

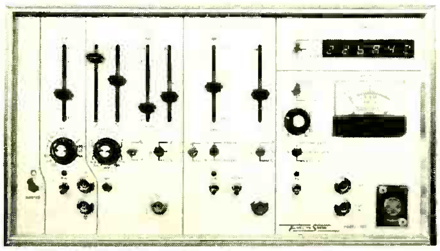

ANALOG VOLTMETERS

continued from page 71

or range. This is quite common, especially with the crowded scales of a versatile multi-function meter. For example, it is easy to have the voltmeter set on the 15-volt range and take the reading from the 50-volt scale. A more subtle version of this problem is to take a 1.5-volt AC reading from the 15-volt scale rather than the special scale provided for the 1. 5 VAC range.

Errors in reading can be generated from parallax. Parallax is the difference in readings obtained by viewing the meter from different angles. Generally, errors due to parallax are important only when high-precision measurements are being made. Where parallax is a severe problem, a mirror-backed meter scale helps maintain all readings from a single point.

Another operator error is to make measurements with the probe tip switch in the wrong position. Either the switch is in the DC position, (which places one megohm in series with the probe) and the measurement is either AC volts or ohms, or DC measurements are made without the series resistance and all measurements are 10% high.

Resistance measurements made with current still flowing in the circuit are invalid. The ohmmeter, in the final analysis, measures voltage. Any extra current in the resistance being measured sets up a voltage, which is a source of error. If the meter is not protected, there may also be damage to the ohmmeter circuits.

Resistance measurements made on transformer windings (or other highly inductive components) are susceptible to two problems. The first is caused by a lack of transformer knowledge. The operator discards a good transformer because the resistance of a winding appears to be low. What has been forgotten is the reflected impedance from the other windings. The second problem is caused by the high inductance itself, and is normally a problem only with power transformer primaries and high-voltage secondaries. When the ohmmeter is disconnected from the winding, the magnetic field collapses. This collapse causes a high voltage to appear at the winding terminals. The high voltage can cause electrical shock, damage to the ohmmeter, or both.

Polarity errors are common and come in two forms. First, the user may have the meter set for one polarity and assume another. The second polarity error is associated with ohmmeter measurements: The operator fails to consider the effects ohmmeter polarity may have on a circuit containing semiconductor junctions. If the presence of semiconductor junctions in the measurement is suspected, a simple check is reversal of the test leads. Significantly different resistance readings indicate the presence of semiconductor junctions.

Improper interpretation of the decibel scales often leads to error.

In the area of errors introduced by the meter itself, circuit loading is probably the most common. Often a simplistic view of the VTVM or the TVM is taken, and the presumption is that the electronic voltmeter does not load the circuit at all. Although the electronic voltmeter may be substantially better than the VOM, it still loads the circuit. Looking at the simple DC case, it is apparent that a 10-megohm voltmeter loads a one-megohm source enough to produce a 10 percent error in the reading. This is if DC only is taken into consideration.

If the AC component of the signal is also considered, capacitive loading must also be considered. The meter input capacitance often presents a low-impedance resistive load of the divider. As noted earlier, this must be taken into consideration when making DC as well as AC measurements. This is especially true when dealing with a circuit where the loss of AC shifts the DC values of the circuit. The self-biasing stages of a transmitter are an example of such a case. The isolating resistance of the VTVM is most necessary in these cases.

There are times when the VOM is actually better than the TVOM or the VTVM. For example, the VTVM has an 11-megohm input impedance when used on the 1,500-volt range; however, a VOM with 20,000 ohms per volt input impedance has 20,000 × 1500, or 30 megohms input impedance. When measuring a high-voltage supply, this may be of considerable advantage. The VOM may have the further advantage of having an even higher voltage range (4 to 5 kV for example), and the circuit loading caused by these ranges is even less than that of the VTVM or TVM.

The analog voltmeter is truly not dead nor dying. Although many of its functions are being replaced by the digital multi-meter, there are still many places where the analog insrument is adequate. **R-E**

BIPHONIC SOUND

continued from page 39

products in the future. In a recent visit to JVC's headquarters in New York City, we were treated to yet another experience in sound reproduction. To best illustrate the effects of their binaural-stereophonic and quadriphonic-binaural-stereophonic processors and program material, they devised a special listening chair (see cover photo), equipped with four small speakers in front of and behind the chair's occupant. Despite the obvious fidelity limitations of the small speakers constructed into the framework of the experimental chair, the sound images created by these carefully positioned speakers were beyond description.

At the moment, there are only a few records recorded binaurally in this country, though in Japan it is reported that some twenty such special discs are already available. If interest in binaural sound increases, we may well see additional offerings of such discs in this country and may, perhaps, even witness the resurrection of an old form of sound recording and reproduction that has been dormant for more than forty years. **R-E**

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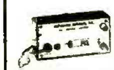

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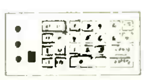

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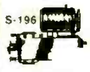

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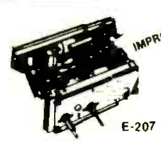

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Includes: 1/8, 1/4, 1/2, 1, 2-watters, carbon, 8 oz. 100% good. 3R3054

BARREL KIT #99 PHOTO ELECTRIC CELLS 10 for $1.98
Asst. GE types, CDS types. Mixed by factory. Big job for us to separate. 100% good. Cat. No. 3R3052

BARREL KIT #93 HALF WATTERS 200 for $1.98
Resistor factory tried to fool us by mixing 100% color-coded resistors in barrel. But value is there. 4 oz. 3R3046 Untested

BARREL KIT #92 3 AMP EPOXY RECTIFIERS 100 for $1.98
Untested. Cosmetic rejects, electrically fine business! You check 'em, it's not for us. Asst. voltages. 3R3204

BARREL #91 SILVER MICAS 100 for $1.98
Axial, red case, variety of physical sizes & values. Cat. No. 3R3018

BARREL KIT #88 LITRONICS LED READOUTS 10 for $1.98
747's, 727's, singles, triples, etc. .33 to 0.6. Bot from factory, all mixed; have fun! No. 3R2861

BARREL KIT #87 NATIONAL IC BONANZA 100 for $1.98
Types 8000, 7400 series, DTLs, ROMs, registers, clock & calc. chips, linears, etc. Cat. No. 3R2860 Untested.

BARREL KIT #86 HOBBY LEDS 40 for $1.98
Untested. 747's, 727's, singles, triples, etc. .33 to 0.6. Bot from factory, all mixed; have fun! 3R2859

BARREL KIT #83 15 for $1.98 LM-340T VOLT REG
Factory rejected them for length of leads. May include 5, 6, 8, 12, 15, 18, 24 volts. Power tab Cat. 3R2635

BARREL KIT #81 SUBMINI RESISTORS 200 for $1.98
PC, upright type, color coded, 1/4 watt. Asst values. Came to us in a barrel. Cat. No. 3R2746 100% good

BARREL KIT #76 1-WATT ZENERS 100 for $1.98
Factory same as 400-mw's. Never-to-see-again offer. 6, 8, 10, 12, 15V, under glass. Double plug. Cat. No. 3R2741 Untested.

BARREL KIT #75 400MW ZENERS 100 for $1.98
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BARREL KIT #73 TRANSISTOR ELECTROS 50 for $1.98
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BARREL KIT #71 CAPACITOR SPECIAL 100 pcs. $1.98
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BARREL KIT #68 2 WATTERS 100 for $1.98
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BARREL KIT #65 MIXED READOUTS 10 for $1.98
Factory returns — such numbers as MAN-4's, MAN-7's, MAN-3's, 11 barrels & no time to separate. Cat. No. 3R2733 Untested.

BARREL KIT #61 POLYSTYRENE CAPS 100 for $1.98
Finest caps made. As a gamble we bought 10 barrels from factory, mixed values; all good. Cat. No. 3R2729

BARREL KIT #58 SLIDE SWITCHES 30 for $1.98
All shapes, sizes, spst, dpdt, momentaries, etc. Tremendous shop pak for 100's of switching projects. Cat. No. 3R2726 100% good

BARREL KIT #56 POWERS! POWERS! $1.98 100 for
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BARREL KIT #54 8 DIGIT READOUTS 10 for $1.98
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BARREL KIT #40 PNP HIGH-POWER TRANSISTORS 20 for $1.98
Popular germanium TO-3 case 3R2618 100% good

BARREL KIT #39 2N3055 HOBBY TRANSISTORS 15 for $1.98
Fallouts of the famous 2N3055. 3R2617 100%

BARREL KIT #37 1 AMP "BULLETT" RECTIFIERS 100 for $1.98
Untested. Famous style, asstd. voltages, silicon, axial includes all types of voltages to 1KV. Cat. No. 3R2615

BARREL KIT #36 GERMANIUM DIODES 200 for $1.98
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BARREL KIT #35 NEON LAMPS 30 for $1.98
100% good. Famous NE-2's. All prime, but factory made millions and barrel'ed 'em. Your advantage Cat. No 3R2613

BARREL KIT #31 METALLIC RESISTORS 100 for $1.98
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BARREL KIT #30 PREFORMED RESISTORS 200 for $1.98
We got barrels of 1/4 and 1/2" watters for pc use. 100 1/4, 100 1/2 watters. No. 3R2608 100% good

BARREL KIT #27 PREFORMED DISCS 100 for $1.98
Hi-Fi mfr's shelf inventory but he dumped 'em in barrels. Preformed, for PC use. Mixed values too! 3R2605

BARREL KIT #26 PLASTIC TRANSISTORS 100 for $1.98
Untested. Type TO-92 (TO-18), all manufacturers, variety of 2N 's. Cat. No 3R2604

BARREL KIT #25 METAL CAN TRANSISTORS 100 for $1.98
Includes TO-5, TO-1, TO-18, etc., assorted 2N numbers, unmarked etc. Cat. No. 3R2603 Untested.

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☐ SN7403N	.16	☐ SN7447N	.69	☐ SN74100N	.98	☐ SN74165N	.99
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☐ SN7409N	.18	☐ SN7470N	.45	☐ SN74121N	.38	☐ SN74181N	2.05
☐ SN7410N	.16	☐ SN7472N	.34	☐ SN74123N	.59	☐ SN74184N	1.75
☐ SN7411N	.25	☐ SN7473N	.36	☐ SN74125N	.59	☐ SN74185N	1.75
☐ SN7413N	.45	☐ SN7474N	.31	☐ SN74126N	.59	☐ SN74190N	1.15
☐ SN7417N	.32	☐ SN7475N	.49	☐ SN74132N	1.00	☐ SN74191N	1.05
☐ SN7420N	.16	☐ SN7476N	.31	☐ SN74141N	.88	☐ SN74192N	.87
☐ SN7421N	.29	☐ SN7478N	.79	☐ SN74145N	.69	☐ SN74193N	.83
☐ SN7423N	.35	☐ SN7483N	.69	☐ SN74148N	1.29	☐ SN74195N	.73
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Cat. No. 2R1981

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BARREL KIT #17 LINEAR & 7400 DIPS 100 for $1.98
Untested. Marked and unmarked, internal numbers of raw factory stock. No. 3R1431

BARREL KIT #14 PRECISION RESISTORS 200 for $1.98
Marked and unmarked 1/4, 1/2, 2 watts. No. 3R2417

BARREL KIT #12 POWER TAB TRANS 40 for $1.98
PNP, plastic TO220 type. Assorted 2N numbers. Cat. No. 3R2426 Untested.

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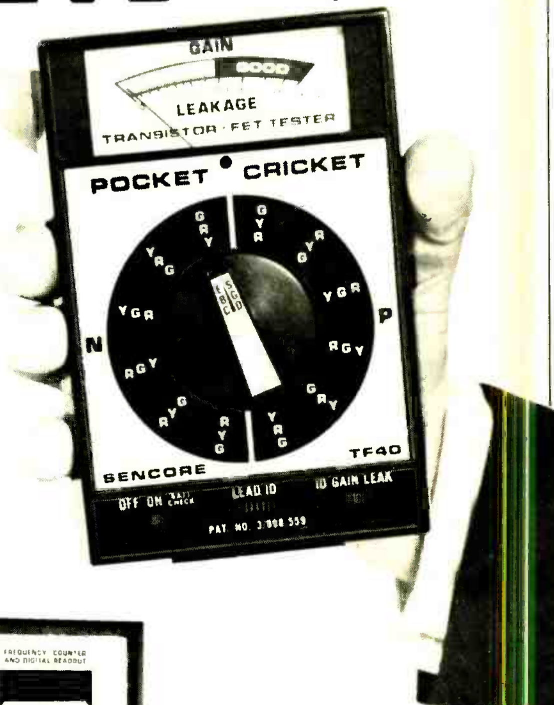

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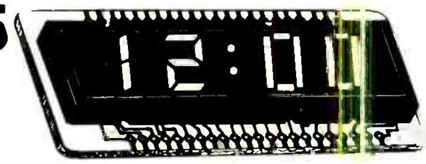

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74LS02—49c	7420—19c	7474—35c	7493—69c	74161—95c
7404—19c	7430—19c	74LS74-59c	7495—75c	74164-1.10
74L04—29c	7432—34c	7475—69c	7496—89c	74165-1.10
74S04—44c	7437—39c	7476—35c	74121-38c	74174—95c
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7401	.16	7453	.17	74154	1.20
7402	.15	7454	.17	74155	.97
7403	.15	7460		74156	.97
7404	.16	7464	.35	74157	.99
7405	.19	7465	.35	74158	1.79
7406	.20	7470	.30	74160	1.23
7407	.28	7472	.30	74161	.97
7408	.18	7473	.35	74162	1.39
7409	.19	7474	.28	74163	1.09
7410	.16	7475	.49	74164	.99
7411	.25	7476	.30	74165	.99
7413	.43	7483	.68	74166	1.25
7414	.65	7485	.88	74170	2.10
7416	.35	7486	.40	74173	1.49
7417	.35	7489	2.25	74174	1.23
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	.98	74185	2.20
7437	.25	74105	.44	74187	5.75
7438	.25	74107	.37	74190	1.15
7440	.15	74121	.38	74191	1.25
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
7448	.79	74150	.97	74199	1.69
7450	.17	74151	.79	74200	5.45

LOW POWER

74L00	.29	74L51	.29	74L90	1.40
74L02	.29	74L55	.29	74L91	1.20
74L03	.23	74L71	.29	74L93	1.50
74L04	.29	74L72	.45	74L95	1.50
74L06	.29	74L73	.56	74L98	2.25
74L10	.29	74L74	.56	74L164	2.25
74L20	.29	74L78	.75	74L165	2.30
74L30	.29	74L85	1.09		
74L42	1.39	74L86	.65		

LOW POWER SCHOTTKY

74LS00	.36	74LS32	.38	74LS95	2.09
74LS02	.36	74LS40	.45	74LS107	.59
74LS04	.36	74LS42	1.40	74LS164	2.20
74LS08	.38	74LS74	.59	74LS193	2.20
74LS10	.36	74LS90	1.30	74LS197	2.20
74LS20	.36	74LS93	1.30		

HIGH SPEED

74H00	.25	74H22	.25	74H61	.25
74H01	.25	74H30	.25	74H62	.25
74H04	.25	74H40	.25	74H74	.39
74H08	.25	74H50	.25	74H101	.58
74H10	.25	74H52	.25	74H102	.58
74H11	.25	74H53	.25	74H103	.60
74H20	.25	74H55	.25	74H106	.72
74H21	.25	74H60	.25	74H108	.72

SCHOTTKY

74S00	.59	74S08	.68	74S22	.65
74S02	.59	74S10	.65	74S32	.68
74S03	.59	74S20	.65	74S74	.68
74S04	.72				

8000 (NATIONAL)

8091	.61	8220	1.49	8811	.65
8092	.61	8230	2.19	8812	1.02
8095	1.25	8288	1.49	8822	2.19
8121	.80	8520	1.16	8830	2.19
8123	1.43	8552	2.19	8831	2.19
8200	2.33	8563	.62	8836	.29
8214	1.49	8810	.70	8880	1.19

8000 (SIGNETICS)

8263	5.79	8267	2.59

9000

9002	.40	9309	.79	9601	.61
9301	1.03	9312	.79	9602	.79

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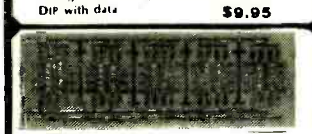
MM5330 — P channel device provides all logic for 4½ digit volt meter. 16 pin DIP with data **$9.95**



IC BREADBOARD

Accommodates 5 16 pin IC's with additional interconnection holes. 1/16" phenolic with silver plated copper circuits. 2 5/16" x 6 9/16" **$1.50 ea.**

UNIVERSAL BREADBOARD

Silver plated copper circuit board 3-3/16" x 5-1/16" 2 rows of 27 holes for DIP IC's + space for transistors, resistors & capacitors. Versatile and simple for breadboarding IC circuits **$1.50 ea.**

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MM5013	1024 bit accum. dyn.	1.75
MM5016	500/512 bit dyn.	1.59
SL5-4025	Quad 25 bit	.99
2504	1024 bit multiplexed dyn	3.95

IC SOCKETS

Solder Tail - low profile

8 pin	$ .17	24 pin	.42
14 pin	.20	28 pin	.59
16 pin	.22	40 pin	.69
18 pin	.29		

WIRE WRAP - gold plate
14 pin .49

AUTO CLOCK KIT

6 digits .375" red led's
Operates from 12V DC or AC
Crystal control for high accuracy
Supplied with case & mounting bracket
Contains internal 9V battery for operation of timing circuit (without display) when removed temporarily from power.
Uses 5314 clock circuit
Supplied with all necessary components and assembly instructions **$33.95**

COMPLETELY ASSEMBLED **$44.95**

1702A

2048 bit static PROM elect. prog. - UV eras. 24 pin **$6.95**

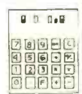
2102

1024 BIT STATIC RAM DTL/TTL comp. 16 pin **$1.49**

99¢ SPECIALS

KEYBOARD

20 KEYS
2 SLIDE SW
3" x 3¾"

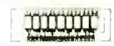


99¢ ea.

5 VOLT REGULATOR

340 T (7805) TO-220 99¢

CALCULATOR DISPLAY



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RED 7 SEG .127" LED
17 TERMINAL BOARD
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OP AMP

741 mini DIP

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EDGE CONNECTOR

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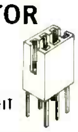

ELCO MODULAR UNIT
6 PIN 3 POSITION
WIRE WRAP. GOLD PLATE

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1101	256 bit RAM MOS 16 pin	1.39
1103	1024 bit RAM MOS dynamic 18 pin	1.95
1702A	2048 bit PROM static electrically programmable UV erasable 24 pin	10.95
2102	1024 bit RAM static 16 pin	1.95
5203	2048 bit PROM static electrically programmable UV erasable 24 pin	10.95
5260	1024 bit RAM MOS dynamic 16 pin	1.95
5261	1024 bit RAM MOS dynamic 16 pin	1.95
7489	64 bit ROM TTL 16 pin	2.25
82S23	256 PROM-SCHOTTKY 16 pin	3.69
F93410	256 bit RAM bi-polar 16 pin	1.95
74187	1024 bit ROM TTL 16 pin	5.75
74200	256 bit RAM tri-state 16 pin	5.45

CLOCK CHIPS

MM5311	6 digit multiplexed BCD, 7 seg, 12-24 Hr, 50-60 He — 28 pin	4.45
MM5312	4 digit multiplexed BCD, 7 seg, lpps. 12-24 Hr. 50-60 Hz — 24 pin	3.95
MM5314	6 digit multiplexed 12-24 Hr, 50-60 Hz 24 pin	4.45
MM5316	4 digit, 12-24 Hr, 50-60 Hz, alarm 40 pin	4.95
5375AA	4-6 digit, 12 hour, 60 Hz snooze alarm brightness control capability, alarm tnne output — 24 pin	4.95
CT7001	6 digit, 12-24 Hr, 50-60 Hz, alarm, timer and date circuits — 28 pin	6.95

CALCULATOR CHIPS

CT5002	12 digit, 4 function fixed decimal battery operation — 40 pin	1.95
CT5005	12 digit, 4 function plus memory, fixed decimal — 20 pin	2.49
MM5725	8 digit, 4 function, floating decimal 18 pin	1.98
MM5736	6 digit, 4 function, 9V battery operation — 18 pin	2.95
MM5738	8 digit, 5 function plus memory and constant floating decimal, 9V battery operation — 24 pin	3.95
MM5739	9 digit, 4 function, 9V battery operation — 22 pin	3.95

OPTO ISOLATORS

MCD2	Opto isolator diode	1.09
MCT2	Opto isolator transistor	.70

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Solid dipped +20%

.1 mfd	35V	$ .25	10 mfd	16V	$ .40
.33 mfd	35V	.25	10 mfd	25V	.45
1 mfd	35V	.25	15 mfd	10V	.40
2.2 mfd	20V	.25	15 mfd	20V	.45
2.2 mfd	35V	.30	22 mfd	16V	.45
3.3 mfd	35V	.30	33 mfd	10V	.40
4.7 mfd	16V	.30	47 mfd	6V	.40
6.8 mfd	6V	.30	56 mfd	6V	.45
6.8 mfd	50V	.40	150 mfd	15V	.50

4 Digit Clock Kit

MM5312 and 4 NS71 .27" displays 12-24 hours, 50-60 Hz. One P.C. board accommodates clock, displays, and all necessary transistors, resistors, capacitors, diodes, 2 switches, complete instructions and schematics for assembly.

CK4-2 .... $10.95

Mark I

A six digit clock kit with one double sided P.C. board accommodates MM5314 clock chip and 6 FND359 .375" displays. 12-24 hour, 50-60 Hz. Contains all necessary components. 3 switches and complete assembly instructions with schematics. Connections for remote displays.

Mark I $13.95

DISPLAYS

MAN1	$1.95
MAN2	3.95
MAN3A	.19
MAN5	2.25
MAN6	2.49
MAN7	1.49
MAN8	2.25
MAN66	2.25
DL10A	2.19
FND500	1.89
NS71L	1.39

DISCRETE LED'S

ME4	$ .29
MV50	.12
NSL100	.12
NSL101	.12
NSL102	.15
MV5020	
RED	.15
GREEN	.15
AMBER	.15
CLEAR	.15

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372	AF-IF Strip Detector DIP	2.93
546	AM Radio Receiver Subsystem DIP	.75
1310	FM Stereo Demodulator DIP	2.90
1496	Balanced Modulator-Demodulator	.99
1800	Stereo multiplexer DIP	2.48
ULN2208	FM Gain Block 34db (typ) mDIP	1.18
ULN2209	FM Gain Block 48db (typ) mDIP	1.35
2513	Character Generator 64x8x5 DIP-24	10.20
3046	Transistor Array DIP-14	.73

MARCH SPECIALS

2518	Hex 32 static shift reg.	$3.95
MV10B	Led clear lens TO-18	.15
7410	Triple 3 input NAND gate	.12
7438	Quad 2 input NAND buffer (o.c.)	.17
7442	BCD to decimal decoder	.39
7453	Exp. AND-OR-INVERT gate	.14
7474	Dual D flip-flop	.19
7493	4 Bit binary counter	.35
74121	One shot .29	
74153	Dual four-input multiplexer	.69
301	Hi Perf OP AMP mDIP TO-5	.21
311	Hi Perf V Comp mDIP TO-5	.69
723	V Reg DIP	.46

MULTIPLE DISPLAYS

NSN33	3 digit .12" red LED	1.79
HP5082-7405	5 digit .11 red LED	3.49
HP5082-7414	4 digit .11 red LED	3.25
SP-425-09	9 digit .25 gas disch	1.79

LINEAR CIRCUITS

300	Pos V Reg (super 723) TO-5	$ .71
301	Hi Perf Op Amp mDIP TO-5	.29
302	Volt follower TO-5	.53
304	Neg V Reg TO-5	.80
305	Pos V Reg TO-5	.71
307	Op AMP (super 741) mDIP TO-5	.26
308	Mciro Pwr Op Amp mDIP TO-5	.89
309K	5V 1A regulator TO-3	1.35
310	V Follower Op Amp mDIP	1.07
311	Hi perf V Comp mDIP TO-	.95
319	Hi Speed Dual Comp DIP	1.13
320T	Neg Reg 5, 12, TO-220	1.39
320K	Neg Reg 5.2, 12 TO-3	1.39
322	Precision Timer DIP	1.70
324	Quad Op Amp DIP	1.52
339	Quad Comparator DIP	1.58
340K	Pos V reg (5V, 6V, 8V, 12V, 15V, 18V, 24V) TO-3	1.69
340T	Pos V reg (5V, 6V, 8V, 12V, 15V, 18V, 24V) TO-220	1.49
372	AF-IF Strip detector DIP	2.93
373	AM/FM/SSB Strip DIP	2.42
376	Pos V Reg mDIP	.68
380	2w Audio Amp DIP	1.30
380-8	.6w Audio Amp mDIP	1.25
381	Lo Noise Dual preamp DIP	1.75
382	Lo Noise Dual preamp DIP	1.75
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562	Phase Locked Loop DIP	3.39
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739	Dual Hi Perf Op Amp DIP	1.07
741	Comp Op Amp mDIP TO-	.32
747	741 Dual Op Amp DIP or TO-5	.71
748	Freq Adj 741 mDIP	.35
1458	Dual Comp Op Amp mDIP	.62
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3900	Quad Amplifier DIP	.49
7524	Core Mem Sense AMPL DIP	.71
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75452	Dual Peripheral Driver mDIP	.35
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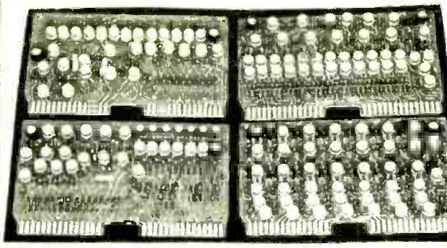
COMPUTER/PARTS BOARDS



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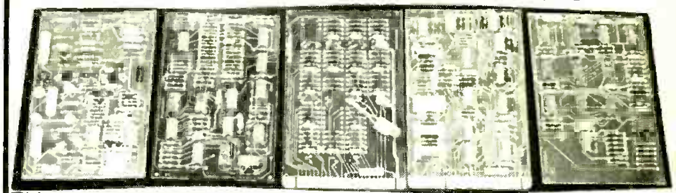

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2N3906 PNP Si TO 92	5/	$ 1.00
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4002	22	4019	25	4050	40
4006	1.20	4022	95	4055	1.50
4007	22	4024	75	4066	80
4009	42	4027	40	4071	22
4010	42	4028	88	4076	70
4011	22	4029	1.10	4081	22
4012	22	4030	22	4520	1.15
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7404	.20	7448	70	74155	70
7405	.20	7450	.20	74157	70
7406	.25	7472	33	74161	85
7407	.25	7473	35	74164	95
7408	.25	7474	35	74165	1.05
7409	21	7475	49	74173	1.40
7410	.15	7476	.35	74174	95
7411	20	7480	35	74175	.92
7412	20	7483	70	74177	79
7413	45	7485	88	74180	70
7414	.70	7486	30	74181	2.10
7416	25	7489	1.85	74190	1.20
7417	25	7490	45	74191	1.20
7420	20	7491	70	74192	85
7425	28	7492	50	74193	85
7426	25	7493	45	74194	.85
7427	30	7494	70	74195	75
7430	20	7495	70	74196	88
7432	25	7496	70	74257	1.25
7437	25	74107	32	74279	90
7438	25	74121	38	75324	1.75
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7441	85	74125	40	75492	65

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LM307 Op Amp	$ .30
LM 309K 5V 1A REGULATOR	$ .95
723 - 40 + 40VV REGULATOR	$ .50
301/748-Hi Per. Op. Amp.	$ .31
3201 5,12,15 or 24V NEG REG	$1.25
709C Op Amp	$ .31
741A or 741C OP AMP	$ .31
710 COMPARATOR	$ .35
CA 3047 Hi Per. Op. Amp.	$ .95
340T 5, 6, 8, 12, 15, 18, 24V POS REG TO-220	$1.10
101 OPER. AMP. HI PERFORM.	$ .75
LM 308 Oper. Amp., Low Power	$ .95
747 DUAL 741	$ .65
556 DUAL TIMER	$1.00
537 PRECISION OP. AMP	$1.70
LM 3900 QUAD OP AMP	$ .49
LM 324 QUAD 741	$1.50
560 PHASE LOCK LOOP	$2.00
561 PHASE LOCK LOOP	$2.00
565 PHASE LOCK LOOP	$1.25
566 FUNCTION GEN	$1.65
567 TONE DECODER	$1.50
LM 1310N FM STEREO DEMOD.	$2.75
8038 IC VOLTAGE CONT. OSC.	$3.90
LM 370 AGC SQUELCH AMP.	$1.15
555 2μs - 2 HR TIMER	$ .45
553 QUAD TIMER	$2.50
FCD 810 OPTO-ISOLATOR	$ .80
1458 DUAL OP AMP	$ .60
LM 380 2W AUDIO AMP	$ .95
LM 377 2W Stereo Audio Amp.	$2.50
LM 381 STEREO PREAMP.	$1.50
LM 382 DUAL AUDIO PREAMP	$1.50
LM 311 HI PER. COMPARATOR	$ .90
LM 319 Dual Hi Speed Comp.	$1.25
LM 339 QUAD COMPARATOR	$1.50

TRIACS / SCR'S

PRV	TRIACS 1A	TRIACS 10A	TRIACS 25A	SCR'S 1.5A	SCR'S 6A	SCR'S 35A
100	.40	.70	1.30	.40	.50	1.20
200	.70	1.10	1.75	.60	.70	1.60
400	1.10	1.60	2.60	1.00	1.20	2.20
600	1.70	2.30	3.60		1.50	3.00

Terms: FOB Cambridge, Mass. Send Check or Money Order. Include Postage, Minimum Order $5.00, COD'S $20.00

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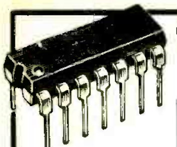

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Quality Electronic Components

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2102-1	8080A	LM3909
$1.99	$24.95	69¢

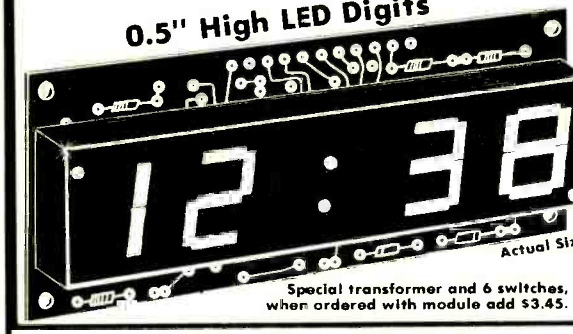
NATIONAL SEMICONDUCTOR CLOCK MODULES

"Assembled and tested. The IC & other parts are on the back of these compact modules."

MA1010A 12 Hour (AM-PM) Version . . . $13.00
MA1010C 24 Hour Version $13.00

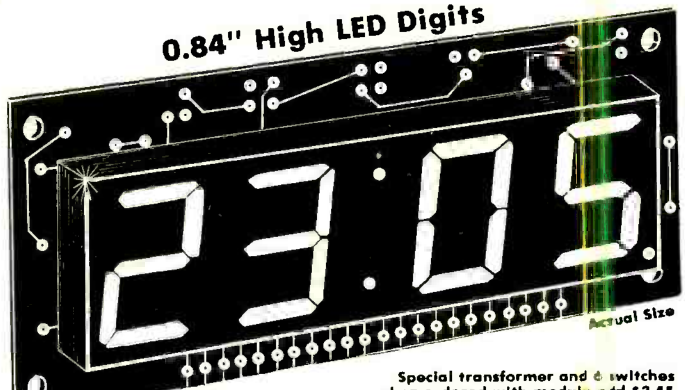
MA1002A 12 Hour (AM-PM) Version $10.50
MA1002C 24 Hour Version $10.50

0.5" High LED Digits



Special transformer and 6 switches, when ordered with module add $3.45.

0.84" High LED Digits



Special transformer and 6 switches when ordered with module add $3.45

Hobby-Wrap-30 $5.95

Strips, Wraps and Unwraps 30 ga. wire on standard wire wrapping pins

STRIP **WRAP** **UNWRAP**

NATIONAL

MA1002 & MA1010 Series Electronic Clock Modules

The MA1002 & MA1010 Series Electronic Clock Modules are assembled and pretested modules which combine a monolithic MOS-LSI integrated clock circuit, 4-digit LED display, power supply and other associated discrete components on a single printed circuit board to form a complete electronic clock movement. The user need add only a transformer and switches to construct a digital clock for application in clock-radios, alarm or instrument panel clocks. Timekeeping may be from 50 or 60 Hz inputs and 12 or 24 hour display formats may be chosen. Direct LED drive eliminates RF interference. Time setting is made easy through use of "Fast" and "Slow" scanning controls.

The MA1002A and MA1010A have a 12 hour display with an AM and PM indicator. The MA1002C and MA1010C have a 24 hour display.

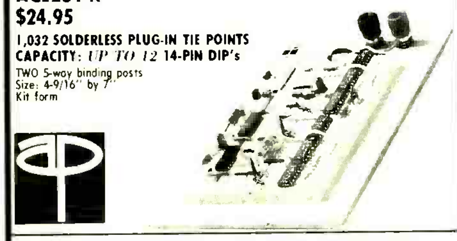
Features include alarm "on" and "PM" indicators, "sleep" and "snooze" timers and variable brightness control capability. The modules are extremely compact — the MA1002 measuring 1.375" by 3.05", the MA1010 measuring 1.75" by 3.75". This small size is achieved by bonding the I.C. to the back of the circuit board.

It is highly recommended that the transformer be obtained with the clock module as it is a special dual secondary type not otherwise readily available.

Double Digit Discounts Save You Even More!

ACE201-K
$24.95

1,032 SOLDERLESS PLUG-IN TIE POINTS
CAPACITY: *UP TO 12* 14-PIN DIP's
TWO 5-way binding posts
Size: 4-9/16" by 7"
Kit form



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	NE5608	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	.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	82525	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		

SILICON TRANSISTORS

MPS918, MPS930, MPS2222A, MPS2369A, MPS2712, MPS2907A, MPS3392, MPS3393, MPS3394, MPS3395, MPS3563, MPS3565, MPS3638, MPS3638A, MPS3640, MPS3641, MPS3643, MPS3645, MPS3646, 2N3904, 2N3906, 2N4124, 2N4126, 2N4401, 2N4403, 2N4410, PN4888, 2N5087, 2N5089, PN5129, PN5133, PN5134, PN5137, PN5138, PN5139, 2N5210, PN5964 . . . . .16, $1.55/10, $13.60/100 of same part no.

MPF102 .36 $30.60/C 2N5457 .48 $41.00/C MPSA13 .28 $24.00/C 2N3055 .99 $85.00/C

ENTIRE ROCKWELL CALCULATOR LINE ON DISCOUNT IN OUR LATEST CATALOG

NEW

WIRE WRAPPING WIRE IN BULK

Red or Black 30 ga. Kynar

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

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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

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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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Single Pole Single Throw
.15 — 1.20/10 — 10.00/C

Double Pole Double Throw
.23 — 2.00/10 — 19.00/C

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1-AA . . . 26c
2-AA . . . 42c
1-C 35c
2-C 42c
1-D 35c
2-D 42c

PERF BOARD

0.1" spacing between holes
4½"x 6" — $1.71
4½"x17" — $4.25

TERMINALS

for above perf board
$1.50/C

LED LAMPS

NSL5053 T-1 ¾ .18 $15/C
NSL5056 T-1 ¾ .18 $15/C

LED DISPLAYS

FND357 CC .375" . . $1.35
FND500 CC .500" . . $1.35
FND 507 CA .500 . . $1.35
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DATA BOOKS

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Memory IC's 592 p. $3.00
Interface IC's 464 p. $4.00
Volt. Regs. 128 p. $3.00
Linear Appl. 1 432 p. $4.00
Linear Appl. 2 246 p. $3.00
Audio 196 p. $3.00

BISHOP GRAPHICS Printed Circuit Drafting Aids are now available from Digi-Key

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	470/10V	.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	[illegible]	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			

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$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
8-32 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

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$ 0.00-$ 4.99	add $2.00	$ 50.00-$99.99	add $0.25
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$25.00-$49.99	add $0.50		

Includes shipping and insurance to USA & Canada

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DIGI-KEY CORPORATION

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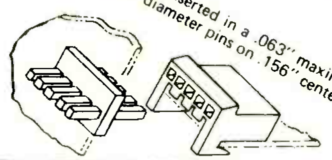
CIRCLE 70 ON FREE INFORMATION CARD

wafers are meant to be inserted in a .063" maximum thickness board and have .043" diameter pins on .156" centers.

NEW



CATALOG NUMBER	DESCRIPTION	PRICES 1-10	PRICES 11-99
13-0001	12 pos. rt. angle connector	.60	.50
13-0002	12 position wafer	.60	.50
13-0003	9 pos. rt. angle connector	.60	.50

SPECIAL!
1000 Molex IC terminals for $7.50
2000 for $13.50

SPECIAL!
Motorola 741 Mini Dip
35¢—10 for $3.00

ELECTROLYTIC CAPACITORS

PLEASE ORDER IN MULTIPLES OF 5 PER ITEM
RADIAL LEADS

(uF)	WORKING VOLTS DC	$
10	£16,35,50	.16
20	£16,35,50	.16
30	16	.16
50	£16,35	.22
100	£16,35,50	.25
200	16	.22
500	16	.34
1000	16	.52
2200	16	.80

£ Specify ONE

LINEAR

NE501A	2.80
NE555A	.50
A710CA	.60
A741V	.40
A747CA	1.10
A748CV	.74
A723CA	1.00
MC1468L	3.90

Red Led & Mtg. Hardware
T 1-3/4

1-10	11-100
.35	.29

MINIATURE FILM CAPACITORS

VALUE (uF)	PRICE TABLE 1-14	15-50	51-100
.001	.10	.10	.06
.0047	.10	.10	.06
.01	.10	.10	.06
.05	.19	.17	.15
.1	.20	.18	.16
.22	.25	.23	.21

These units are made by Internation Components Corp. All units 100 V

FIXED POWER SUPPLY KITS

Specifications	F0510	F1210	F1510
Input Voltage (50-500Hz)	105-125v	105-125v	110-125v
Output Voltage	5v ± 5%	12v ± 5%	15v ± 5%
Output Current (T_A = 25° C)	1.5A Max.	1.5A Max.	1.1A Max.
PRICE	$14.00	$14.50	$14.50

INDEFINITE SHORT CIRCUIT PROTECTION. Price includes Pre-drilled G-10 Board, All Parts and Transformer

DISPLAY BEZELS

CATALOG NUMBER	FILTER COLOR	PRICE 1-24	DIMENSION C
905-60	Red	$2.75	1.37
£ 910-60	Red	2.80	2.00
£ 915-60	Red	2.90	3.00
920-60	Red	2.95	4.00
920-70	Amber		4.00

These bezels are heat resistant plastic with a black matte finish. Filters are circular polarized type.

£ For Green Add A G to Part number

SOCKETS
LOW PROFILE
These sockets are from TI.

NUMBER OF PINS	5-99	100
8	.21	.18
14	.25	.20
16	.28	.24
24	.40	.35
28	.50	.45

TRANSISTORS

2N3638A	P	.5	TO-92	.25
2N2222A	N	.5	TO-18	.20
2N5133	N	.05	TO-18	.25
2N5494	N	7.00	TO-220	1.05
2N4401	N	.60	TO-92	.60
2N4403	P	.60	TO-92	.30
TIP32	P	3.00	TO-220	1.05

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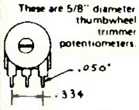

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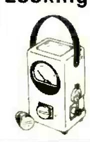

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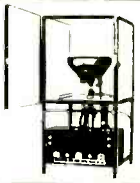

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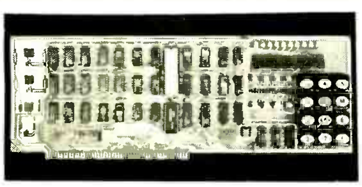

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CD4025	.25	CD4566	3.00	74C173	2.60
CD4027	.69	74C00N	.39	74C193	2.75
CD4028	1.65	74C02N	.55	74C195	2.75
CD4029	2.90			MC4044	4.50
CD4030	.65			MC14016	.56

LINEAR

LM300H	.80			LM1310N	2.95
LM301H	.35			LM1351N	1.65
LM301CN	.35			LM1414N	1.75
LM302H	.75			LM1458C	.65
LM304H	1.00	LM370N	1.15	LM1496N	.95
LM305H	.95	LM373N	3.25	LM1556V	1.85
LM307CN	.35	LM377N	4.00	LM2111N	1.95
LM308H	1.00	LM380N	1.39	LM2901N	2.95
LM308CN	1.00	LM380CN	1.05	LM3065N	.69
LM309H	1.10	LM381N	1.79	LM3900N	.55
LM309K	.99	LM382N	1.79	LM3905N	.50
LM310CN	1.15	NE501K	8.00	LM3909	1.25
LM311H	.90	NE510A	6.00	LM5556N	1.85
LM311N	.90	NE531H	3.00	MC5558V	1.00
LM318CN	1.50	NE536T	6.00	LM7525N	.90
LM319N	1.30	NE540L	6.00	LM7535N	1.25
LM320K-5	1.35	NE550N	.79	8038B	4.95
LM320K-5.2	1.35	NE555V	.39	LM75450	.49
LM320K-12	1.35	NE560B	5.00	75451CN	.39
LM320K-15	1.35	NE561B	5.00	75452CN	.39
LM320T-5	1.75	NE562B	5.00	75453CN	.39
LM320T-5.2	1.75	NE565H	1.25	75454CN	.39
LM320T-8	1.75	NE565N	1.25	75491CN	.79
LM320T-12	1.75	NE566CN	1.25	75492CN	.89
LM320T-15	1.75	NE567H	1.95	75494CN	.89
LM320T-18	1.75	NE567V	1.50	RCA LINEAR	
LM320T-24	1.75	LM703CN	.45	CA3013	2.15
LM323K-5	9.95	LM709H	.29	CA3023	2.56
LM324N	1.80	LM709N	.29	CA3035	2.48
LM339N	1.70	LM710N	.79	CA3039	1.35
LM340K-5	1.95	LM711N	.39	CA3046	1.30
LM340K-6	1.95	LM723H	.55	CA3059	3.25
LM340K-8	1.95	LM723N	.55	CA3060	3.25
LM340K-12	1.95	LM733N	1.00	CA3080	.85
LM340K-15	1.95	LM739N	1.00	CA3081	2.00
LM340K-18	1.95	LM741CH	.35	CA3082	2.00
LM340K-24	1.95	LM741CN	.35	CA3083	1.60
LM340T-5	1.75	LM741 14N	.39	CA3086	.85
LM340T-6	1.75	LM747H	.79	CA3089	3.75
LM340T-8	1.75	LM747N	.79	CA3091	10.20
LM340T-12	1.75	LM748H	.39	CA3123	2.15
LM340T-15	1.75	LM748N	.39	CA3130	1.39
LM340T-18	1.75	LM1303N	.90	CA3140	1.25
LM340T-24	1.75	LM1304N	1.19	CA3600	1.75
LM350N	1.00	LM1305N	1.40	RC4194	5.95
LM351CN	.65	LM1307N	.85	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	.49	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
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

FAIRCHILD TECHNOLOGY KITS FAIRCHILD

- Complete Specifications on back of each kit
- Packaged for WALL DISPLAY APPEARANCE
- Dealer's Inquires Invited — Price List Available

7205 - Stop Watch Chip $19.95

DIGITS		
FTK0001	0.5" High Common Cathode Digit	$1.00
FTK0002	0.5" High Common Anode Digit	1.00
FTK0003	.357" High Common Cathode Digit	.75
FTK0004	0.8" High Common Cathode Digit	2.00
FTK0005	0.8" High Common Anode Digit	2.00

0.8" HIGH DISPLAY ARRAYS		
FTK0010	12 Hour, 3½ Digit Clock Display	7.00
FTK0011	24 Hour, 4 Digit Clock Display	8.00

LED LAMPS		
FTK0020	10 Red LED Lamps	1.00
FTK0021	5 Mixed Colored LED Lamps	1.00
FTK0022	10 LED Mounting Clips	1.00
FTK0023	5 Three Piece LED Mounting Adapters	1.00

PHOTO TRANSISTORS		
FTK0030	5 Flat Lens Photo Transistors	1.00
FTK0031	5 Round Lens Photo Transistors	1.00
FTK0032	3 Flat Lens Photo Darlingtons	1.00
FTK0033	3 Round Lens Photo Darlingtons	1.00

PHOTO ARRAYS		
FTK0040	9-Element Tape Reader Array	16.00
FTK0041	12-Element Card Reader Array	24.00
FTK0042	Reflective Opto Coupler	4.00

COUPLERS		
FTK0050	3 General Purpose Opto Couplers	1.00
FTK0051	Darlington Opto Coupler	1.00

MOS CLOCK CIRCUITS		
FTK0400	Digital Clock Calendar Circuit (FCM7001)	7.00
FTK0401	Digital Clock-Calendar with BCD Outputs (FCM7002)	7.00
FTK0402	Direct Drive Digital Clock Circuit with AC Output (FCM3817A)	5.00
FTK0403	Direct Drive Digital Clock Circuit with DC Output (FCM3817D)	5.00
FTK0405	Direct Drive Digital Clock/Calendar Circuit (FCM7015)	6.00

KITS		
FTK0106	Automobile Clock Kit	40.00

DISCRETE LEDS

.125" dia.			.90" 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
			XC111	Orange	4/$1

.200" dia			.185" dia.			.200" dia.			.085" dia.
XC22	Red	10/$1	XC526	Red	10/$1	XC556	Red	10/$1	MV50
XC22	Green	4/$1	XC526	Green	4/$1	XC556	Green	4/$1	.085" dia Micro
XC22	Yellow	4/$1	XC526	Yellow	4/$1	XC556	Yellow	4/$1	red LED
XC22	Orange	4/$1	XC526	Orange	4/$1	XC556	Orange	4/$1	6/$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   DL338

TYPE	POLARITY	HT		TYPE	POLARITY	HT	
MAN 1	Common Anode	270	2.95	MAN 3620	Common Anode-orange	300	1.75
MAN 2	5 x 7 Dot Matrix	300	4.95	MAN 3640	Common Cathode-orange	300	1.75
MAN 3	Common Cathode	125	.39	MAN 4710	Common Anode-Red	400	1.95
MAN 4	Common Cathode	187	1.95	DL701	Common Anode-red	300	.99
MAN 7	Common Anode	300	1.25	DL704	Common Cathode	300	.99
MAN 7G	Common Anode-green	300	1.95	DL707	Common Anode	300	.99
MAN 7Y	Common Anode-yellow	300	1.95	DL 728	Common Cathode	500	1.95
MAN 52	Common Anode-green	300	1.75	DL 747	Common Anode	600	2.25
MAN 64	Common Anode-red	400	1.75	DL 750	Common Cathode	600	2.49
MAN 72	Common Anode	300	1.25	DL 338	Common Cathode	110	.50
MAN 74	Common Cathode	300	1.50	FND70	Common Cathode	250	.75
MAN 82	Common Anode-yellow	300	1.75	FND503	Common Cathode	500	1.00
MAN 84	Common Cathode-yellow	300	1.75	FND507	Common Anode	500	1.00

IC SOLDERTAIL — 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				

SOLDERTAIL STANDARD (TIN)

	1-24	25-49	50-100		1-24	25-49	50-100
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				

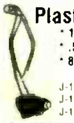
SOLDERTAIL STANDARD (GOLD)

	1-24	25-49	50-100		1-24	25-49	50-100
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

	1-24	25-49	50-100		1-24	25-49	50-100
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

Plastic Push Button Switch



- 18 AWG Solid Wire - 5" Long
- .50 (wide) X .60 (high) ⅜-27 Thread
- 8 AMP @ 14 Volt - 1 AMP @ 110 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

MINATURE TOGGLE SWITCH

JMT-221	DPDT	on/off/on	$1.95
JMT-223	DPDT	on/none/on	$1.75
JMT-121	SPDT	on/off/on	$1.50
JMT-123	SPDT	on/none/on	$1.25

CLIPLITE *SPECIAL*

NEW LED MOUNTING SYSTEM — to be used with XC556 LEDS — SPECIFY COLORS — RED — GREEN — AMBER — YELLOW **8/$1.49**

50 PCS. RESISTOR ASSORTMENTS $1.75 PER ASST.

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.) **$10.95 ea.**

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

Spec Sheets - 25¢ — Send 24¢ Stamp for 1977 Catalog
Dealer Discount Available — Request Pricing

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James ELECTRONICS

1021-A HOWARD AVE., SAN CARLOS, CA. 94070
PHONE ORDERS WELCOME — (415) 592-8097
All Advertised Prices Good Thru March

WIRE WRAP CENTER

HOBBY-WRAP TOOL-BW-630

- Battery Operated (Size C)
- Weighs ONLY 11 Ounces
- Wraps 30 AWG Wire onto Standard DIP Sockets (0.25 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 30 AWG Wire
- 50 pcs each 1", 2", 3" & 4" lengths — pre-stripped white 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

THUMBWHEEL SWITCHES

THUMBWHEEL SWITCH ONLY

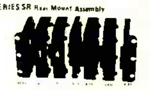
Part No.	Description	Price
SF 12	Single Pole 10 Position	$2.50
SR 12	Decimal	3.00
SF 21	10 Position BCD only	2.50
SR 21		3.00

Ordering: Order desired switch or switches and add necessary accessories for your particular application.

SF Front Mount SR Rear Mount

SERIES SF Front Mount Assembly

SERIES SR Rear Mount Assembly



ACCESSORIES

Part No	Description	Price
SF EP	End Plate (Pair)	.50
SF DP	Divider Plate (each)	.40
SF BB	Blank Body (each)	.40
SF HB	Half Body (each)	.40

ACCESSORIES

Part No	Description	Price
SR EP	End Plates (pair)	$.50
SR DP	Divider Plate (each)	.40
SR BB	Blank Body (each)	.40
SR HB	Half Body (each)	.40

Permacel Electrical Tape

- ¾" (wide) X 66 ft (long)
- All weather
- Not Import

$1.49 per roll — $12.50 per 10 roll package

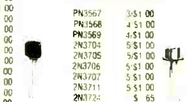
ZENERS — DIODES — RECTIFIERS

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
PN2415	5/$1.00	2N3706	5/$1.00	2N5086	4/$1.00
2N2484	4/$1.00	2N3707	5/$1.00	2N5087	4/$1.00
2N2906A	4/$1.00	2N3711	5/$1.00	2N5088	4/$1.00
2N2907A	5/$1.00	2N3724	$.65	2N5089	4/$1.00
2N2925	5/$1.00	2N3725	$1.00	2N5129	5/$1.00
2N3053	2/$1.00	2N3903	5/$1.00	2N5138	5/$1.00
2N3055	$.89	2N3904	4/$1.00	2N5139	5/$1.00
MJE3055	$1.00	2N3905	4/$1.00	2N5209	5/$1.00
MJE2955	$1.25	2N3906	4/$1.00	2N5951	5/$1.00
2N3392	5/$1.00	2N4013	3/$1.00	C106B1SCR	2/$1.00
2N3398	5/$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 11 ON FREE INFORMATION CARD

Smallest and lightest duplex radio for paramedics.

A new Emergency Medical Service (EMS) full duplex/multiplex portable radio now aids the paramedic in lifesaving operations. The new Motorola APCOR is the smallest and lightest of its type now available. Weighing only 13 pounds, it can be carried easily to the scene of almost any emergency.

THE APCOR EMS RADIO in a simulated emergency situation.

Duplex/multiplex operation makes possible simultaneous transmission of ECG (electrocardiogram) and voice information from the patient to the hospital. Other features of the APCOR radio are: two watts of audio power, extended range via vehicular repeaters, a full hour of continuous operation, 1-hour rechargeable battery, private-line squelch encode/decode capability and reliable plug-in modules.

New patents improve test instrument

Two new patents of interest to electronic service technicians have been granted to engineers of Sencore, Inc., Sioux Falls, SD.

Patent No. 3,990,002, proudly displayed by Robert Baum, Sencore Engineering Director, is on a simplified yoke and flyback tester. With it, a TV technician can check flyback transformer and deflection yokes in-circuit and out-of-circuit by simple ringing counts from full excitation to 25 percent decay. The rings are converted into voltage steps and applied to a simple analog meter, making it possible to design a tester with a GOOD-BAD scale.

SENCORE ENGINEERS Marvin Westra and Robert Baum, with their patents and the devices in which they are embodied.

Patent No. 3,990,008 is used in the Sencore DVM32 digital portable multimeter, to preserve battery life. A circuit installed in the test lead input and excited by a very small fraction of a volt turns on the digital display. Since the display draws 100 milliamperes as against only 10 for the operating circuit, battery life is roughly ten times as long as that of digital multimeters that are not turned off when no testing voltages are applied.

New device eliminates converter on 20-channel CATV systems

Magnavox has announced a new device, an isolation amplifier, that makes a 20-channel converter unnecessary when used with a Magnavox 25-inch varactor-tuned color-TV set. It is designed for Cable TV (CATV) markets that carry more than the normal 12-VHF channels and use the eight midband CATV channels B through I. The converter had been necessary to prevent possible electronic tuner interference to other cable-system users, a possibility the isolation amplifier eliminates.

If users are subscribers to a Home Box Office (HBO) system transmitting a scrambled signal, a converter will still be necessary to unscramble the signal and receive the channels, unless the HBO uses an electronic filtering system.

Isolation amplifier kits (which must be installed by a service technician) for the Magnavox STAR system and the Videomatic Touch-Tune units are available at Magnavox dealers, with a suggested retail price of $14.95. **R-E**

CIRCLE 38 ON FREE INFORMATION CARD

CIRCLE 5 ON FREE INFORMATION CARD

Shakespeare's White Knight. The best antenna going. And coming.
Shakespeare comes on strong for the new 40 channel era. With high performance CB antennas that turn on the power on all 23 or 40 channel CB transceivers.
Shakespeare's new White Knight Antenna combines the rugged, mechanical strength of gleaming white fiberglass with precision engineered electronic components. Components like the high quality loading coil permanently fused in a solid polycarbonate thermoplastic base. Totally impervious to the environment. And pre-tuned to an SWR of 1.9 to 1 or less over the 40 channel band (1.3 to 1 or less at the center). To assure maximum range and peak performance everytime you key the mike. That's what sets the White Knight antenna apart from all the others.
Ride full tilt into the 40 channel era with the new White Knight CB Antenna. And take the Shakespeare performance route home.
The White Knight Antenna, Style 4125/available in a variety of pre-assembled mounting styles. Complete with cables and connectors. Under $25.
CB ANTENNA
Shakespeare
Shakespeare
Coming on strong for the Knights of the Road.
Shakespeare Company/Antenna Group, P.O. Box 246, Columbia, S.C. 29202
In Canada: Len Finkler Ltd., Ontario.
CIRCLE 33 ON FREE INFORMATION CARD
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