

CB REPORT—KOMPUTER KORNER—NEW IC'S

75c ■ AUG. 1976

Radio-^{IND}Electronics

THE MAGAZINE FOR NEW IDEAS IN ELECTRONICS

RETAILER: SEE PAGE 96 FOR
SPECIAL DISPLAY ALLOWANCE PLAN

DIGITAL CLOCK KITS
R-E Tries Them All

CB TRANSCEIVERS
New Equipment Roundup

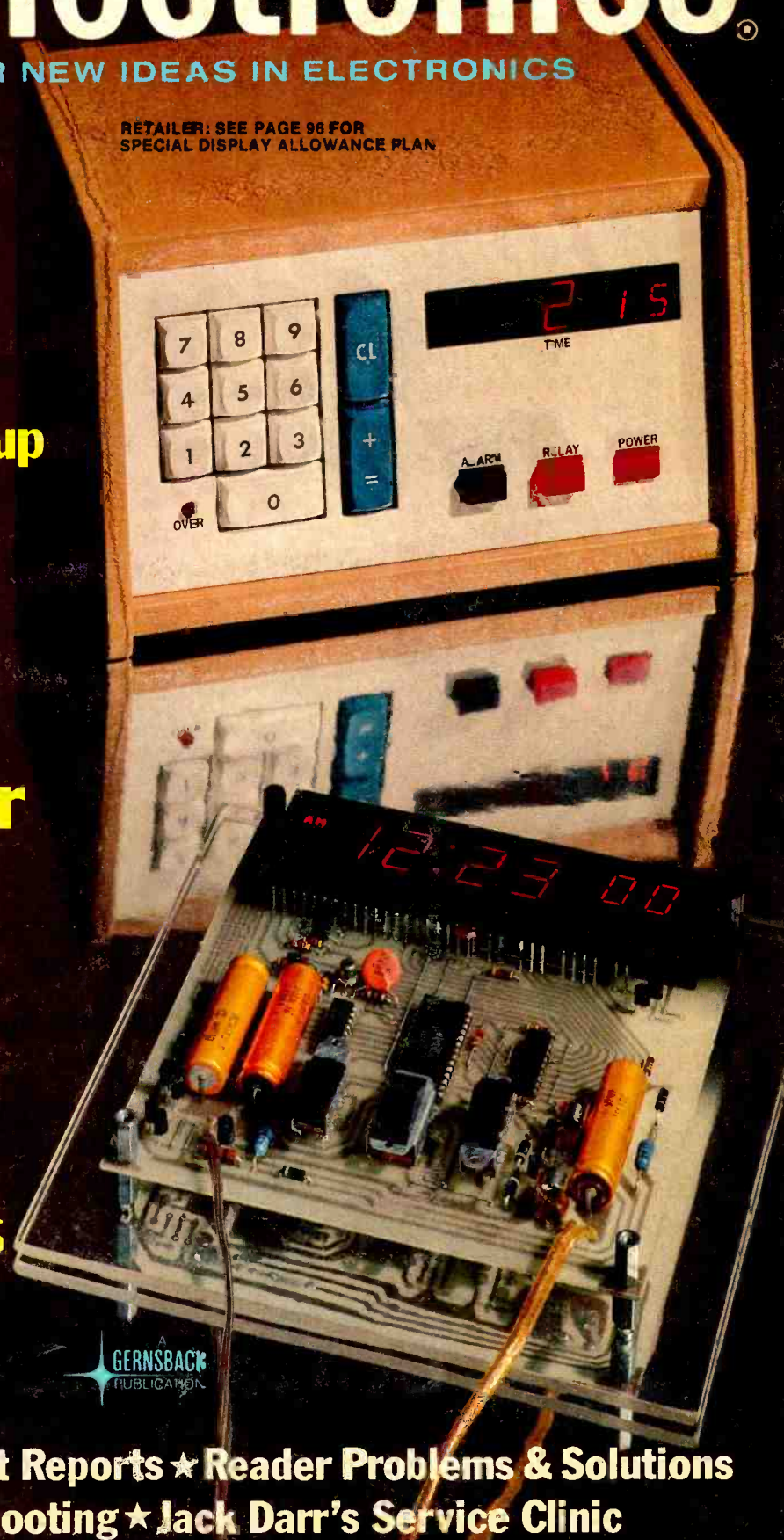
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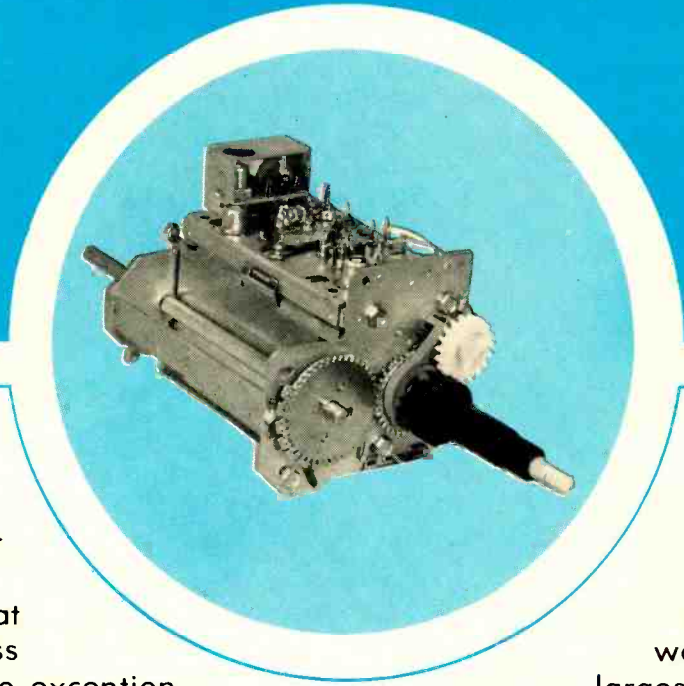
★ Looking Ahead ★ Equipment Reports ★ Reader Problems & Solutions
Step-By-Step Troubleshooting ★ Jack Darr's Service Clinic



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AUGUST 1976

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Our 1976 "rally 'round the tab" award program is under way, and a lot of dealers and technicians are already collecting awards ranging from coffeemakers to camping gear.

You can start collecting, too. All you have to do is tear off the tab—the end flap of Sylvania receiving tube boxes with the Waltham, Third Ave. or Broadway address on it.

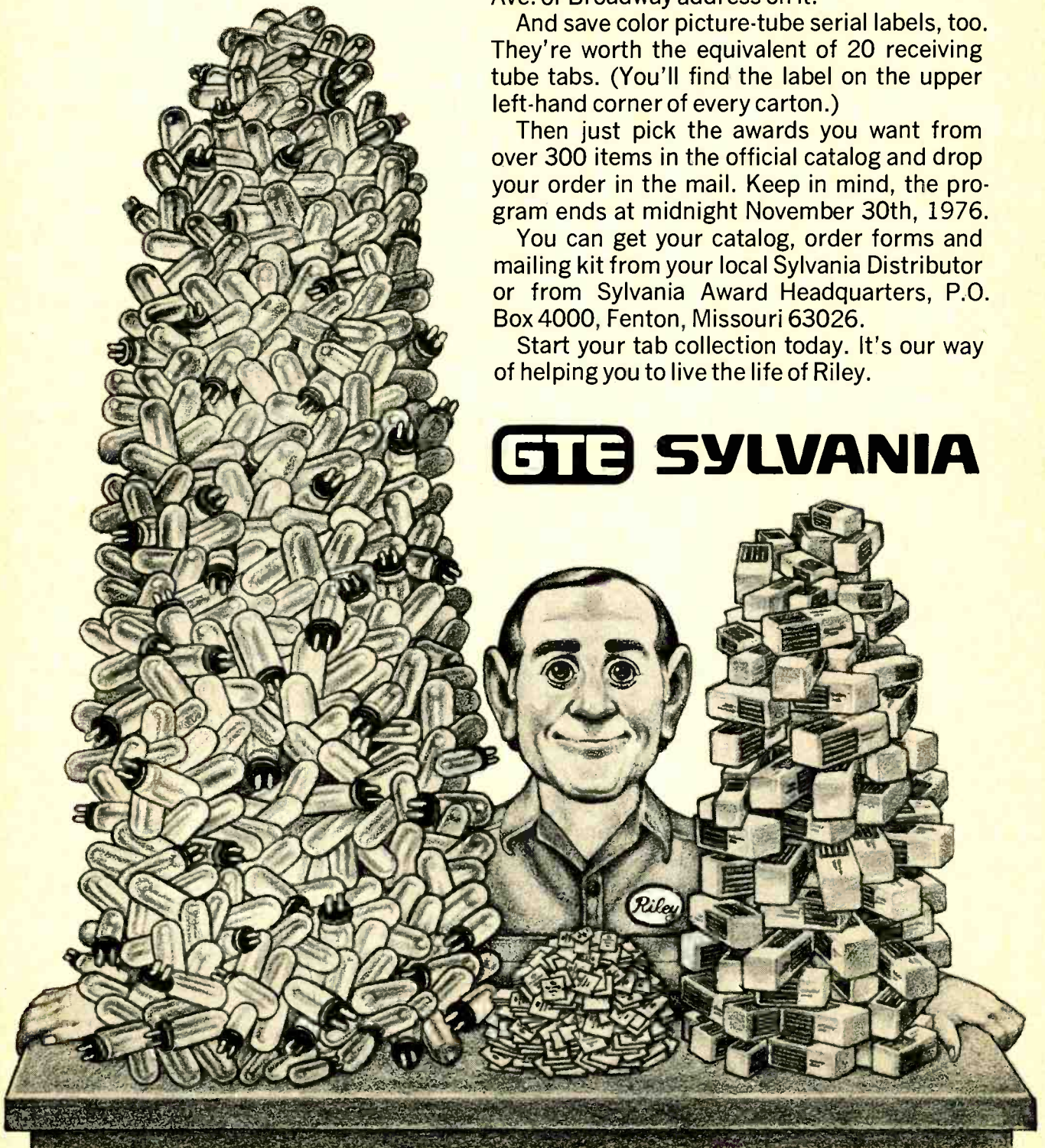
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GTE SYLVANIA



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Electronics publishers since 1908

AUGUST 1976 Vol. 47 No. 8

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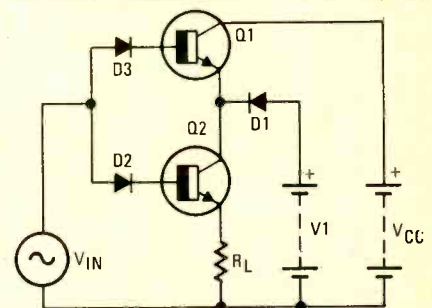
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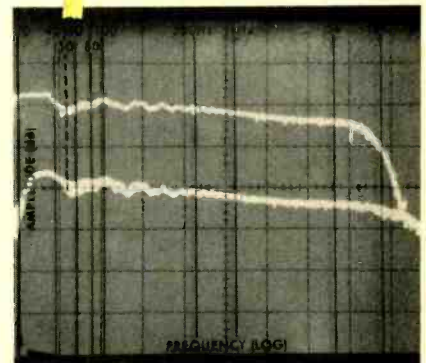
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ON THE COVER

A digital countdown timer that can be used to control external devices. The time interval is entered via a keyboard and can be programmed in one-second increments from one second to approx. 11,000 years. To get started on this project, turn to page 43.



CLASS-G HI-FI AMPLIFIER provides increased efficiency that can result in reduced size, weight and cost of future equipment. For the complete story, turn to page 47.



PERFORMANCE OF HITACHI D-3500 with low-noise ferric tape. Get all the performance specs starting on page 53.

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looking ahead

1977 TV preview

Television set changeovers for 1977 promise to be extensive. We've already reported here on G-E's set that adjusts the picture to the vertical interval reference (VIR) signal (R-E, July 1976) and Zenith's new picture tube (R-E, June 1976). Here are some other major changes:

Sony—The new Trinitron Plus tube is a negative-matrix design, increasing brightness and contrast. A new chassis is designed for greatly improved serviceability and more interchangeability of parts among models. Remote-control sets now have silent 12-channel electronic varactor tuning. A new 21-inch model has the largest screen Sony has ever offered in the United States, to be followed next year by a 25-inch. This will give Sony a full range of sizes consistent with its position as a domestic manufacturer (Sony builds sets 17-inches and larger for the U.S. market in a modern plant near San Diego, CA).

Magnavox—Digital tuning is the thing again. The "Star" models have added on-screen time display, presumably to compete with RCA's ColorTrak remote models that do the same thing. A new lower-priced digitally-tuned set provides the same calculator-keyboard tuning at the set, but unlike Star it must be set to receive 20 selected channels. Remote versions have more conventional tuning. One major innovation in the Magnavox line is optional remote control on 25-inch models with its new digital tuner; the remote unit can be installed by the dealer at the time of purchase or later.

Panasonic—A new 19-inch color chassis, designed for automated production and power consumption as low as 108 watts, was introduced. It's scheduled to be used in all such sets made or marketed by Matsushita affiliates throughout the world, to realize substantial economies through standardization. The

same chassis is expected to show up in the JVC and Quasar lines. Panasonic also introduced two models with electronic channel readout that displays the time when it's not being used for tuning.

Zenith—The new color tube is expected to make its appearance in 19-inch sets. Zenith's introductions had not yet been made by presstime, but a sophisticated new tuning system is expected in 25-inch sets.

Although there are no major changes in the RCA and Sylvania lines for 1977, both are extending their "automatic" chassis—ColorTrak for RCA and GT-Matic for Sylvania—virtually throughout their range of models so that "self-adjusting" color will be available at lower prices.

In giant-screen projection TV, a major new entry is Advent's second model—this one designed for home use but still carrying the rather hefty price tag of \$2,495 (the original VideoBeam sells for \$3,995). The new projector, like VideoBeam, uses a system of three projection tube-and-lens assemblies and a separate reflective screen. The new screen measures six feet diagonally, just a foot less than the VideoBeam's Ektalite screen, and is said to be more resistant to damage. The system will be marketed in Canada under the Electrohome name by that Canadian firm, which is producing the electronic chassis to Advent specs for both the American and Canadian versions.

Interference crackdown

The FCC is getting tougher on all devices capable of emitting RF radiation, partially as a result of mounting complaints of CB interference with TV sets. In what appears to be the start of an all-out attack on these problems, the Commission took these recent actions: 1. Proposed that all CB receivers be subject to certification of their specs to make sure they don't cause interfer-

ence. Currently, the transmitter portion of a CB transceiver must be approved by the FCC, but there are no receiver requirements. 2. Sponsored a task group of CB manufacturers to determine what can be done about CB-caused interference. 3. Proposed broad new rules requiring certification for such devices as coin-operated electronic games, RF-switched power supplies, wireless intercoms and other short-range "restricted-radiation" devices using RF for communication. It indicated that such widely used products as electronic watches, calculators and tape recorders may be added to the list. 4. Took an apparently harder line on approving home video games, rejecting two applicants, presumably because its tests showed antenna isolation switches didn't sufficiently keep game's RF from leaking into the antenna lead-in.

White House and CB

The fact that Betty Ford is "First Mama" is only coincidental—but Citizens band has become so important that the White House has been taking a close look at its long-term implications at a high level. A special task force has been established to deal with the problems of personal communications and make recommendations to the FCC and Congress. One of the proposals it's considering is to break the current Citizens band into several different bands of frequencies, each earmarked for separate uses—such as highway safety, telephone interface, personal contact, even hotel and motel reservations. The group is even considering re-allocating some frequencies currently reserved for government use to be devoted to the new person-to-person service. The task force is determined to make CB "more than just a hobby service." It's also expected to propose legislation to make licensing simpler.

Another home VTR

The second home videocassette recorder to go on the U.S. market will be introduced by Sanyo in October. Designed to compete with Sony's Betamax (R-E, June 1976), it will sell for approximately the same price—about \$1,300, including tuner and timer. Sanyo has taken aim on what it believes are the vulnerable spots in the Sony system—playing time and flexibility. Where the Sony Betamax will record and play for only one hour on a single \$15.95 cassette, Sanyo's V-Cord II can be switched from an hour to two hours on a \$19.95 cassette—the two-hour time being accomplished by skipping every other field in the television picture.

The Betamax is designed only to record the television picture for later playback. V-Cord II can do this, but also has the ability to record from an external camera (not included), to dub sound on the picture, to provide stop-motion in playback and to feed the audio output into an external high-fidelity system.

Sony has been worrying about the short playing time of the Betamax cassette. In Japan, it demonstrated a prototype cassette changer that can accommodate up to 10 videocassettes, with a changing time of 10 seconds in either record or playback mode. In addition, Sony is considering an optional slower tape-speed and thinner tape to extend recording and playing time per cassette. This is an important issue because it is felt that many consumers will want to use their home videocassette recorders to record automatically programs that are broadcast while they're away from home—and they should be able to accommodate programs of more than an hour's duration.

DAVID LACHENBRUCH
CONTRIBUTING EDITOR

Introducing... SBE Brute

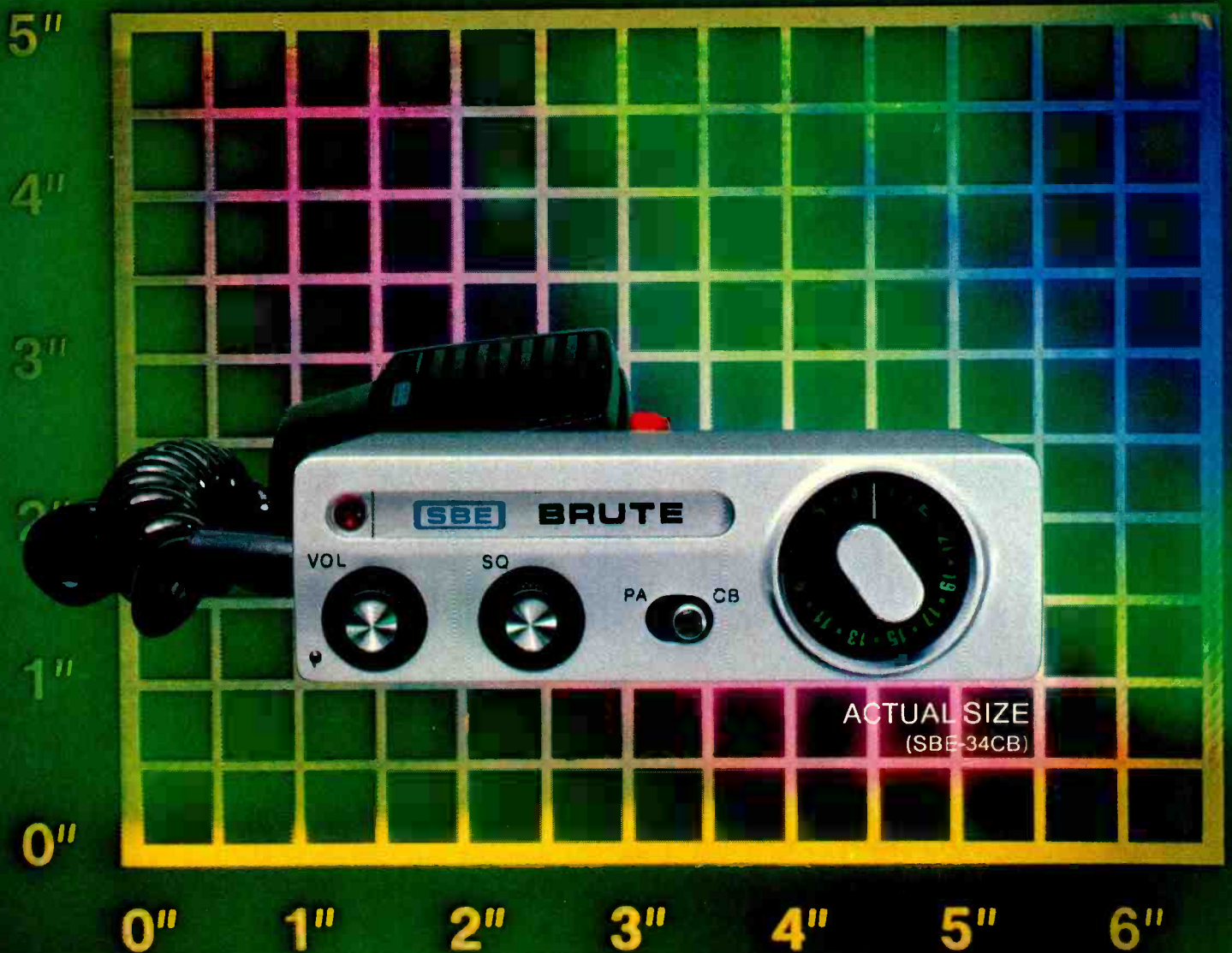
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Circle 54 on reader service card

Cable-TV system improvements may be delayed some years

The FCC ruled, just before the annual National Cable Television Association convention last April, that some improvements that were to be required of cable TV systems by 1977 will not have to be met for another ten years, and that others will not have to be met at all.

In 1972, the Commission ruled that cable systems in the 100 largest television markets would be required to furnish communications for non-broadcast use, such as marketing, meter reading and newspaper facsimile transmission. That ruling also required systems to offer 20-channel capacity, technical capacity for two-way communication and a channel each for public, educational, government and leased-access use in each community served. Deadline was March 31, 1977.

The new revised rules delete the requirements for non-broadcast channels and for the special public, educational government and leased-access channels.

The 20-channel and two-way capacity requirements remain in the rules, but apply only to systems with more than 3,500 subscribers and won't have to be met for another ten years. Qualifications, using such terms as "if technically possible," were also added to several rules.

New Schottky rectifiers work up to 150 volts

A new method of fabricating Schottky diodes—an old but not too-much-used type of solid-state rectifier—has resulted in producing power rectifiers that work at more than four-times the voltage of Schottky rectifiers now on the market. The fabrication process is adaptable to mass production.

The Schottky diode has a metal-to-semiconductor contact, somewhat reminiscent of the old point-contact diodes used in radio reception. Because of their lower forward voltage-drop, as compared to that of P-N junction devices, they have from 60% to 80% lower losses than straight semiconductor diodes. But it has been extremely difficult to manufacture quantities of diodes of nearly identical performance.

The G-E developmental diode is made by sputtering platinum onto a silicon base. Platinum silicide is thus formed, in a reliable, reproducible way, with a barrier height of 0.8 electron volts. The barrier height is somewhat lower than that of platinum silicide formed by heating in a furnace after the components are placed in position.

The problem of premature low-voltage breakdown has been solved by using a

mesa structure for the new diodes. This permits the devices to be operated at ratings up to 150 volts.



PROTOTYPE SCHOTTKY DIODES made by a new technique. These are 50-volt, 50-ampere units. In the foreground is a disc of the hexagonal silicon substrates used in the rectifiers. At left is a diode without its protective cap, showing how the metal to semiconductor contact is made.

The diodes were developed by Dr. Linus F. Cordes, Ernest A. Taft, and Dr. Marvin Garfinkel of the General Electric Research and Development Center, Schenectady, NY, with guidance as to appropriate goals and specifications formulated by the NASA Lewis Research Center.

Nine video-game makers get FCC violation notices

During the months of February and March, at least nine notices to manufacturers of TV game devices have warned them to cease all home video-game activity, states a report in *Electronic News*. The manufacturers were cited for offering the games for sale without first having them tested and approved by the FCC.

Most of the companies were toy manufacturers, but three were reportedly planning to sell home video kits. The orders in February were against Entex, Mobil Oil (which was offering the Entex game in its gift catalog) and Intech Industries. Names of the companies cited in March were not immediately available.

Several companies are now selling FCC type-approved TV games. These include Magnavox, Atari, First Dimension, Executive Games, Broadmoor Industries

and Universal Research. The Magnavox game, *Odyssey*, was described fully and others discussed briefly in **Radio-Electronics**, November, 1975.

Satellites peer into future weather conditions

The climate of North America does not appear to be moving toward harsher winters as some predictions have indicated, according to the National Oceanic and Atmospheric Administration (NOAA). These are the initial findings of a climate study being undertaken with the help of weather satellites, designed and built by the RCA Astro-Electronics Div. in Princeton, NJ. Snow and ice charts based on this satellite-aided study constitute the most complete record of hemisphere snow cover ever made.

The study shows no significant change in North American snow cover during the nine years of the investigation. "Because snow cover is an important, sensitive variable that influences climatic change, the lack of systematic snow increases contradicts evidence that predicts harsher winters could be expected in the Northern Hemisphere," states the NOAA report.

New automatic system detects bombs, explosives in baggage

A new approach to detecting concealed weapons, bombs or explosives in checked airplane baggage is being worked out by Westinghouse Research Laboratories under contract with the Federal Aviation Agency. A similar system for the somewhat easier task of locating weapons in hand-carried baggage has already been demonstrated in prototype form to the FAA.

The model demonstrated is a dual-belt system. A gamma-ray source (barium 133) is mounted in a specially constructed container placed between the two belts. It aims two narrow fan-shaped beams across them. Detectors on the other side of the belts measure the amount of radiation passing through the luggage.

Electronic circuitry scans the detector array each time the conveyor moves ahead one centimeter (about 0.4 inch), producing a vertically scanned density profile that shows how much the radiation is impeded by various objects in the luggage.

When radiation drops below a given point over a minimum area of the scan, an alarm sounds automatically. (The conventional technique displays a visible X-ray image on a screen, which must be

continued on page 12

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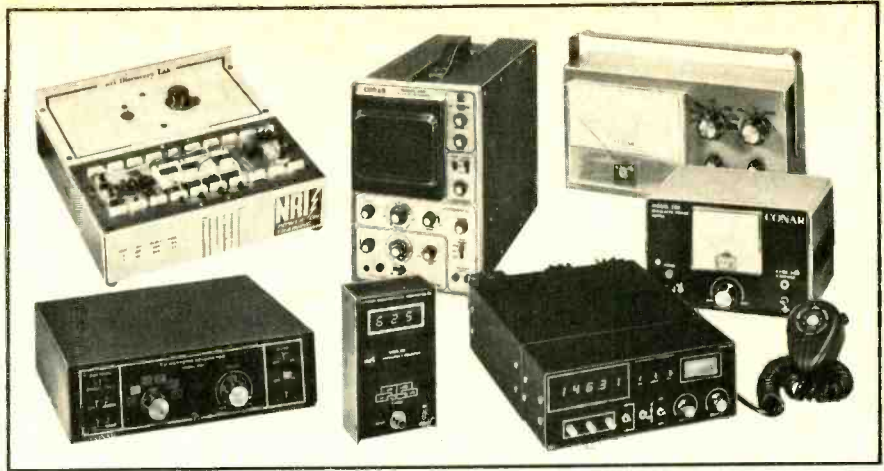
Circle 100 on reader service card

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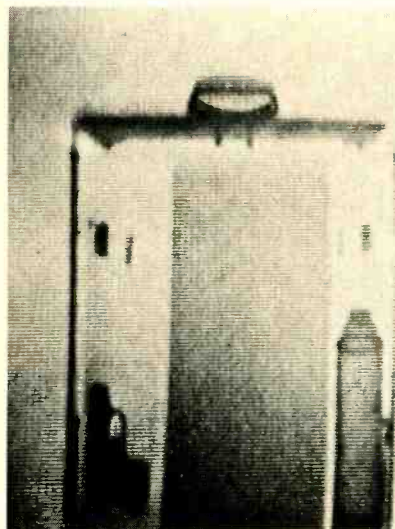


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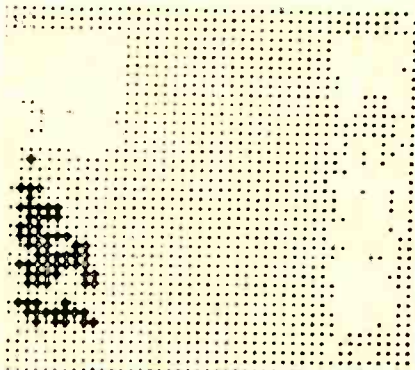
*Summary of survey results upon request.

viewed and evaluated by an operator in attendance.) The system is controlled by a minicomputer, removing the hazards of operator distraction or fatigue.

Because of the narrow beam and short exposures, radiation is held to less than 10% of that required by conventional single-pulse X-ray systems. Camera film is not measurably affected and there is no long-term exposure hazard to operating personnel.



SCANNING DETECTOR VS. X-RAY. Conventional X-ray (above) shows—right to left—a spray can, a book and a gun. A reconstructed image of the gamma-ray transmission through the same piece of luggage (below) indicates high attenuation—more than enough to trigger an alarm—in the area occupied by the weapon. The system is controlled by a minicomputer programmed for a predetermined—and adjustable—attenuation and minimum area. Alarm is automatic and there is no need for an operator to watch the screen constantly.



The dual-belt hand luggage system already demonstrated will handle 12 items per minute. The checked baggage system

under development will have to be faster and more sophisticated, Westinghouse Lab personnel state. Weapons have a higher concentrated density and are therefore easier to spot than the bombs or explosives normally searched for in checked baggage, and the equipment will have to check a minimum of one piece per second.

World's no. 1 radio announcer, Eddie Startz, dies at 77

World-famous radio announcer and commentator, Edward Startz of the international shortwave "Happy Station" program from the "Peace, Cheer and Joy" station PCJ in Hilversum, Netherlands, died March 17, 1976. His age was 77.



After an education in classical languages, the young Startz spent five years wandering the face of the earth earning his bread at all kinds of jobs from dishwasher to interpreter, and incidentally improving his modern languages. Returning to Holland in 1928, his excellent voice and fluency in seven languages made him the first announcer and commentator on the new Philips experimental shortwave broadcast station PCJ. His microphone manner and rapport with listeners in all countries kept him behind the same microphone (with a break only during an underground period while Holland was occupied by the Germans) for more than 40 years. His last broadcast was on December 31, 1969. **R-E**

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When you install a B-T Booster outside, you get a lot of new boosters inside.

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B-T Boosters can produce a dramatic improvement in picture quality, particularly on color and especially in difficult reception areas. After 25 years of making outdoor boosters, B-T is number one in sales, and enjoys the finest reputation for making

products of highest performance and reliability. B-T Boosters do cost a bit more than competition, but they perform and last longer. And that's what makes satisfied customers.

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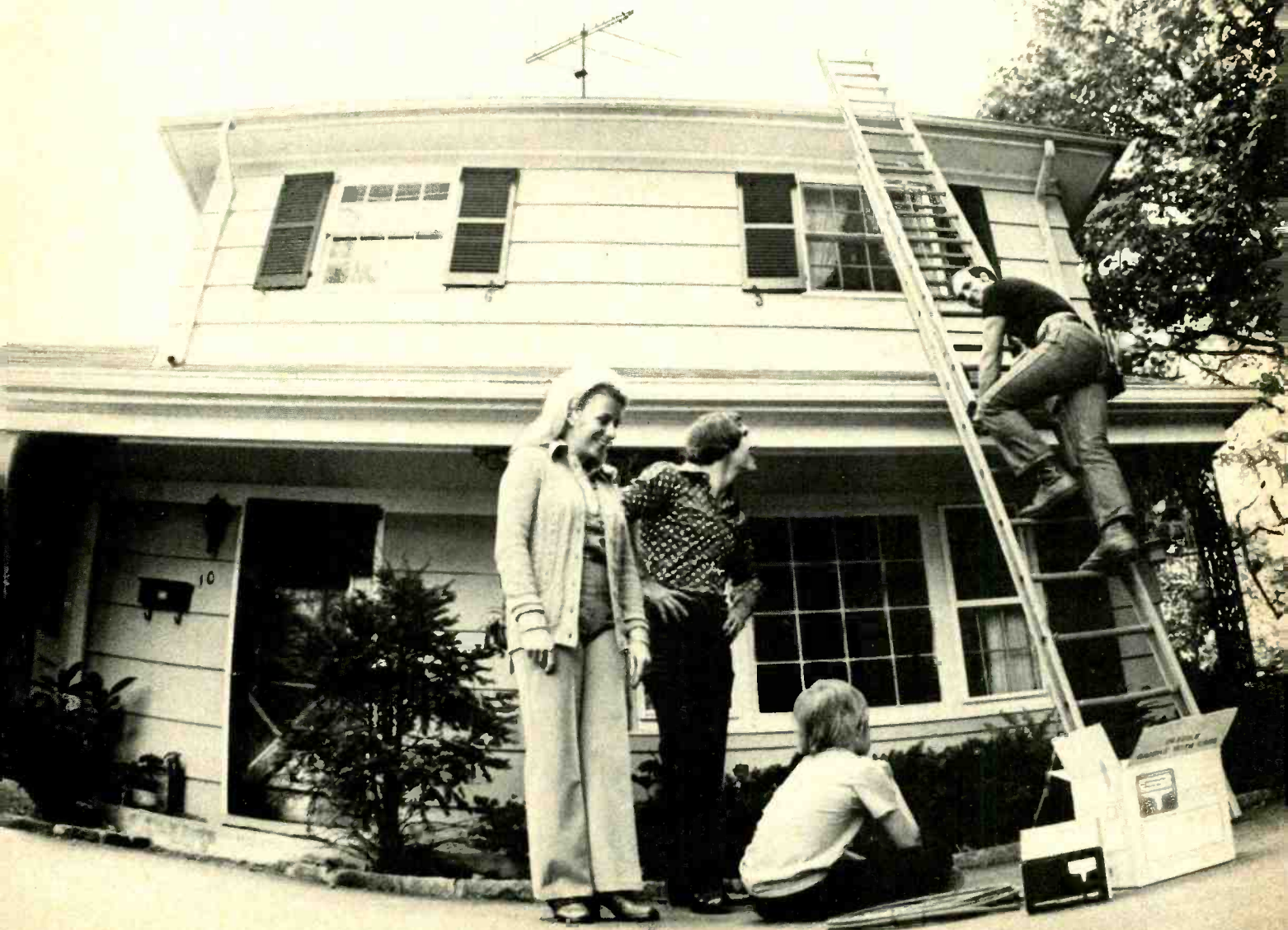
has separate U/V inputs and a coax output. Finally, it's specially designed for lightning prone areas.

The B-T line consists of 5 all-channel models (including the popular VOYAGER); 5 VHF models and 4 UHF boosters (the ABLE-U2b is a favorite).

See your B-T distributor for details. And see why you can count on boosters inside, when you install B-T Boosters outside. Blonder-Tongue Laboratories, Inc., One Jake Brown Road, Old Bridge, N.J. 08857.



BLONDER-TONGUE



Circle 2 on reader service card

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Imagine a microcomputer supported by extensive software including Extended BASIC, Disk BASIC, DOS and a complete library of business, developmental, and industrial programs.

Imagine a microcomputer that will do everything a mini will do, only at a fraction of the cost.

You are imagining the Altair[™] 8800b. The Altair 8800b is here today, and it may very well be the mainframe of the 70's.

The Altair 8800b is a second generation design of the most popular microcomputer in the field, the Altair 8800. Built around the 8800A microprocessor, the Altair 8800b is an open ended machine that is compatible with all Altair 8800 hardware and software. It can be configured to match most any system need.

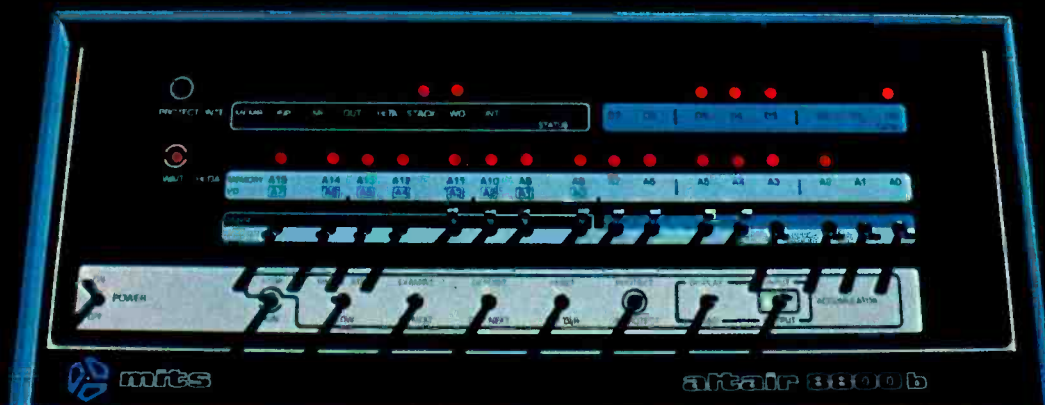
MITS' plug-in compatible boards for the Altair 8800b now include: 4K static memory, 4K dynamic memory, 16K static memory, multi-port serial interface, multi-port parallel interface, audio cassette record interface, vectored interrupt, real time clock, PROM board, multiplexer, A/D convertor, extender card, disc controller, and line printer interface.

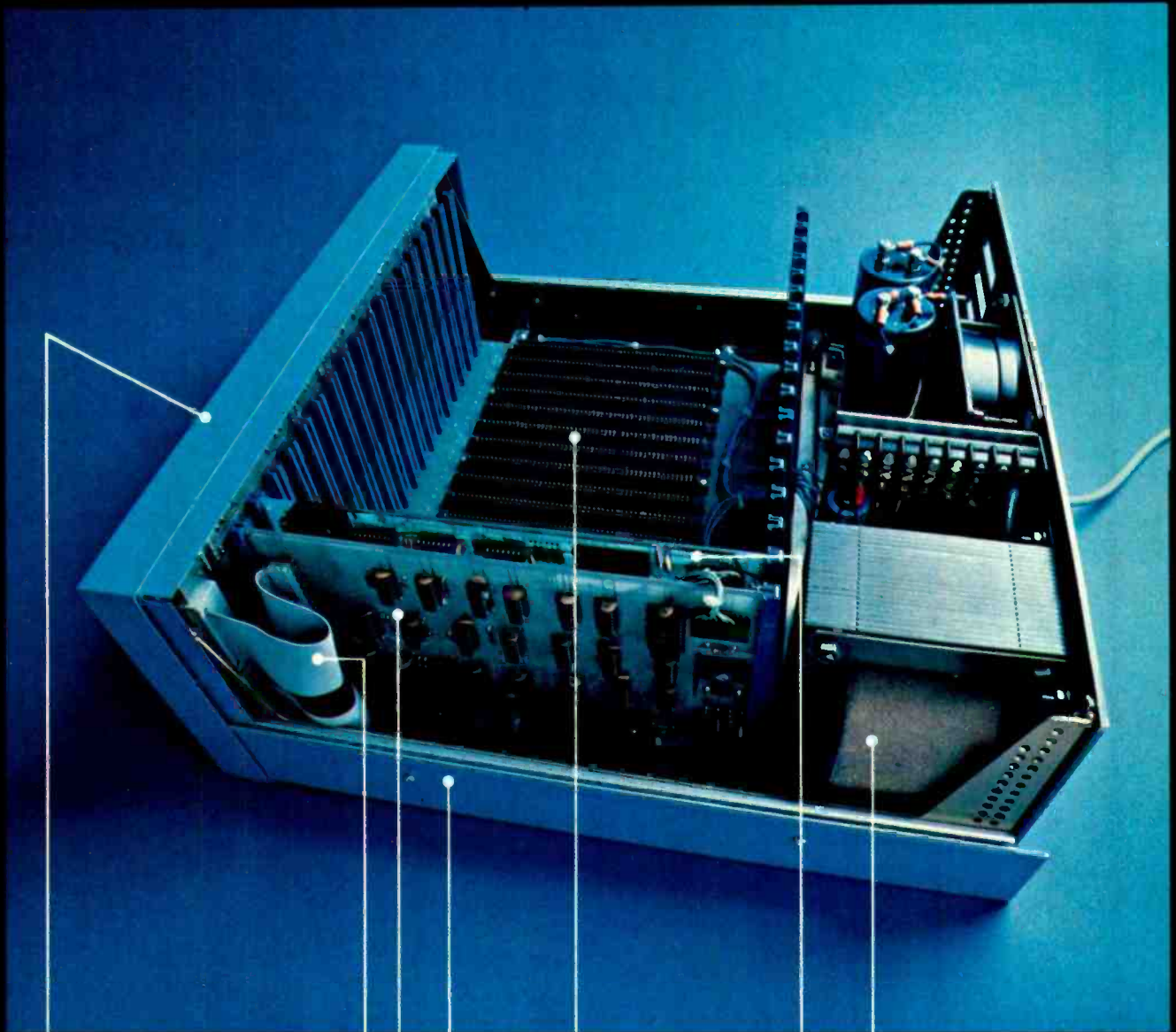
MITS' peripherals for the Altair 8800b include the Altair Floppy Disc, Altair Line Printer, teletypewriters, and the soon-to-be-announced Altair CRT terminal.

Introductory prices for the Altair 8800b are \$840 for a kit with complete assembly instructions, and \$1100 for an assembled unit. Complete documentation, membership into the Altair Users Club, subscription to "Computer Notes," access to the Altair Software Library, and a copy of Charles J. Sippl's Microcomputer Dictionary are included. BankAmericard or Master Charge accepted for mail order sales. Include \$8 for postage and handling.

Shouldn't you know more about the Altair 8800b? Send for our free Altair Information Package, or contact one of our many retail Altair Computer Centers.

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Circle 60 on reader service card

letters

REACT REACTION

In reference to the article "REACT—What's It All About," by Fred Shunaman in the January issue, I must disagree with several key points.

Mr. Shunaman states, in effect, that "the CB'er is *highly mobile*" while the "amateur must *set up his portable equipment.*" With the advent of VHF-FM and UHF-FM hand-held radios and repeater systems, a typical local amateur net can cover an area not possible by even a higher powered CB base station.

In addition, the amateur has the flexibility of choosing frequency bands to accommodate transmitting-range needs.

As a CB'er and member of a REACT group, and as a ham associated with RACES and AREC I have compared the two services and find both quite valuable. REACT provides fine local service communications, while RACES and AREC assist in both local *and* distant emergencies.

Let us not forget the licensed radio amateur, whose number is small in proportion to licensed CB's, but does a job comparable to the CB'er and performs distant work that no CB'er can.

DEREK W. YELLY
WB4DAM/KFW-1030
Alexandria, VA.

DIGITAL STOPWATCH

In this column in the April issue, a reader indicated that the newer Novus Mathbox model 650 calculators cannot be used in the digital stopwatch (November 1975 and February 1976 issues). This is not true. I have used both and have achieved equally good results. However, pin connections are different in the two versions. The connections at the edge of the display board are (left-to-right with the display facing you) as follows: 1—B—(ground), 2—B+, 3—D4, 4—D2, 5—D1, 6—D3, 7—K3, 8—D5, 9—D6, 10—K1 and 11—K2.

These are the only pins used. With this information, readers should be able to use either Mathbox they happen to have.

Thanks for the article. It stimulated my interests. Keep up the good work and let's have more articles using digital techniques.

BRUCE COLEMAN
Belton, MO.

TVT-II AND ASCII-TO-BAUDOT CORRECTIONS

I have enjoyed building and studying the TV Typewriter II. I have made all the boards and have learned a lot about digital techniques by going through the theory of the system. At some points, however, the theory wouldn't fit the circuitry.

These turned out to be misprints in the articles and some drawing errors.

In case some of your readers are having the same difficulty, I have listed the errors that I have found. The following errors are on the schematic for the main board. (The foil pattern of the PC board is correct.)

Output of IC13-a pin 8 should also be connected to the input of IC12-a pin 3. There should be no connection between IC12-a pin 3 and IC20-c pin 13.

There should be no connection between Bit-4 and Bit-6 at input pin 9 of IC32-c. (Only Bit-6 is used.)

In the March issue of **Radio-Electronics**, there also seems to be errors in the schematic for the ASCII to BARDOT converter. (Fig. 1.)

There should be no connection between IC6 pin 12 and IC6 pin 2. IC6 pin 12 should be connected to IC12 pin 3.

On Fig. 3 (connections to TVT-II), I think pin 8 and pin 9 have been swapped. A should be connected to pin 8, and B to pin 9.

In the modification procedure on page 58, it is stated that the foil on the main PC board should be cut at IC36 pin 3, but this will make only partial storage of Bit-7 possible. I think the foil should be cut at the output of IC11-b pin 8. Am I right? The new wiring for the memory board seems strange, is the procedure correct?

I hope this information will help other readers. I also have some questions I hope you can answer.

Are the PROM's in the ASCII to BAUDOT kit programmed for this application?

Is it possible to use other PROM's with the same capacity?

Why must the foil be cut between J8-14 and IC36 pin 5?

Is it necessary to use a Computer Cursor board with the converter application? Otherwise, I can't see any reason for connecting J7-10 to J4-4 since the latter is not used on Manual Cursor board.

What type of board is supposed to be mounted on J1?

I will appreciate any assistance you can offer in answering these questions.

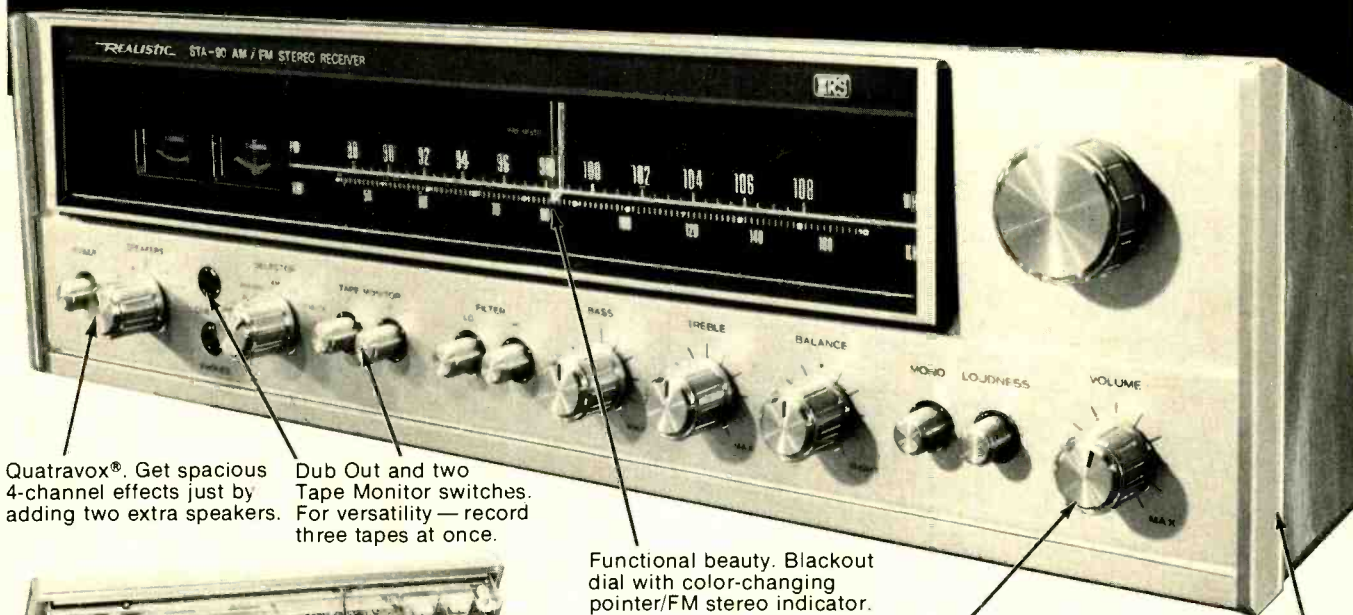
BJORNER DRAGNES
Honefoss, Norway

Regarding the errors you found in the ASCII to BAUDOT converter, I will answer them in the same order that you listed them in your letter:

continued on page 22

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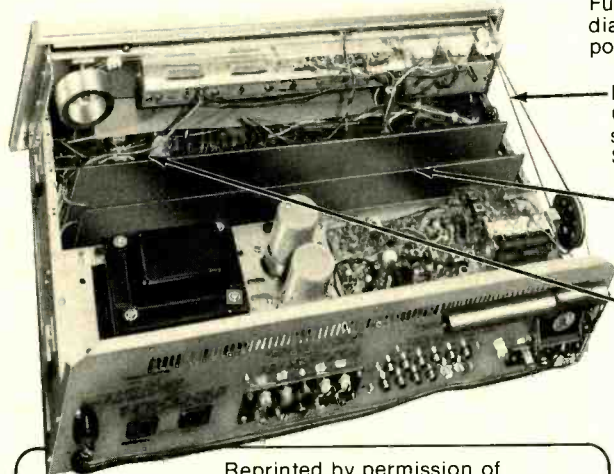
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 Total Harm. Dist.: 0.8%
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Circle 64 on reader service card

AUGUST 1976

17

Should your career in electronics go beyond TV repair?

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There is no doubt television repair can be an interesting and profitable career field. TV repair, however, is only one of the many career areas in the fast growing field of electronics.

As an indication of how career areas compare, the consumer area of electronics (of which TV is a part) makes up less than one-fourth of all electronic equipment manufactured today. Nearly twice as much equipment is manufactured for the communications and industrial fields. Still another area larger than consumer electronics is the government area. That is the uses of electronics in such areas as research and development, the space program, and others.

Just as television is only one part of the consumer field, these other fields of electronics are made up of many career areas. For example, there are computer electronics, microwave and satellite communications, cable television, even the broadcast systems that bring programs to home television sets.

As you may realize, career opportunities in these other areas of electronics are mostly for advanced technical personnel. To qualify for these higher level positions, you need college-level training in electronics. Of course, while it takes extra preparation to qualify for these career areas, the rewards are greater both in the interesting nature of the work and in higher pay. Furthermore, there is a growing demand for personnel in these areas.

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AUGUST 1976

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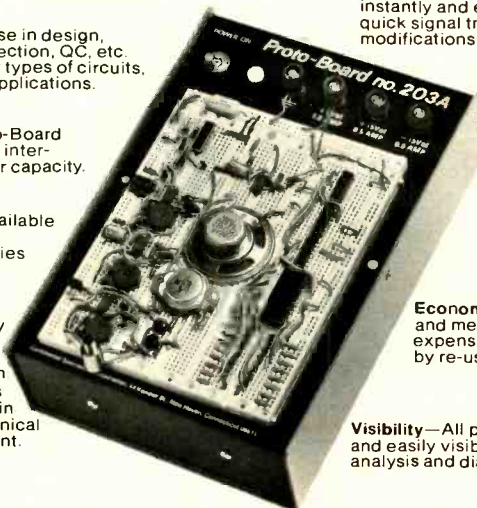
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Circle 40 on reader service card

LETTERS

continued from page 16

Yes, there is an error in the connection of pin 12 of IC6. Pin 12 of IC6 should connect to IC12 pin 4 and IC10 pin 1.

Yes—pins 8 and 9 in Fig. 3 were reversed.

Yes, you are correct. IC9-a must not be cleared or you will clock out the character in IC36 thru IC39 at the next strobe. Cut foil at IC11 pin 8 and insert a STORE switch there.

Yes. Bit-7 is at J4 pin 4 which you wire to J7 pin 10, then to pin 11 of the new 2102 IC. J8 pin 14 is the path used to connect output of the 2102, but connection to IC36 pin 5 must be cut.

Here are the answers to the other questions you asked:

No, the PROM's are not programmed. Too many BAUDOT codes exist to match everyone's machines.

Yes, other PROM's could be used (such as 74188A).

See above.

See above.

See April, 1976, issue of *Radio-Electronics* for BAUDOT to ASCII circuit.

I hope these answers help.
ROGER L. SMITH

SK-10 EQUAL FOR DYNA-MICRO

The May issue of *Radio-Electronics* featured an 8080 microcomputer construction article. One of the components specified in the parts list was an E & L Instruments SK-10 breadboarding socket.

I feel that it should be brought to the attention of your readers that this is not a proprietary item available only from E & L Instruments. Other companies, including Continental Specialties Corporation, produce a direct replacement for the breadboarding socket.

Continental Specialties Corporation's equivalent of the SK-10 is one QT-59S connected to two QT-59B's.

RONALD J. PORTUGAL

Continental Specialties Corp.

P.O. Box 1942

New Haven, CT 06509

I'm dropping you this note to point out that the A P Products *Super-Strips* are exact replacements for the solderless breadboard used in the Dyna-Micro construction article.

Super-Strips are available at many dealers and distributors, or may be ordered direct from A P Products, Inc., Box 110-P, 72 Corwin Drive, Painsville, OH 44077. Model SS-2 (order #923252 at \$17.00) features nickel/silver terminals. Model SS-1 (order #923748 at \$18.90) features gold-plated terminals.

MARTIN WEINSTEIN

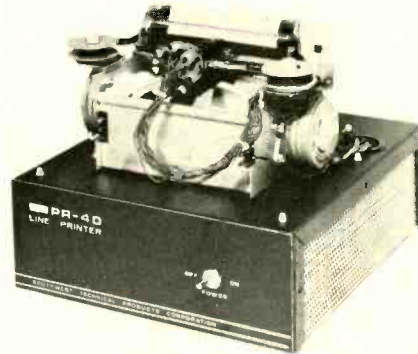
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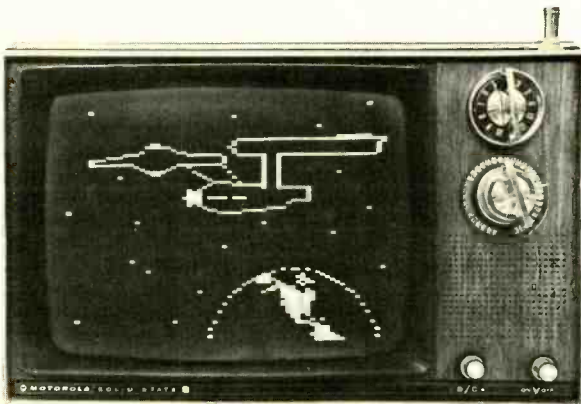
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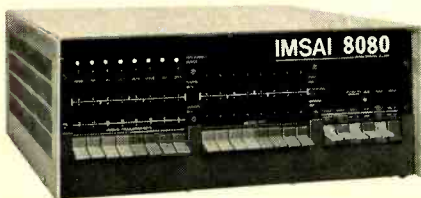
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Dept. RE-8

KOMPUTER KORNER

DAVID LARSEN, PETER RONY,
and JOHN TITUS*

THIS MONTH, WE SHALL DISCUSS THE INTERFACING OF AN 8080-BASED MICROCOMPUTER TO A VERY VERSATILE LABORATORY INSTRUMENT, THE KEITHLEY MODEL 160B DIGITAL MULTIMETER AND MODEL 1602B DIGITAL OUTPUT. WE PURCHASED THIS MULTIMETER ONE YEAR AGO AND FOUND IT TO BE AN EXCELLENT EXAMPLE OF WHAT MANUFACTURERS CAN DO TO FACILITATE THE INTERFACING OF THEIR INSTRUMENTS.

The Keithley model 160B is a general-purpose 3½-digit multimeter than can function as a DC voltmeter, DC ammeter, or ohmmeter. A total of twenty-six different ranges exist for the multimeter in its three modes of operation. The lowest range scales provide maximum readings of 1.999 mV, 19.99 nA, and 1.999 Ω. The 1.999 mV scale has an accuracy of ± 0.1% of reading ± 1 digit. Thus, a display reading of 1.000 mV will have an uncertainty of ± 0.002 mV, or 2 μV. The highest possible readings associated with the three different ranges are 1200 V, 1999 mA and 1999 megohms, with the megohm reading being accurate to only ± 30%.

(ADC) that can handle most laboratory requirements for digital data acquisition provided that the rate is no greater than one measurement per second. Switching between the twenty-six different ranges is performed manually. We would expect that, in the future, such switching will be performed by a built-in microprocessor operating under the control of an external computer.

The interface circuit between the Keithley model 160B and a small 8080-based microcomputer is shown in Fig. 1. The two OR gates and the SN74154 decoder generate three different device-select pulses that are required to input data from the Keithley meter to the 8080 microcomputer. Note the \bar{IN} signal at pin 18 of the SN74154 decoder. This interface circuit takes advantage of the fact that the outputs from the model 1602B digital-output board are open collector and can be bussed together as is shown in Figure 1. Notice how pins 16, 12, and 10 on the model 160B are connected to the same 8080 microcomputer input, D7. These three pins are said to be bussed together. Pins 35, 31, and 28 are bussed together to input D6; pins 17, 13, and 9 are bussed together to input D5; and so on. The eight inputs to the 8080, D0 through D7, comprise an eight-bit data bus over which information passes, one group at a time, from the Keithley multimeter to the 8080 microcomputer.

Only one transfer of information can take place at any one time. In Fig. 1, this transfer is accomplished with the aid of the three sets of strobe inputs. When a logic 0 is applied at strobes 1 and 2, the BCD codes corresponding to the 10⁰ and 10¹ digits are transferred to the accumulator of the 8080. Similarly, strobes 3 and 4 and also strobes 5 and 6 permit the acquisition by the microcomputer of the remaining output data from the Keithley multimeter. Therefore, three device-select pulses permit the strobing of 20-bits of data from the multimeter to the microcomputer over a set of eight data bus-lines D0 through D7.

A simple program that accomplishes the data transfer from the multimeter to the microcomputer is provided in Table 1. The entire data acquisition and movement of data to registers C, D, and E occurs in 21μs, a time that is fast when compared to the rate of five conversions-per-second by the multimeter. Clearly, considerable time is still available to the microcomputer to manipulate the acquired data before new data is input into the accumulator.

Not shown in Fig. 1 are eight 4700-ohm resistors that are the required pull-up re

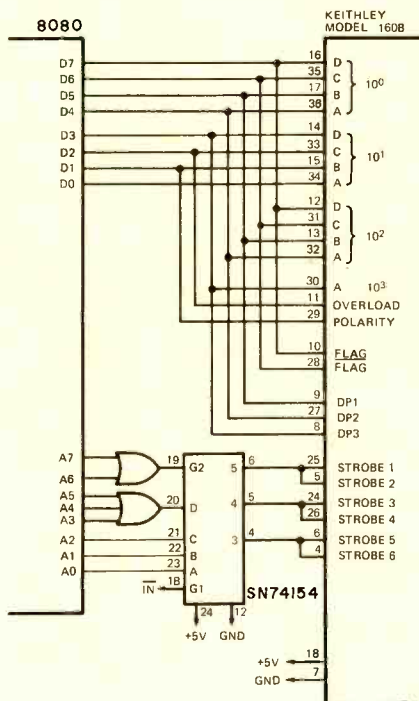
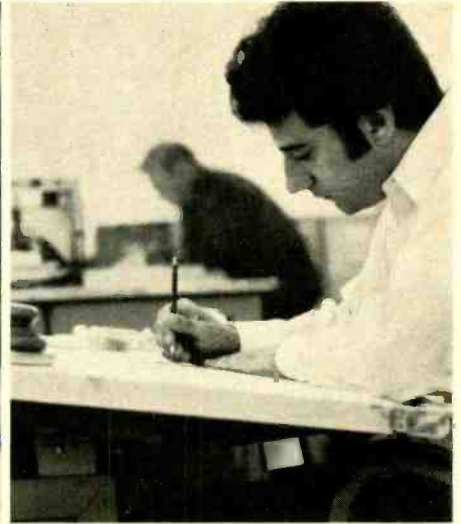


FIG. 1

The model 160B multimeter is basically a sophisticated analog-to-digital converter

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

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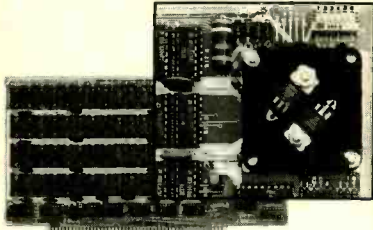
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continued from page 24

sistors for the eight open-collector bus lines. One pull-up resistor is required for each of the eight data bus inputs. One end of the resistor is tied to +5 volts, and the other end to the bus line. These resistors are not shown in the diagram because

small when compared to the added value of the instrument. We expect future instruments to be microcomputer oriented in the sense that data-bus outputs will be provided to permit the direct interfacing of the instruments to microcomputers via simple wire interconnections. We hope that these columns encourage manufacturers to provide minicomputer- and mi-

TABLE 1—DATA ACQUISITION PROGRAM

LO memory address	Instruction byte	Mnemonic	Clock cycles	Description
000	333	IN 5	10	Generate device select pulse that strobes the 10 ⁰ and 10 ¹ digits into the accumulator
001	005	—	—	Device code for strobe inputs 1 and 2
002	117	MOV C,A	4	Move accumulator contents to register C
003	333	IN 4	10	Generates device select pulse that strobes the 10 ² digit, the 10 ³ bit, and the overload and polarity outputs into the accumulator
004	004	—	—	Device code for strobe inputs 3 and 4
005	127	MOV D,A	4	Move accumulator contents to register D
006	333	IN 3	10	Generate device select pulse that strobes the Flag, DP1, DP2, and DP3 outputs into the accumulator
007	003	—	—	Device code for strobe inputs 5 and 6
010	137	MOV E,A	4	Move accumulator contents to register E

At this point, twenty data-bits are stored in registers C, D, and E. The microcomputer can now take this information and manipulate it in different ways. With the aid of the BCD digits and DP1, DP2, and DP3 (DP = Decimal Point), it can determine the magnitude of the input decimal number. With the aid of the polarity input, the sign of the decimal number can be determined.

they can be added to the circuit board within the Keithley multimeter. The 8080 data bus normally employs an alternative bussing technique called three-state bussing. The interface circuit shown in Fig. 1 is actually the combination of two bussing-techniques, open collector and three-state. The 4700-ohm resistors do add a load to the data bus, but this does not prevent other devices from being tied to the bus provided that each bus connection in the other devices can sink, in the logic-0 state, the additional 1 mA current produced by the 4700-ohm pull-up resistor.

At the beginning of this column, we stated that the Keithley multimeter is an example of what manufacturers can do to facilitate the interfacing of their instruments. In this case, what Keithley did was to provide open-collector outputs for all twenty output pins on the model 1602B digital-output board. The added cost was

microcomputer-oriented digital outputs, and also to document such outputs as well as Keithley has done with the model 160B.

R-E



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KARL SAVON
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RCA CA3130 operational amplifier

The schematic diagram of this new op-amp is much simpler than what you probably had expected to see. In itself, sche-

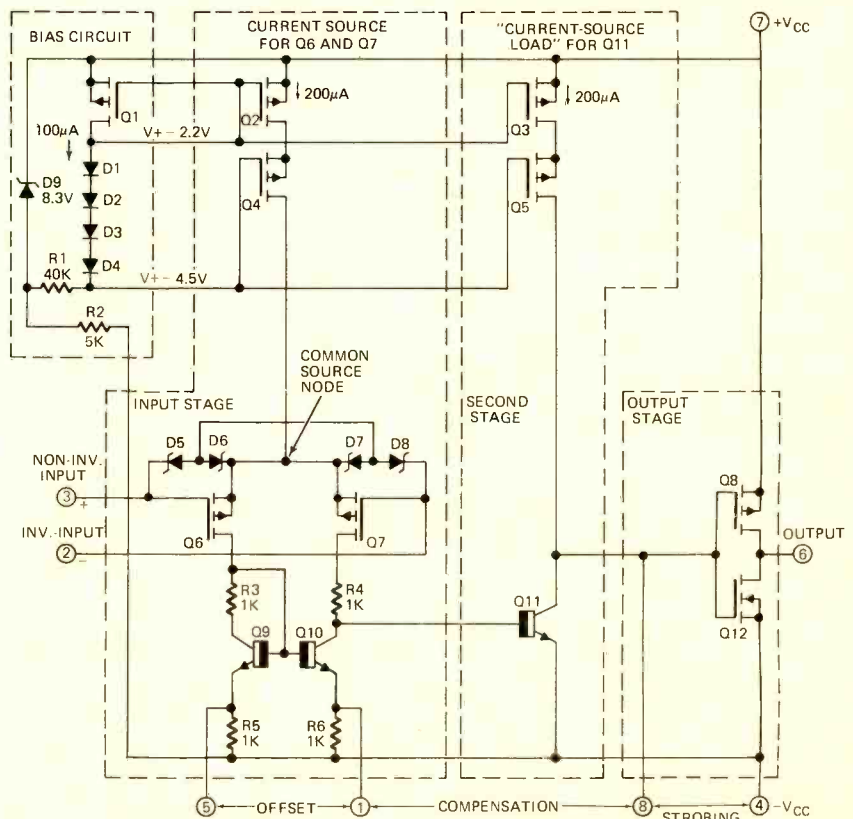
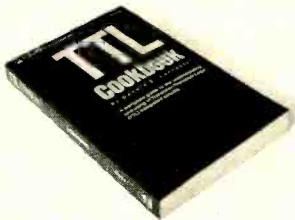


FIG. 1—RCA CA3130 operational amplifier.

continued on page 30

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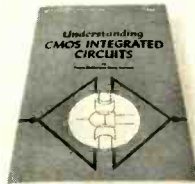
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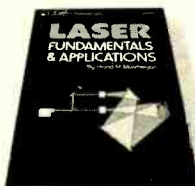
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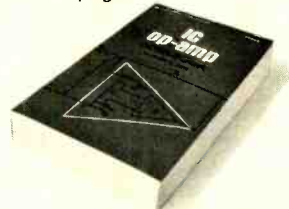
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STATE OF SOLID STATE

(continued from page 28)

matic simplicity is not a technical feat. But when added to a list of exceptional circuit traits, it is the icing on the cake. Circuit simplicity is an indicator of how well the pieces go together. PMOS devices become active loads for bipolar transistors. And a COS/MOS inverter is simple; there are no complicated biasing schemes and no load resistors.

Looking at the schematic for a short while (See Fig. 1), you'll notice there is something glaringly missing! Nowhere on the diagram can you spot a PNP transistor. It is no accident. Talk to an integrated circuit engineer and undoubtedly he'll say, "I wish we had a better PNP." The PNP devices they use simply don't work that well. They are compromise devices lost in a process designed primarily to make good NPN's. Their gain-bandwidth products are poor, they have a generally low beta and high saturation-resistance. Addition of COS/MOS circuitry allows the elimination of PNP's normally used in amplifier and current "mirror" level-shifting stages. There are three easily separable gain stages in the CA3130; a PMOS input differential amplifier, a high-gain common emitter NPN amplifier, and a COS/MOS output inverter. The picture is completed by a diode and PMOS current source and that's it.

Let's look at the circuit in detail. The gates of the differential amplifier PMOS FET's (Q6 and Q7) are connected di-

rectly to the input terminals. The two transistors are analogous to the PNP differential amplifier that often appears in this spot. PNP's or PMOS input amplifiers can be biased close to or at ground potential, a big application plus. The CA3130 inputs can swing 0.5 volt below V_{ee} . Gates of MOS devices that contact the outside world must be protected from static charges that can build up excessive voltages. Voltages above 100 volts endanger the oxide layer below the gates. Because of the very high input impedances, it is not hard to store sufficient charge to exceed the 100 volt level. Input resistance of this amplifier is 1.5 teraohms (tera = 10^{12}) and is calculated by dividing half of a 15 volt supply voltage, 7.5 volts, by the 5 picoamp input current. Above the room temperature reference of 25°C, the current doubles for every 10°C increase. Diodes D5 through D8 are the protection system. Voltage stress across the gate oxide is limited to a safe value by conduction of the Zeners when the gate to source voltage of either Q6 or Q7 exceeds the Zener breakdown voltage.

PMOS types are also used as a current source to energize the input amplifier. Q1 and Q2 is a current "mirror" and even though made from PMOS devices, operates in much the same way as the bipolar "mirrors" I've described in previous columns. Because of their common source and gate connections and because of their close thermal and diffusion profiles, the current in Q1 is proportionately reproduced in Q2. The area of Q1 is twice that of Q2 and so Q2 supports twice the cur-

rent set up in Q1. Q1 conducts a current determined by the voltage developed across Q1. Subtracting the 2.2 volts across Q1 and the 2.3 volt sum of the four diode junctions (D1 through D4) from 8.3 volts yields 3.8 volts. The current in Q1 is 3.8/40K or about 100 microamps, and Q2 becomes a 200 microamp source. When the power supply drops below 8.3 volts, D9 does not regulate and the bias current falls below the nominal value. Q4 is a cascode transistor that raises the impedance of the current source to contribute to the 70 dB minimum common-mode rejection of the CA3130. Common-mode signals raise the input voltage on both transistor gates (Q6 and Q7) by the same amount. The voltage rise is transferred to the common source node. If the current source presents a high impedance, this change in voltage gives a minimal change in the currents through the input transistors with a correspondingly small change in the amplifier output.

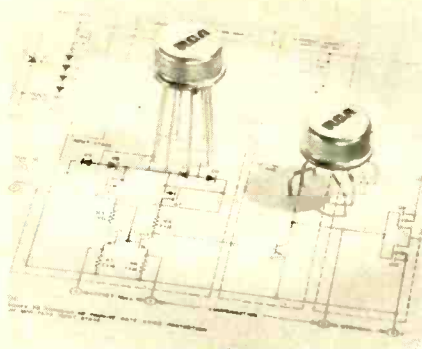
The drains of Q6 and Q7 are connected to an NPN current "mirror" Q9 and Q10. This one functions as a balanced to single-ended converter; in effect, a transistorized balun. Compared to a single-ended output, it doubles the input stage gain and increases the common-mode rejection. The first factor is important if you realize that the low transconductance of the FET reduces the voltage gain of the first stage to only about 5 times. Gain in the first stage influences the noise output of the amplifier. Transistor Q10 carries the same current as Q9 because of its common base connections and matched emitter resistors.

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IC terminals 1 and 5 can be connected to opposite ends of a grounded-wiper 100K offset-nulling pot. Resistors R3 and R4 are subtler design details. To minimize offset voltages of the input MOS pair, it is desirable to operate both transistors with equal source-to-drain voltages. At balance, when the current is split between Q6 and Q7, each carries half the current source bias or 100 microamps. The drain of Q6 is at the 0.6 volt base-to-emitter voltage of Q10



RCA CA3130 operational amplifier.

plus the 0.1 volt drop across R6. The collector of Q10 is lower; it is fixed at one V_{be} above $-V_{cc}$ because of the base connection of Q11. Even though Q11 conducts 200 microamps, twice that of Q9, doubling current only raises the junction voltage 18 millivolts. The 0.1 volt drop across R4 raises the drain of Q7 to about 0.7 volt, the same as Q6. Resistor R3 drops the voltage on Q9's collector by 0.1 volt,

matching the collector to emitter voltages across Q9 and Q10. When the current in Q6 and Q7 are equal, Q7 is supplied completely by Q10 and there is no net current into the base of Q11. As the current in Q7 increases, the currents in Q6, Q9, and Q10 decrease by an equal amount. The net current change into the base of Q11 is twice the current change in Q7. The current drive arrangement requires no gain robbing load resistors at the base of Q11. Input offset for the CA3130, CA3130A, and the CA3130B is 2, 5, and 15 mv.

Transistor Q11 is the second stage and the highest gain contributor of the op-amp. Its voltage gain is about 600. Transistors Q3 and Q5 are a cascoded high-impedance current load for Q11; they are in parallel with Q2 and Q4 and supply the same 200 microamp current. Again there is no load resistor. The high impedance of the current source paralleled with the very high gate input impedance of the output amplifier is an extremely high AC collector load for Q11 giving the high stage gain. Stability compensation is easily applied to this point. A single capacitor, normally 47 pF, connected between IC pins 8 and 1 will provide stable unity-gain operation.

Finally, the output stage (Q8 and Q12) is the COS/MOS part of the circuit. Large complementary PMOS and NMOS transistors are connected with their drains and gates tied together and with their sources connected to opposite supply voltages. When the gate voltage rises, Q8 tends to turn off and Q12 on. At the extremes of the gate swing, one device is turned com-

pletely on and the other is off. Attached to an output impedance that is high compared to the channel resistances, the output can swing within 10-mV of either supply rail. The amplifier output can be strobed or disabled by pulling IC pin 8 down to $-V_{cc}$. The COS/MOS output inverter sources and sinks a minimum of 12 mA and typically 20 mA. Many operational amplifiers use extra devices to protect the output stages from excessive currents. Even with such protection they can sometimes be destroyed under transient conditions. The COS/MOS output stage has inherent protection due to its finite channel resistance. In this case, the important spec is the maximum current which is 45 mA. Quiescent current in the stage is 8 mA when the output is at 7.5 volts and the amplifier supply is 15 volts. With a 2000-ohm load tied to IC pin 6, the gain of the third stage is about 30 times. The output will drive standard COS/MOS logic circuitry or 7400 series TTL.

Supply voltage range for the CA3130 series is 5 to 16 volts. Typical unity gain bandwidth with a 47 pF compensation capacitor is 15 MHz. Estimating the total open-loop amplifier gain using the three values mentioned above we get: $5 \times 600 \times 30 = 90,000$. Converting to dB: $20 \log 90,000 = 20 \times 4.996$ or about 100 dB. The more accurate data sheet specification reads 110-dB typical.

The 3130 can be used in digital-to-analog converters, peak detectors, full-wave signal rectifiers, power-supply error amplifiers, multivibrators and long duration timers. **R-E**

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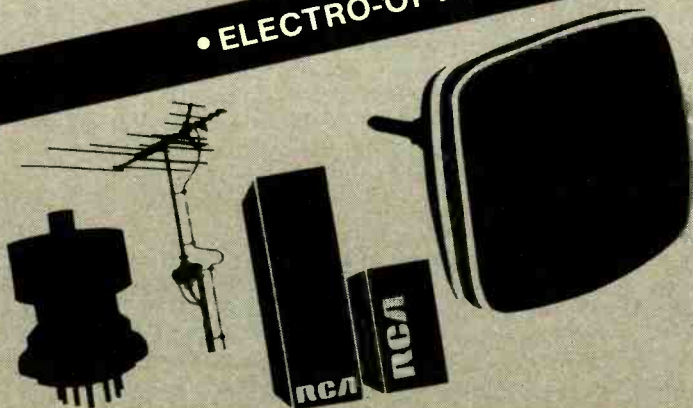
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STATE-OF-SOLID-STATE

(continued from page 31)

Semiconductor memory continues to nudge traditional cores from their intricately wired boards. The achievement record of IC technology in the last few years makes it difficult to imagine the physical wiring complications of core from competing much longer. Inevitably, this trend will put the minicomputer into the home, probably in the next decade. A TV-display keyboard system will control the entertainment and work machine.

Non-volatility—the ability to store data for long periods of time without power—is essential in some applications. Even here, where cores have a natural upper hand, the economics permits standby battery power supplies to be included in the IC system and yet be cost competitive.

There hardly seems to be an argument when it comes to ROM (Read Only Memory.) The IC ROM is as non-volatile as core—even more so because its mask-programmed ones and zeros cannot be erased or altered even with failure of auxiliary control circuits. Once the memory has been manufactured, it cannot be changed by electrical write signals, there are in fact no write terminals on the device.

Semiconductor ROM's are used in computers, data terminals, anywhere where fixed programs or data tables are committed to permanent storage. It is always less expensive than RAM (Random Access Memory) and becomes the obvious choice where the application calls for ROM.

Peripherals like teletypes and card readers must be able to communicate with the computer. A computer with a blank memory is helpless; communication with anybody or anything is impossible. Bootstrap program loading routines are stored in ROM's. They are transferred to the main memory by pushing a button. More complex programs are then entered from paper tape, magnetic tape, or magnetic disk to allow more efficient transfer of information to and from. Even if the computer main memory is jumbled by some programming "accident", the ROM remains intact. The push of a button restores the system for program correction and another try at execution.

IC ROM's are also finding wide applications as code translators, programmable waveform generators, in display systems, as character generators, and as one we will take a closer look at—electronic look-up tables.

Table look-up ROM's

American Microsystem's S8771 is a 5120-bit high-speed MOS read-only-memory. It can be used as a 4096-bit conventional "4K" ROM by altering its organization with input pin voltages. Not all of the cells are used in this case. Two standard preprogrammed versions, the S8771A and S8771B, use all 5120 bits. The first is a sine/cosine look-up table, and the second an arc-tangent look-up table. The memories are compatible with TTL logic. Outputs are three-state. Besides the active 1 and 0 output states there is the third state, an inactive open condition in which the

output leads are left floating. This setup allows the outputs of many chips to be paralleled so they can be combined to form large composite memories. Individual circuits are selected by output enable terminals.

Figure 1 shows the general organization of the device. Address terminals A1 through A9 select the columns and rows of the memory to locate individual words. 512 10-bit words addressed by the inputs are transferred to the B1 through B10

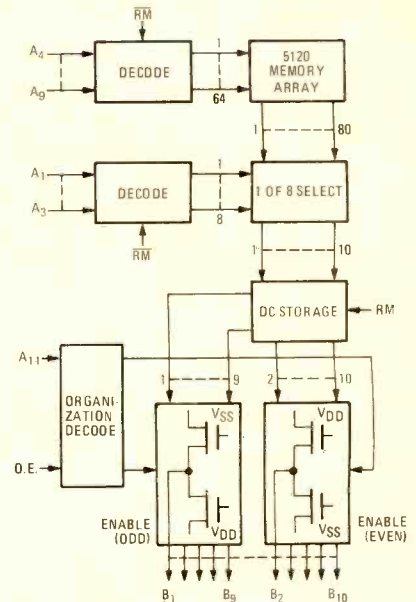


FIG. 1—THE S8771 HIGH-SPEED ROM.

output terminals when the output enable pins are energized. If A11 and O.E. are low, all outputs are disabled. Raising A11 to a high logic level enables the odd outputs B1, B3, B5, B7, B9. Putting a high logic level on O.E. enables the even outputs. The memory looks like a 1024 × 5 or 1024 × 4 arrangement when these pins are used to enable half the outputs at a time.

The terminal arrangement of the A version is shown in Fig. 2. The output enable and A11 inputs are jumpered to enable all outputs simultaneously.

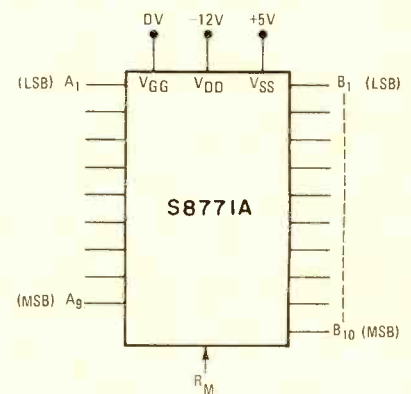


FIG. 2—SINE-COSINE LOOK-UP TABLE.

The S8771A will find the sine of an angle between 0 and 90 degrees. By subtracting multiples of 180 degrees from larger angles and applying the correct sign depending on the quadrant of the angle, the sine of any angle can be found.

(continued on page 74)

DIGITAL CLOCK KIT ROUNDUP

PART I. A comparison between the various digital clock kits that are currently available

FRED BLECHMAN



DIGITAL CONCEPTS model EC-2000K.



ESE model ES-112K.



FORMULA INTERNATIONAL model MM5314.



HEATHKIT model GC-1094.

"TIME FLIES" . . . "TIME IS MONEY" . . . "A STITCH IN TIME SAVES NINE" . . . "TIME heals all wounds" . . . "TIME is of the essence." These and countless other familiar phrases abound, since TIME, reputed to be the fourth dimension, is so important in all our lives. The latest evidence of the consuming interest in TIME is the proliferation of watches and clocks with digital readouts. Who hasn't seen the familiar "countdown" numerals displayed on TV during space launches?

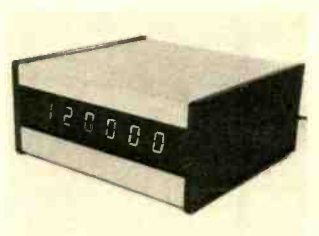
Early-generation digital timepieces contained ingenious mechanical or electro-mechanical movements. These were followed by electronic "modules," solid-state crystal-controlled microcircuits—very expensive, but highly accurate and reliable. With broad acceptance, technological advances and the resultant economies of high production, electronic module price structures have collapsed encouraging even higher sales, more production, and still lower prices. This is most noticeable in the digital wristwatch field. Today you can buy a five-function (hour, minute, second, day and date) digital wristwatch for \$39.95, with good likelihood of some models at year-end selling for \$19.95. A digital readout watch of the same kind cost over \$200 just two years ago!

The digital clock field has been much less dynamic. Electro-mechanical movements abound, stimulated by the clock-radio and bedside alarm market. Size and life requirements are much less demanding than in wristwatches, allowing the use of cheap mechanical contraptions from "flip-cards" to light-shutter devices. Only recently, with the availability of sophisticated, specially-designed IC's, are electronic digital clocks making an impact in the consumer marketplace. With 1/60th-second accuracy, 6-digit readouts in various colors and sizes, alarm accuracies to the minute and no moving parts, electronic digital clocks are beginning to challenge the "old-timers." With technology advancing by leaps and bounds, formerly hard-to-get parts are becoming readily available at realistic prices, as a survey of the advertisers at the back of this magazine will confirm.

Therefore, it's not surprising that many suppliers and manufacturers are jumping on the electronic clock-kit bandwagon. One supplier reported that they fill orders for 50 clock kits a day, at \$19.95 each, and another claimed they had sold 25,000 clock kits at \$9.95 before discontinuing that design! Until about a year ago, it was hard to find a digital clock kit for under \$50, and they were relatively complex units. Today, as a glance at the accompanying comparison chart will show, you can get kits for under \$12, and—perhaps the best news of all—several of them are really easy to build!

Many of the terms used in the digital clock field are peculiar in their application to this area, so explanations follow. By referring to these explanations, the comparison chart will be found to contain a great deal of valuable information if you are con-

*(chart on page 34 & 35)
(text continues on page 36)*



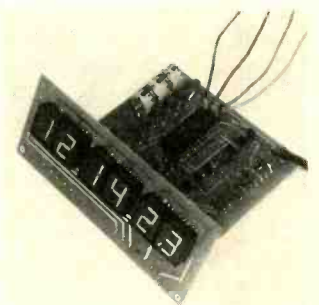
ALTAJ—"THE KING."



BABYLON SPACE-AGE CLOCK.



CARINGELLA model DWC-1.



QUEST ELECTRONICS

6C1082D	79.95	6	.5	ORANGE	—	✓	—	①	—	—	⑱	MOSTEK 50178A	BROWN	PLASTIC	2 1/2	8 3/8	4 7/8	EXCEL-LENT	HARD	BATTERY-POWERED OSCILLATOR FOR POWER FAILURE INDICATOR. CALENDAR DISPLAYS MONTH & DATE.
HEATH COMPANY BENTON HARBOR, MICHIGAN 48022 (CON'T)	64.95	4	.5	ORANGE	✓	—	✓	①	—	—	—	S1866A	BROWN & BLACK	PLASTIC & METAL	1 7/8	4 5/8	4 3/4	EXCEL-LENT	HARD	CAR-CLOCK ALSO DISPLAYS ELAPSED TIME. CRYSTAL-CONTROLLED TIME-BASE
INTERNATIONAL ELECTRONICS UNLIMITED P.O. BOX 3036 MONTEREY, CA 93940	49.95	6	.5	ORANGE	⑱	✓	—	—	✓	7	✓	MOSTEK MK5017PAA	BLACK & WALNUT	PLASTIC	2 1/2	7	4 3/4	EXCEL-LENT	HARD	
	11.95	6	.25	RED	—	✓	—	—	—	—	—	NATIONAL MM5314	NOT SUPPLIED	NOT SUPPLIED				FAIR	EASY	② ③ ④ ⑩ ⑳ ㉑
	19.95	6	.3	RED	—	✓	—	—	—	—	—	NATIONAL MM5314	WALNUT	WOOD	3 1/8	6 5/8	2 1/2	GOOD	MEDIUM	④ 29 JUMPER WIRES—OTHERWISE SIMPLE ASSEMBLY. NO SWITCH TO HOLD SECONDS
JAMES ELECTRONICS P.O. BOX 822 BELMONT, CA 94002	34.95	6	.5 & .3	RED	—	✓	—	—	—	—	—	NATIONAL MM5314	WALNUT	WOOD	4 3/4	7 1/2	2	POOR	MEDIUM	④
	49.95	4	3.5	RED	—	✓	—	—	—	—	—	NATIONAL MM5314	WALNUT	WOOD	5 5/8	18 5/8	1 3/4	FAIR	MEDIUM	④ ASSEMBLED: \$59.95 (SPECIFY 12 OR 24 HR)
	69.95	6	3.5	RED	—	✓	—	—	—	—	—	NATIONAL MM5314	WALNUT	WOOD	5 5/8	27 5/8	1 3/4	FAIR	HARD	④ ASSEMBLED: \$79.95 (SPECIFY 12 OR 24 HR)
MESHNA SURPLUS P.O. BOX 62 E. LYNN, MASS. 01904	14.00	4	.25	GREEN	⑳	✓	—	⑳	⑳	⑳	—	NATIONAL MM5316	NOT SUPPLIED	NOT SUPPLIED				GOOD	EASY	② ③ ④ ⑥ ⑬
	21.00	6	.3	RED	—	✓	—	—	—	—	—	NATIONAL MM5314	BLACK	PLASTIC	3 3/4	5 1/2	4 3/4	FAIR	MEDIUM	CASE INCLUDES SPEAKER & VOLUME CONTROL
NEXUS TRADING CO. 80X 3357 SAN LEANDRO, CA 94578	34.95	6	.3	RED	—	—	—	—	—	—	—	NATIONAL MM5314	BLACK	PLASTIC	1 3/4	3 1/2	3 1/8	GOOD	MEDIUM	\$29.95 WITHOUT CASE & SWIVEL MOUNT CRYSTAL-CONTROLLED TIME-BASE
	45.95	6	.6	RED	—	—	—	—	—	—	—	NATIONAL MM5314	BLACK	PLASTIC	6	3	1 1/2	GOOD	MEDIUM	ASSEMBLED: \$59.95, NO CASE KIT: \$39.95 CRYSTAL-CONTROLLED TIME-BASE
NOVIUS 1177 KERN AVE. SUNNYVALE, CA 94086	29.95	4	.5	RED	—	—	—	①	✓	7	✓	NATIONAL MM5375 OR MA1002	BLACK, WHITE OR BROWN	PLASTIC	2	4	4 1/2	—	—	NOT A KIT! COMPLETELY ASSEMBLED.
QUEST ELECTRONICS P.O. BOX 4430 SANTA CLARA, CA 95054	17.45	6	.5	RED	—	—	—	—	—	—	—	NATIONAL MM5314	NOT SUPPLIED	NOT SUPPLIED				GOOD	MEDIUM	KIT WITHOUT XFMR & PC BOARDS: \$12.95
SABTRONICS INTERNATIONAL P.O. BOX 64683 DALLAS, TEXAS 75206	18.50	6	.5	RED	—	—	—	—	⑳	—	—	NATIONAL MM5314	NOT SUPPLIED	NOT SUPPLIED				GOOD	MEDIUM	② ③ ④ ㉑ .25 DIGITS KIT: \$13.50
S.O. SALES CO. P.O. BOX 28810 DALLAS, TEXAS 75228	16.50	6	.3	RED	—	—	—	⑪	—	10	✓	MOSTEK 50252	NOT SUPPLIED	NOT SUPPLIED				GOOD	MEDIUM	② ③ ④ ㉑ ㉒
SINCLAIR RADIODINCS 375 PARK AVE. NEW YORK, NY 10022	29.95	4	.12	RED	—	—	—	⑪	—	—	—	UNKNOWN	BLACK	PLASTIC	1 7/8	1 1/8	3/8	GOOD	EASY	HOURS, MINUTES, SECONDS & DATE BATTERIES & STRAP INCLUDED (THIS IS A WRISTWATCH, NOT A CLOCK)

NOTES: *BUILT FROM KIT BY AUTHOR

① PHOTOCCELL SENSOR.
② LINE CORD NOT INCLUDED.
③ WIRE NOT INCLUDED.

④ SOLDER NOT INCLUDED.
⑤ MOLEX PINS NOT INCLUDED.
⑥ OPTIONAL SLEEP SWITCH.
⑦ TEMPERATURE & CHIME MODULES OPTIONAL.

⑧ 24 HR. ON 50 HZ. ONLY.
⑨ FLASH IN 10 SEC. CODE
⑩ SWITCHES NOT INCLUDED
⑪ BRIGHT-DIM SWITCH
⑫ PRE-CUT WIRES INCLUDED

⑬ SWITCH DISPLAYS SECONDS
⑭ OTHER COLORS AVAILABLE
⑮ 24 HR. ON REQUEST
⑯ BLINK—STEADY OPTIONAL
⑰ ORANGE OPTIONAL

⑱ TIME OR ALARM SET ONLY
⑲ BATTERY-POWERED FOR POWER FAILURES, KEYS COUNTING.
⑳ 12V TRANSFORMER NOT INCLUDED
㉑ REMOTE READOUTS OPTIONAL
㉒ PARTS NOT INCLUDED

⑳ CAN BE ADDED
㉑ DECIMAL POINTS USED AS COLONS
㉒ INSTRUCTIONS SHOW AS OPTION; PARTS NOT INCLUDED

COMPARISON CHART - ELECTRONIC DIGITAL CLOCK KITS

MANUFACTURER OR DISTRIBUTOR	MODEL	KIT PRICE (\$)	DISPLAY										CASE					ASSEMBLY		NOTES & REMARKS
			NUMBER OF DIGITS	DIGIT HEIGHT (IN.)	COLOR	AM/PM INDICATOR	12/24 HOUR OPTION	COLONS	ADJUSTABLE BRIGHTNESS	ALARM	SNOOZE TIME (MINUTES)	POWER FAILURE	CLOCK IC	COLOR	MATERIAL	HEIGHT (IN.)	WIDTH (IN.)	DEPTH (IN.)	MANUAL	
ALTAJ ELECTRONICS P.O. BOX 38544 DALLAS, TEXAS 75238	4-DIGIT* ALARM CLOCK	21.50	4	.25	RED	✓	-	-	①	✓	7	-	MOSTEK 70380	CREAM & WALNUT	2 1/2	5 1/4	6 1/4	GOOD	MEDIUM	5" DIGITS FOR \$22.50 ②③④⑤⑥ ZERO SECONDS.
	THE KING	23.50	6	.3	RED OR YELLOW OR GREEN	✓	⑧	-	①	✓	10	-	MOSTEK 70250	GRAY & BLACK	3 1/4	7 1/4	7 1/4	GOOD	HARD	SPECIFY COLOR DISPLAY. 5" OR 6" DIGITS (RED ONLY) FOR \$26.50 ②③④⑤⑦
	SPACE* AGE CLOCK	19.95	4	.25	RED	-	✓	⑨	-	-	-	-	NATIONAL MM5314	METAL & PLASTIC	1 7/8	3 1/4	1 1/2	FAIR	EASY	④ SMALLEST. BUILT-IN TIME-SETTING SWITCHES
	SON-OF* A-CHEAP. CLOCK	14.50	6	.3	RED	✓	✓	-	-	-	-	-	NATIONAL MM5314	NOT SUPPLIED				FAIR	MEDIUM	②③④⑩ SOCKETS FOR IC & ALL DIGITS. ②①②② ASSEMBLED: \$84.95 ⑬
BABYLON ELECTRONICS P.O. BOX 41778 SACRAMENTO, CA 95841	DOC-1*	59.95	6	.6 & .4	WHITE- YELLOW	-	✓	-	⑪	-	-	-	NATIONAL MM5314	SMOKE GRAY & WALNUT	3 1/4	7 1/2	4 3/4	GOOD	MEDIUM	ASSEMBLED: \$199.95 ⑫ CRYSTAL CONTROLLED OSCILLATOR FOR POWER FAILURE IMMUNITY.
	DWC-1	159.95	6	3.5 & 2.5	RED	-	✓	-	-	-	-	⑱	NATIONAL MM5314	WALNUT	8	21	3	GOOD	HARD	ASSEMBLED: \$74.95 ⑫
	LOC-1	59.95	1	3.5	RED	-	-	-	-	-	-	-	NATIONAL MM5314	WALNUT	7 INCH HIGH HEXAGON			GOOD	MEDIUM	ASSEMBLED: \$124.95 ⑫ CRYSTAL CONTROLLED OSCILLATOR FOR POWER FAILURE IMMUNITY.
	MDC-1	99.95	6	.6 & .4	WHITE- YELLOW	-	✓	-	⑪	-	-	-	NATIONAL MM5314	SMOKE GRAY & WALNUT	3 1/4	7 1/2	4 3/4	GOOD	MEDIUM	ASSEMBLED: \$49.95 ⑬
DIGITAL CONCEPTS CORP 249 ROUTE 46 SADDLE BROOK, NJ 07662	SOC-1	39.95	1	.6	WHITE- YELLOW	-	-	-	-	-	-	-	NATIONAL MM5314	SMOKE GRAY & WALNUT	3	5	4	GOOD	MEDIUM	ASSEMBLED: \$84.95 ⑬
	SSC-1	59.95	6	.6 & .3	RED	-	✓	-	-	-	-	-	NATIONAL MM5314	WALNUT	2 3/4	5 3/4	3 1/4	GOOD	MEDIUM	ASSEMBLED: \$84.95 ⑬
	EC-2000K*	29.95	4	.5	BLUE ⑭	✓	⑮	-	①	-	-	✓	ELECTRONIC ARRAYS DCC7301	CLEAR ACRYLIC TUBE 2 7/8 DIA. 3 1/2 X 3 1/2 WOOD END BLOCKS (WALNUT, ROSEWOOD OR ZEBRA WOOD)			EXCEL- LENT	EASY	WITHOUT CASE OR SWITCHES: \$24 ALARM/SNOOZE VERSION ⑬ OPTIONAL AT EXTRA COST.	
	CK-131	59.95	6	.55	RED ⑰	-	✓	-	-	-	-	✓	MOSTEK MK50178B	WALNUT	4 3/4	6 1/2	4	EXCEL- LENT	MEDIUM	INCLUDES CALENDAR READOUT WITHOUT CASE: \$47.95 (CK-100)
ESE 505% CENTINELA AVE. INGLEWOOD, CA 90302	ES-112K	85.00	6	.6	WHITE- YELLOW	-	⑮	-	-	-	-	-	15 DISCRETE IC'S	GRAY & WALNUT	2 1/2	8 1/4	6	GOOD	MEDIUM	ASSEMBLED: \$130 DIRECT DRIVE NOT MULTIPLEXED
	MM5314*	19.95	6	.32	GREEN	-	✓	-	-	-	-	-	NATIONAL MM5314	GRAY	2 1/4	4 1/2	3 3/4	POOR	MEDIUM	③ ④
	OC1030	29.50	4	.5	GREEN	✓	✓	✓	-	✓	7	✓	TMS 3834	ORANGE	3	5 3/4	2 1/2	FAIR	MEDIUM	③ ④
	OC1032	35.90	4	.1	ORANGE	✓	✓	✓	-	✓	7	✓	TMS 3834	WALNUT	3 1/2	5 1/4	5	FAIR	HARD	③ ④ ⑬ COLON BLINKS
HEATH COMPANY BENTON HARBOR, MICHIGAN 49022	GC1092A	79.95	6	.5	ORANGE	⑱	✓	-	①	✓	7	⑱	MOSTEK 5017AA	BROWN	2 1/2	8 3/8	4 7/8	EXCEL- LENT	HARD	BATTERY-POWERED OSCILLATOR FOR POWER-FAILURE OPERATION

sidering buying a kit, or if you just want to be more familiar with this "branch" of electronics. To help, Fig. 1 is a schematic of the simplest of the units reported on, the *Space Age Clock* from Babylon Electronics, yet it contains all the essential elements of a basic electronic digital clock. Figure 2 shows another schematic. This one is for the Caringella model *DDC-1* desk clock.

Display

This is what you see, the "readout." Most of the kits feature 6 digits, with two for hours, 2 for minutes, and two for seconds. Those with four digits normally display only hours and minutes, and are not very exciting to watch. Some four-digit clocks shift to unit-minutes and second display with a switch. Colors and size cover a broad range. Several years ago, only very large (0.6 inches high) or very small (0.125 inches high) characters were available in kits. Now the smallest digits any respectable kit supplier offers are 0.25 inches high—easily readable from 15 feet with normal eyesight. The largest digits in any of the kits shown are 3½-inches high, and you can read them from at least 200 feet away.



DIGITAL CONCEPTS model EC-2000K, rear view.



FORMULA INTERNATIONAL model OC1030.

The most common displays are red, but the ones listed as white-yellow in the chart can be made to appear almost any color by placing colored plastic or glass in front of them. You can even make each *digit* a different color if you want a really unique display! One manufacturer, Digital Concepts, will color your display to order, with their standard display an outstanding bright blue (model *EC-2000*).

Some displays are fluorescent vacuum tubes, some light-emitting diodes (LED's), some gas-discharge types, and some are incandescent. All the units reported on use seven segments to

form the numbers, as shown in Fig. 1. Before long you can expect units with alphanumeric readouts to show the day of the week on calendar clocks.

AM/PM indicators are provided within some displays as actual letters, but a less expensive, and hence more popular method of designating AM or PM is to use a decimal point or separate LED. In some kits, the first digit is mounted inverted so that the decimal point appears at the upper left corner of the display. This AM/PM designator allows 12-hour format alarm clocks to be set for repeating in 24 hours. For the non-alarm clocks, the AM/PM indicator is hardly a necessity, except for submarines, caves or dungeons!

Many of the kits can be wired for either a 12- or a 24-hour display. The 24-hour format is popularly known as "military time," but is used worldwide in time measurement. Midnight is 00:00:00, noon is 12:00:00, 1 PM is 13:00:00, 6 PM is 18:00:00 and one second before midnight is 23:59:59. AM/PM indicators are not needed with 24-hour displays, since any number under 12:00:00 is AM, and any number larger is PM.

Surprisingly, many of the clocks omit colons (:) between pairs of hours, minutes and seconds digits. Six-digit displays without colons are confusing, especially if there isn't wide spacing between the pairs of digits. Some of the 4-digit clocks have blinking colons that go on and off every second, adding some action to an otherwise lifeless display. The most interesting of these blinking colons is in the *Babylon Space Age Clock*, where the upper and lower points of the colon are coded to count seconds from 1 to 0 with a change every second. This is done by having the upper colon point driven by the segment E command to the non-displayed sixth digit, and the lower colon point driven by the segment D command to the same digit. Figure 1 shows when each colon is on during the seconds count. The colon display is different every second, and repeats every 10 seconds. This is useful in precise time-setting of the minute digit.

The purpose of adjustable brightness is to dim the display in low ambient light environments, so the display doesn't overpower its surroundings, and to conserve power. This is done in most clocks with a light-sensing photocell, although some use a bright-dim switch. The Digital Concepts *EC-2000* was outstanding in its photocell control of brightness, from a pleasant blue glow in darkness to a very bright display in highly-lighted areas.

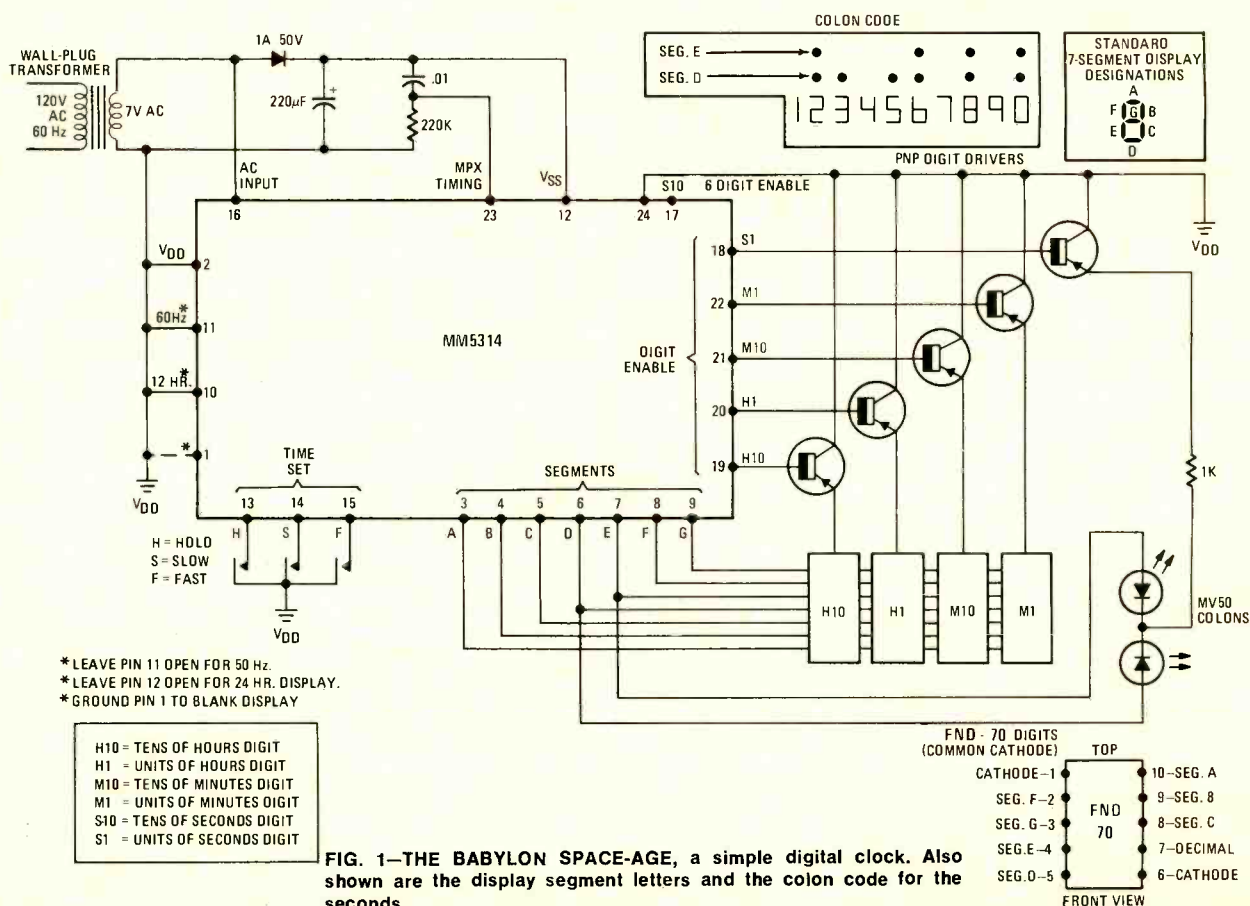


FIG. 1—THE BABYLON SPACE-AGE, a simple digital clock. Also shown are the display segment letters and the colon code for the seconds.

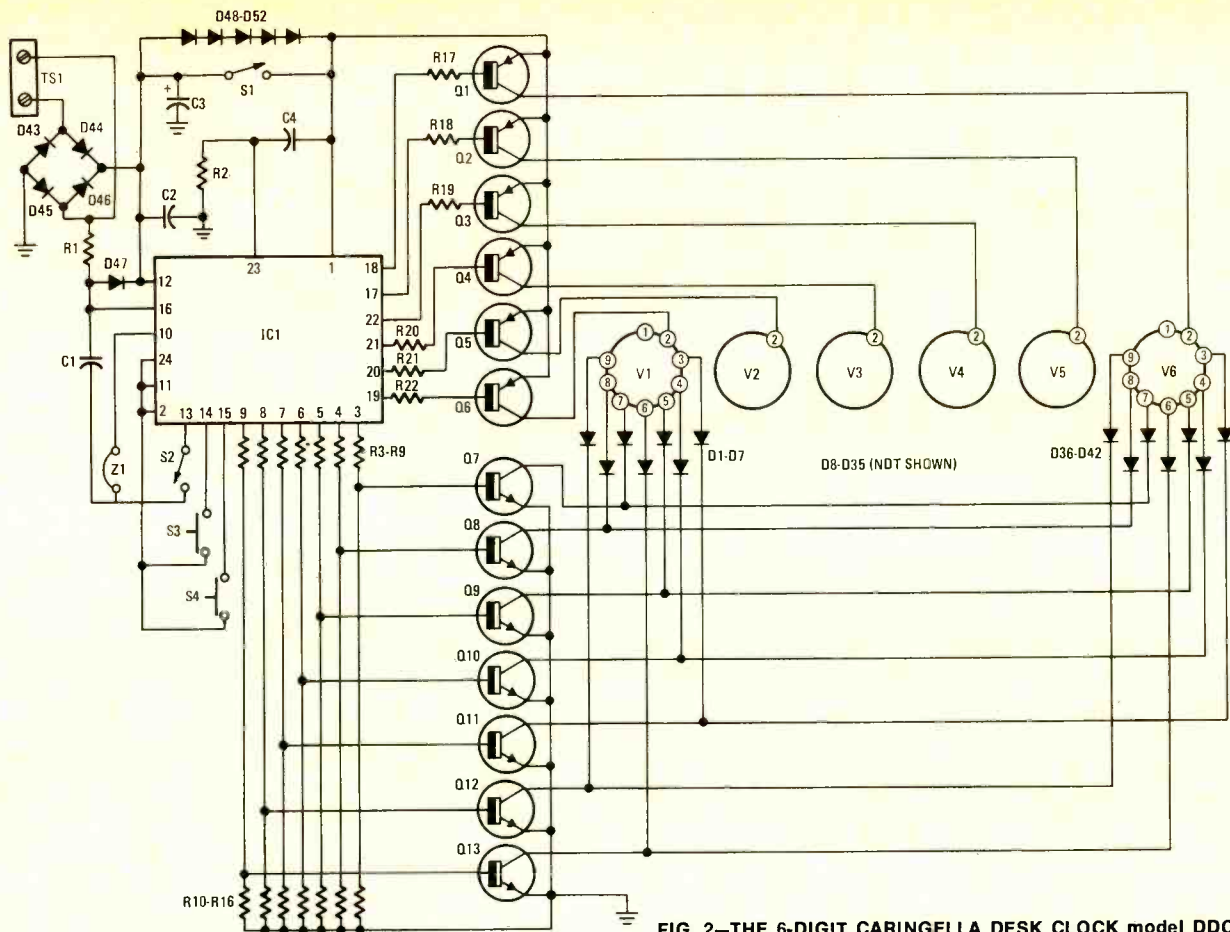


FIG. 2—THE 6-DIGIT CARINGELLA DESK CLOCK model DDC-1.

Alarms

Many of the clock kits available now can be used as bedside alarms. In addition, the Altaj *4-Digit Clock* and the Meshna *SP-284 Clock Kit* can be used to control an external radio to turn on or off (sleep switch). The alarms, instead of a raucous buzzer, are a beeping tone from a built-in speaker. All the alarm clocks have a "snooze" switch that shuts the alarm off for a short period of time (7 or 10 minutes). The big advantage of the alarm on these clocks is that they can be set to the *minute*, and most can literally be set to go off at the desired second (*exactly* on a minute change). Also, all the alarm clocks have 24-hour repeatability, with the use of the AM/PM indicators for alarm-time setting. This means you can shut off the alarm when it sounds, turn it right back on again, and it will repeat 24 hours later! Try that with a regular alarm clock!

Power failure indicator

With most regular electric clocks, if the power is interrupted for a short time, they start automatically when power returns, and are slow by the length of time the power was off. You could be completely unaware of this time inaccuracy. Since power outages often occur in the middle of the night, you could be late for work! Electronic clocks are not that callous! They will respond, depending on their design, one of three ways to an AC power loss when the power returns: 1. the clock starts counting at some random, completely inaccurate time—usually around zero; 2. the display comes back on after going off, and is right on time (battery-driven time-base oscillator keeps counting during the outage) or 3. the display "signals" that the power has been interrupted. This "signal" may be a non-counting display locked on 12:00:00, or 88:88:88, or a blinking AM/PM indicator, or blinking colons, or the sounding of the alarm, or some combination of the above (or none of the above!). The alarm going off is particularly important for those who depend on the alarm to wake them and experience a middle-of-the-night power loss.

Clock IC

All but one of the clocks on the Chart use a main clock "chip" that performs wave-shaping, counting and control functions in-

stead of having an abundance of individual IC's. The IC only needs DC power and a source of 60 (or 50) Hz; it counts down to seconds and signals the proper segments of each digit to display the correct number for that instant. Also, most of the clock IC's shown "multiplex" the digit signals; all segment commands are carried on parallel lines to each digit, and the individual digits are enabled one at a time at a rate too fast for the eye to follow—this eliminates flicker. The scanning rate is controlled by a resistor-capacitor circuit to the clock IC, with typical values yielding a multiplex frequency of 2000 Hz. (See the 0.01 capacitor and 220K resistor in Fig. 11).

Multiplexing reduces the number of leads between a 6-digit display and the clock control from 42 to 13, as well as saving 29 driver-transistors and 35 current-limiting resistors in most applications! Most clock IC's can't handle display current requirements directly, and require driving transistors and current-limiting resistors. However, more "direct drive" clock chips are appearing on the market, eliminating many of the resistors and transistors to drive the displays. Many parts can be eliminated by clever design and component selection. The Babylon *Space Age Clock* (Fig. 1) and the International Electronics Clock drive the segments of the FND-70 low-current displays directly, and depend on the current-limiting of the MM5314 IC to keep the LED display from "avalanching" and burning out—this eliminates seven transistors and seven resistors! Several clock kits use direct-drive IC's that eliminate almost all the transistors and resistors.

Enclosures

Some of the kits do not include a case, and the builder is left to his own ingenuity. It can take more time to "package" the clock than to build it! So, unless you have a custom application, it's recommended that you buy a kit that includes a case. Some of the cases are exotic—Digital Concepts offers a variety of wooden decorator end-blocks for its *EC-2000 Clock* that is enclosed in a clear plastic tubular enclosure. The Altaj clocks have sturdy, modern-design metal and plastic cases, punched to accept switches and mounting hardware for the electronics. Some have wooden cases, with the most unusual in this group being the

(continued on page 93)

CB

Transceiver Roundup

With the number of CB transceivers increasing, it's getting difficult to keep track of what's available. Here's a sampling of the market

ROBERT F. SCOTT
TECHNICAL EDITOR

THERE ARE A GREAT NUMBER OF DIFFERENT MAKES AND models of CB transceivers on the market at this time. Just how many models there are, no one knows precisely, as the number of FCC type-approved sets increase in number day by day.

To get an idea as to the trends in CB transceiver design, note that for this directory, we asked each manufacturer and importer for a photo and complete specifications on one of his models. Some sent details on their latest models, others

included their best-sellers. Most, however, asked us to include the top-of-the-line model.

Quite a few of the models have interesting circuit features that we will describe for you in the coming months. These will include different types of synthesizers, noise-reducing circuits and other features. The most interesting and pertinent items are included in the description of each model in this round-up. We included all manufacturers who responded to our request.

Alaron B-1050
A 23-channel mobile transceiver with all required crystals included. Among its features are a delta-tune switch, PA switch, variable squelch control, full-time automatic noise limiter, self-contained speaker and illuminated channel selector. The plug-in dy-



amic mike has a fastener-type connector and coil-cord. Jacks are provided for external speaker for monitoring or PA use. Four watts maximum RF power output. Requires 12 volts DC, positive or negative ground. Mounting bracket and hardware, mike holder and power cord included. 6¼" × 7½" × 2¼".—**B & B Import-Export, Inc.**, 185 Park St., Troy, MI 48084.

Audiovox MCB-1000
This unit uses frequency synthesis for full crystal-controlled receive and transmit on all 23 channels. The receiver circuitry uses ceramic filters for superior selectivity. Variable squelch and a high-impedance automatic noise limiter reduce annoying noises when

the receiver is in the receive and standby modes. Other features include S/RF meter, on-air indicator light, local-dis-



tance switch, PA/CB switch, external speaker jack. Can be used on 12-volt electrical systems having either positive or negative grounds.—**Audiovox Corp.**, 150 Marcus Blvd., Hauppauge, NY 11767.

Automatic CXB-2472
A new in-dash CB transceiver with AM/FM stereo radio. It is a full-feature CB rig with



delta tuning, squelch control, S/RF meter, illuminated channel selector and detachable microphone. The AM/FM multiplex radio has a stereo indicator light, and on-off, volume, tone, balance and fader controls. A unique feature in a unit as comprehensive as this

is a "monitor" circuit that lets the user enjoy the AM/FM stereo radio without missing any activity on a selected CB channel. The control shafts are adjustable for secure and convenient installation in most cars.—**Automatic Radio**, 2 Main St., Melrose, MA 02176.

Blaupunkt BCB-5231
A mobile unit for under-dash mounting that uses 14 crystals in a synthesizer to produce 23 crystal-controlled transmit and receive frequencies. The re-



ceiver has adjustable squelch, a series-gate noise limiter and delta tuning with a ± 1 kHz adjustable range. Transmitter provides 100% modulation with 4-mV microphone output. Maximum power output is 4 watts. Transmitter power input 6.6 watts at 13.8 VDC. Other features are PA switch, external CB switch for feeding receiver output to external speaker and RF gain control.—**Robert Bosch Corp.**, Car Radio Div., 2800 S. 25th Ave., Broadview, IL 60123.

Bon Sonic CB-23
Compact all-transistor mobile transceiver providing 23 crys-

tal-controlled transmit and receive channels. Receiver is dual-conversion type featuring a ceramic filter and delta tuning with ± 2 kHz on each channel, switchable ANL, and



S/RF power meter. An S-9 signal equals 100 μ V input at the antenna terminal. The push-to-talk dynamic microphone provides convenient send-receive switching. Operates from 13.8-volt DC source with either positive or negative ground.—**Hanabashiya Ltd.**, 39 W. 28th St., New York, NY 10001.

Browning Golden Eagle
Deluxe base station comprising separate transmitter and receiver for AM and SSB modes. Each is fully independent with its own power supply operating from 117 V, 60-Hz lines. Circuits include 20 vacuum tubes performing 28 functions. Transmitter RF output up to 12 watts PEP on upper or lower sideband and up to 4 watts on AM. AM

modulation capability is limited to 100%. SSB carrier suppression better than 70 dB. Transmitter frequency control is adjustable in ± 100 , 300, 500 and 700 Hz steps with a "spot" switch for zero-beating with the received signal.



Lighted panel indicators show mode of emission. The receiver features exceptional sensitivity and selectivity with 70 dB minimum adjacent-channel rejection. There are two noise-limiters. Pulse-diode type for SSB and series-gate type for AM. Channel selector provides continuous tuning with separate bandspread control for coverage up to 27.595 MHz. Both units are 6.75" H \times 15.50" W \times 9.88" D.—**Browning Laboratories**, 1269 Union Avenue, Laconia, NH 03246.

Challenger 550
Compact, lightweight solid-state transceiver delivering 4 watts RF power output. In-



cludes a continuously variable squelch, 10-crystal frequency synthesizer, automatic modulation control, three-position delta-tune, illuminated S/R/F output meter, output jacks for PA and auxiliary speakers. Audio power output 3 watts into 8 ohms; PA output 4.3 watts into 8 ohms. Operates from 13.8 VDC negative or positive ground power source. 6 1/2" \times 2 1/2" \times 7 3/4".—**TRS International Ltd.**, 4825 N. Scott St., Schiller Park, IL 60176.

Cobra 139
Base-station transceiver featuring console-type styling in walnut-grain finished cabinet. Transmits and receives in the AM and single-sideband



modes. Transmitter delivers the full maximum power of 4 watts on AM and 12 watts PEP on upper and lower side-

bands in the SSB mode. Has separate modulation and RF output/signal strength meters. The dual-conversion receiver circuit includes RF gain control, and switchable noise limiting and noise blanking for maximum interference elimination. The Voice-Lock delta tuning system varies the receiver tuning over ± 600 Hz. The transmitter carrier is suppressed 40 dB in the SSB mode. The Cobra 139 operates from 13.8 volts DC, positive or negative ground or 117 volts AC.—**Dynascan Corp.**, 6460 W. Cortland, Chicago, IL 60635.

Commando 2310
Mobile unit features synthesized frequency control on AM transmit and receive functions.



Transmitter output into 50-ohm load is 3.8 W, no modulation and 4.8 W with 100% modulation. Receiver is dual-conversion superhet. Operating voltage 13.8 VDC, battery drain on receive; no-signal, 230 mA transmitter drain, no modulation, 690 mA; 100% modulation 1.190 A. 5 3/16" \times 2" \times 9".—**Commando Communications**, Chattanooga, TN.

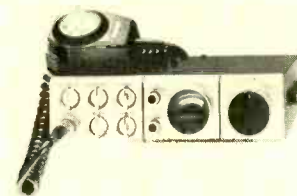
Cornell-Dubilier Mark X
Frequency synthesized base unit with all crystals supplied for full 23-channel operation.



Shown beside the antenna rotor control box, the unit has quite a few notable features. Among them are: dual-conversion superheterodyne receiver with ceramic filter for superior selectivity, variable squelch and high-impedance automatic noise limiter, separate S/Mod, power and SWR meters, headphone jack on the panel, delta tuning, digital channel readout, separate RF and IF gain controls, ANL switch and a dual power supply for 117 VAC or 13.8 VDC operation.—**Cornell-Dubilier Electronics**, 150 Avenue L, Newark, NJ 17101.

Craig 4103
Mobile transceiver that can deliver the full 4 watts RF output authorized by the FCC. High-

level modulation is used for full 100% modulation. Built-in microphone preamplifier circuit provides special voice-frequency shaping and dynamic compression to maintain maximum intelligibility through a



high average modulation without the danger of overmodulation. The dual-conversion receiver includes a 455-kHz ceramic filter to reduce adjacent-channel splatter. Standard automatic noise limiting (ANL) is always on to reduce atmospheric noise. A switchable noise blanker blanks the receiver for a microsecond or two during noise impulses, stopping the noise before it reaches the audio circuits. A variable squelch circuit silences noise between transmissions. The RF gain control can be set so you can hear weak distant signals or prevent "blasting" from nearby stations. Other features include delta tuning, a LED modulation indicator lamp, S/R/F/SWR meter, 8 1/4" \times 2 3/8" \times 8 7/8".—**Craig Corp.**, 921 W. Artesia Blvd., Compton, CA 90220.

EICO 7723
Compact mobile transceiver with full 23-channel synthe-



sized circuitry, dual-conversion superhet receiver with full-time ANL and AGC. Other features include a variable squelch control, tuned RF stage, PA switch, combination S/R/F meter and a facility for either positive or negative ground operation from 14 VDC supply. It is 1 3/4" \times 5" \times 8 1/2" in a metal cabinet and comes with mike and power cord.—**EICO Electronic Instrument Co.**, 283 Malta St., Brooklyn, NY 11207.

Fulcomm 15-2301
Mobile transceiver operating on 23 frequency-synthesized channels with 4 watts maximum RF power output. It features delta tuning, ANL, illu-

minated S/R/F power meter, squelch control, modulation indicator, built-in, speaker, ex-



ternal speaker jack and PA capability. Requires 13.8 VDC, positive or negative ground. 6 1/4" \times 2 1/4" \times 7 3/4".—**Arthur Fulmer Communications**, P.O. Box 177, Memphis, TN 38101.

Gemtronics GTX-23
Powerful and compact, this unit features 3-position delta tune switch, S/R/F meter, squelch control, PA/CB selector, noise limiter and modula-



tion indicator lamp. Covers the 23 channels with synthesizer frequency control. Receiver is dual-conversion superhet with 10.595–10.635-MHz first IF and 455 kHz second IF. 6" \times 2" \times 8 3/8".—**Gemtronics**, P.O. Box 1408, Lake City, SC 29560.

General Electric 3-5820
A 23-channel mobile unit with 1-channel priority monitor and LSD digital channel readout. The channel priority feature allows the user-selected priority channel to be received regardless of the setting of the channel selector. (The crystal for the priority channel is available as a user-selected accessory.) The unit features PLL synthesized transmit and receive frequency control. RF



gain and volume controls help balance distant and near-by stations for equal clarity. Adjustable squelch eliminates background noise when the monitored channel is not in use. Can be adjusted for weak or very strong stations. The delta-tune circuit provides 3-position fine tuning. Transmitter has push-to-talk microphone and automatic modulation control circuit. 7 1/4" \times

2 1/4" x 8 3/8".—**General Electric Co.**, Audio Electronics Products Dept., Syracuse, NY.

Globe 9001

Maximum transmit range is assured by the 4-watt maximum RF power capability and the AMSC (Automatic Modulation Stabilization Circuit). The



sensitive dual-conversion superheterodyne receiver circuit assures a receiving range that matches the capabilities of the transmitter—you can't work 'em if you can't hear them. Twenty three phased-locked loop (PLL) synthesized channels with delta tuning for fine-tuning off-frequency stations. S/R/F meter indicates both receiver and transmit signal strengths. Positive- or negative-ground operation in any vehicle with 12-volt DC battery. Receive battery drain 0.25 to 1.6 A. Maximum audio at external speaker jack 3 watts. Transmitter power input 5 W, output 4 W without modulation. Battery drain without modulation 0.9 A.—**Globe Electronics**, Div. of Hydrometals, Inc., Rockford, IL 61101.

Handic 2350

Base-station transceiver designed for 120/240 VAC line or 12 VDC operation. Includes



a sub-receiver that can be crystal controlled on a priority channel. When there is a signal on the priority channel, the priority lamp flashes and the signal is heard in the loud speaker, no matter to which channel the channel selector is set. The squelch for the sub-receiver is set so the main receiver is not interrupted by noise. The 2350 base unit includes a special jack for connection to the S-12 selective call unit. This selective call unit responds only to calls with its own private tone code and so the user need not listen to a lot of other traffic on the monitored channel. Other features include S/SWR/RF meter, automatic noise limiter, built-in PA amplifier, switch and control for calibrating the SWR meter, jacks for external

and PA loudspeakers.—**Handic USA**, Kennedy Building, 14560 N. 60th Ave., Miami Lakes, FL 33014.

Hy-Gain Hy-Gain VIII

Base transceiver with both AM and SSB capabilities. It has a crystal matrix frequency-synthesizer for 23 AM channels plus upper and lower sideband. Extra features include adjustable noise limiter for atmospheric noise, a switchable noise blanker to eliminate man-made noise and a crystal filter for superior adjacent-channel rejection. A black-out face conceals the signal/modulation and SWR/RF meters, receive and transmit LED indicators and digital readouts for



time and channel. Controls are provided for volume, channel, squelch, function, fine tuning, tone, RF gain, SWR calibration, modulation adjustment, noise blanker, ANL, PA, SWR bridge and power. Supplied with plug-in microphone. Jacks for optional telephone handset and remote or external speaker. Operates from 120/240 VAC, 50/60 Hz or 13.8 VDC. 4 3/4" x 11" x 16".—**Hy-Gain Electronics Corp.**, 8601 Northeast Highway Six, Lincoln, NE 68505.

Kris XL-23

Mobile unit featuring variable squelch, PA and ANL and internal-external speaker switches, illuminated S/R/F meter, transmit indicator light, external-meter jack, transmit-relay contacts and TVI filter adjustment. The receiver is a sensitive dual-conversion type with mechanical filter that re-



duces interference from adjacent channels. 8.375"D x 6.50"W x 2.25"H.—**Kris Inc.**, N144 W5660 Pioneer Rd., Cedarburg, WI 53012.

Lafayette Telsat SSB-100

A base station that has 69-channel capability—46 upper and lower-sideband channels as well as 23 standard AM channels. Features include two dual-function meters displaying RF output and "S" read-

ings plus SWR and % modulation readings. Both meters have external calibration controls that can be adjusted without external gear. Additional features include a delta tune, circuit, RF gain control, switchable ANL, a special



noise blanker, built-in range-boost circuit, automatic modulation control, variable squelch, PA and tape-recorder output. For 105–120 volt, 50/60 Hz AC operation, the SSB-100 is capable of emergency DC operation when used with the optional power cord and an external 12-volt battery.—**Lafayette Radio Electronics**, 111 Jericho Turnpike, Syosset, NY 11791.

MetroSound MS-357

23-channel mobile unit with pushbutton noise blanker, pushbutton local/DX switch,



variable squelch, special RF gain circuitry, plug-in dynamic mike with push-to-talk switch, dual-conversion receiver, pushbutton ANL switch, pushbutton PA/CB selector, S/PWR meter, receive/modulation lights, external speaker and PA jacks. 6 1/2"W x 2"H x 8 1/2"D. 12 VDC, negative or positive ground.—**MetroSound**, 11144 Weddington St., North Hollywood, CA 91601.

Midland 13-882C

Deluxe full-power 23-channel mobile unit with both switchable ANL and noise blanker. The transmitter provides a maximum of 4 watts RF power output with high-level modulation for maximum talk power. The dual-conversion receiver has a tuned RF stage for good sensitivity and front-end selec-



tivity. The advanced PLL synthesizer uses only three crystals. A warning light shows antenna mismatch or failure.

Controls include on-off/volume, variable squelch, PA, delta tune, channel selector, noise blanker, ANL, external CB speaker jack, S/R/F meter and dynamic push-to-talk microphone. Power source 13.8 VDC, positive or negative ground. 2 1/4" x 6 3/8" x 7 7/8".—**Midland International, Communications Div.**, P.O. Box 19032, Kansas City, MO 64141

Motorola Mocat 2020

Full solid-state mobile transceivers with digital phase-locked-loop synthesizer that holds the receiver and trans-



mitter on frequency, a large illuminated S/R/F meter, positive or negative ground operation, LED digital channel indicator with dimmer control and a mounting bracket for under-dash or overhead installations. The transmitter features TVI filter, burn-out protection to prevent damage to the set if antenna is damaged or set is operated without antenna. Audio compression for maximum talk power and a stronger signal. The receiver has adjustable squelch, ANL with variable threshold, noise blanker and ceramic filters for improved adjacent-channel selectivity. 2.46 in. high, 7.24 in. wide and 9.4 in. deep.—**Motorola Inc.**, Communications Div., 1301 Algonquin Rd., Schamburg, IL 60172.

Nuvox TC-5020

Mobile unit supplied with all crystals for 23-channel opera-



tion. Has lighted S/R/F power meter, dual-conversion superhet with ceramic filter for superior selectivity, squelch control, ANL and 3 1/2" speaker. The four-stage transmitter is Class-B modulated and delivers a minimum of 3.8 watts RF output. 7 1/2"D x 4 3/8"W x 2"H.—**Nuvox Electronics Corp.**, 150 5th Ave., New York, NY 10011.

Pace CB 166

Mobile transceiver with synthesized 23-channel operation

made possible with only one crystal and an integrated circuit module containing a phase-locked loop (PLL) circuit. The dual-conversion



superhet receiver has tuned IF filters for immunity from adjacent-channel bleed-over. The narrow-band filters are also responsible for the added noise reduction. Features include S/RF meter, ANL control, switchable noise blanker, PA function, adjustable squelch and transmit and receive indicator lamps. Approximately 6 $\frac{5}{8}$ " \times 1 $\frac{7}{8}$ " \times 9".—**Pathcom Inc.**, 24-49 Frampton Ave., Harbor City, CA 90710.

Palomar Digicom 100
23-channel AM/SSB mobile unit with a unique programmable digital frequency synthesizer. There are two channel



selector knobs; one for each digit of the channel number. For example channel 13 would be selected by turning 1 on the left knob and 3 on the right knob. The synthesizer is programmable for any future increase in the number of channels authorized by the FCC. The transmitter is delivered in-operative for channels 24 through 99. Other unique features are a pre-emphasis noise blanker, full automatic RF gain control utilizing a PIN diode attenuator, source-injection JFET mixer to minimize cross-modulation, dual-made 8-pole crystal filter for superior selectivity on both AM and SSB, PIN-diode antenna switching and transmitter automatic level control (ALC). 13.5 VDC operation. 10 $\frac{1}{4}$ " \times 14 $\frac{1}{2}$ " \times 2 $\frac{1}{2}$ " \times 9".—**Palomar Electronics Corp.**, 665 Oppen St., Escondido, CA 92025.

Panasonic RJ-3200
Receives and transmits on all 23 channels with full 4-watt



output capability. A 3-position delta tune switch shifts the receiver frequency \pm 1 kHz. Also

included are switchable ANL, S/RF power meter, 2-step tone control, "on-the-air" LED indicator, modulation indicator, CB/PA switch and built-in speaker. Modulation percentage is 90% and power output is 4 watts with 6 mV at the mike input jack. Comes with dynamic mike, quick-release bracket, power plug and jacks for external and PA speakers.—**Matsushita Electric Corp. of America**, 50 Meadowlands Parkway, Secaucus, NJ 07094.

Pearce-Simpson Simba SSB
Base unit for AM and SSB operation providing maximum outputs of 4 watts RF on AM



and 12 watts PEP on either lower or upper sideband. Unique feature is a digital clock that sounds an alarm and turns on the set at a predetermined time. A variable pre-amp, built into the unit, allows you to set your modulation as you want it. A modulation meter keeps check on your operation. A desk mike is standard equipment. The Slide-O-Tune circuit lets you move the receive and transmit frequencies for best possible SSB communications. Among the other features are RF-type noise blanker, built-in 117 VAC/12 VDC power supply, S/RF/Modulation and SWR meter. 7 $\frac{3}{8}$ " \times 12" \times 15" \times 15".—**Pearce-Simpson, Div. of Gladding Corp.**, P.O. Box 520800, Biscayne Annex, Miami, FL 33152.

Ray Jefferson CB-711 Saturn
Designed for the boatsman, this unit operates on all 23 CB



channels and receives VHF/FM Weather I and Weather II. The receiver RF gain control eliminates nearby station override for sharper and clearer reception. The unit is solid-state with maximum permissible power output. Built-in meter measures signal strength and RF power output. Operates from any 12 VDC power source, is 7 $\frac{1}{2}$ " \times 3" \times 9" \times 9" and comes with power cord, universal mounting

bracket and push-to-talk microphone.—**Ray Jefferson**, Main and Cotton Sts., Philadelphia, PA 19127.

RCA 14T200
A solid-state mobile transceiver that uses a crystal frequency



synthesizer and comes ready for operation on all 23 channels. The transmitter features full 4 watts RF maximum output and automatic level control for correct modulation. The S/RF meter measures the strength of incoming signals and the relative RF power output level. An external CB speaker jack is provided so a separate speaker can be used in noisy areas such as truck cabs and in power boats. Delta tuning permits clear reception of signals that are slightly off frequency. 6 $\frac{1}{2}$ " \times 2 $\frac{1}{4}$ " \times 7 $\frac{3}{4}$ ". Power source 13.8 VDC, positive or negative ground.—**RCA, Distributor and Special Products Div.**, Cherry Hill Offices, Camden, NJ 08101.

Realistic Navaho TRC-57
Base unit for AM and SSB operation with FET's and IC's used in all key electronic cir-



cuits. The digital PLL circuit is accurate to within 100 Hz. A "Clarifier" (delta tune) is provided for best speech intelligibility on incoming signals. The receiver has a crystal-lattice filter for superior selectivity. The RF gain control permits sensitivity to be reduced to cut background noise in strong-signal areas. The built-in electronic digital clock operates on AC only. There are two meters on the panel, S/RF output and SWR. Operates from 120 VAC or 12 VDC positive or negative ground systems. 3 $\frac{7}{8}$ " \times 14 $\frac{7}{8}$ " \times 10 $\frac{1}{2}$ ".—**Radio Shack Stores** or catalog.

Robyn DG-30
23-channel mobile unit that converts quickly to base operation when plugged into the accessory SX-7 module containing a regulated 14-volt DC supply. Receiver is a dual-conversion superhet with switch-

able ANL and adjustable squelch and tone. Transmitter provides up to 4 watts RF out-



put and 100% modulation. Channel indicator is a two-digit 7-segment LED display. Power consumption 200 mA on standby, 1.5 amps on transmit with 100% modulation. Dimensions 2 $\frac{3}{32}$ " \times 6 $\frac{3}{4}$ " \times 7 $\frac{1}{32}$ " \times 7 $\frac{1}{32}$ ".—**Robyn International, Inc.**, P.O. Box 478, Rockford, IL 49341.

Regency CR-240
A mobile transceiver designed with marine use in mind. Its 4-watt RF output and 10-watt hailer/fog horn/alert horn help you get your message across while the receiver and ANL circuits ignore the most



stubborn noise and splatter. PLL controlled on all 23 channels. Includes illuminated S/RF meter, DX switch, delta tuning, high-cut tone control. Complete with mounting bracket, mike hanger and power cord. 12-VDC operation.—**Regency Electronics**, 7707 Redords St., Indianapolis, IN 46226.

Royce 1-662
Transceiver incorporates the manufacturer's Wireless chassis design. Each circuit module is automatically tuned and tested to strict computer programs. There are no wires con-



necting the modules. Each is mated with the master board by precision assembly techniques. The 1-662 features the Vol-U-Mike circuit which allows the volume to be controlled from the microphone or the front panel. Other features include the LED digital channel indicator with push-button dim/bright switch, PLL 23-channel operation, S/RF meter, dual-conversion receiver with tuned RF stage,

variable squelch control, LED transmit light and automatic modulation control. Receiver operation is enhanced by continuous RF gain control and ANL circuits, three ceramic filters and amplified AGC. Power 13.8 VDC, negative or positive ground.—**Royce Electronics Corp.**, 1746 Levee Rd., North Kansas City, MO 64116.

Rytl CBR-1800
Dual-conversion superheterodyne transceiver with frequency synthesis circuit to pro-



vide 23 crystal-controlled send and receive channels. Delta tuning (± 2 kHz) improves clarity when receiving stations that are not exactly on frequency. Features switchable ANL, CB/PA switch, S/RF power meter, modulation indicator and a low-threshold full-range squelch. The receiver incorporates a ceramic filter in the 455-kHz IF section for high adjacent-channel rejection and low-noise performance. Comes with push-to-talk dynamic mike, fused DC power cable and mobile mounting bracket.—**Rytl Electronics Corp.**, 328 N.W. 170th St., North Miami Beach, FL 33169.

SBE Console II, SBE-16CB
Full 23 channel synthesized transceiver that operates in the full-carrier AM mode as well as fully suppressed carrier, single-sideband mode, upper or



lower sideband. The Console II features proportional output meter, crystal lattice filter and single-conversion receiver for both AM and SSB. The equipment has internal provision for VOX (voice-operated relay) and the SBE-1NB noise blanker. An "ON THE AIR" lighted panel indicates when the transmitter is energized. The 3-function meter displays relative power output, receive "S" units and VSWR. Automatic load control (ALC) on SSB, modulation limiting and AGC are self-adjusting. The 117-volt AC power supply is built in. Set shifts automatically to 12-

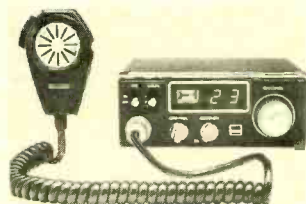
volt DC external source if AC power fails. Comes with plug-in dynamic mike with coiled cord but can be used with the 100X and 200X desk mikes. Current drain at 13.8 VDC: Squelched receive 306 mA, 2 watts audio output 600 mA. Transmit AM w/o modulation, 1.2 A; SSB, full PEP output, 2.2 A. 5" H \times 12" \times 10 1/4" D. The slip-on natural-grain wood cabinet shown in the photo is an extra-cost accessory.—**SBE**, 220 Airport Blvd., Watsonville, CA 95076.

Shakespeare GBS/5000
Solid-state high-performance transceiver operating in the AM and SSB modes for effective 69-channel coverage using frequency synthesizer. Features include squelch control, noise blanker, RF gain switch, S/RF power meter, PA speaker jack and single-conversion superhet on SSB and dual-



conversion superhet circuit on AM. Transmitter modulation employs filter method. Antenna impedance adjustable to 50 or 52 ohms. 9.37" W \times 2.7" H \times 10.58" D.—**Shakespeare Electronics Group**, P.O. Box 246, Columbia, SC 29202.

Sharp CB-800
The most noticeable feature in this mobile transceiver is LED digital channel indicator that



blinks on and off when set to channel 9. Other main features include a dual-conversion superhet receiver with variable squelch and ANL (series-gate type), PA and delta tuning. Frequency control is crystal synthesized. The delta tuning switch has three positions (+1 kHz, normal and -1 kHz) for pinpoint tuning of incoming signals. The automatic level control prevents over modulation and splatter. 5 3/4" W \times 2 1/4" H \times 7 7/8" D.—**Sharp Electronics Corp.**, Paramus, NJ 07652.

Siltronix Cherokee SSB-23A
Fully solid-state transceiver operates on 23 AM channels plus 46 channels in the SSB mode. A sharp IF filter insures excep-

tional tuning selectivity and rejection of adjacent-channel interference. Other features include delta tuning, PA amplifier, CB/PA selector and PA volume control, voice modulation indicator, adjustable squelch, variable RF gain con-



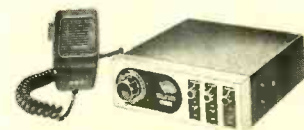
trol, automatic noise blanker and S meter. The rig is 2.5 inches high, 8 inches wide and 11 inches deep. Operates from 13.8-volt DC source and draws 250 mA to receive and 1.2 amps to transmit.—**Siltronix**, 330 Via El Centro, Oceanside, CA 92054.

Sonar FS-3023
This transceiver is unique in that it is the only one covered that is not all solid-state. It uses frequency-synthesized crystal control (12 crystals) to cover the 23 transmit and receive control frequencies. Features low-noise dual-purpose power supply for 120 VAC and 12 VDC operation, adjustable squelch, switchable gated-series type noise limiter and



built-in low-pass filter for TVI prevention. Draws 96 watts on 120 VAC, 7.0 amps from 12 VDC source. 11 3/4" W \times 5 3/4" H \times 11 3/4" D.—**Sonar Radio Corp.**, 3918 N 29th Ave., Hollywood, FL 33020.

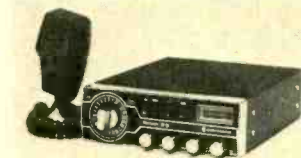
Sparkomatic CB-2023
Full-featured solid-state transceiver that is designed for mobile installations. Among its operating conveniences are delta tuning, variable squelch



control, variable intensity modulation light, ANL, switchable noise blanker, PA switch, separate output jacks for CB and PA speakers, operates from positive or negative ground supplies. 2 3/8" H \times 7" W \times 7 1/2" D.—**Sparkomatic Corp.**, Milford, PA 18337.

Standard Horizon 29
An all solid-state transistorized transceiver employing PLL

controlled synthesizer frequency control. Receiver is dual-conversion type with the first IF at 5.575 MHz and the



second IF at 455 kHz. Convenience features include switchable ANL and noise blanker, variable squelch, delta tune, RF gain control and "hailer" output jack for marine applications. Output to the hailer jack is 10 watts maximum with 15 mV input. Power supply 12 to 16 VDC. 8 1/2" L \times 6 1/8" W \times 2 1/4" H.—**Standard Communications Corp.**, Los Angeles, CA 90009.

Surveyor 2600
Fully transistorized receiver/transmitter designed for either



mobile or base service. It has a variety of features such as built-in PA amplifier, 3-position delta tune switch, ANL, S/RF power meter, on-air lamp and jacks for external speaker and PA speaker. Powered by 12 VDC negative or positive ground or appropriate AC/DC converter for fixed-station operation.—**Surveyor Manufacturing Corp.**, 29245 Stephenson Highway, Madison Heights, MI 48071.

Teaberry Racer "T"
23-channel mobile transceiver featuring PLL frequency synthesizer and delta tuning. Also includes ANL, PA function,



jack for external speaker, S/RF meter, modulation indicator and slide mounting bracket. 6 1/2" W \times 9 1/4" D \times 2 3/16" H.—**Teaberry Electronics Corp.**, 6330 Castleplace Drive, Indianapolis, IN 46250.

Trans-Comm 2701
Unique design incorporating a 23-channel transceiver, AM/FM/FM stereo radio and 8-track stereo player. Tape cartridge inserts through-the-dial. Three large speakers. All in a leather-tone, crush-resistant carrier. Complete with microphone.
Continued on page 92

build a digital countdown timer

A versatile countdown timer with keyboard programming that can control various external devices. The time interval can be programmed in increments of one second from one second to approx. 11,000 years

GEORGE R. BAUMGRAS



TIMERS OF ONE TYPE OR ANOTHER, ranging from the simple mechanically actuated switches to highly sophisticated electronic controls, are an essential part of modern technology. Industrial processes, laboratory experiments, photography, functional testing and similar operations represent only a few of the more serious applications, but we also find them useful in the household as appointment reminders, alarm clocks, kitchen aids and so on. Somewhere within this broad spectrum there are many requirements for a reasonably-priced programmable countdown timer that affords superior accuracy and versatility and is not too difficult to build.

Most of the recent circuits, although they may use the latest in integrated circuits, usually suffer from at least one of several drawbacks—precise intervals cannot be programmed, the time period available is somewhat limited, or calibration is frequently required and uncertain at best. The countdown timer described here eliminates all of these deficiencies, and for that reason is

called SPOT (Superior Programmable Optimized Timer). The prime objectives established for its development were: acceptable cost—about \$125 for parts, the use of readily available and generally well understood components, long-term accuracy without need for calibration and, of course, a wide range of uses. SPOT can be programmed, in increments of one second, for any period from one second to eight digits worth of hours (about 11,000 years), which is of course, far beyond any possible need but does eliminate one of the drawbacks mentioned. Assuming there will be diligent frequency monitoring by the local electric utility and there are no power failures, the total timing error for any period selected will be .17 seconds plus the pull-in time of the relay, both of which are known factors. On a percentage basis, this represents an error of about .3% for one minute, and correspondingly less for longer periods.

Operation

Using the timer is extremely simple—

the desired interval is entered manually via the keyboard in the same manner that a number is entered into a calculator. The ALARM and RELAY switches on the front panel are set for the desired operation and the START pushbutton is depressed—and that's it. In the prototype, the START pushbutton is labeled "+" for convenience. This pushbutton also enters a negative number into the calculator memory. At the end of the programmed time period, the alarm will sound if the ALARM pushbutton was depressed, and the relay will open or close depending on the position of the RELAY pushbutton.

The LED display continuously shows the remaining time in seconds, minutes and the last significant hour as it is being programmed in, and throughout the timing period. Most entries will be for less than 10 hours which is why only 5 digits are displayed. However, if there are 6 or more digits stored in the memory, a small LED lamp will light to indicate that there may have been a keyboard error or that there are hours in the memory.

The digits may be entered into the program in any convenient form, in some cases eliminating the need to convert seconds into minutes or minutes into hours. For example, 90 seconds is equal to 1 minute and 30 seconds. This time period can be entered in either form. An entry of 9 hours, 99 minutes and 99 seconds is therefore exactly the same amount of time as if we had entered 10 hours, 40 minutes and 39 seconds. The display will eventually revert to normal readings. In the latter example, at the end of 40 minutes and 40 seconds it would read 9:59:59 and continue to read in "clock" time from thereon.

The timer described here contains one modification that the original does not. This modification permits the timer to emit an audible "beep" at one-second

intervals. This feature can be inhibited by a rear-panel MUTE switch. The countdown timer (see Fig. 1) consists

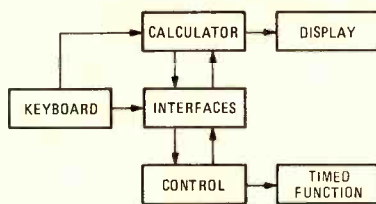


FIG. 1—FUNCTIONAL BLOCKS of the countdown timer are shown.

of a calculator circuit, control circuit, interface IC, keyboard display and timed function. The calculator circuit (see Fig. 2) closely resembles the circuit specified for the CT-5001 calculator IC. The difference being that it is

tailored to perform only add and subtract arithmetic, and the \div , \times , minus sign, overflow decimal point, and 6 of the digit outputs have no function. This particular IC was selected because, in addition to being available at low cost (under \$4), it can handle a diode-encoded keyboard system and readily accepts external commands at a suitable rate.

The control circuit (see Fig. 3) has many functions, performing as a time-base, decimal-to-clock converter, electronic keyboard simulator and zero balance detector in addition to manipulating the alarm and relay functions. The 7400 series TTL logic IC's were selected as a practical alternative, again because they are available at low prices and are not particularly difficult to design a circuit around. The interface

PARTS LIST CALCULATOR AND KEYBOARD

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

- R1-R14—100,000 ohms
- R15—150,000 ohms
- R16-R27—4700 ohms
- R28-R31—27,000 ohms
- R32—5100 ohms
- R33—2200 ohms
- R34-R46—12,000 ohms
- R47—1000 ohms
- R48—10,000 ohms

- R49—680 ohms
- R50, R51—470 ohms
- R52-R58—47 ohms
- R59—330 ohms
- C1—10- μ F, 25 volt, electrolytic
- C2, C3—470-pF disc
- C3, C4—220-pF, 5%, disc
- D1-D8—1N4001
- D9-D29—1N914 or 1N4148
- LED 1—discrete LED, 0.16-inch

- maximum diameter
- Q1-Q26—MPS6563 or equal, TO-92 case
- Q27-Q41—2N2222, 2N3904, or equal, TO-92 case
- IC1—CT5001 calculator IC
- MISC.—Keyboard switches with "0" through "9", "CL" and "+ =" legends (Oak Industries, Inc., Switch Division, Crystal Lake, IL 60014. Switch No. 415), 40-pin socket for DIP.

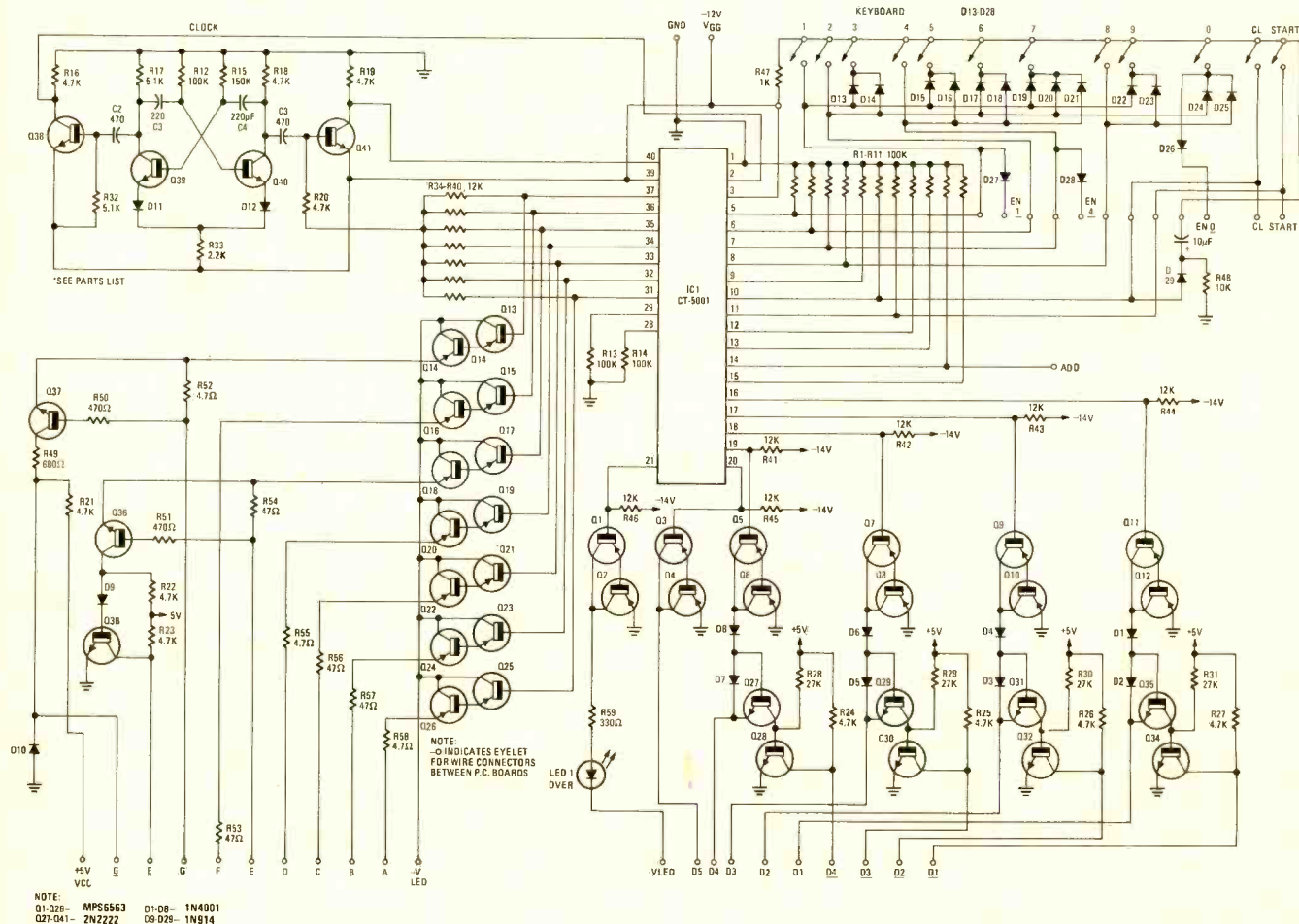


FIG. 2—CALCULATOR AND KEYBOARD circuitry is built around CT-5001 integrated circuit.

PARTS LIST ALARM CIRCUIT

All resistors are 1/4-watt, 5%, unless noted.

- R1—10,000 ohm
- R2—1 megohm
- R3, R5—13,000 ohm
- R4—50,000-ohm trimmer
- R6—100 ohm
- R7—6800 ohm
- R8—3300 ohm
- R9—4700 ohm
- C1—0.47- μ F disc
- C2—.005- μ F disc
- C3—20- μ F, 25V, electrolytic
- D1-D3—1N4000
- Q1, Q2—2N2222
- S4—SPST switch
- IC1, IC2—555 timer
- SPKR—3-inch, 4-8 ohm, speaker

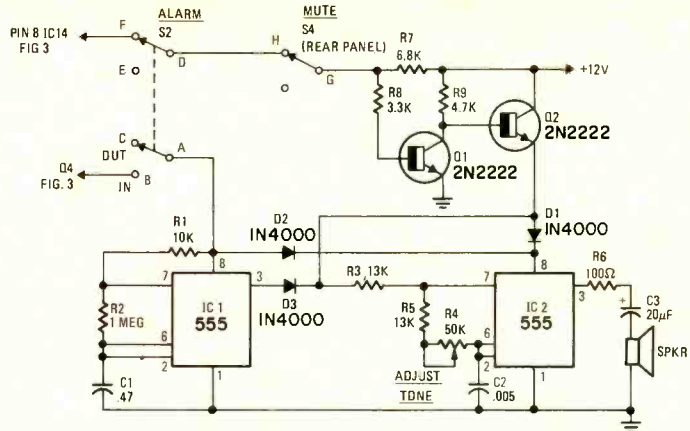


FIG. 5—ALARM CIRCUIT emits an audible alarm at the end of the programmed interval. Mute switch inhibits alarm from emitting an audible "beep" once-every-second during the programmed interval.

PARTS LIST CONTROL CIRCUIT

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

- R1-R3—300 ohm
- R4—10,000 ohm
- R5—33,000 ohm
- R6, R7—1000 ohm
- R8, R9—12,000 ohm
- R10-R19—18,000 ohm
- R20-R24—4700 ohm
- R25—470 ohm
- R26—470 ohm, 1/2 watt

- R27-R29—3300 ohm
- R30—2700 ohm
- C1—4.7- μ F, 20V, electrolytic
- C2, C3—10- μ F, 20V, electrolytic
- C4—2.2- μ F, 20V, electrolytic
- C5—0.1- μ F, 50V, disc
- C6—0.47- μ F, 50V disc
- Q1-Q3, Q5—2N2222, 2N3904, or equal
- Q4—2N5296 or equal
- Q6-Q13—MPS6563 or equal
- D1-D8—1N914 or 1N4148

- D9—1N4001
- IC1, IC2—7420
- IC3, IC4, IC7, IC13, IC15—7400
- IC5, IC8, IC9, IC14, IC16—7490
- IC6—7442
- IC10, IC11—7404
- IC12—7410
- IC17—7492
- S1, S2—DPDT switch, push-push type (Radio Shack)
- RY1—DPDT, 12VDC coil, 10A contacts

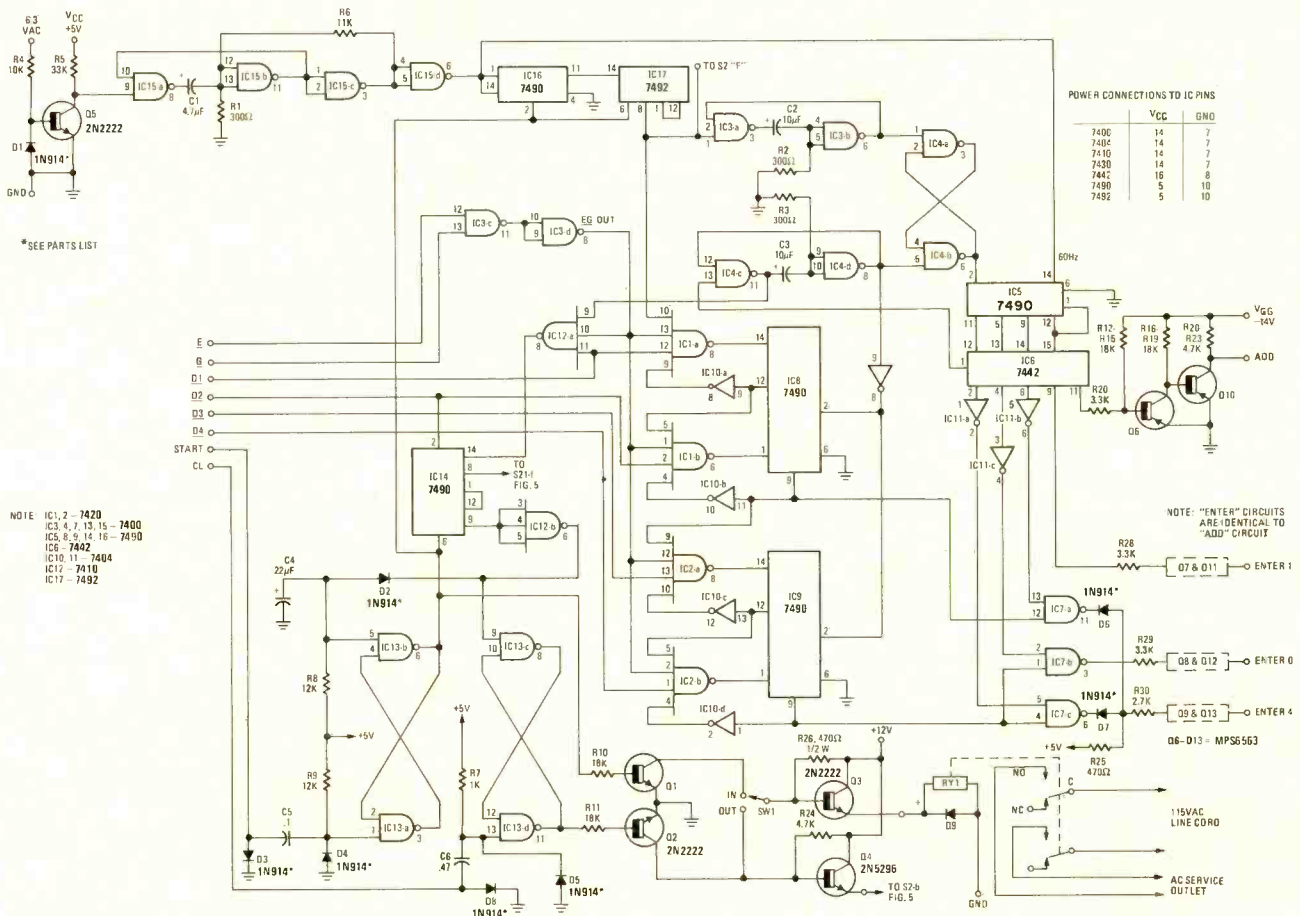


FIG. 3—CONTROL CIRCUITRY contains the timebase, decimal-to-clock converter, electronic keyboard simulator and zero-balance detector.

components are required because of the difference in logic levels and polarity between the two systems. The display circuit is the conventional multiplexed common anode type, plus the addition of the colon. The LED displays must be as specified or very similar because the segment current (20 mA average) is used to trigger the interface circuits.

The power supply circuit shown in Fig. 4 was designed around four IC voltage regulators, all of which operate well under their specified ratings. The LED voltage from IC4 can be varied over a -7 to -10 volt range by means of the voltage divider R1, Q1 and the trimmer R3. Trimmer R3 is used to vary the display brightness over a narrow range and should initially be set at minimum. At some setting of R3, the display will be at or near the specified brightness and the current through the segments will be within the limits required to operate the interfaces.

The alarm circuit shown in Fig. 5 emits a hee-haw sound. An assortment of sounds is possible, ranging from whistles to bird calls, or a commercial unit such as a Sonalert could be used.

Next month, the article continues with the construction details and the circuit board and component layouts.

PARTS LIST DISPLAY BOARD

IN1-IN3—MAN6A, 7-segment, 0.6-inch high
 IN4-IN5—MAN 64A, 7-segment, 0.4-inch high
 LED1, LED2—discrete LED's, 0.16-inch maximum diameter
 R1—120 to 330 ohms, ¼-watt (value required to suit LED's selected)

R1—4700 ohm, ¼ W, 10%
 R2—6800 ohm, ¼ W, 10%
 R3—5000-ohm trimmer
 C1, C2—1000- μ F, 16V, electrolytic
 C3, C4—1000- μ F, 35V, electrolytic
 C5-C8—220- μ F, 25V, electrolytic
 C9—0.1- μ F, 50V, disc
 D1-D6—1N4001 or equal
 Q1—2N2222 or equal

IC1—LM309K, +5V regulator
 IC2—LM340T, +12V regulator
 IC3—SD320, -15V regulator
 IC4—SD320, -5V regulator
 S3—SPDT switch, push-push type (use DPDT, Radio Shack or equal.)
 T1—117V primary, 12.6V @ 1.2A secondary

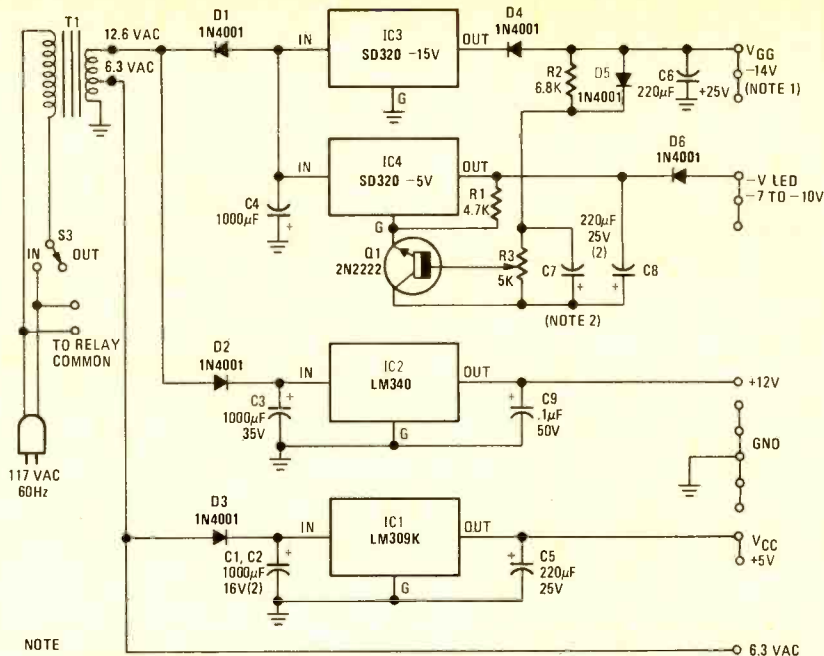
PURPLE POEM

*I think that I shall never see
 Anything drive me up my tree
 Quite as fast as a balky TV.
 This occurred, balky, blind, TV
 Is a black-and-white Sears model 528.70623.
 The sound is O.K. clear and nice,
 The screen has a raster but blank as ice.
 From Sams Photofacts 1134,
 I dove into the circuit to give it whatfor.
 An audio signal at the video detect
 Produced bars on the screen as sure as heck.
 The volts in the IF I checked just for fun
 For the sound from the speaker said they weren't the ones.
 I've checked by every known means
 All components from IF to picture screen.
 I'd appreciate help if you don't mind my rhyme
 Before I completely go out of my mind.—D.G., West Chester, PA.*

If I were you, the AGC
 I'd check as closely as can be.
 For this if dead can well suffice
 To make the screen as blank as ice.
 It kills the picture, as you see,
 Tho' sound can often sneak home free!

FLYBACK REPLACEMENT

I can't locate a replacement flyback for this Setchell-



- NOTE
1. THE CT500, IC MAY NOT OPERATE PROPERLY AT LESS THAN -15V, HOWEVER, VGG SHOULD NOT BE MORE THAN -14V. ADD A DIODE IN SERIES WITH D4 IF VGG IS HIGHER THAN -14V AT 40 MA.
 2. SET R3 INITIALLY FOR MINIMUM LED VOLTAGE. AFTER ASSEMBLY, INCREASE TO ADEQUATE LED BRIGHTNESS, APPROXIMATELY -9V. IF -V LED IS TOO HIGH OR TOO LOW, INTERFACE CIRCUITS FOR SEGMENTS E AND G WILL BE ADVERSELY AFFECTED.

FIG. 4—POWER-SUPPLY CIRCUIT uses IC regulators to derive the various voltages.

PARTS LIST POWER SUPPLY

Carlson black-and-white TV, and the company is out of business. Do you know where I could find one?—G.P., Governor's Island, NY.

I don't, but my Triad catalogue does! It's listed in there. A Triad D-638 flyback will replace the original TWF-110X.

THIN WHITE LINE

Read your Clinic for years. I laughed a little but I also learned a lot. Now I need help. Magnavox T915 set with everything fine except for a thin white line in the center of the picture (and raster). Tried everything I can think of with no results.—W.P., Columbus, OH.

If my memory serves me (which it usually doesn't), this is due to an open .0082 μ F capacitor connected from the hot terminal of the yoke socket to ground on the horizontal yoke connection. Be sure to use one with at least a 1 kV rating, there's a pretty good pulse voltage at this point.

(Field Feedback: Your memory is good! That was it.)

HUM PROBLEM

If you have audio hum in a Truetone GEC4617A-67 color TV, relocate the ground lead from the volume control. It's now connected to the negative terminal of filter capacitor C904. Move this to the grounded terminal of the terminal strip located above and to the left of C904. This is directly to the metal chassis. (Thanks to a Truetone factory service note.)

CLASS G

High Efficiency HI-FI

Amplifier

A new high-efficiency audio amplifier circuit that can reduce the size, weight and cost of future hi-fi amplifiers. Here's an inside look at the theory and circuitry



SOME TIME AGO, THE AUDIO INDUSTRY WAS startled by the announcement that Infinity Systems, Inc. (best known for their loud-speaker systems) had come up with a more efficient way to build audio power amplifiers. They called the technique "Class D" amplification. Briefly, the system involves the use of high-frequency (in excess of 200 kHz) pulses that are first modulated by the audio signal to be amplified and then decoded by an integrating circuit that restores the audio envelope or waveshape. Since the duty cycle of each high-frequency pulse is relatively short, conduction of the output transistors is such that heat dissipation is a fraction of that encountered with more conventional Class-B circuits and overall efficiency (at least when the amplifier delivers close to its maximum power output) is high. Thus far, the product has not reached the consumer market but Infinity claims that all production problems have been licked and that the Class D, or "switching" amplifier will soon be a commercial reality.

In the meanwhile, other companies have been working on improving the efficiency of audio amplifiers. This work is so widespread, in fact, that the Hitachi Company of Japan (whose approach to better amplifier efficiency is the subject of this article) has had to change the name of their invention from Class E (which they had first proposed to use) all the way to Class G, the designation they currently plan to assign to the new and innovative circuitry we will describe here.

Class-B efficiency

When a Class-B audio amplifier delivers its maximum rated power, its efficiency (power delivered to the load divided by power used by the amplifier) is quite high—70% or more. Studies show, however, that under music listening conditions, an

LEN FELDMAN*
CONTRIBUTING HI-FI EDITOR

audio amplifier is called upon to deliver full or nearly full output for only a very small fraction of the time it is operating. Figure 1 represents the results of studies

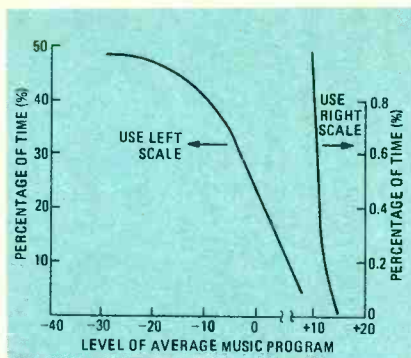


FIG. 1—AVERAGE MUSIC PROGRAM LEVEL expressed in terms of percentage of total time at which that level exists.

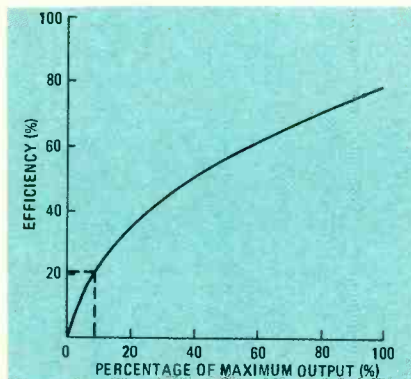


FIG. 2—CLASS-B EFFICIENCY at various percentages of maximum output.

of a variety of musical selections. It shows that while music may reach peaks of +14 dB (referred to a 0-dB average power level), for much of the time, actual power levels are even well below the 0-dB average level. In fact, for nearly 50% of the time (Fig. 1, left hand vertical scale), power levels are some 30-dB below the 0-dB point, while a +10-dB level is reached for only 0.7% (Fig. 1, right hand vertical scale) of the time. Even allowing for highly compressed music (in which dynamic range is restricted and music is therefore more uniformly "loud") and assuming only a 10-dB crest-factor (average power is 10% of peak power), we can see from the curve of Fig. 2 (efficiency of a Class-B circuit versus the ratio of actual output to designed maximum output) that for most of the time that an amplifier of this type is reproducing music, it is operating at approximately 20% efficiency.

The Class-G idea

Hitachi's invention is designed to enable amplifiers to operate more efficiently over more of their operating range, based upon the way in which they are called upon to actually amplify musical signals. The simple diagram of Fig. 3 illustrates the Class-G idea. The input voltage, V_{IN} , is the signal to be amplified and it is ap-

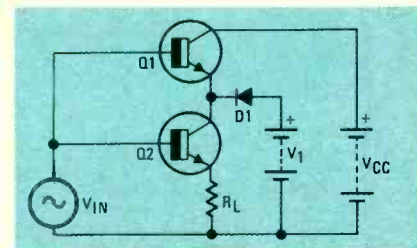


FIG. 3—BASIC CLASS-G amplifier.

plied to the base of transistors Q1 and Q2. A load resistor, R_L , is connected to the emitter of Q1. Supply voltage V_1 is applied through diode D1 to the collector Q1 and the emitter of Q2. The collector of Q2 is connected to a second supply voltage V_{cc} that is higher than supply voltage V_1 .

Operation of the circuit is as follows: If input signal voltage V_{in} is lower than V_1 , Q2 is reverse biased between its base and its emitter and is therefore cut off. Current flowing through load R_L is supplied from V_1 through diode D1. Under these conditions, the instantaneous efficiency of the circuit is given as: Efficiency (%) = V_{in}/V_1 . If the signal voltage increases to a value beyond that of V_1 (but less than V_{cc}), transistor Q2 becomes forward biased and is turned on. Current flowing through load R_L is now supplied from the second, higher supply-voltage V_{cc} through Q2. If we neglect saturation voltage between collector and emitter of Q2 (assuming it is sufficiently low), the instantaneous efficiency of the circuit is given as: Efficiency (%) = V_{in}/V_{cc} .

Figure 4 represents the two efficiency

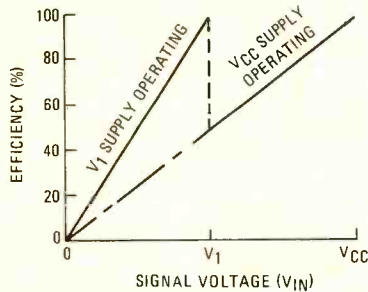


FIG. 4—INCREASED EFFICIENCY results from two-level power-supply system in Class-G amplifier.

levels of the system and the vertical line represents the point at which the supply voltage transition takes place. Thus, in the lower ranges of input signal voltage, the efficiency of this circuit is improved considerably and the amount of heat generated in the output transistor is reduced compared with conventional Class-B amplifiers. Referring once more to Fig. 3, it should be noted that diode D1 also serves to prevent current flowing from the higher supply-voltage source (V_{cc}) from flowing back into the first power source V_1 .

The thermal efficiency of the system will, of course, depend upon the choice of the two power-supply operating voltages.

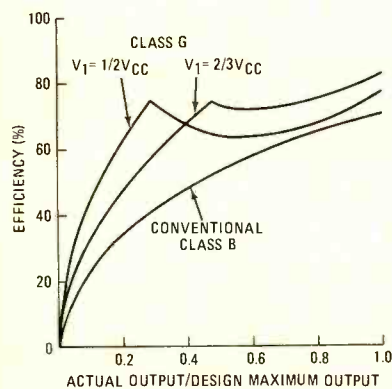


FIG. 5—EFFICIENCY OF CLASS-G amplifier depends upon V_1/V_{cc} ratio.

Figure 5 compares the efficiency level at various outputs (expressed as a fraction of maximum design output) for two different Class-G designs having different V_1/V_{cc} ratios as compared with conventional Class-B operation. Regardless of whether V_1 is half or two thirds as great as V_{cc} , we see that efficiency is far greater than that of Class-B operation, particularly at lower output levels where, as we have seen earlier, the amplifier is likely to operate most of the time when reproducing actual music programs.

Along with improvement in efficiency comes reduced internal heat dissipation of the output devices used in the Class-G approach. Figure 6 illustrates this point for

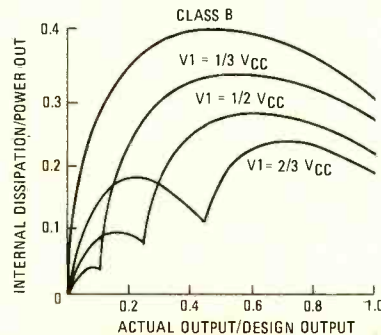


FIG. 6—HEAT DISSIPATION for various V_1/V_{cc} ratios.

various V_1/V_{cc} ratios. Internal dissipation is plotted as a fraction of maximum power output on the vertical axis, while the ratio of output power to designed maximum power is shown along the horizontal axis of the graph. As expected, internal dissipation is lower at all operating conditions for Class-G compared with conventional Class-B operation.

Distortion

Closer examination of Fig. 3 points up certain problems that exist in the basic concept of Class G. In the simple form

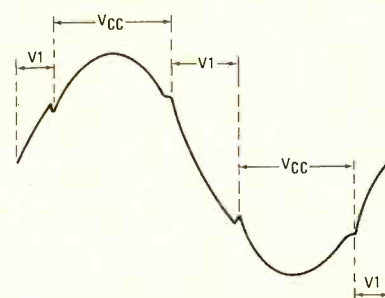


FIG. 7—DISTORTION that would result from simplest form of Class-G circuit.

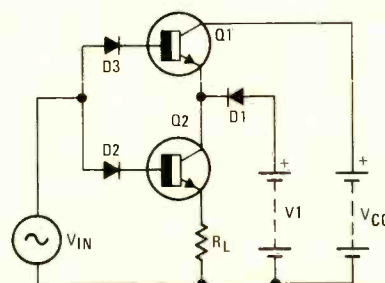


FIG. 8—SWITCHOVER DISTORTION is reduced by the addition of diode D2.

of the circuit shown, Q2 is not turned on until input signal voltage exceeds the collector voltage of Q1 by an amount equal to the base-emitter voltage V_{be} of Q2. Thus, when the value of input signal voltage V_{in} is in the range between V_1 and $V_1 + V_{be}$, Q1 is already saturated (between collector and emitter) before conduction of Q2 begins. This results in a distorted output waveform signal as shown in Fig. 7.

To prevent this form of distortion during the changeover from one power supply level to the other, the circuit must be modified so that saturation of Q1 does not occur until Q2 is turned on. This is accomplished by adding another diode, D2, as shown in the simplified schematic of Fig. 8. Now, when V_1 is less than the input signal, the voltage between the collector and the emitter of Q1 is lower than the saturation level by an amount equal to the threshold value of D2 and thus Q1 remains unsaturated. Diode D2 may be a Zener diode or even a resistor since it is only required to maintain a voltage difference equal to the V_{be} voltage of Q2. Still another diode, D3, is added to the basic circuit as shown in Fig. 7. Since a reverse bias is applied between the base and emitter of Q2 when the signal voltage is lower than supply voltage V_1 , the base-emitter junction of Q2 must be able to stand a reverse voltage higher than V_1 . Since the maximum inverse voltage of the base-emitter circuit of most transistors is generally low, diode D3 is provided to prevent the flow of reverse current through the base-emitter junction of Q2, thus protecting this junction against the reverse voltage.

Push-Pull operation

Figure 9 shows the required configura-

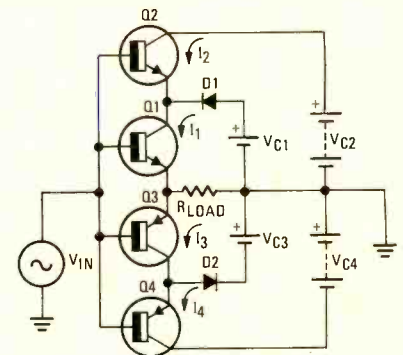


FIG. 9—PUSH-PULL Class-G amplifier.

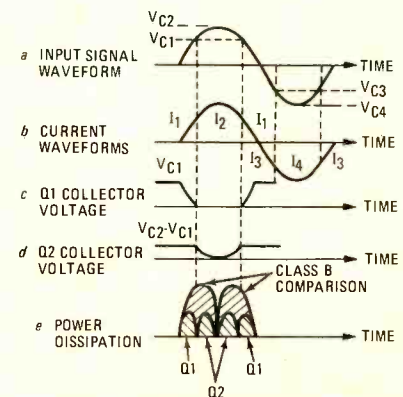


FIG. 10—VOLTAGE AND CURRENT relationships in push-pull Class-G amplifier.

tion for a push-pull output circuit. Diodes D2 and D3 shown in Fig. 8 have been omitted for the sake of clarity. Two values of positive and negative supply voltages are required and transistors Q3 and Q4 operate at opposite polarity voltages compared with Q1 and Q2 to form the familiar complementary configuration (NPN and PNP pairs are used). Fig. 10-a shows the input signal waveform, together with the voltage levels V_{C1} and V_{C2} (for the first half of the cycle) and V_{C3} and V_{C4} for the opposite half of the signal waveform. Fig. 10-b shows the current waveforms resulting from the four supply-voltages (two voltages for each polarity). Fig. 10-c represents that portion of the output waveform powered by the lower-level supply voltage V_{C1} , while Fig. 10-d shows the contribution of output waveform powered by the higher supply voltage V_{C2} . Finally, Fig. 10-e shows a comparison of power losses (or dissipation) in Q1 and Q2 (for the half cycle shown) as compared with the power loss that would take place in a conventional Class-B configuration.

Practical Class-G circuit

The first product which Hitachi intends to introduce that will incorporate the Class-G principle is their Model SR-903 AM/FM stereo receiver, pictured in Fig. 11. By way of illustrating the improvement



FIG. 11—HITACHI SR-903 stereo receiver uses Class-G output circuit.



FIG. 12—HITACHI HMA-8300 power amplifier will be introduced in the near future and will contain Class-G output circuitry.

in efficiency attained because of this new output circuit, Dr. Gentaro Miyazaki of Hitachi Consumer Products Research Center was kind enough to supply me with some advance comparisons between this 75 watts-per-channel receiver (from 20-Hz to 20-kHz, 8-ohm loads, 0.3% maximum THD) and a typical Class-B unit having the same FTC power rating. The SR-903 will weigh in at 28.7 lbs as against 40.8 lbs for the Class-B unit. Under "music power" measurement conditions (abandoned by the industry since the advent of the FTC power rule, but nevertheless indicative of the short-term power output capability of an amplifier), the SR-903 will deliver 160 watts-per-channel

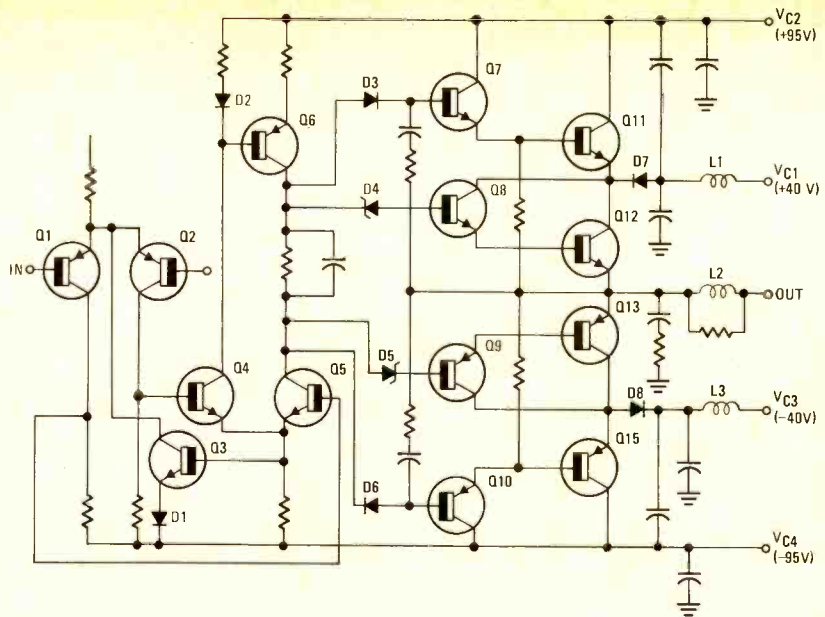


FIG. 13—OUTPUT CIRCUIT of the Hitachi HMA-8300 power amplifier.

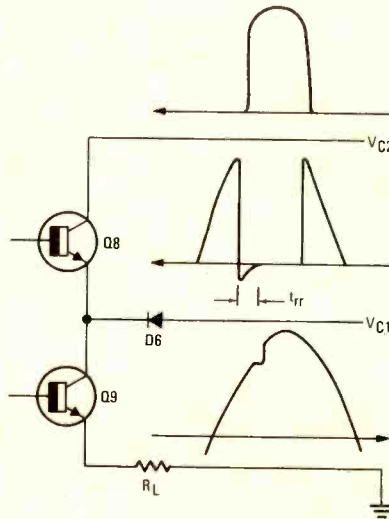


FIG. 14—DISTORTION resulting from storage time delay in Class-G circuit.

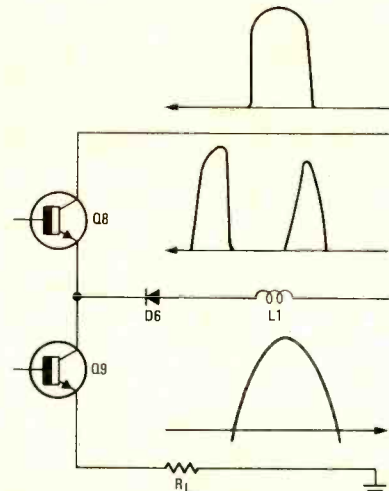


FIG. 15—DISTORTION resulting from storage time delay is reduced by the addition of L1 to circuit.

as opposed to 110 watts-per-channel for the Class-B unit against which it was compared.

Hitachi plans to introduce many more units employing Class-G circuitry. Typical of these will be the stereo power amplifier, model HMA-8300, pictured in Fig. 12. A circuit of the power output stages of this unit is shown in the schematic diagram of Fig. 13. In addition to the circuit elements already described, we see one more refinement that should be mentioned. Note that in series with supply voltages V_{C1} and V_{C3} are small inductors L1 and L3. Because transistors have finite turn-on and turn-off times, a form of distortion can be introduced to the output waveform as illustrated in the waveforms of Fig. 14. This form of distortion is due to an effect known as storage time-delay and is quite independent of the base-emitter V_{be} voltage discussed earlier. To counteract this effect (and to further reduce output waveform distortion in Class-G circuits), a coil is added in series with diode D6 shown in the improved circuit of Fig. 15.

The effect of storage delay would be

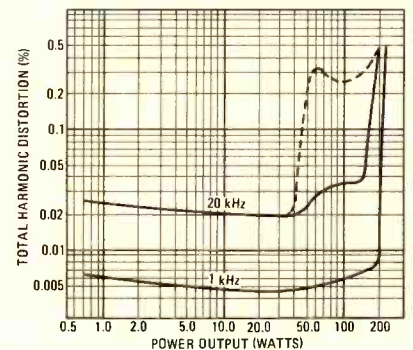


FIG. 16—THD VS. POWER OUTPUT at 20-kHz before and after addition of L1 (Fig. 15) in circuit. Distortion characteristic at 1-kHz is also shown.

particularly noticeable when reproducing high frequencies, since the time required for amplification of a single cycle of a 20 kHz signal is only 50 microseconds. The curves of distortion versus output measured at 1 kHz and 20 kHz for a typical Class-G circuit shows clearly that without

(continued on page 87)

MIND POWER: ALPHA

THANKS TO MODERN ELECTRONIC TECHNOLOGY, the idea that your brainwaves can control a video display on a TV screen is no longer in the realm of science fiction. Mindpower: Alpha makes use of state-of-the-art techniques and components to make that dream of science-fiction writers into concrete *fact!* Whether you build it just to find out if you have the *mindpower* to control the display on your TV set screen, or because you have a serious interest in experimenting with altered states of consciousness and the alluring prospects of achieving more complete control of the brain-body matrix, you'll find Mindpower: Alpha a fascinating instrument unlike any other you've ever seen!

How the circuit works

Figure 1 shows the complete schematic diagram of the Mindpower: Alpha circuit. The sweep voltages required to control the picture tube's electron-beam position are derived from the 60-Hz AC line. The 60-Hz sinusoidal voltage appearing across the secondary of transformer T1 is applied to the base-emitter junction of Q9, driving this stage into saturation on each peak of the sinewave. The square-wave output of Q9 provides the input signal to the CMOS phase-locked loop (IC1) and to Q4.

IC1 consists of a phase comparator and a voltage-controlled oscillator (VCO) connected through a low-pass filter (R49, C19, R50, C20) to form a closed-loop frequency feedback system. The center frequency of the VCO is nominally 15.36 kilohertz and is determined by the value of C21, R47 and R48. The output of the VCO is applied to a CMOS ripple counter/divider (IC21) that divides the VCO center-frequency to 60 Hz. The output of IC21 is connected to one input of the phase comparator; the squared 60 Hz input from Q9 is the other input. So long as the two inputs are exactly the same, the phase comparator output is zero, signifying that the 15.36 kHz oscillator is precisely on-frequency. If the VCO tends to drift, the comparator develops a proportional error voltage output that precisely corrects the VCO frequency. In this way, the horizontal sweep-frequency is maintained in a phase-locked relationship to the 60 Hz line frequency.

The 15.36 kHz output of IC1 is differentiated by C24 and R63, and is applied to Q3 to generate 9- μ s horizontal-sync pulses. These pulses are summed by Q1 and Q2, and applied to the video driver Q12. Meanwhile, the output pulses of Q3 are also applied as control pulses to horizontal discharge switch Q10 to determine the flyback interval of the horizontal ramp generator IC13. The ramp generator is a linear integrator whose period is determined by C25 and R66. The output of

Part II. Build this biofeedback device that displays the presence of alpha waves on a TV screen. You can use it to learn how to control your alpha waves and gain from the benefit of the relaxation that comes with it

NOTE

Mindpower: Alpha is an intriguing device for entertainment and experimentation in video biofeedback. It is not a therapeutic instrument, neither is it suggested as a cure for individuals suffering from psychological or physiological disorders.

IC13 rises linearly from 0 to 10 volts in a period of approximately 65 μ s. Each horizontal scan line is written on the picture tube during one such period. At the end of this period, the sync pulse input from Q3 turns on Q10 for a period of approximately 9 μ s., discharging C25 and instantaneously resetting the integrator to zero. (During this brief period, the spot flies back to the left of the screen to commence a new line.) The horizontal ramp output of IC13 thus consists of an endless series of linear sawtooth waves of 65 μ s duration, separated by 9- μ s flyback periods during which the output is 0 volts. These are applied to the inputs of horizontal comparators IC5 and IC8.

The vertical sweep is considerably simpler than the horizontal sweep because the vertical sweep frequency is synonymous with the 60 Hz AC power line frequency. Thus, the squared output of Q9 is simply differentiated by C22, R51 and R52, and is applied to Q4. Transistor Q4 produces a pulse of approximately 1.2 ms duration every 16.7 ms. These vertical sync pulses are summed with the horizontal sync pulses by Q1 and Q2.

The vertical sync pulses also control the period of the vertical ramp generator IC16 by causing Q11 to discharge C23 every 16.7 ms. Operation of IC16 as a linear integrator is identical to that described for IC13. Thus, IC16 produces an endless series of linear sawtooth waves of 1/60th second duration, separated by 1.2 ms periods during which the output is zero volts. These are applied to the inputs of horizontal comparators IC9 and IC12.

Display logic and video driver

The function of the display logic is to detect the points on each line written on the picture-tube face where the electron beam is to be turned-on and turned-off, so as to create the white rectangle (beam on), on the dark field (beam off). This requires four detect-points for the hori-

zontal and four detect-points for the vertical. Also, because the size of the rectangle must be controllable, the detect-points of all comparators must be proportionally variable. However, the detect-points must remain in-ratio with one another so as not to distort the rectangle as its size changes.

For simplicity, we will first look at the vertical comparators, IC9 and IC12. These are LM311-types that feature very closely controlled characteristics making them well-suited to this application. The waveforms associated with the comparators is shown in Fig. 2.

The vertical ramp output of IC16 is applied to the inverting inputs of IC9 and IC11, and to the non-inverting inputs of IC10 and IC12. The non-inverting input of IC11 is biased from the positive 15-volt supply through R76, and the non-inverting input of IC9 is biased a constant 0.6 volts less positive, by the forward voltage drop across D9. Also, the inverting input of IC12 is biased from the negative 15-volt supply through R44, and the inverting input of IC10 is biased a constant 0.6 volts less negative by the forward voltage drop across D10.

The comparators receive two vertical display control inputs, consisting of the voltage output of IC18 (which is a fixed voltage in mode 1, under quiescent conditions; or, a 0-5 volt ramp voltage in mode 2), and an inverted form of the IC18 output, obtained from IC17. These two vertical control inputs are respectively applied to the non-inverting input of IC9 and to the inverting input of IC10.

Looking now at the states of the vertical comparators, as the vertical sweep ramp starts to rise from zero, IC9 and IC11 outputs are at a logic 1 level. The output of IC10 and IC12 are at logic 0 level. As the sweep ramp rises (assuming that the circuit is operating in mode 1, where the vertical display control signals

text continues on page 52

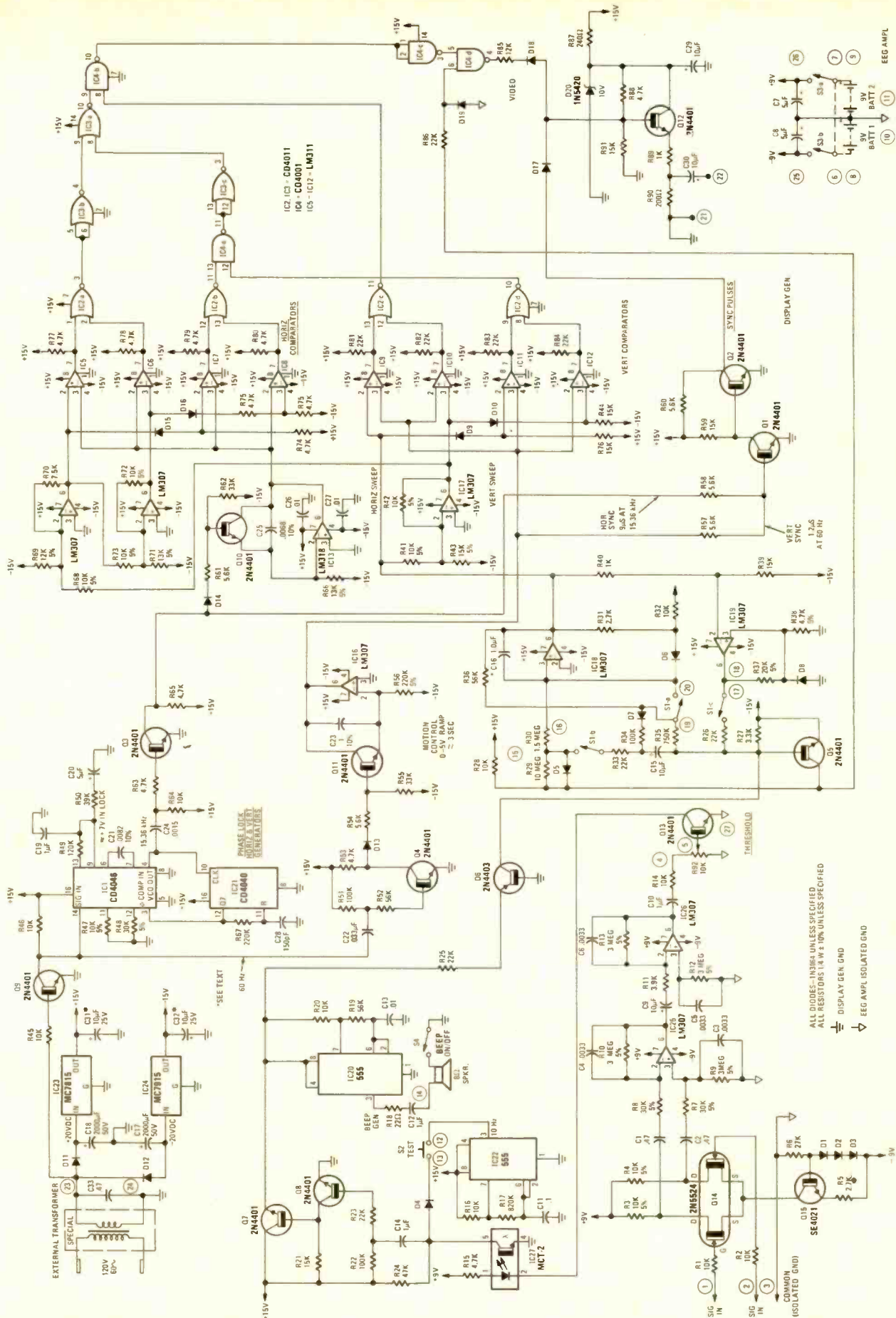


FIG. 1—COMPLETE SCHEMATIC DIAGRAM OF MINDPOWER: ALPHA. The EEG amplifier in the front-end is battery powered and optically isolated. Thus, the user is safely isolated from the AC power line.

Part of the price we pay for the comfort and convenience of living in an advanced, industrialized society is the acceptance of a high degree of *anxiety and stress*. Sociologists, psychiatrists, and medical investigators agree that the forces of our complex, technologic, and ever-changing society hammer away incessantly on the individual. Shock waves of change and new crisis wash over us so rapidly that, scarcely have we prepared ourselves to deal with a problem, when suddenly, it mutates or disappears, leaving us confronted by a new threat. In rapid succession, we find ourselves buffeted by an Energy Crisis, Inflation, Recession, Shortages, Lay-offs, Corruption in High Government, and the countless smaller forces in our daily lives which keep us constantly "on-edge" and defensively anxious.

This anxiety and the stress of being always ready to ward off the blow of some new crises can have fearfully great effects upon our health and our ability to lead a "normal" life. Extreme, prolonged stress is believed to be linked to high blood pressure, increased incidence of heart attacks and strokes, and serious deterioration of important organs of the body. What's more, constant stress and anxiety exert a debilitating effect on the *mind* as well as the body. That "always tired" feeling—the inability to hold a problem in focus and think through a solution—both may originate from *constant stress!*

Small wonder that Transcendental Meditation (TM) has found so many new converts in our overwrought society. Combining the mysticism of the East with varied exercises in meditation, TM seems to have proven helpful to many people in the relief of stress. Unfortunately, the technique is long in learning for many people and requires a daily regimen of meditation which some busy people find as hard to swallow as their dentist's demand for thrice-daily brushing!

However, there is another approach to stress—relief, relaxation, and the rejection of anxiety. Here's how to build an Alpha-Wave trainer to help you learn how to control these stresses.

are fixed positive and negative voltages), IC9 reaches its threshold point and its output falls to a logic 0 level. IC11 remains at a logic 1 level because of the 0.6-volt drop across diode D9, until the ramp has reached a higher level corresponding to its threshold point, after which it switches to a logic 0 level. As the ramp rises higher, the outputs of all the vertical comparators are a logic 0 level, until the threshold level of IC12 is reached, causing its output to go to logic 1. A further increase in the ramp voltage accounts for the constant drop across D10, and IC10 switches to a logic 1.

In effect, comparators IC9 through IC12 have now determined the "top" and "bottom" bar segments of the rectangle, and D9 and D10 have set the thickness of these segments. The apparent size of these elements is a function of the display control voltages supplied by IC18 and IC17. Thus, if that voltage is not fixed, but is a ramp, the threshold points along the vertical sweep ramp can be smoothly varied to create the illusion of expanding display

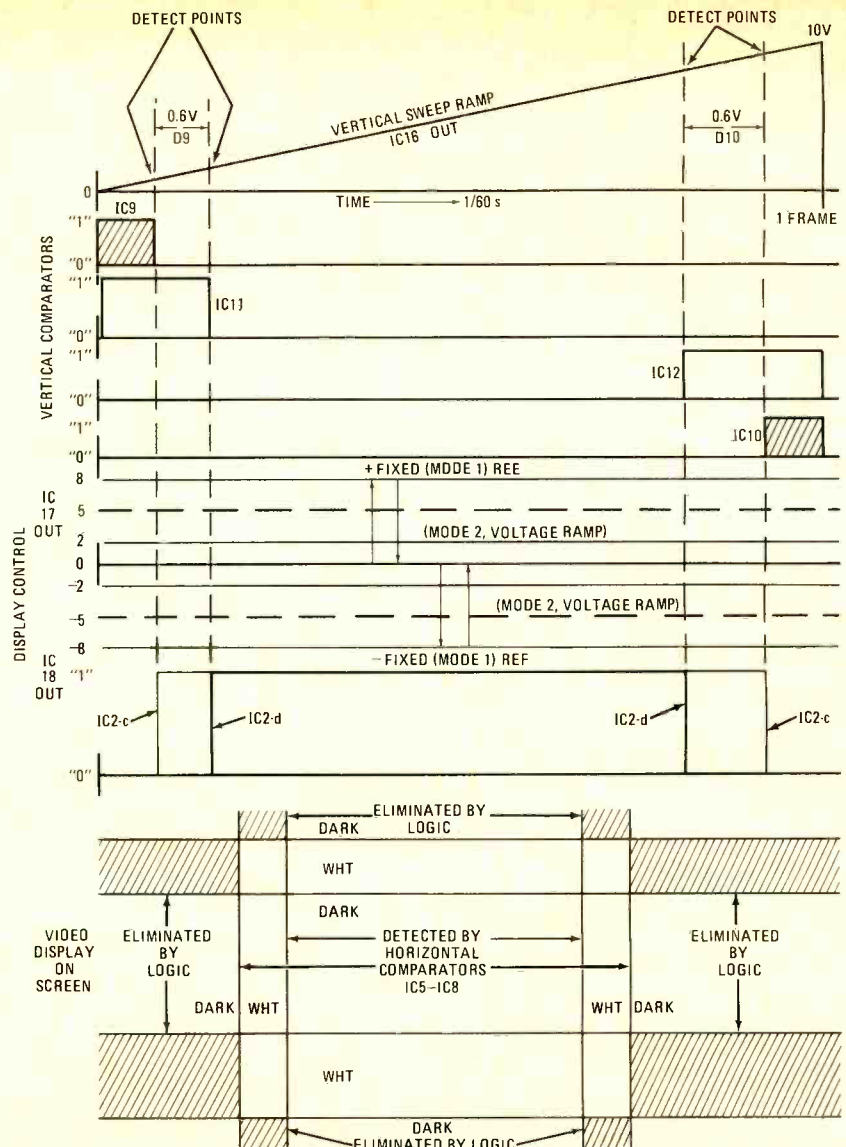


FIG. 2—TIMING WAVEFORMS associated with the comparators in the display logic and video driver section. Generation of the video display on the picture tube is also shown.

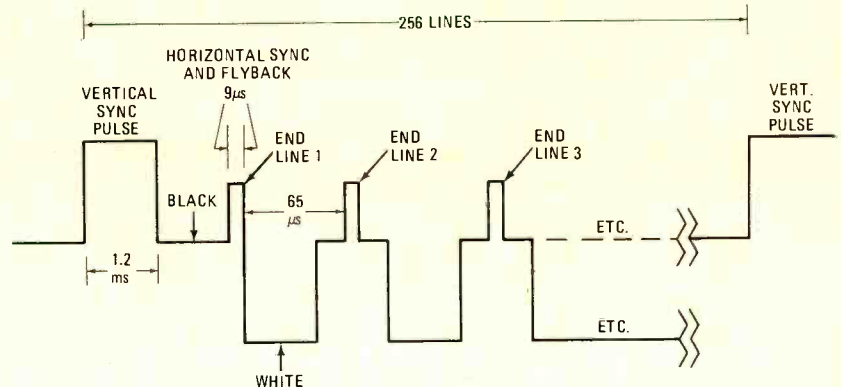


FIG. 3—COMPOSITE VIDEO SIGNAL produced from Mindpower: Alpha.

segments. Also, if the display control voltages are changed sharply, in response to a proportional level of alpha activity, these segments will abruptly "shrink" as the threshold-points are shifted.

The horizontal comparators IC5 through IC8 are identical in function to the vertical comparators, and are controlled from the output of IC17 through IC14 and IC15.

Having now established two pairs of controllable bars, overlying each other

horizontally and vertically to form a crosshatch (rather like a tic-tac-toe pattern, we still have to eliminate those bar segments that lie outside the rectangle defined by the intersections of the vertical and horizontal bars. This is achieved by comparing the logic states of the horizontal and vertical comparators, and appropriately gating video output.

In order to gate the video beam on (that is, to write a white segment), the

(continued on page 66)

Radio-Electronics

Tests Hitachi D-3500

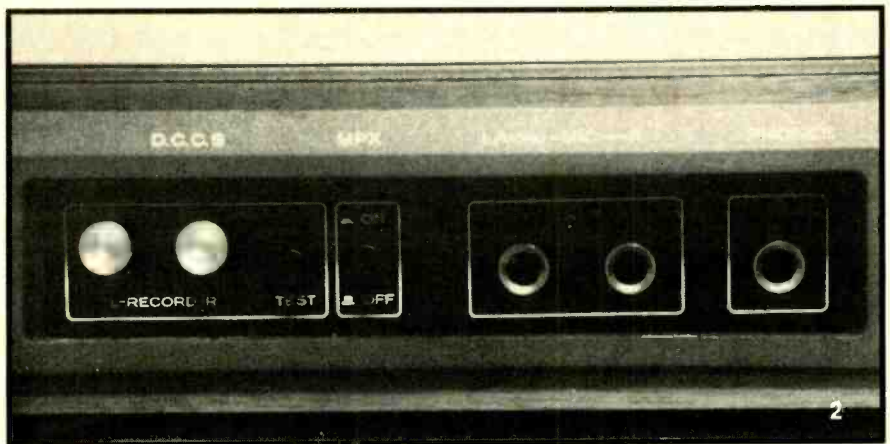
LEN FELDMAN
CONTRIBUTING HI-FI EDITOR

YOU CAN COUNT THE NUMBER OF "THREE-headed" stereo cassette tape decks available to consumers on the fingers of one hand, and most of them cost more than twice as much as this neat little deck from Hitachi. For those who aren't quite sure of the distinction between "two-headed" and "three-headed" decks, let me explain that by far the vast majority of cassette machines use a single record/playback head that performs both functions. The "second" head is usually the erase head that is mounted ahead of the record/play head relative to the direction of tape travel. It is well known that the ideal construction for a record head differs from the ideal required for optimum playback. Thus, all two-headed machines represent a compromise in head design. While it is relatively easy to use separate record and play heads in an open-reel tape deck (and most open-reel machines do use at least three heads) the configuration of the standard cassette (that was never envisioned as a high-fidelity tape medium by its inventors originally) makes the problem difficult indeed. Hitachi has solved the problem by building two heads and gap arrangements into a single housing, so arranged that the tape passes the record gaps before passing the playback gaps. The three-head arrangement, besides offering the optimization possibility for each function, permits tape monitoring (the ability to listen to the recorded results a small fraction of a second after recording has taken place) via the usual tape-output and tape-input jacks commonly provided on hi-fi component amplifiers and receivers.

A top view of the Hitachi D-3500 is shown in Fig. 1. The sloped section of the rear panel contains a pair of fast-acting VU meters at the left. A three-digit tape counter and lights that indicate recording or playback mode are located to the right

of the meters. Below the meters, on the flat surface of the panel, are six identical pushbuttons and associated indicator lights to denote their use. The pushbuttons include a METER SELECT switch, a MEMORY rewind switch (used in conjunction with the 3-digit counter), a TAPE SELECT

The front apron of the D-3500, shown in Fig. 2, has a recessed well that contains a pair of Dolby record-level calibration controls, a 400-Hz test tone switch, a pair of microphone input jacks and a phone jack. Overseas manufacturers have a penchant for "initializing" circuits and



switch (with positions for chrome or regular ferric oxide tape), a DOLBY NR on/off switch, an INPUT SELECT switch (that selects line inputs or line plus mic inputs that can be mixed) and a MONITOR SELECT switch (that determines which signals reach the output jacks of the unit). Six slide-controls below the pushbuttons adjust the level of the individual line input, mic input and mic output for each of the two stereo channels. Control keys below the cassette compartment area include STOP/EJECT, RECORD, PLAY, REWIND, FAST FORWARD and PAUSE. It is necessary to depress PLAY and RECORD simultaneously to activate the record function, but if the PAUSE key has been previously depressed, tape motion will not start until it is released so that all record levels can be properly set up before the tape starts to move.

functions and it took us a while to figure out that Hitachi's D.C.C.S. nomenclature above the Dolby calibration controls and test tone switch must stand for Dolby Calibration Control System (Everyone knows that, right?).

The rear-panel contains the usual line-input and line-output jacks plus a DIN record/play multiple-pin connector and an output on/off switch (which, if accidentally left in the off position, could lead to needless service calls). Since just about any amplifier that the deck might be used with has provisions for switching off the tape program sources (if headphone listening directly from the deck is desired) we wonder why Hitachi elected to include this sort useless switch.

Circuitry

A block diagram of the D-3500 is shown in Fig. 3. Twenty five transistors, 21 IC's, 26 diodes, a Zener diode and two thermistors comprise the active elements of the circuit and there are a total of five separate printed-circuit boards used. An excellent and complete service manual is available from the company that details both mechanical and electrical construction of the unit and provides a complete guide to all adjustments that might ever be required. A 4-pole synchronous motor coupled to a 4-inch diameter flywheel is used in the drive system and the capstan

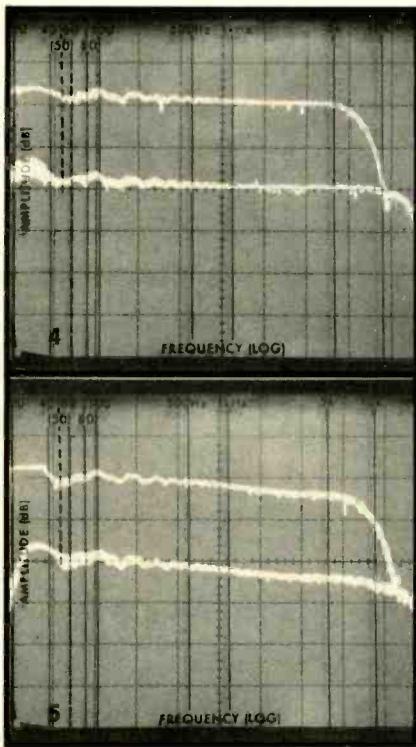
MANUFACTURER'S PUBLISHED SPECIFICATIONS:

Frequency Response: Chrome: 20 Hz to 20,000 Hz; Normal: 20 Hz to 15,000 Hz. **Wow-and-Flutter:** 0.05% WRMS. **Signal-to-Noise Ratio:** Dolby "off": 55 dB; Dolby "on": 63 dB. **Distortion:** 2.0% (at 0-dB, 1 kHz). **Erase Ratio:** 65 dB. **Crosstalk:** 60 dB. **Input Sensitivity:** Line: 35 mV; Mic: 0.18 mV. **Output Level:** more than 0.5 volts. **Fast Rewind Time:** 90 seconds (C60). **Power Consumption:** 20 watts. **Dimensions:** 16-15/16" wide \times 5 1/2" high \times 11 1/8" deep (43.0 \times 14.0 \times 28.3 cm). **Weight:** 15.4 lbs. **Suggested Retail Price:** \$420.00.

is said to have a roundness accuracy of 0.1 micron. A fully mechanical system of end-of-tape automatic stop is incorporated in the machine that we found to be effective if a bit slow in its response. A multiplex filter switch is also included in the recess of the front apron, useful in eliminating high-frequency content from the stereo FM tuner outputs that might upset the action of the Dolby encoding circuits when recording such broadcasts.

Laboratory measurements

Our performance measurements on the D-3500 are listed in Table I. While Hitachi fails to assign a "plus and minus" dB tolerance to their stated frequency response specification, they need not have been so cautious. It is extremely good, with response for low-noise ferric tape (we used Maxell UD in our tests) ranging from 22 Hz to 19,500 Hz ± 3 dB, as confirmed in the spectrum analyzer photo of Fig. 4 (lower trace taken at a record level of -20 dB) and from 20 Hz to 18,000



Hz ± 3 dB using chrome tape (lower curve of Fig. 5).

When chrome tape is used, the deck has an automatic sensing system that flips the circuits over to correct bias and equalization for such tapes that have an extra notch on the cassette housing even if the user forgets to depress the tape selector button. The rather unusual response characteristic observed using chrome tape (gradual roll-off from one frequency extreme to the other) can only be accounted for by the record (and possibly the play) equalization curves built into this machine, since the very same "tilt" was observed both at the high (0 dB) and low (-20 dB) level frequency-sweeps with which we tested this tape.

On the basis of results obtained with this sample we would tend to use better grades of ferric tape with the D-3500 rather than chrome despite the slight

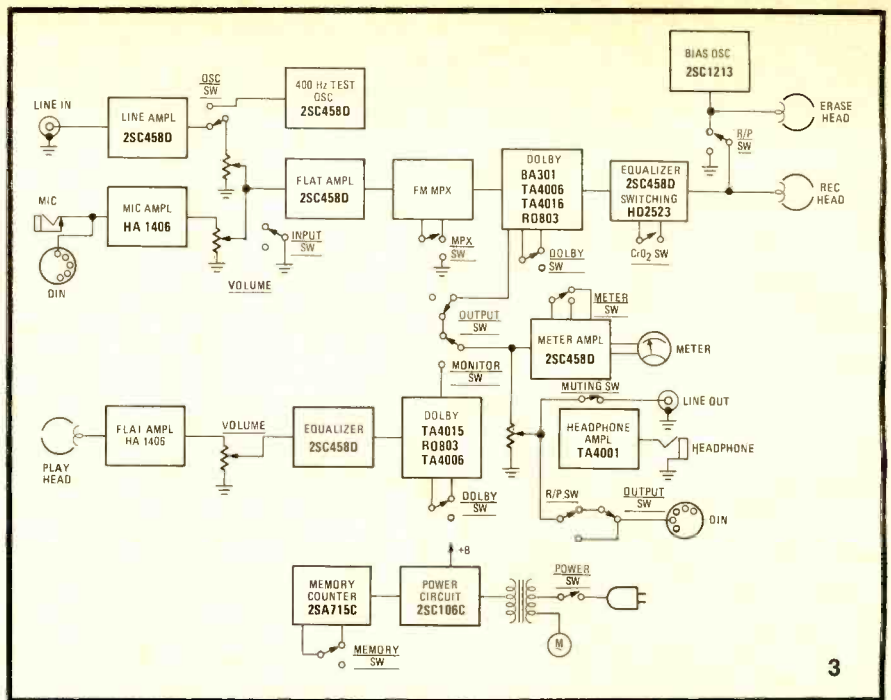


TABLE I
RADIO-ELECTRONICS PRODUCT TEST REPORT

Manufacturer: **Hitachi**

Model: **D-3500**

CASSETTE TAPE DECK MEASUREMENTS

FREQUENCY RESPONSE MEASUREMENTS

Frequency response, standard tape (Hz-kHz \pm dB) 22-19, 5 \pm 3, 0
 Frequency response, CrO₂ Tape (Hz-kHz \pm dB) 20-18, 0 \pm 3, 0
 Frequency response, other (see text) (Hz-kHz \pm dB) —

R-E
Measurements 22-19, 5 \pm 3, 0
R-E
Evaluation Excellent
Very good

DISTORTION MEASUREMENTS (RECORD/PLAY)

Harmonic distortion @ -10 VU (1 kHz) (%) 3.0/
 Harmonic distortion @ -3 VU (1 kHz) (%) 1.8/
 Harmonic distortion @ 0 VU (1 kHz) (%) 1.8/2.0
 Harmonic distortion @ $+3$ VU (1 kHz) (%) 2.5/3.0

Std./Chrome
 3.0/
 1.8/
 1.8/2.0
 2.5/3.0
(Mostly noise)
Fair
Good/Good
Very good/Good

SIGNAL-TO-NOISE RATIO MEASUREMENTS

Standard tape, Dolby off (dB) 50
 Standard tape, Dolby on (dB) 55
 CrO₂ tape, Dolby off (dB) 53
 CrO₂ tape, Dolby on (dB) 61

Very good
Very good
Excellent
Excellent

MECHANICAL PERFORMANCE MEASUREMENTS

Wow and flutter (% WRMS) 0.06
 Fast wind and rewind time, C60 (seconds) 75

Excellent
Good

COMPONENT MATCHING CHARACTERISTICS

Microphone input sensitivity (mV) 0.2
 Line input sensitivity (mV) 40
 Line output level (mV) 840
 Phone output level (mV) 34 (8 ohms)
 Bias frequency (kHz) 105

TRANSPORT MECHANISM EVALUATION

Action of transport controls
 Absence of mechanical noise
 Tape head accessibility
 Construction and internal layout
 Evaluation of extra features, if any

Very good
Average
Good
Excellent
Very good

CONTROL EVALUATION

Level indicator(s)
 Level control action
 Adequacy of controls
 Evaluation of extra controls

Very good
Good
Excellent
Excellent

OVERALL TAPE DECK PERFORMANCE RATING

Very good

TABLE II
RADIO-ELECTRONICS PRODUCT TEST REPORT

Manufacturer: Hitachi

Model: D-3500

OVERALL PRODUCT ANALYSIS

Retail price	\$400.00
Price category	Medium/High
Price/performance ratio	Excellent
Styling and appearance	Good
Sound quality	Excellent
Mechanical performance	Very Good

Comments: While we categorize the price of Hitachi's D-3500 as "medium/high," we must hasten to add that in terms of such three-headed cassette machines as are currently available it is almost "bargain priced." We were intrigued by Hitachi's solution to the problem of "crowding" separate record and play heads into the available space of the exposed openings of the cassette housing and admire their solution to this problem (discussed in the main section of this test report). The slightly "sloped" record/play response of the machine when using Chrome tape is obviously a function of imprecise equalization (we cannot tell whether the error is in record or playback equalization), and that may be common only to the sample we tested. If it is present in all machines bearing this model number, that's rather a pity since this is one of the few machines we have tested recently that actually delivers significantly better S/N ratios when using Chrome tape compared to the S/N achieved with low-noise ferric tape. Even if response using Chrome were "tilted" back to where it belongs, the S/N advantage would still be significant.

In our sample, at least, low-noise ferric tape wins hands down as far as overall response and distortion are concerned and the 50 dB S/N ratio observed using such tape (without Dolby) renders this machine quit usable for serious music recording.

reduction in signal-to-noise capability (which was excellent with either kind of tape but better when chrome tape was employed). All S/N measurements were made with reference to the 3% total harmonic-distortion point for the particular

tape used. That point occurred at +3 dB (1 kHz) for chrome tape and at +4.5 dB for the low-noise tape.

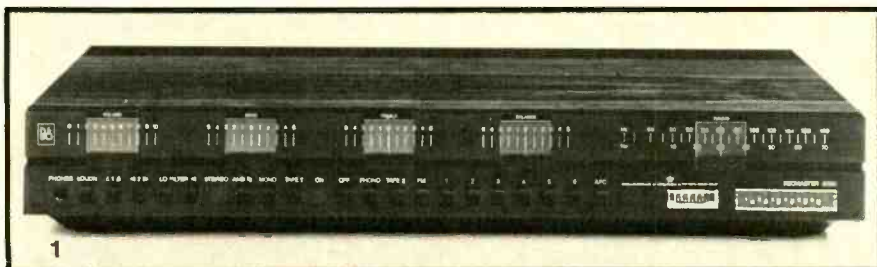
Using the Hitachi D-3500

This deck, while not the quietest run-

ning machine we have checked, did provide truly excellent wow-and-flutter numbers. Action of the transport keys is a bit "clunky," especially when the automatic end-of-tape stop returns the depressed key to its off position. Level-meter action is good and can be classified as "peak reading," though meters are placed ahead of record equalization so that readings fall-off rapidly with high frequencies applied. We felt that the line-input sensitivity was actually too high (that is, it takes very little line-input signal to reach 0 dB record levels). Since the tape-output terminals of most receivers or amplifiers generally provide 150 mV or even 200 mV of signal for normal inputs, this means that the user must work the record level controls at their bottom range during most recording work done from amplifier or receiver derived program sources. This reduces the usefulness of the long-range slide controls somewhat. If you care enough about this, an external resistive pad ahead of the line inputs could easily rectify this minor flaw.

Because of the unique two-in-one-but-separate record/play head construction of the D-3500, there was no need for azimuth alignment between record and play heads (a feature considered a must on other three-headed machines) which simplifies operation considerably compared to those few more expensive three-headed cassette units. All in all, if you have been frustrated by your inability to monitor recorded results "as you go" and are not quite prepared to spend upwards of a thousand dollars for a machine having that capability, the Hitachi D-3500 offers a worthwhile alternative—and unusually good recording performance at its price level. **R-E**

B&O 4000 FM Receiver



MANUFACTURER'S PUBLISHED SPECIFICATIONS:

TUNER SECTION:

IHF Sensitivity: 2.0 μ V at 75 ohms (17.4 dBf). **Signal-to-Noise Ratio (mono):** Greater than 65 dB. **Harmonic Distortion:** (mono) 0.4%. **Frequency Response:** 20Hz to 15000Hz \pm 1.5 dB. **Stereo Separation,** (1 kHz): 35 dB. **19 kHz and 38 kHz Suppression:** 40 dB.

AMPLIFIER SECTION:

Power Output: 60 watts continuous into 4 ohm loads at any frequency from 40 Hz to 20,000 Hz with no more than 0.4% total harmonic distortion. (No rating supplied for 8-ohm operation.) **IM Distortion:** 0.3%. **Damping Factor:** Greater than 20. **Input Sensitivity:** (phono) 3 mV; (tape) 250 mV. **Signal-to-Noise Ratios:** (phono) 62 dB; (tape) 75 dB. **Tape Out Level:** 170 mV. **Bass Control Range:** (at 40 Hz) \pm 17 dB. **Treble Control Range:** (at 12.5 kHz) \pm 14 dB.

GENERAL SPECIFICATIONS:

Power Requirements: 117 V, 60 Hz, 20 to 275 watts maximum. **Dimensions:** 22-13/16" W \times 3 3/4" H \times 10 1/2" deep. (57.94 W \times 9.53 H \times 26.99 D cm.) **Weight:** 22 lbs. (9.97 Kg.) **Suggested Retail Price:** \$595.00.

IF YOU HAVE EVER VISITED THE NEW YORK Museum of Modern Art you may have noticed that there is displayed a high-fidelity turntable system designed and produced by Bang & Olufsen of Denmark. That turntable system is as different in appearance and operation from most other turntable systems as the model 4000 FM receiver is from any other receiver you may have seen in the past. Both the turntable system and the 4000 (shown in Fig. 1) are beautifully styled, with the emphasis on human engineering and aesthetics. Having visited B & O's facilities in Struher, Denmark last year, we can attest to the fact that other products made by this Scandinavian company are equally well styled and functional. (The company is a producer of mass-entertainment products such as TV sets that are sold only in Europe and which bear the same distinctive Scandinavian industrial design approach.) While execution of the exterior of the 4000 and its control arrangement is innovative and appealing, measured performance of this relatively expensive receiver is a bit disappointing, at least when compared with other receivers selling for approximately the same price.

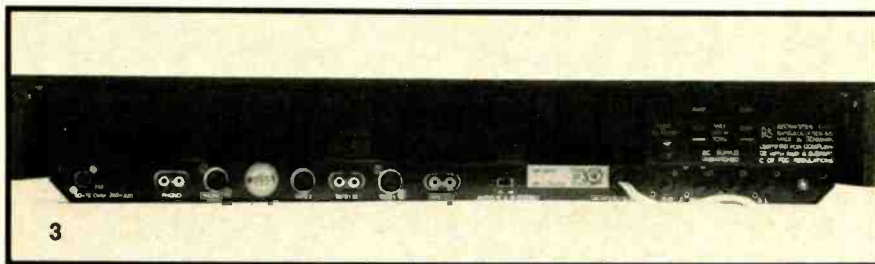
The all-black, slim and long front panel of the 4000 is divided vertically into two sections. The upper portion of the panel has what look like five "slide rule" indicators. Each transparent indicator slides horizontally, controlling such functions as VOLUME, BASS, TREBLE, BALANCE and TUNING. The tuning bar, or indicator, is additionally equipped with two tiny thumbwheels along its bottom to facilitate vernier action of the slider.

The lower section of the front panel contains a HEADPHONE jack, STEREO and POWER-ON indicator lights, a signal strength meter, twin light indicators for center-of-channel tuning, six tiny thumbwheel controls with which six pre-selected stations can be tuned and nineteen small downward depressable switches. The switches select loudness circuitry, either or both of two pairs of speakers, low and high cut filters, ambience connection of the second pair of speakers (for synthesized 4-channel sound), MONO/STEREO, tape monitoring, power OFF (choosing any program source automatically turns power on), PHONO, TAPE 2 (a non-monitorable input) or FM, the six pre-tuned stations and AFC. A closeup view of the tuning slider and pre-tune controls is shown in Fig. 2.

Access to the tape and phono inputs on



the rear panel (See Fig. 3.) is either by means of DIN connectors or standard phono-tip jacks. A coaxial connector is provided for 75-ohm transmission line from FM antennas, but if a 300-ohm line is used it is necessary to connect wire ends to a separately provided plug that fits neatly into a mating socket on the rear panel. All speakers are connected by means of polarized plugs (supplied in an accessory bag) that require no soldering and have the advantage of maintaining correct speaker phasing if speakers are



ever unplugged for transporting, cleaning, etc. B & O's own speaker systems come equipped with suitable plugs and cables, so that the accessory plugs are only needed if you use other makes of speakers. A pair of convenience outlets are also provided on the rear panel along with a bracket which is intended to hold an op-

TABLE I		
RADIO-ELECTRONICS PRODUCT TEST REPORT		
Manufacturer: Bang & Olufsen		Model: 4000
FM PERFORMANCE MEASUREMENTS		
SENSITIVITY, NOISE AND FREEDOM FROM INTERFERENCE	R-E Measurement	R-E Evaluation
IHF sensitivity, mono: (μ V) (dBf)	3.5 (16.3)	Fair
Sensitivity, stereo (μ V) (dBf)	4.0 (17.4)	Good
50-db quieting signal, mono (μ V) (dBf)	7.0 (22.3)	Good
50-db quieting signal, stereo (μ V) (dBf)	38.0 (37.0)	Fair
Maximum S/N ratio, mono (dB)	67	Good
Maximum S/N ratio, stereo (dB)	63	Very good
Capture ratio (dB)	3.2	Fair
AM suppression (dB)	55	Good
Image rejection (dB)	N/A	Not rated
IF rejection (dB)	N/A	Not rated
Spurious rejection (dB)	80	Good
Alternate channel selectivity (dB)	55	Fair
FIDELITY AND DISTORTION MEASUREMENTS		
Frequency response, 50 Hz to 15 kHz (\pm dB)	0.5	Very good
Harmonic distortion, 1 kHz, mono (%)	0.45	Fair
Harmonic distortion, 1 kHz, stereo (%)	0.26	Good
Harmonic distortion, 100 Hz, mono (%)	0.30	Good
Harmonic distortion, 100 Hz, stereo (%)	0.65	Poor
Harmonic distortion, 6 kHz, mono (%)	1.20	Fair
Harmonic distortion, 6 kHz, stereo (%)	1.3	Good
Distortion at 50 dB quieting, mono (%)	1.8	Fair
Distortion at 50 dB quieting, stereo (%)	0.4	Very good
STEREO PERFORMANCE MEASUREMENTS		
Stereo threshold (μ V)	4.0	Very good
Separation, 1 kHz (dB)	35.0	Good
Separation, 100 Hz (dB)	32.0	Good
Separation, 10 kHz (dB)	20.0	Fair
MISCELLANEOUS MEASUREMENTS		
Muting threshold (μ V)	N/A	No muting
Dial calibration accuracy (\pm kHz @ MHz)	-250 @ 108	Poor
EVALUATION OF CONTROLS, DESIGN, CONSTRUCTION		
Control layout		Excellent
Ease of tuning		Very good
Accuracy of meters or other tuning aids		Poor
Usefulness of other controls		Good
Construction and internal layout		Excellent
Ease of servicing		Excellent
Evaluation of extra features, if any		Very good
OVERALL FM PERFORMANCE RATING		
		Fair

tionally available "rabbit ears" antenna made by B & O.

Figure 4 illustrates the type of component equipment that can be used with the 4000. The second pair of speakers may be used stereophonically in a remote location or to complete an "ambience" type

Construction and Circuitry

The 4000 is easily disassembled for servicing and/or alignment, and a top view of the chassis with wood cover removed is shown in Fig. 5. Visible at the upper left is a tuning wheel that rotates a precision potentiometer, since the front end of the 4000 is varactor-diode tuned and varying the voltage applied to four tuned circuits of the front end alters the frequency to which the tuner is tuned. It is this arrangement that makes possible the six pre-set station capability, since the controls used to set up favorite stations are nothing more than six tiny potentiometers. The RF amplifier uses a pair of FET's in a cascode arrangement and an FET is used for the mixer stage as well. Fixed solid-state 10.7 MHz filters are used in the FM IF circuitry that is contained on a single board along with a fairly conventional stereo multiplex decoder circuit that uses six adjustable coils and transformers as opposed to more modern phase-locked-loop circuitry.

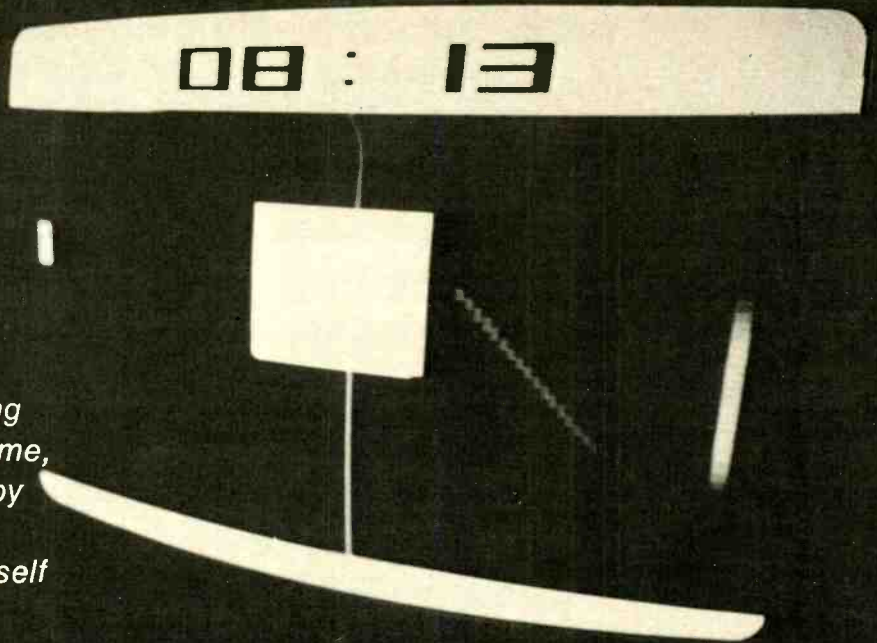
Preamp input stages are contained on a separate PC board and discrete transis-

(continued on page 88)

4-channel arrangement in a single listening room. B & O calls this arrangement "ambio system," but it is essentially no different from the out-of-phase or "left minus right" rear speaker arrangement first proposed by Dynaco in this country several years ago and requires no additional channels of audio amplification.

Build This Great TV Game

Part III. With on-screen digital scoring and a unique alternate "bumper" game, this ping-pong game can be played by two or four people or it can be set to play a perfect game against you or itself



IN THIS FINAL SECTION WE'LL TAKE A LOOK at the circuitry for Bumper and examine the methods for connecting the game to a TV set. In addition, we will describe a trouble-shooting system to use if you can't get your game to work.

Bumper is generated by four one-shots. Two of them determine the bumper's position. The other two determine its dimensions. The vertical position is set by the signal from pin 12 of IC24 and pin 8 of IC23. The vertical dimension is set by the signals from pins 8 and 12 of IC23. The horizontal position is determined by the signals from pins 8 and 10 of IC24. The horizontal dimension is determined by the signals from pins 2 and 6 of IC24. These one-shots work similarly to the one-shots used to generate the center line and top boundaries (see *Radio-Electronics*, July 1976). The output of the bumper comes from pin 12 of IC25 and it AND's the vertical and horizontal dimensions to produce the rectangle.

A third input is used to enable or disable this game with the GAME SELECT switch. The output is inverted and displayed on the screen. And also AND'ed with the ball signal from pin 13 of IC5. This output is used to clock IC10, the horizontal position flip flop. When the ball enters the bumper, IC10 is clocked. This causes the ball to reverse horizontal direction. However, because of the size and shape of the bumper, and the various entry angles, the ball will not always immediately leave the bumper. Thus, on successive lines, the ball may still be in the bumper. When this happens IC10 will continue to be clocked and the ball will continually reverse direction until it is finally clear of the bumper. Since the length of time the ball remains in the bumper is random, the direction of the emerging ball is unpredictable. The signal from pin 8 of IC 25 is used as an OR gate to combine the hit signals with the signal from the reserve timer.

Audio for both games is generated by IC18, IC19 and IC6. When a ball is hit with a paddle, or when a ball strikes a boundary, a one-shot made of two sections of IC18 is triggered. The diodes D19, D20 and D21 are an OR gate. And the signals from pins 3 and 6 of IC19 comprise a free-running oscillator operating at about 1kHz. Thus, a series of pulses are generated at pin 6 of IC19 for the period of the one-shot. This pulse string is amplified by Q6 and is the "bink" heard on a hit or rebound.

The "brapp" missound is generated by ANDing the vertical sync pulses with a longer pulse generated by the flip flop, pin 6 of IC17. Capacitor C45 determines the length of the "brapp." When IC17 sets, the Q output is inverted via IC23 and differentiated by capacitor C45 and resistor R74. On a re-serve, the ball crosses through the top boundary and could cause a false "brapp" signal. This is prevented by pin 8 of IC17 which is set on a re-serve and cleared the first time the ball crosses the center line. With pin 8 of IC17 set, pin 3 of IC19 is disabled.

IC13 is used to combine all of the video outputs from the boundaries—paddles, ball, center line, and bumper—into one video signal to be displayed on the TV screen. The scoring video output is OR'ed for the top boundary video through diode D2 to produce black numerals on the white top boundary field. The output goes through a voltage divider R37-R38 which is used to adjust for the correct video level. The resulting video signal is then OR'ed with the combined vertical and horizontal sync from pin 3 of IC8 in IC5. The resulting video signal is buffered by an emitter-follower circuit, transistor Q5, and is available for direct connection to a video display unit via the video detector.

Connecting to the TV set

Connecting external devices delivering

an RF signal to the antenna terminals of a television set is prohibited by FCC rules. Therefore, the only acceptable method is to feed the signal from our TV game directly into the set's video detector/amplifier. To do this, there are two preliminary steps that must be taken. **First, you must be sure that the TV set you intend to use has a power transformer and is not an AC/DC set that has one side of the power line connected to the chassis. Sets such as these offer a potentially dangerous shock hazard, and must not be used with the circuits recommended here. Before proceeding further, be sure that the set you plan to modify is safe to use for the game and that the chassis is isolated from the power supply.** Next, you must secure a complete set of schematics of the set, either directly from the manufacturer or from a Howard Sams' Photofact. This schematic is a necessary part of hooking up our game to your TV.

The point for direct connection is shown in Fig. 1. Locate this point in the schematic for your TV set and then find that point physically in the TV set where the input signal first enters the first video amplifier.

If your set is a vacuum tube type, look at Fig. 2. The modification here consists of three simple sections—a self-biasing cathode circuit, an input jack with bypass resistor, and a game/video selector switch. The cathode bias circuit provides about 2 volts (positive) on the cathode for game playing. (And the switch re-establishes the typical 0 cathode voltage for TV watching). For both tube and transistor type sets, the sync level runs about 2 volts below the white level. Any existing bias network on the cathode must be increased to bias the black level (vs. white) for game playing.

If the TV set is a transistor type, use any of the circuits shown in Fig. 3. These will provide the necessary white level/

black level biasing through which the diode drops within the transistors (and in a separate diode for case 3). When no video signal appears, the video driver is driven below the black level to about 1.2 volts. When a white signal of 2 volts appears, the video driver is biased to its usual 3+ volts. The ideal direct video connection circuit will provide the same level of white level bias and black level bias for game playing as for TV watching.

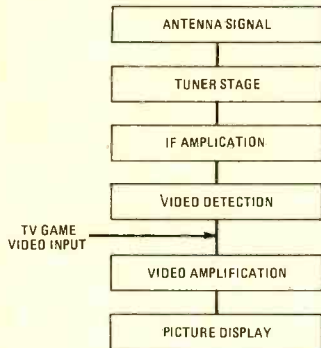


FIG. 1—TV GAME is connected directly to input of video amplifier stage.

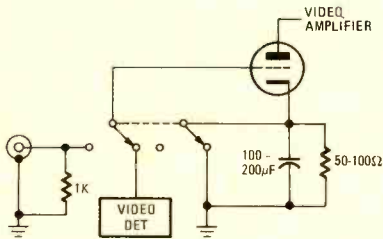


FIG. 2—TUBE-TYPE TV requires minor modification to connect TV Game.

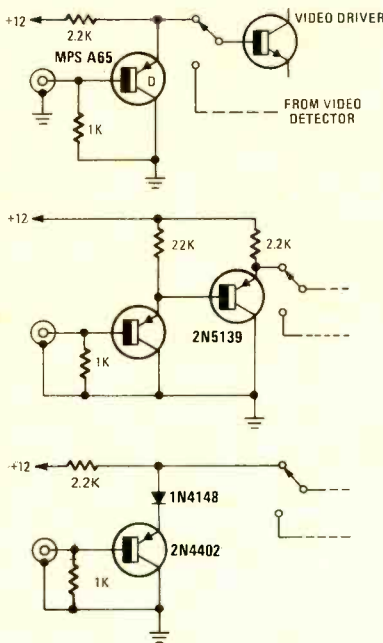
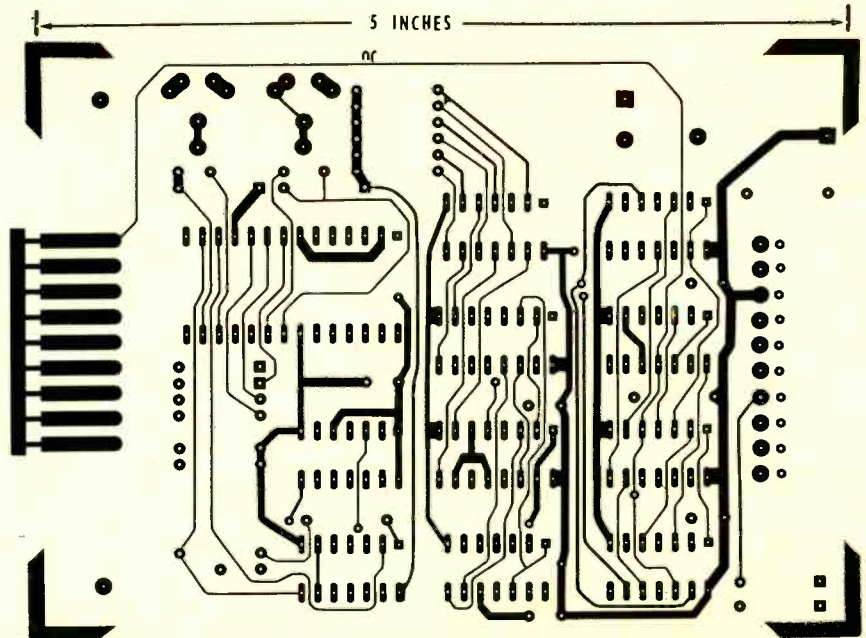
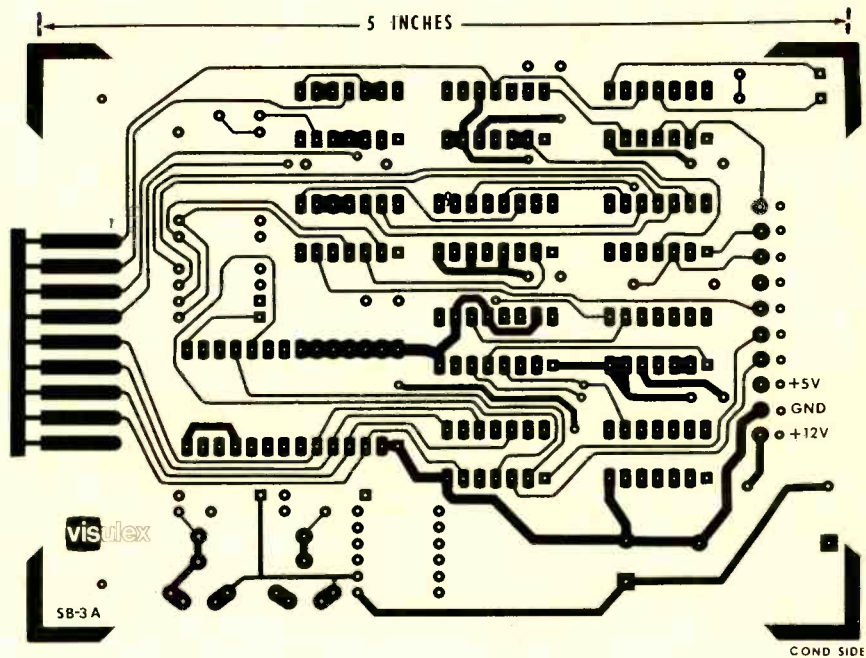
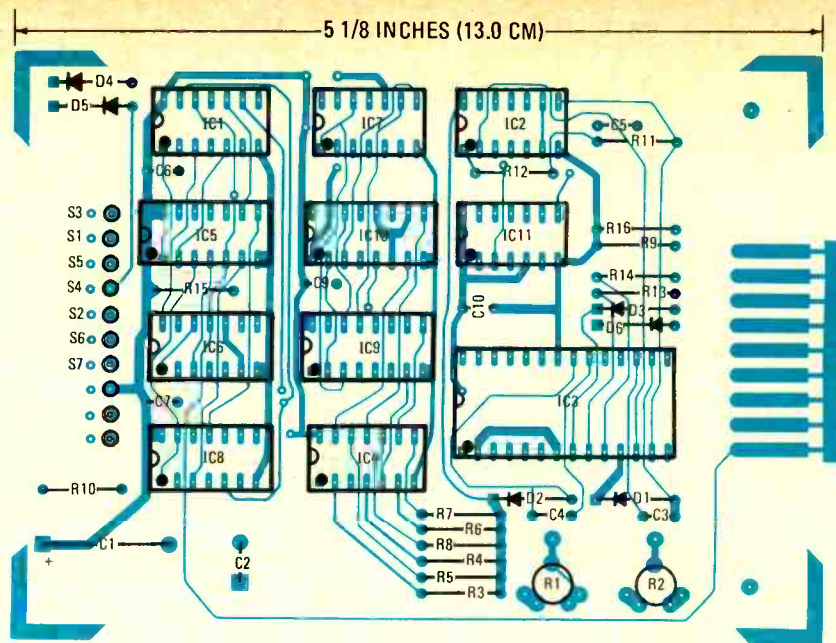


FIG. 3—TYPICAL CONNECTIONS to a transistor-type TV receiver.

The single-pole double-throw switch is designed to isolate the detector and normal bias network when the video input jack is used. Use leads as short as possible and make sure that if any lead run is



DIGITAL SCORING BOARD, component placement diagram (left, top). Foil pattern (left, middle) of component-side of double sided board. Foil pattern (left, bottom) of bottom-side of double sided board. Board measures 5 × 3½ inches.

PARTS LIST SCORING BOARD

All resistors ¼-watt 5% unless noted
 R1, R2—50,000 ohms, trimpot
 R3, R4, R5, R6, R7, R8, R9, R13, R14, R16—5100 ohms
 R10—15 ohms
 R11—510 ohms
 R12—2000 ohms
 R15—47,000 ohms

All capacitors 25 volts or more

C1—50 µF, 25 volts
 C2—1000 µF
 C3—1000 pF
 C4, C6, C7, C8, C9, C10—.05 µF
 C5—270 pF

Diodes

D1 to D6—1N4148 or equal

Integrated Circuits

IC1, IC11—7400
 IC2—74C00
 IC3—5841 display IC provided with circuit board.
 IC4—7406
 IC5—75C04
 IC6, IC7—74C90
 IC8—7474
 IC9, IC10—74153

Connectors

1 Ten-circuit male (Molex 09-64-1103 or 04)
 1 Ten-circuit female (Molex 09-52-3102)

longer than 3 inches, that you use shielded cable for these connections. (For additional information on direct TV connections, we recommend you refer to Don Lancaster's comprehensive article in the October 1975 issue of *Byte* magazine.)

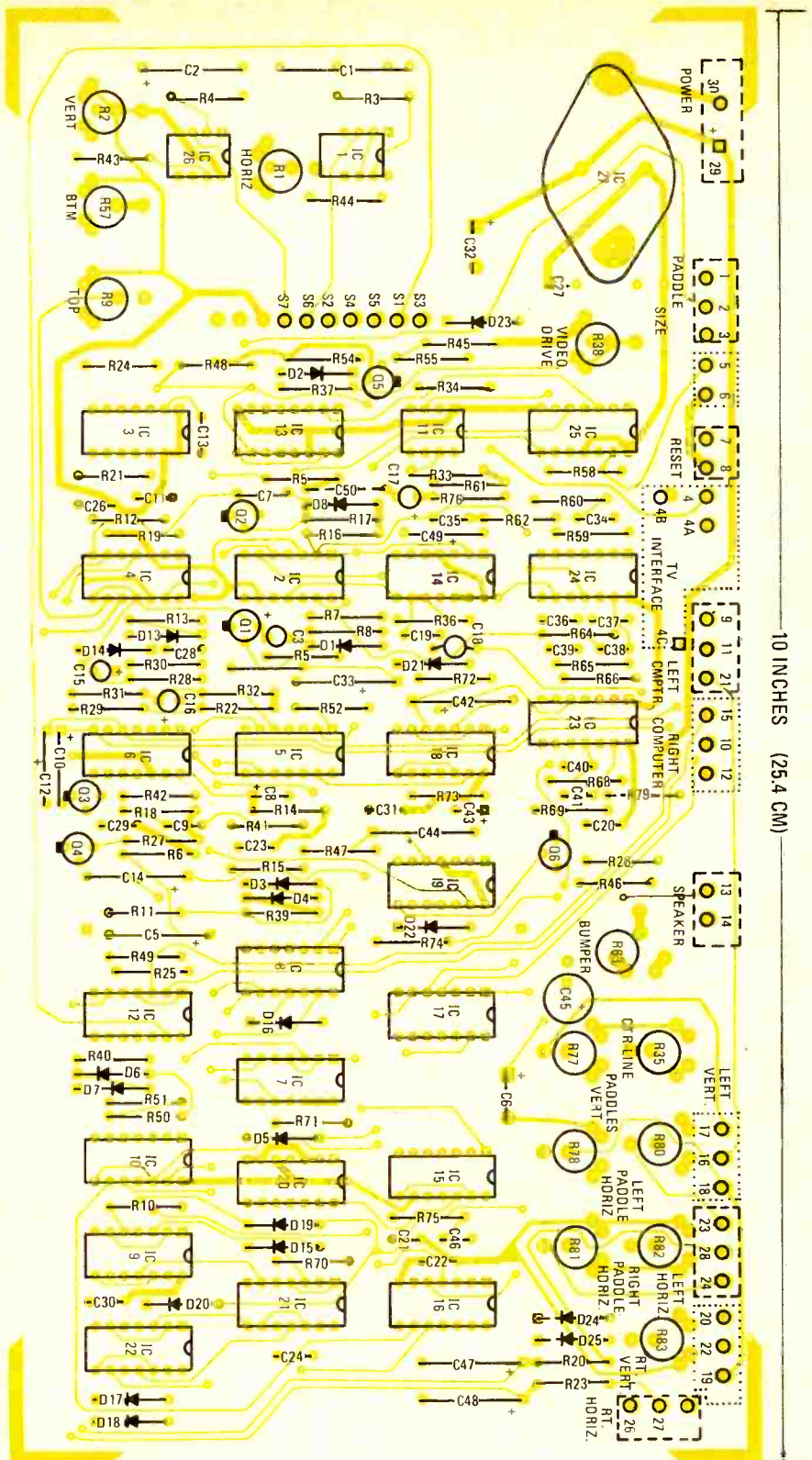
After you have completed the modification to the set, connect the game output, interconnect pads 4 and 4a to the video input jack with 2-wire 24-gauge lamp cord (Since the signal power is relatively low, unshielded wire will usually work. However, where even this potential interference is undesirable, use shielded wire). The lead on pad 4a should connect to the video jack ground terminal. Limit wire length to 15 feet.

When using this direct video connection, replace resistor R55 with a 10-µF capacitor (positive side goes to the emitter of Q6).

Operating instructions

Attach the unit's video output to the video input jack as just described in the previous section. Connect the power supply to 117 volts AC. Adjust the TV set's contrast control to maximum for deepest black. And lower the brightness control until the screen's raster is black. Only the paddles, ball, center line, and boundary should appear white.

Use the RESET button to put the game in the starting position with the score 0-0. If the game is shut down at a score of 18 and no ball can be seen, push the RESET button and release. The ball should re-serve in about 2 seconds. If the ball is in motion, it will be necessary to allow the ball to go off-screen to either the right or



COMPONENT PLACEMENT DIAGRAM of main circuit board.

left and then to push and release the button before the ball re-serves.

When you want to play "BUMPER", use the GAME SELECT switch to select that game.

When automatic play is desired, flip one of the COMPUTER CONTROL switches to "ON." In this mode, one person can play against the machine. When both switches are on, the machine will play against itself.

In the manual mode, (COMPUTER CON-

TROL switches off) use the player controller to control the horizontal and vertical position of the paddles. The game ends when the one player scores 18 points.

Trouble shooting

Most first-time or one-of-a-time projects of this size require some trouble shooting and debugging. The best tools are a scope, comprehensive circuit description, schematic diagram, and a set of scope traces.

continued on page 86

Step-by-step

TV Troubleshooters Guide

*Servicing private-label receivers
can be a real challenge*

STAN PRENTISS

AS CHANGES COME FAST AND FURIOUSLY to TV manufacturing around the country, servicing routines appear to be shifting somewhat, too, as more private-label receivers keep popping up at rural and suburban shops. True, wholesale parts prices aren't the rule when dealing with a retailer, but you can still lend a helping hand wherever you can even though service information may present an additional challenge. It's possible this could be remedied shortly and, in the meantime, hang loose and see if a tube, transistor, capacitor, or resistor won't put a few sets back in working order.

Sears chassis

The chassis is a Sears 564.80020. The first three numbers represent the source and the remaining five identify the model and its various changes. A quick check shows this color set has 20 tubes, 14 diodes, and no transistors. Heaters are strictly series-string with a filament transformer for picture tube

and shunt regulator, but only a hot chassis for the 280–380-volt power supplies. Source here, I'm told, is 564 for Sanyo, 562 for Toshiba, and 528 for domestic Warwick.

When this one arrived in the shop, these were multiple problems because its owner had allowed it to run down to the point of desperation. There was no picture, peculiar AGC, complaints of poor sync, weak color, indistinct pictures, etc. Of course considerable time was requested for repairs, and parts could be received by mail as needed. So the task was begun, mostly between jobs when rush work was slack and sufficient time became available for careful examination and analysis. Replacing the 1st video amplifier aided our AGC problem somewhat and a 10JY8 in the keyed AGC and 2nd video amplifier cured both AGC and what appeared to be a pressing high-voltage problem, but was nothing more than an erratic output luminance amplifier. However there still remained poor horizontal and verti-

cal sync, so this needed clearing up before continuing.

Tracing inadequate sync

Whenever there is a sync problem, always start with the 1st video amplifier and work through the sync separator and amplifier immediately. Then, you'll not confuse AGC signal compression with poor sync separation and can quickly locate the particular circuit that's at fault. As stated repeatedly before, the overall composite video waveform consists of 25% sync tips and 75% video information at 100% modulation. This ratio is, for all of us, in-violate!

What turned up in this set was the usual class-C problem of a typical tube sync separator. The schematic diagram is shown in Fig 1. Here, signal drive comes from the L118 series plate peaking coil of the 1st video amplifier through dropping resistor R143, coupling capacitor C118, grid leak bias C119–R145 and 2.2-megohm grid resistor R146. As you see from the schematic diagram, conduction of V106-a draws grid current, C119 charges negatively and a voltmeter on the grid reads -2.3 volts or more depending on the sync tip amplitude of the incoming signal. So since this tube conducts some 1.4 ms during each 16.664-ms field, and about $10 \mu\text{s}$ for every 63.5- μs line, it can be called a class-C amplifier because it conducts less than 50% of the overall waveform time. Capacitor C119 discharges mainly through R146, consequently the negative bias is dissipated when the next positive sync pulse comes along to trigger the tube into conduction. Capacitor C119 is then charged positively on the C118 side, and its time constant with R145 passes well-shaped vertical and horizontal pulses. Sync separator V106-a inverts these pulses for stable operation of the vertical and horizontal sweep oscillators.

As you might imagine, capacitor C118 was leaky and letting some video into the sync signal making it unstable. This affected both the vertical and horizontal oscillators. Capacitor C119

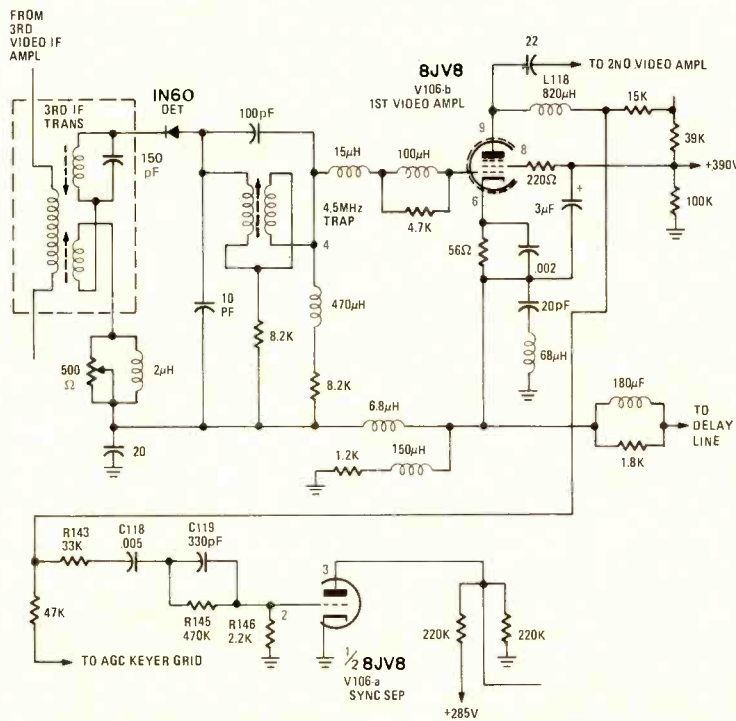


FIG. 1—AGC, SYNC SEPARATOR and 1st video amplifier stages of a Sears 564.80020 chassis.

was also replaced for good measure, but both R145 and R146 checked good. The vertical oscillator now seemed to free-run nicely at 59.94 Hz, but horizontal sync was not that fortunate—it still had significant problems.

The horizontal oscillator

This circuit (see Fig. 2) is similar to RCA's original Synchro-Guide twin-triode oscillator, less perhaps a little feedback but with additional components added for extra stability. The circuit, purely and simply, is a blocking oscillator with feedback from plate to grid through coil terminal 1 and timing capacitor C307, although another winding between terminals 2 and 3 helps produce a sinewave. This sinewave is used to increase the slope of the grid waveform as it recovers from cut-off and to prevent line voltage changes or critical circuit parameters from falsely triggering the oscillator, thus causing loss of horizontal sync. That's why this section of L301 is called a stabilizer coil.

Plate voltage from the 380-volt supply is routed across R310, thermistor TH1 (shunting R365), and on through the stabilizer and main coil of the blocking oscillator to V112-b, pin 6. Initial grid bias through R308 forces tube V112-b into conduction and conduction continues depending to a large extent on the L301-C308 tank circuit. To keep grid-plate voltage transients out of the power supply, VDR1 has been added between dividers R307-R308, and R312. Although the cathode of V112-b is at ground, additional positive bias has been added to the cathode of V112-a oscillator control tube. However, instead of the conventional Synchro-Guide capacitor being connected to this cathode, a pair of diodes have been inserted in the grid circuit to compare feedback from the stabilizer coil through R309-C304 and incoming sync via C301.

This type of circuit is called an automatic frequency control circuit. The AFC diodes D3-a and D3-b and related circuitry provide zero voltage to the grid of V112-a if there is no phase difference, and more positive or negative voltages if there is. The plate current through V112-a then develops lesser or greater voltages across R307-R308 to control the grid of the V112-b oscillator, slowing or increasing the repetition rate. A manual bias for this same purposes is furnished by external horizontal hold control between the 380-volt supply and ground. Other circuit components such as R304-C303 form an anti-hunt network to prevent oscillator overcorrections from transient changes, while C306 is a smooth filter.

When V112-b is cut off during line trace, C309 charges toward B+ through R365 and R310 to form the grid drive sawtooth for the horizontal output tube V113. C311 and R313 couple to a resistive amplitude output drive control on the rear control board. C310 then becomes both a V113 output-coupling and grid-leak capacitor, which discharges through R314 since V113 draws grid current when conducting and charges C310 negatively. This charge leaks off through R314 so that the exponential waveform generated by C309 will force the tube to conduct for half of its 52.4- μ s rising-curve following cutoff. The other half of the curve, of course, occurs during conduction of the high-voltage damper (not shown). R910 helps prevent grid oscillations.

The ultimate problem

The circuit problem rested entirely in this blocking oscillator. Sears instructions say "short the stabilizer coil" across C308 and adjust the lower core of the transformer for stable picture with the receiver tuned to an active channel. Unfortunately, each time this step was attempted, we picked up a

condition that seemed to be a combination of AFC malfunctions, pie crust, squeeging and Christmas tree symptoms all rolled into one, even though the horizontal hold was mechanically centered and several 8FQ7 oscillator tubes were replaced in the circuit. Now, as everyone in our business knows (or should), the horizontal oscillator will usually operate independently of AFC diodes and incoming sync, especially with no incoming signal. In other words, the oscillator should be able to work on its own without "help" from the AFC. As a check, simply remove the short from terminals 2 and 3 of L301 and connect your jumper wire between R301-R202 and ground, canceling the effects of the AFC diodes and feedback from the stabilizer coil. Most oscillators under these circumstances will barely hold sync, or slowly sweep through the sync point—a condition that's perfectly normal.

For voltage measurements, B+ was closer to 400 volts than 380 volts—and that's all to the good—and tube measurements were: pin 1, 24 volts; pin 2, 0 volts; pin 3, 1.7 volts; pin 6, 265 volts; pin 7, -86 volts; and pin 8, 0 (ground). Now you may think three of these variations are significant, but pins 1 and 3 depend on the setting of the horizontal hold control, and the voltage at pin 6 is largely determined by the characteristics of warm-up thermistor TH1 (and R310), a special part that isn't usually available except from the manufacturer. With V112 out of socket, and B+ disconnected at point DD, a quick check of other resistive components showed insufficient reason for any changes. Anti-hunt capacitor C303, timing and coupling capacitors C307, C308 and C310 however, were replaced on the basis of age and for good measure since they could all affect final stability of the circuit.

Regardless of these precision changes, a short across the stabilizer

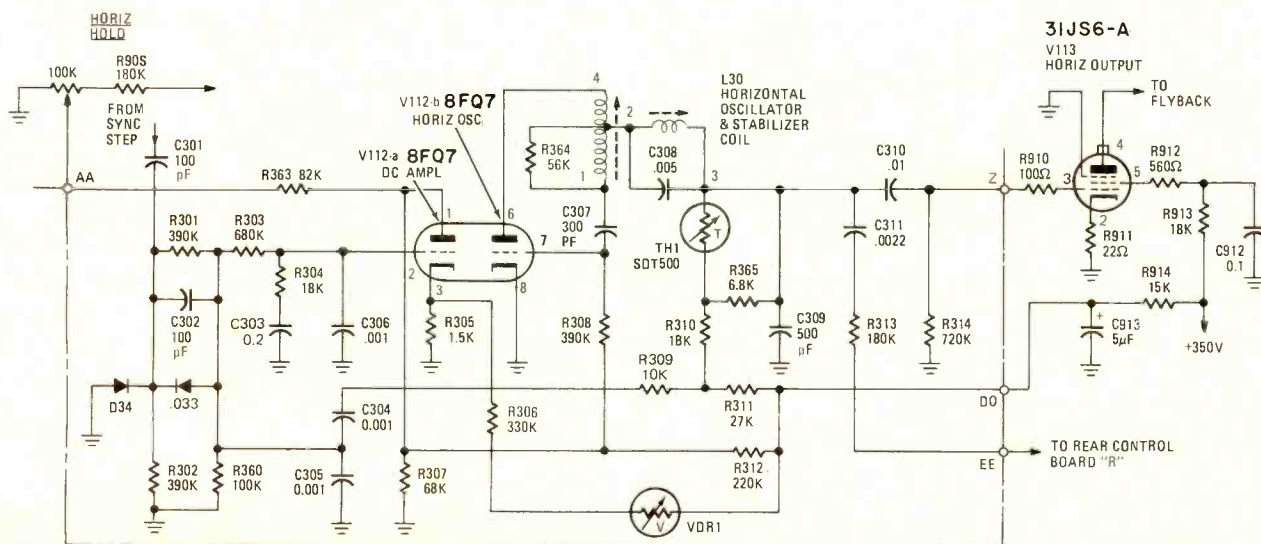
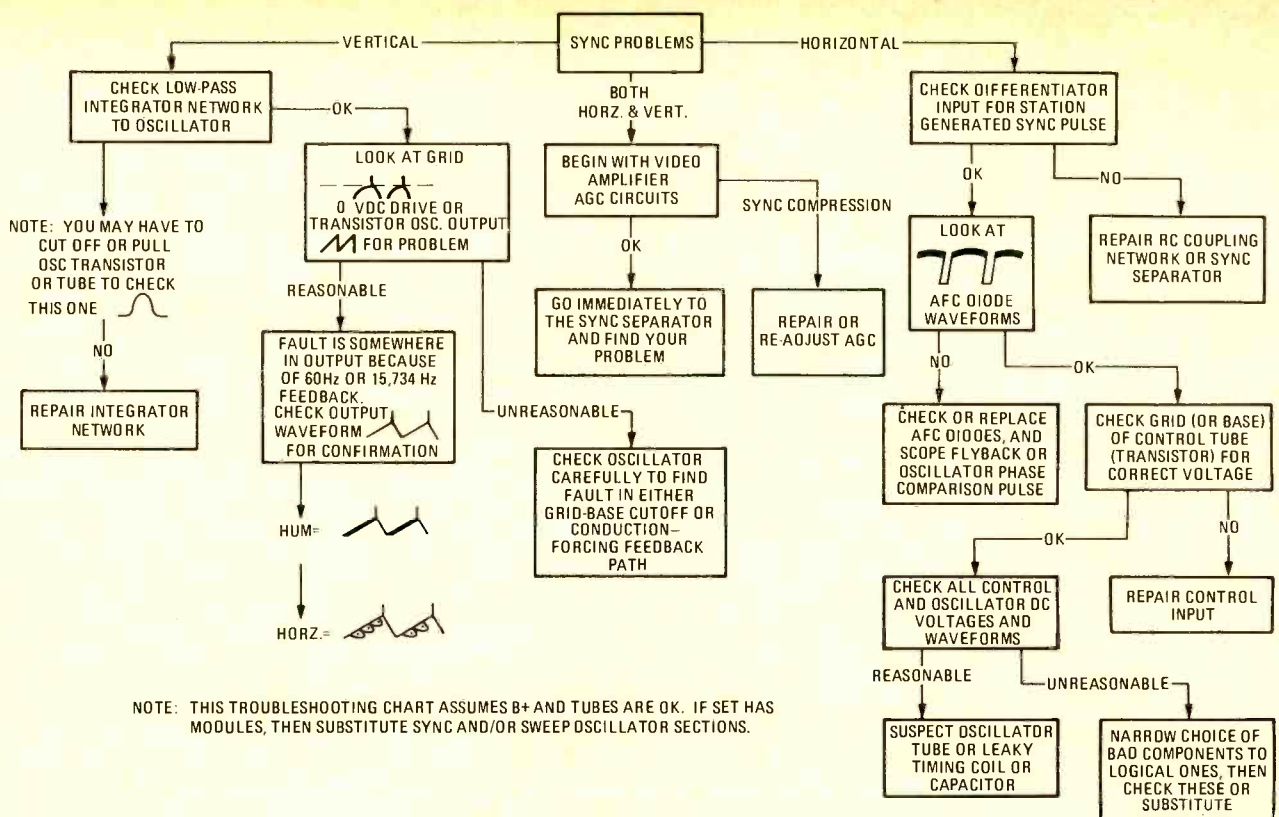


FIG. 2—AFC, HORIZONTAL oscillator and horizontal output stages.



NOTE: THIS TROUBLESHOOTING CHART ASSUMES B+ AND TUBES ARE OK. IF SET HAS MODULES, THEN SUBSTITUTE SYNC AND/OR SWEEP OSCILLATOR SECTIONS.

TROUBLESHOOTING CHART—Sync Problems

still wouldn't permit anything like a locked picture by twiddling the oscillator's lower ferrite core. Removing the short, we decided to look at the oscillator plate and grid waveforms with our trusty oscilloscope. The signal at pin 7 (Fig. 3, lower trace.) wasn't

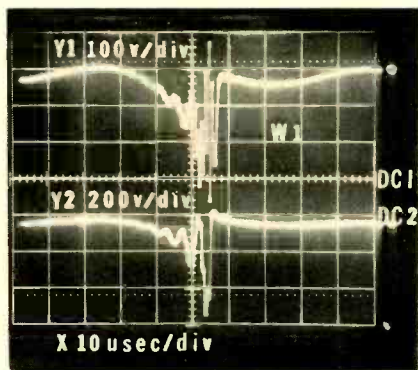


FIG. 3—HORIZONTAL OSCILLATOR grid waveform (lower trace) is good, but plate waveform (upper trace) shows excessive ringing.

bad, and VDR1 cut the transients, but considerable oscillations did show at pin 6 (Fig. 3, upper trace.) between conduction and cutoff. So we decided that L301 had to be the problem, and tried a new one. Unfortunately, same difficulty, same results. We couldn't short the stabilizer coil and tune the oscillator.

Final recourse

At this point, you really have only one basic step left. Try a different brand 8FQ7 oscillator tube. There is such a

thing as *interelectrode capacitance*, and something else might just match the circuit. Fortunately an RCA 8FQ7 did the trick and the oscillator tuned just fine. There is also an upper core for L301, remember, and this must be tuned so that the second waveform peak is about half that of the first (taller) peak. If you have a good scope this can fool you. In Fig. 4, the upper trace is displayed at 5V/div., whereas the lower trace is displayed at 10V/div., with the time base

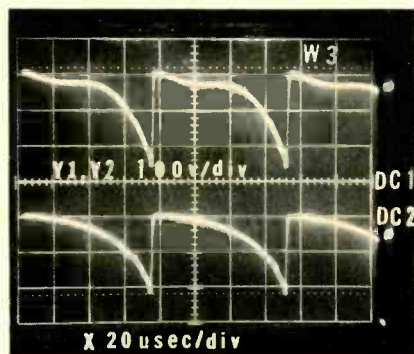


FIG. 4—STABILIZER COIL is adjusted by setting the ratio of the waveform peaks. Be careful, however, as oscilloscope setting can affect the ratio. Upper trace is displayed at 5 V/div and lower trace is displayed at 10 V/div.

set at 50 μ s. Obviously, the peak amplitudes differ from waveform to waveform. So, adjust the lower peak for a null with the top core of L301, and this will give you maximum dip between peaks and the proper ratio setting. Sears now says turn the horizontal hold control fully clockwise and readjust the

bottom core of L301 for 10 to 20 bars sloping to the left, then set the hold control for pull in. This is your option, and you can check it out with receiver operation. But if your receiver locks in reasonably well on warm-up and regular reception, leave it alone.



FIG. 5—GOOD WAVEFORMS of transformer pin 2 (upper trace) and the grid of the horizontal output tube (lower trace).

Final waveforms at transformer pin 2, and the grid of horizontal output tube V113 are shown in Fig. 5 upper and lower traces, respectively. The 564.80020 also stood in need of an IF sweep alignment touchup—which is possible on this and most vacuum tube receivers—with just a little negative bias to the Z terminal on the video and sound board and -10 volts to the AGC terminal of the VHF tuner. Connect sweep generator to the mixer test point and twiddle with care. Response can be slightly double humped with chroma at 50% and video at 40% \pm 5%. R-E

R-E's Service Clinic

Output Transistor Failure

How to avoid repeated failures

JACK DARR
SERVICE EDITOR

DO YOU GET TIRED OF REPLACING THE output transistors in small and medium-powered amplifiers over and over again? Especially when they blow in less than two weeks and you're stuck with a warranty replacement? This can be distressing to say the least, especially if you like to make a profit. There are ways of getting around this pitfall.

Most of these amplifiers are import types with the output transistors shockingly underrated and the power output overrated. They're being driven to almost their peak voltage or current with the inevitable result. The "repeater" problem is more apt to come up if you use exact-duplicate replacement transistors. Some of these carry very well-known brand names, too.

voltage transformer and slowly increase the AC line voltage while monitoring the collector current. Now check for excess resting current (no-signal condition.) If this is too high, your full-load current will be completely out of the ball park.

For the typical small amplifier shown in Fig. 1, note that the resting current is 36 mA and the maximum current 500 mA. This is a stereo amplifier, so the 500-mA current is for both channels, 250 mA each channel. This kind of reaction is typical of the *Output TransformerLess* (OTL) class-B circuits almost universally used.

If the resting current is too high, check the bias on the output transistors. If this is way off, turn the amplifier off

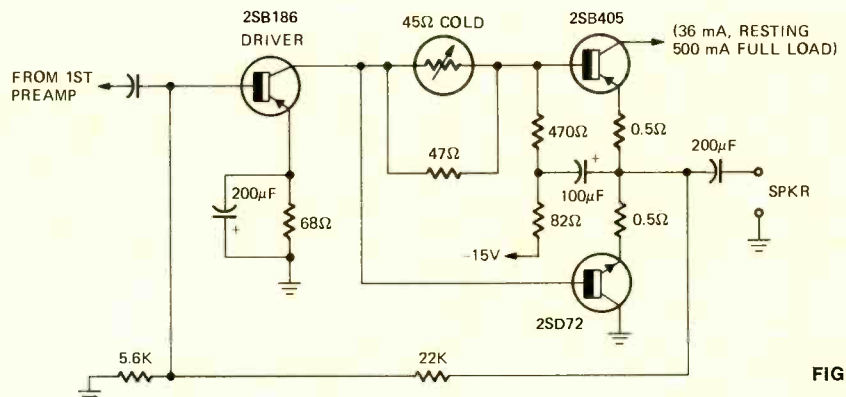


FIG. 1

There are two ways of avoiding this problem. One is to select a replacement transistor with a much higher voltage and current rating. You'll find full specifications on these in the listings in the replacement guides. I like to derate very heavily (spelled *safety factor*). Read the maximum DC voltage from the power supply and then double it. If you see 35 volts DC, use a replacement with at least a 70-volt collector break-down rating, or more. You can get an idea of the maximum current from the values given in the Sams schematics. More on this in a minute. Be sure that your replacement can handle at least twice the value shown.

The safest way to check one of these is by using a variable-voltage transformer. After installing the replacement, open the collector supply lead and hook in a DC milliammeter. Now plug the amplifier into the variable-

and make a careful check for such things as open or shorted bias diodes, burnt bias resistors, and so on. In many of these you'll find thermistors in the base circuits that are usually shunted by resistors. You can check these with an ohmmeter. Not too long ago, we had an epidemic of bad solder joints in this circuit! In this one (and in the ones I had so much trouble with), note that the thermistor reads 45 ohms cold, shunted by a 47-ohm resistor. The combination reads about 22 ohms. If you get 45 ohms, either the resistor or the thermistor is open! Bias diodes can also be checked with the ohmmeter. Oddly enough, in one amplifier, the only thing I could find besides the blown output transistors was an *open* bias diode. Evidently this was the cause, for it worked after I replaced the transistors and the diode. I haven't figured this out yet but I saw it.

turn page

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After checking the bias circuitry, bring the line voltage up to normal and recheck the resting current. If this is in the ball-park, fine. Now feed in a low-level audio test signal and slowly increase the volume while keeping an eye on the collector current. **CAUTION:** Do **NOT**—repeat **NOT**—feed in a high-frequency sinewave audio signal at a high level. You can pop a pair of perfectly good transistors by doing this. It keeps the transistors turned on too long and they dissipate too much power! Use a music signal from a test record or tape, etc. Check the peak current at full volume. If this goes above the maximum rating shown on the schematic, back off *quick!* In some circuits you'll see *peak* swings of a far greater current than the maximum rating. I've seen swings of 600-700 mA in circuits that were supposed to draw 500 mA!

If the unit has a history of blowing output transistors or if you're locked into using exact duplicates (unit still in warranty, etc.), there is a way of getting around this. It's a bit of a Q&D (Quick and Dirty) way, but it does work. Open the collector supply circuit to the output stages *only*, and insert a small current-limiting resistor. The value of this isn't too critical; somewhere around 220-230 ohms 1-watt. Now go back and recheck at full vol-

ume and you'll be surprised to see how this holds those high peaks down. Also, this seems to have very little effect on the maximum *loudness*. I first used this on a set that was working on its *fourth* set of output transistors in less than two months. It hasn't been back since. I have used the same trick on several others with good results. I have also heard from readers saying that they had used it.

Heat-sinking is very important. Be sure to put the replacement transistors back snugly into the heat-sinks. A lot of these use the TO-1 transistors such as 2SD405. They use an "ox-bow" shaped heat-sink tightly clamped to the chassis. I made some deliberate "test to destruction" checks with one of these. The originals would last only for a minute or two at full volume when they weren't clamped to the heat sinks. A pair of slightly higher-rated transistors lasted a little longer, but still burned up. Using these higher-rated types in the heat sinks, they held up nicely. Watch out for replacement transistors in this case with the collector electrically tied to the case! If you have these, you'll have to insulate the heat-sinks with thin sheets of mica, liberally daubed with silicon grease.

If the original heat-sinking doesn't look too good, you can add more.

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Clamping to the metal chassis is the best. If the transistors aren't getting too hot, you can use the push-on heat-sinks; RCA, G-E, Motorola and many others have quite a few different types, look in the back pages of the replacement guides. If necessary, you can mount the new transistors on the metal chassis and run some longer leads to them.

Be sure to check *everything* in the output circuit. Many of these amplifiers do not use the emitter resistors found in the better designs, for over-current protection (as in Fig. 1.) Check all resistors that could have been damaged when the output transistors blew. Even though they are not discolored, lift one end and read the resistance on an accurate ohmmeter. **R-E**

reader questions

INTERMITTENT WEAKNESS

This Rambler 5BA auto radio almost drove me nuts. It had intermittent low sensitivity. Hammer on it or touch the PC board on the foil side and it came back! I checked a whole lot of things. Finally found that I could touch the board near C18, the emitter bypass on the RF stage. Taking this out, it

checked perfectly on a bridge and with no leakage. Apparently, the thing had an intermittent high-impedance condition for RF only!

One more; if you take the PC board out for servicing, as you must, look out for an open *ground* where it circles around the bottom side. This is completed by the metal frame when it's in place. To make it work, you must complete this ground circuit with a jumper, and another from here to the frame!

(Thanks to Richard Niessen of East Dubuque, IL for this tale!)

FIX FOR SYNC PROBLEMS

Thanks for the helpful letters on my problems with a CTC-10 RCA that I am reworking. A friend told me about a fix he remembered for the sync problems. There's a 2.0 μF electrolytic capacitor on the screen grid of the 6AW8 video-output amplifier. This was open. Replacing it brought back the sync, steady as a rock. Don't know why but it works, and thanks!—R.W., Bachmann, Andover, MA.

Yes. Now *I* remember that one! (Now you remember it!) Used to be fairly common. Evidently, the open bypass on the screen causes a feedback that cancels out the sync. Glad you got it going!



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Circle 18 on reader service card

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MINDPOWER: ALPHA

continued from page 52



FRONT PANEL of the assembled Mindpower: Alpha unit.

output of NAND gate IC4-d must be at logic 0. Beam off (black) is obtained with a logic 1. Looking backwards to the vertical comparators, NOR gate IC2-c, and NOR gate IC2-d respectively gate the outputs of the two comparators that define the beginning and end of a bar segment. Thus, if either comparator output is at logic 1, the NOR gates will be at logic 0. If both comparators are at logic 0, the output of the NOR gates will be logic 1. In the horizontal section, NOR gates IC2-a and IC2-b perform the same function.

The output of NOR gate IC2-a is inverted by IC3-b and applied to NOR gate IC3-a. Meanwhile, the output of NOR gate IC2-b is applied to NAND gate, IC4-a, along with the output of NOR gate IC2-d. The output of IC4-a is inverted by IC3-c, supplying the second input to IC3-a. The outputs of IC3-a and IC2-c are then gated by IC4-b. At this point, if either input is a logic 0, the output of IC4-b will be a logic 1. If both inputs are at logic 1, the output will be logic 0. This is inverted by IC4-c and supplies the video input to NAND gate IC4-d, which gates it with the output of Q5 in the display motion generator section. In effect, any of the comparator outputs representing bar segments that occur when there are no coincident outputs from the comparators controlling bar segments in the other display axis, will result in a logic 1 output from IC4-d—corresponding to blanking of the electron beam. Where the

display logic does detect the required coincidence, the output of IC4-d goes to logic 0, providing a beam-on video signal to write a white-bar segment. The result is a white, open-center rectangle, appearing on a dark field.

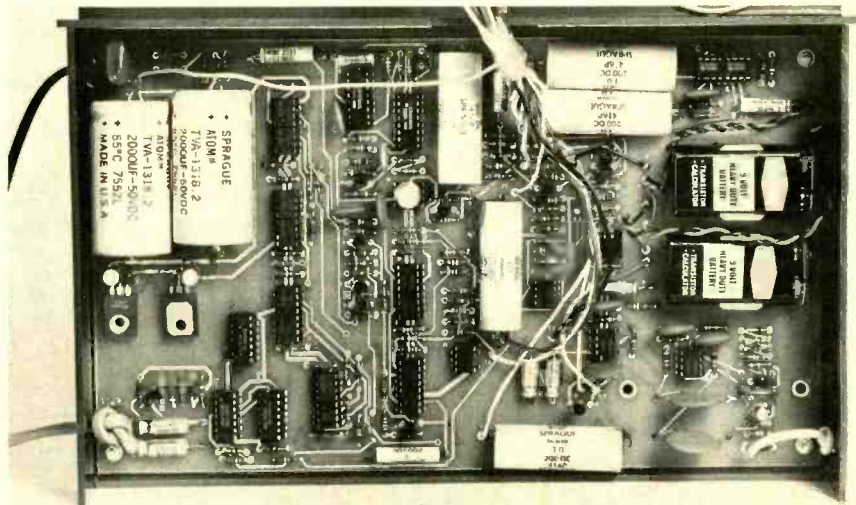
The video signal thus created is applied through diode D18 to video driver Q12, an emitter follower that supplies the signal to the TV set. Horizontal and vertical sync pulses from Q1 and Q2 are supplied to the base of Q12 through diode D17. A representative illustration of the composite video signal appearing at Q12's output is shown in Fig. 3.

Isolated EEG amplifier

The very low amplitude of brainwave signals at the skin surface of the head necessitates use of a differential input amplifier that possesses a high common-mode rejection-ratio (CMRR) and an input impedance that is very high with respect to the equivalent impedance measurable between the electrodes.

The optimum choice for an EEG amplifier subjected to these wide extremes is a matched-FET input amplifier (Q14 in Fig. 1). The 2N5524 FET features very high input impedance, by virtue of the "floating gate" configuration used. Resistors R1 and R2 provide current-limiting in the input circuit to limit the effect of static potentials applied to the electrodes. Gate-source protection is provided by diode junctions within the 2N5524 structure, which prevent the gate potentials from rising to a level that might damage the FET structure. The excellent CMRR of the dual FET input stage is maintained by use of a constant-current source, consisting of bipolar stage Q15. Fixed bias for this stage is obtained by diodes D1, D2, D3. Noise potentials common to both electrodes are applied to the base of Q15 from the common isolated ground electrode. These potentials are inverted by Q15 and thus, cancel the common mode noise potentials appearing at the gates of the dual FET. The gain of the Q14 stage is about 4.

The outputs of Q14 are coupled to the non-inverting and inverting inputs of IC25, a differential amplifier. The values of C1 and C2 limit the low frequency re-



MINDPOWER: ALPHA with front panel removed reveals the printed-circuit board and the components. Speaker is mounted against front panel.

sponse of IC25 to about 8 Hz. Feedback provided by C4, R10, C3 and R9 sets the upper frequency response limit of IC25 to about 13 Hz. Within the bandpass of the amplifier, a gain of approximately 300 is provided. The single-ended output of IC25 thus represents the amplified alpha wave content of brain wave potentials picked up by the active headband electrodes. The alpha signal is further amplified by IC26.

The alpha wave output of IC26 is coupled by C10 and R14 to the THRESHOLD control R92. Here, the amplified alpha signals are picked-off and applied to Q13, which converts the alpha impulses into keying signals for the light-emitting diode (LED) half of optical isolator IC27.

The optical isolator consists of an LED and a photo-transistor, separated by an air gap of about 10 mm. Each time Q13 conducts in response to alpha, the LED is turned-on, illuminating the photo-transistor and causing it to switch from the off-state to the on-state. Thus, the alpha waves are converted to square waves of equal amplitude, whose width depends upon the duration of the alpha input. Importantly, the alpha signal conversion is accompanied by the fact that the signal transmission occurs over an *optically coupled path*. This path offers no electrically conductive pathway between the isolated circuitry driving the LED and the transformer-powered circuitry that receives its signal input from the excited photo-transistor.

The isolated EEG amplifier is powered by a dual 9-volt battery supply, B1, B2. Power input is controlled by switch S3-a, S3-b, and decoupling is provided by capacitors C7 and C8.

Audio control section

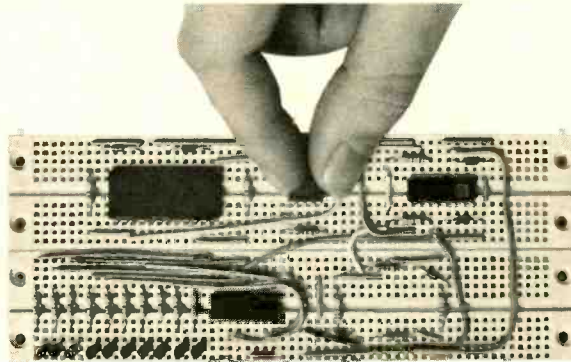
The optically coupled alpha signal (now uniform squarewave pulses) from IC27 is applied to pulse shaper/differentiator Q8, Q7, that provides a switched keying signal to IC20—a type 555 connected as an audio oscillator. IC20 provides an audio output to the loudspeaker through C12 and R18. The speaker can be silenced by opening switch S4. Assuming, however, that S4 is closed, an alpha-burst keys on Q7 so that IC20 receives power for the duration of the burst, thus issuing a "beep" for that period.

The output of transistor Q7 is applied through Q6 to the display motion generator, Q5, IC18, IC19. Transistor Q6 is connected in a noise-immunizing configuration, so that a definite switching input is required from Q7 before a signal is passed. In this way, noise is prevented from securing control of the video display's size.

Transistor Q5 is connected as a switch, capable of pulling-down the input voltage to IC18 each time an alpha burst occurs. IC18 has two modes (Mode 1 and Mode 2), determined by the position of switch S1. In Mode 1 (S1-a open, S1-b open, S1-c closed), IC18 receives a bias voltage through R28, R29, and R30. (The value of R30 determines the rate of response of the stage to an alpha burst. For a quicker response, values down to 330K can be used.) This causes a fixed voltage to appear at output pin 6, thus providing a fixed reference to the vertical and horizontal

continued on page 72

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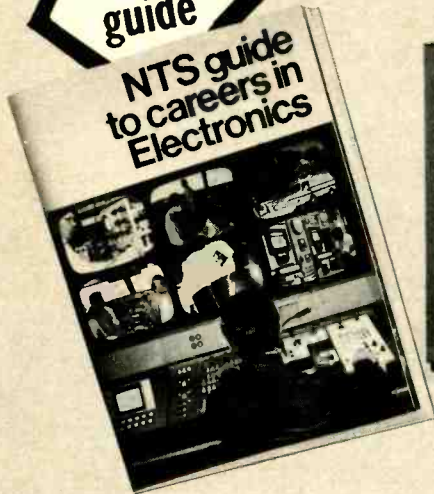
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Circle 41 on reader service card

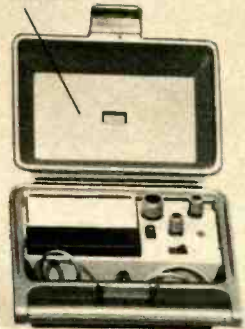
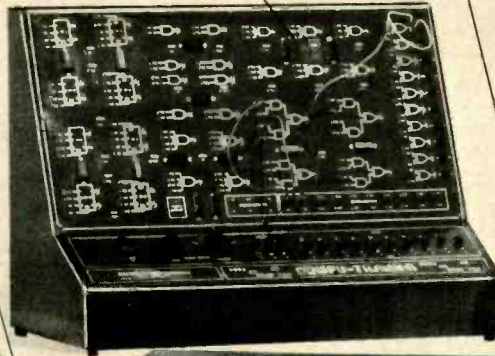
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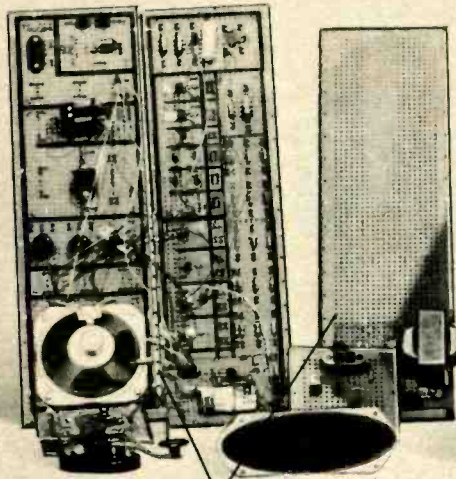
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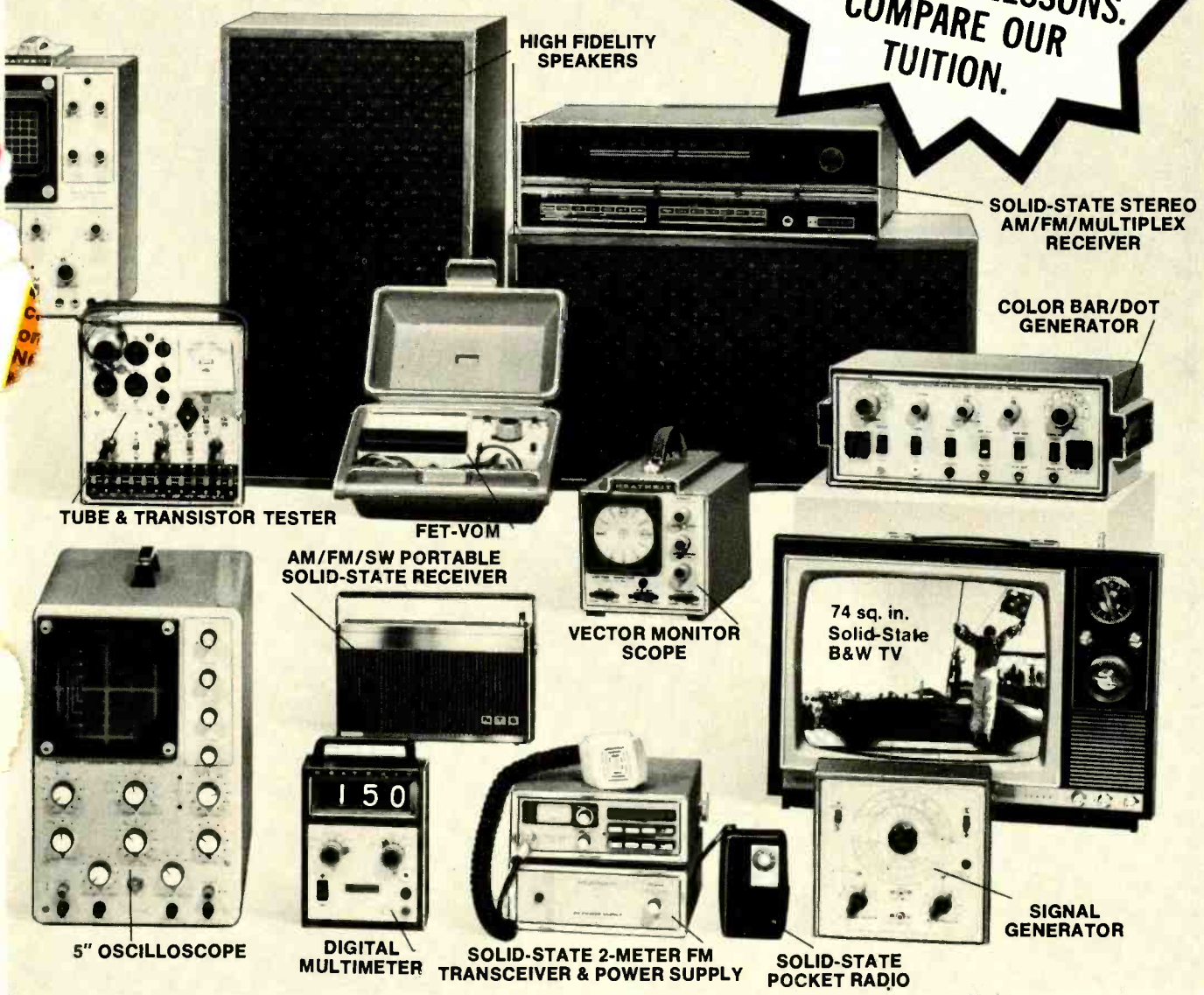
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MINDPOWER: ALPHA
(continued from page 67)

comparators through IC14, IC15 and IC17. As a result, the video display on the TV set screen is a stationary rectangle in this mode. However, when an alpha burst is applied to Q5, it switches on, instantly pulling-down the bias to IC18 through diode D5. This reduces the output of IC18 and shrinks the size of the rectangle on the screen. To speed up the process, IC19 is regeneratively connected from the output of IC18 to the base of Q5. The added gain of IC19 significantly reduces the on-screen size of the rectangle, overcoming the integrating effect of C16. When the alpha burst ceases, Q5 switches off and

IC18 receives normal DC bias. As C16 recharges, the rectangle on the TV screen grows back to its normal, quiescent, size.

Assuming now that switch S1 is in the Mode 2 position (S1-a closed, S1-b closed, S1-c open), IC18 now functions as an active integrator. The input bias to the stage now is applied to C15 through the resistive ladder of R28, R29, and R33. An exponential voltage is applied to the IC18 input, resulting in a ramp output of 0-5 volts. This slowly increases the size of the rectangle display on the TV screen from a small size at screen center to a larger rectangle that disappears at the screen edges, bringing on the next cycle. An alpha burst switches on Q5, partially discharging C15. The output of IC18 falls,

thus causing the rectangle to shrink. If the alpha burst has ceased, C15 recharges and the rectangle resumes its growth/reappearance/growth cycle.

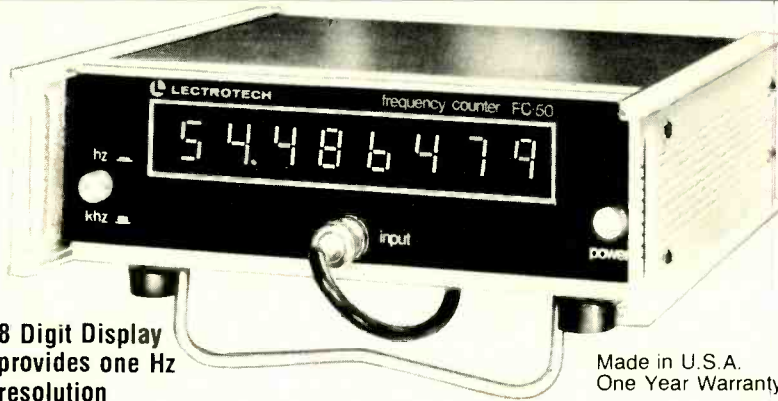
Power supply

Other than the isolated EEG amplifier, all stages of Mindpower: Alpha are powered from the AC line through external plug-in transformer T1.

The input from the transformer is rectified by diodes D11 and D12, each of which is filtered by a 2,000 μ F capacitor (C18, C17). In order to provide "stiff" supply voltages under load, the filtered outputs are applied to integrated voltage regulators IC23 and IC24. As a result, the +15 and -15-volt DC power supplies that serve the non-isolated circuitry of Mindpower: Alpha are maintained constant under varying load conditions.

Because the power supply is an integral part of the many circuits, it is essential that the supply impedance be as low as possible to minimize the possibility of circuit interaction through the supply impedance. For this reason, the regulator outputs are bypassed by 10 μ F decoupling capacitors, soldered to the parts side of the board. Also, to prevent the horizontal or vertical sync stages from responding to noise (transients) coupled through the inter-winding capacitance of transformer T1, a 0.47 μ F bypass capacitor is connected across the line input terminals (23 and 24) of the printed-circuit board. **R-E**

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Circle 7 on reader service card

PARTS LIST

- All resistors 1/4-watt 10% unless noted**
- R1, R2, R14, R16, R20, R28, R32, R45, R46, R64—10,000 ohms
 - R3, R4, R41, R42, R47, R68, R72, R73—10,000 ohms, 5%
 - R5, R31—2700 ohms
 - R6—27,000 ohms
 - R7, R8, R48—30,000 ohms, 5%
 - R9, R10, R12, R13—3 megohms, 5%
 - R11—3900 ohms
 - R15, R53, R63, R65, R74, R75, R77, R78, R79, R80, R88—4700 ohms
 - R17—820,000 ohms
 - R18—22 ohms
 - R19, R36, R52—56,000 ohms
 - R21, R39, R44, R59, R76, R91—15,000 ohms
 - R22, R34, R51—100,000 ohms
 - R23, R25, R26, R33, R81, R82, R83, R84, R86—22,000 ohms
 - R24—47,000 ohms
 - R27—3300 ohms
 - R29—10 megohms
 - R30—1.5 megohms
 - R35—750,000 ohms
 - R37—20,000 ohms, 5%
 - R38—4700 ohms, 5%
 - R40, R89—1000 ohms
 - R43—15,000 ohms, 5%
 - R49—120,000 ohms
 - R50—39,000 ohms
 - R54, R57, R58, R60, R61—5600 ohms
 - R55, R62—33,000 ohms
 - R56—220,000 ohms, 5%
 - R66, R71—13,000 ohms, 5%
 - R67—220,000 ohms
 - R69—12,000 ohms, 5%
 - R70—7500 ohms, 5%
 - R85—12,000 ohms
 - R87—240 ohms
 - R90—200 ohms
 - R92—10,000 ohms, linear potentiometer

All capacitors 25V or more unless noted

- C1, C2—0.47 μ F, 100 V, 10%
- C3, C4, C5, C6—.0033 μ F, disc, 10%
- C7, C8, C20—5 μ F, electrolytic
- C9, C15, C29, C30—10 μ F, 25V, electrolytic
- C10, C12, C14, C19—1 μ F, 100V, 20%
- C11, C23—0.1 μ F, 100V, 10%
- C13, C26, C27—0.01 μ F, disc
- C16—(see text)
- C17, C18—2000 μ F, 50V, electrolytic
- C21—.0082 μ F, disc, 10%
- C22—.033 μ F, 100V, 10%
- C24—.0015 μ F, disc, 10%
- C25—.0068 μ F, disc, 10%
- C28—150 pF, disc
- C29, C30—10 μ F, 25V, electrolytic
- C31, C32—10 μ F, 25V, electrolytic

Transistors*

- Q1, Q2, Q3, Q4, Q5, Q7, Q8, Q9, Q10, Q11, Q12, Q13—2N4401
- Q6—2N4403
- Q14—2N5524
- Q15—SE4021

Diodes*

- D1 through D19—1N3064
- D20—1N5240, 10V, 10% Zener

Integrated Circuits*

- IC1—CD4046AE (CMOS)
- IC2, IC3—CD4001AE (CMOS)
- IC4—CD4011AE (CMOS)
- IC5, IC6, IC7, IC8, IC9, IC10, IC11, IC12—LM311N (voltage comparator)
- IC13—LM318N (op amp)
- IC14, IC15, IC16, IC17, IC18, IC19, IC25, IC26—LM307N (op amp)
- IC20, IC22—NE555 (programmable timer)
- IC21—CD4040AE (CMOS)
- IC23—MC7815 (+15V regulator)
- IC24—MC7915 (-15V regulator)
- IC27—MCT-2 photocoupler

Miscellaneous

- Printed circuit board (2 sided, plated through holes)
- Plastic case
- Miniature speaker, 8-ohms
- Headband assembly
- Battery clips
- Battery connectors
- BATT1, BATT2—9-volt alkaline batteries
- Transformer
- S1—3-pole, double throw slide
- S2—N.O. single pole pushbutton (or slide)
- S3—dpst slide
- S4—spst slide
- IC sockets
- Misc hardware

***Do not substitute**

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Circuit board. 2-sided, plated through holes. Order part number NM-P108: \$34.50

Transformer. Order part number NM-T6: \$17.50

Headband. Order part number NM-HA39: \$9.50

Case, punched and drilled. Order part number NM-C56: \$14.75

Set of all semiconductors including 27 IC's and 35 transistors and diodes. Order part number NM—Semis 1: \$99.50

Complete set of all parts needed to build Mindpower: Alpha: \$265.00.

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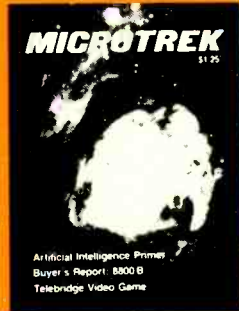
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STATE-OF-SOLID-STATE

(continued from page 32)

For cosines, the complement of the angle θ , $90^\circ - \theta$ is used as the input. This memory could be used by a scientific calculator to find sine values. Other trigonometric functions can also be determined using manipulations inspired by those trigonometric identities you struggled with in high school. The general scheme is labeled a Look-Up Table because the system works just like the printed tables in math reference books. Numbers are stored as their binary equivalents.

The best way to show how it works is to go through an example. Let's pick one

you probably know the answer to already. How about the sine of 30 degrees? If you recall, the sine of 30° is exactly 0.5.

The S8771 takes the 90-degree input range and breaks it up into 512 discrete segments, one for each of the 10-bit words it retains. There are 511 increments between the 512 values, so each step corresponds to $90/511 = 0.1761$ degrees. To find the address of the sine of 30 degrees take $(30 \times 511)/90 = 170.33$ and round it out to the nearest integer 170. Now we must convert this to its binary equivalent for addressing. The largest power of two in 170 is 128 or 2^7 . Now we have to account for the remaining $170 - 128 = 42$. The largest power of two in 42 is 32, 2^5 leaving $42 - 32 = 10$. Continuing in this fashion $2^3 = 8$ leaving 2, and $2^1 = 2$. The

binary address for the sine of 30° (actually $170/511 \times 90$ or $30 \times 0.1761 = 29.94^\circ$) is formed by putting ones in the 8th, 6th, 4th, and 2nd places: 0010101010. When these corresponding inputs are put on the A9 through A1 input points and R_M is activated, the ten-bit word stored at address 170₍₁₀₎ is read out. The actual word in the S8771A at location 0010101010 is 0111111111. To find the sine in base 10 we convert this binary number to decimal by giving the weights 1/2, 1/4, 1/8, 1/16, 1/32, 1/64, 1/128, 1/256, 1/512, 1/1024 to the corresponding bits. Where there is a one in the binary output word, the weight corresponding to that position is added to the decimal accumulation. Where the binary output contains a zero, nothing is added. Of course in a real application a hardware converter or a software conversion routine does the work. For our demonstration we will work it out the hard way. Adding the last nine weights, since the last nine binary bits are all ones, we get $(256 + 128 + 64 + 32 + 16 + 8 + 4 + 2 + 1)/1024 = 511/1024 = 0.4990$. The error is one part in 500 or 0.2%.

The S8771B arc-tangent look-up table works much the same way except the tangent is fed in and the angle is the output.

Direct access through such a table is about the fastest way to get to the answer. The S8771 has a minimum R_M cycle time $t_c = 500$ ns. It is made up of 200 ns address stable time, 250 ns propagation delay time, and an additional 50 ns. Additional conversion times must be added to this figure. In a complex calculation of which the look-up procedures may only be a small part, the output conversion would only be done once with the intermediate arithmetic done directly in base 2. Incidentally such now commonplace computer-inspired procedures as these is one of the reasons for the new math where other base number systems than decimal are studied.

There are other ways of getting trig functions with less memory. Calculators and computers often use series solutions of trigonometric functions. No tables at all are used in the series method. Only relatively few memory cells are tied up in compact routines to calculate the values. An iterative procedure cycles until the function is calculated to within a small enough error. Various floating-point routines are shared with other functions in the system and the overhead of the trigonometric function is low. Another method uses shorter words and stores the increments only from one step to the next. To get the table value for any input the increments up to that point must be successively summed. Both these alternate procedures are going to take longer to get the answer because of the numerous intermediate steps. The series of arithmetic and comparison steps eat up many machine cycles. If there is sufficient time they offer good alternatives to the straight ROM look-up table. Where speed is of the essence it's hard to beat the larger table.

Another ROM type, the S8773, is a similar but smaller 2560-bit circuit. The chip is divided into 256 10-bit words. It is also available preprogrammed as a sine/cosine look-up table. The outputs are weighed differently than in the S8771. The

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lines B9 through B0 are weighted from 0.512 or $2^n \times 0.001$ to 0.001 or $2^0 \times 0.001$. The S8773 is also available as a $64 \times 5 \times 7$ bit ASCII character generator in its B version.

American Microsystems, Inc., 3800 Homestead Road, Santa Clara, Ca. 95051.

National LF op-amp series

An important non-obvious point is brought out in a paper by a National Semiconductor Author, James E. Solomon, "The Monolithic Op-Amp: A Tutorial Study." It points out that one of the best ways to get high slew rate, an often elusive quality, is to use a low transconductance input amplifier. I know I have tried selecting a fairly wideband op-amp for use in some switching or waveform generation circuit and have been sadly disappointed to find very slow response in the output. It just didn't swing at the rate I had expected. Wide bandwidth is simply not enough.

Figure 3 is the equivalent circuit of an op-amp. The input differential amplifier stage has high output impedance because the output is the junction of transistor collector terminals. The output current of the input stage feeds the low-impedance input of the following simplified capacitor compensated output stage. The output stage works like an integrator. The amplifier feedback creates a virtual ground at the input to the output amplifier, a point I keep repeating and hope you have picked up. The input is essentially at

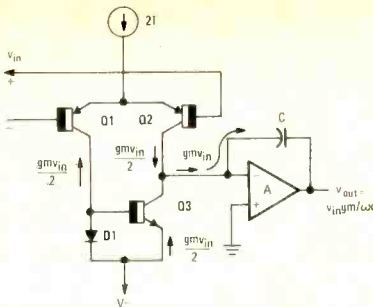


FIG. 3—OP-AMP equivalent circuit.

ground potential and does not shift as the signal current from the differential stage changes. The current can be considered directly entering the capacitor, forcing the output terminal to shift directly as the accumulated charge. This is a fair simplification of the actual situation. Although other distributed poles or RC frequency roll-off points may have an effect on amplifier stability, this equivalent circuit gives a valid representation for basic analysis.

The LF series is divided into three groups depending on current and bandwidth specifications. The fastest in the group is the LF157 with a slew rate of 75 V/ μ s at a voltage gain of 5. Its gain bandwidth product is 25 MHz at this same gain and reduces to 5 MHz at unity gain.

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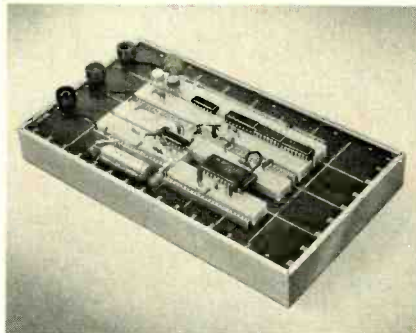
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new products

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

TWO-SIDED DIP BREADBOARD. The model 51X *Klip-Blok* breadboard, mounted on an aluminum chassis, allows components to be attached and interconnections to be made from both sides to increase wiring convenience and reduce clutter. Signal and power bus connections can be made on the bottom, if desired, leaving the top clear for wiring that must be altered. Interconnections can be made with 22-gauge wire. DIP's and most semiconductor units plug in. The board's design concept allows quick, solderless assembly of breadboard circuits. The eight *Klip-Bloks* accommodate a maximum of twelve 14- or 16-pin DIP's, or four 24- or 40-pin devices. *Klip-Bloks* may be quickly repositioned for 0.6 in. spacing of tabs. Additional *Klip-Bloks*, sockets or discrete components may be mounted on the perforated Vectorbord® surrounding the *Klip-Blok* area. The 51X accommodates packages with 0.6 in. lead spacing as well as devices with conventional 0.3 in. spaced leads. *Klip-Strips* supply convenient signal or power busing.

The glass-epoxy mounting board is 4.5 in.



by 8 in., and has a 0.1 in. spaced hole pattern. Printed registration numbers along the edges identify component positions. The 51X board is unclad; however, a model 51X-GP may be ordered with an etched ground plane on the bottom side for breadboarding high-frequency circuits. The 51X is \$25.50; the 51X-GP is \$29.95.—**Vector Electronic, Co., Inc.**, 12460 Gladstone Ave., Sylmar, CA 91342.

Circle 80 on reader service card

DIGITAL STOPWATCHES designed for industrial timing applications. The ET200 and ET202 are decimal minute watches which time to 99.999 minutes. They also have an automatic reset to zero function for timing requirements that exceed 100 minutes. Easy one-hand operation allows use in any of several timing modes: Simple Start/Stop, Time-In/Time-Out, or Split action time for partial readouts. The ET200 is a standard split-action timer for freezing partial event times while continuing to measure total elapsed time. The ET202 has Taylor split-action time which provides for a series of individual event times, or total elapsed time (but not both).

Both stopwatches feature a bright LED display with intensity control and specially designed bezel to enhance readability under all ambient light conditions. Rechargeable nickel-cadmium batteries provide 8 hours of continuous operation, fully recharging in 6 hours. These solid-state electronic watches require no calibration or preventive maintenance to assure quartz-crystal controlled accuracy of better than 0.001 minutes per hour (0.002%). These watches are guaranteed (parts and labor) for a period of one year from date of purchase.



The mechanical specifications of the watches are: weight (with batteries, 6 oz (170 gm); dimensions, 4.45 in. X 2.26 in. X 1.45 in. (11.3 cm X 6.2 cm X 3.7 cm); operating temperature, -12°F to +132°F (-25°C to +55°C); storage temperature -40°F to +158°F (-40°C to +70°C). \$79.95 including a leather carrying case, neck strap and AC charger.—**Siliconix Inc.**, P.O. Box 4088, Agnew Station, Santa Clara, CA 95054.

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PORTABLE TRANSISTOR TESTER, model 510, provides fast go/no-go in-circuit transistor testing. Uses digital high-current, low



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tion of all three leads, in-circuit or out-of-circuit. Tests transistors, FET's and SCR's. Identifies transistors as NPN or PNP. Indicates whether FET is N-channel or P-channel. Identifies FET gate lead, identifies all leads of transistors in LO drive, base lead in HI drive. Identifies all leads of SCR's. Weighs 1 lb., measures 3.75" x 6.63" x 1.75". \$90.00.—**B & K Precision**, Division of Dynascan, 1801 W. Belle Plaine Ave., Chicago, IL 60613.

Circle 82 on reader service card

NEW CB RADIO, *Realistic TRC-56*, features a telephone-type mike and speaker handset which is said to virtually eliminate background noise.

A speaker/handset switch lets you listen through the handset, built-in speaker or both. When using the handset speaker, replacing the handset in the cradle automatically switches operation to the transceiver's built-in speaker. A push-to-talk switch is built into the handset.

The *TRC-56* comes with all crystals for full 23-channel operation and is rated at 4 watts maximum AM output. Includes automatic modulation gain circuit for constant "talk power" without overmodulating. The sensitive receiver features dual-conversion circuitry plus ceramic filters for top selectivity, and delta tune switch to help pull in



off-frequency stations. A built-in automatic noise limiter and noise blanker switch provide superior noise suppression from auto ignitions and other forms of electrical interference, according to Radio Shack.

An adjustable squelch control silences the receiver between calls. The *TRC-56* also has an S/RF power output meter which indicates the strength of incoming signals while receiving and monitors power output when transmitting. The meter includes a built-in modulation light.

Receiver sensitivity is given as 0.5µV for 10 dB S+N/N; selectivity, ±3 kHz at -6 dB; adjacent channel rejection, -50 dB; audio power output, 3 watts. Size: 5 x 8 3/4 x 7". For 12 VDC, positive or negative ground. \$179.95 with mobile mounting bracket and power cable.—**Radio Shack**, 2617 W. 7th Street, Ft. Worth, TX 76107.

Circle 83 on reader service card

METERLESS TESTERS. Two new testers use LED's to indicate continuity, voltage and polarity. The LED indicators provide fast, easy readings without the confusing scales associated with meters. The testers were designed especially for the do-it-yourselfer for use around the home, car, boat, RV, snowmobile, motorcycle, trailer, etc.

The *Sea, Road & Home Tester*, priced at \$22.95, uses five LED's. Four are used on the combination AC and DC voltage tests of 6, 12, 110 and 220 volts, nominal. The fifth LED is used as an indicator for the continuity test. The tester will also show polarity of DC voltages and the "hot" side of AC power lines.

The four voltage test levels were chosen as those most often encountered in normal do-it-yourself repair and installation projects. The 6 and 12 volt tests help in working on cars, RV's, boats, cycles, etc., with the capa-

(continued on page 82)

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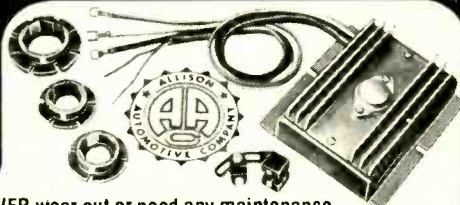
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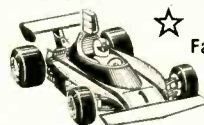
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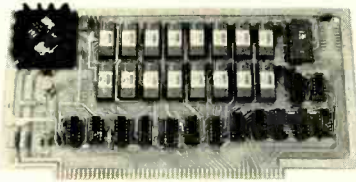
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NEW PRODUCTS

(continued from page 77)

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Both testers use solid-state circuitry and the *Sea, Road & Home* model also incorporates integrated circuits. Both will test continuity of circuits with voltage present without "blowing"—a feature believed to be unique in continuity testers. The testers have survived rigorous drop-testing and continue to function (don't try that with those delicate meters). An ordinary 9V transistor radio battery (not supplied) give the testers "go-anywhere" portability. The probes will reach test points as far as 50" apart. The red (positive) probe is an integral part of the tester case to make readings even more convenient with the LED readouts being right in your hand at the test point. The cases are hand size, measuring just 8" X 1 1/2" X 1", and weighing just a few ounces.

These new meterless testers are available in the U.S. by mail order from **E/B.A. Marketing**, Box 727, St. Joseph, MI 49085.

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SINE/SQUARE WAVE GENERATOR. A fast-rising squarewave for testing transient response and low distortion sinewave are among the features of the LAG-26 generator. It has a sinewave output range of 20 Hz—200 kHz at 0—5 VRMS with ±1 dB flatness and with distortion at less than 0.5% below 20 kHz. Squarewave output is 20 Hz—20 kHz in the 0—10 VP-P voltage range with 0.5 μs risetime. The new product also synchronizes signals from an external source and has a calibration accuracy of ±3%. Output impedance is 600 ohms unbalanced and the frequency range is in four decade bands.

The LAG-26 offers a 115/230 V; 50/60 Hz; 3 VA approx. power supply. It measures 6" H X 10" W X 5" D and weighs 5.5 lbs. \$139.95.—



Leader Instruments Corp., 151 Dupont St., Plainview, NY 11803.

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nel. With 4 VU meters and 1 tuning meter. It also includes 2 kinds of matrix circuitry. \$529.95.—Technics by Panasonic, 200 Park Avenue, New York, NY 10017.

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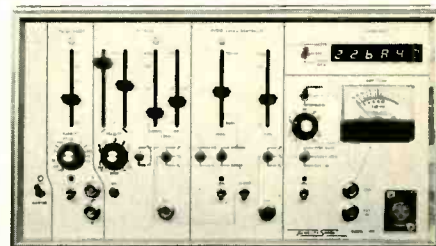
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Dimensions: 8 x 14 x 3. Warranty: 1 year. \$525, stock
to 30 days.

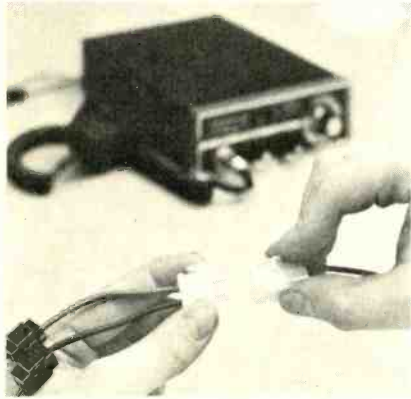
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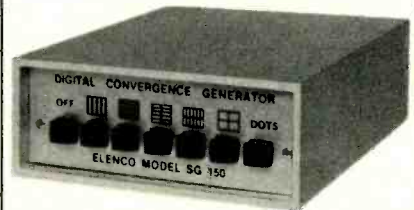


earphone. Operated from built-in penlite batteries, draws only 3 mA. Operating frequency is around 300 kHz. \$29.50.—**Amtroncraft Kits, Ltd.**, One West 13th St., New York, NY 10011. R-E

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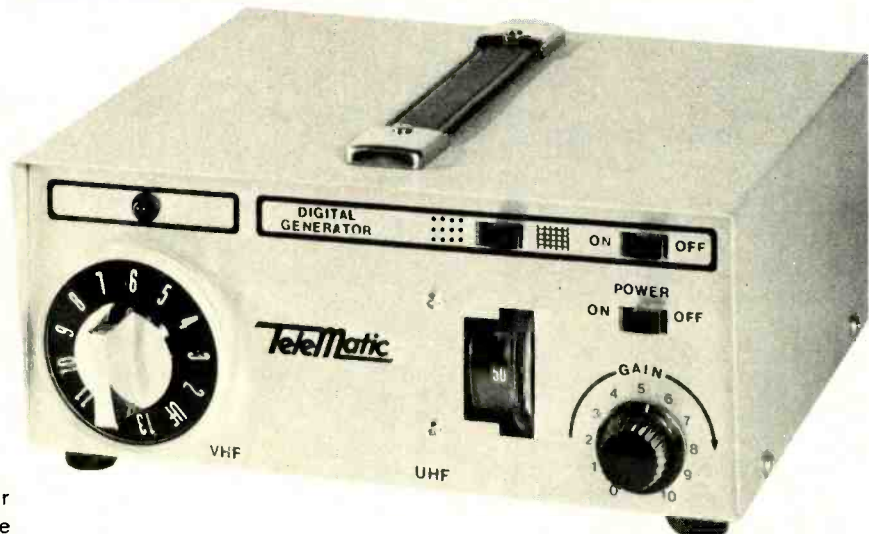
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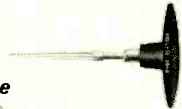


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Circle 14 on reader service card

TV GAMES

(continued from page 59)

As a first step in your trouble shooting approach, we suggest you read through the circuit description that appeared in the first part of this article and become familiar with the various circuits. As you go through the description, refer to the schematic to clarify the logic theory and refer to the scope traces shown here for verification of the circuit functions.

The TV screen is also an important tool in isolating trouble areas. For example, if the screen shows no paddles, you would immediately look at the outputs of IC4 and IC6 to determine if the paddle signals exist. Similarly, if the ball is not seen, look at the collectors of Q3 and Q4 to determine if rising and falling voltages are present. The screen can even be used to retweak the horizontal and vertical sync frequencies controlled by IC1 and IC26.

The best troubleshooting approach uses the circuit description as a roadmap. Follow the write-up and use a scope to confirm that the signals are present and functional. In troubleshooting there is often a tendency to suspect components and overlook some of the more common faults that work their way into construction projects. The most common problems will be traceable to solder shorts, cold-solder joints, misconnections, mislocated components and backward connections.

Some problems, especially intermittent ones, can be traced to inadequate decoupling. Because TTL circuitry is noise prone, it is important to provide adequate decoupling between +5 volts and ground. Builders, who provide their own layout, may need to experiment with different decoupling capacitors (other values and types) at different circuit locations. As a general rule, be sure that you have provided a 1000- μ F main filter. Provide .01 to .05- μ F disc capacitors on a 1 for every 2 IC's basis. Where ceramic discs appear to be ineffective, use dipped tantalums of higher values (0.1 to 2.2 μ F). Try a 5 to 40- μ F tantalum capacitor at various board locations.

As a systematic approach to trouble shooting, you may want to follow this sequence. Confirm that the individual horizontal and vertical sync signals exist at pins 10 and 3 of IC1 and 10 and 3 of IC26, and the combined signals at 10 and 3 of IC8 and 10 and 1 of IC5. Next, determine that the vertical and horizontal ramps appear at the collectors of Q1 and Q2. Then go to the horizontal and vertical ball signals on pins 1 and 2 of IC4 and pins 1 and 2 of IC6. Make sure that these signals are present and do vary with the movement of the four external paddle controllers. The next step would be to look for ball direction changes by checking for logic level changes on pin 5 of IC9 and pin 9 of IC10. Then check to see that the randomizing counter, IC20, is clocking. Beyond this, a combination of checking out the circuit description, the schematic, and following the logic signals through the circuitry with a scope should uncover any remaining problems. We do hope you've enjoyed this story and will expect to hear that you have had many hours of enjoyable game playing with both Super-Pong and Bumper. R-E

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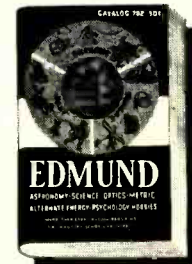


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CLASS-G AMPLIFIERS

(continued from page 49)

the addition of the extra coils (L1 and L3) in the circuit of Fig. 13, harmonic distortion would rise more rapidly for a 20 kHz signal while remaining at a much lower level for lower frequency signals. With the addition of this final refinement, total harmonic distortion is maintained at very low levels for both md- and high-frequencies, as shown by the solid-line 20-kHz curve of Fig. 16.

FTC and Class-G

The Class-G circuit seems to be particularly attractive at this time in light of the pre-conditioning tests now required by the FTC in connection with determining the power output ratings of audio amplifiers. As many readers know, the FTC requires that amplifiers be able to sustain one third of their rated continuous power output for one hour. In Class-B circuits, this power level results in almost the greatest internal heat dissipation for the output devices and, in many cases, this has forced designers to increase heat-sink dimensions (and cost to consumers) without really providing audible benefit to users. On the other hand, Class-G operation can result in very nearly the most efficient operation at this one-third rated point (and at lower levels more often encountered in musical reproduction) with appropriate economies in weight, power-supply demands and, most important of all, retail prices that the consumer has to pay for high-quality audio amplification.

R-E

*The author is indebted to Dr. Gentaro Miyazaki of Hitachi for allowing us to publish the first definitive description of Hitachi's innovative new amplifier circuit. Several claims of a pending U.S. (as well as foreign) patent have already been allowed by the Patent Office, and it should be noted that the actual inventor of the Class-G circuit is Mr. Tohru Sampei, of Hitachi. At one point in its development, classes of amplifiers seemed to be developing so rapidly that the company had thought to call the new circuit the "S"-system in honor of its inventor, but they settled for Class-G instead, after researching the matter thoroughly here and abroad.



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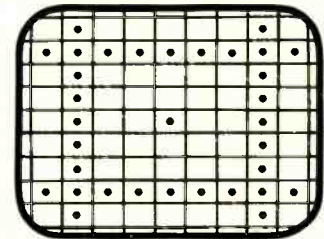


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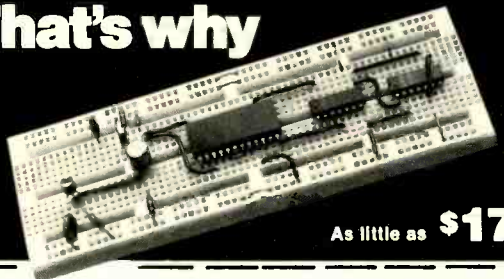


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Circle 13 on reader service card

AUGUST 1976

HI-FI TEST REPORTS

(continued from page 56)

tors are used throughout this section as well as on the separate voltage amplifier/ tone/driver combination PC board. A single-polarity 70-volt supply energizes the PNP-NPN complementary output pairs which require a 5000 μ F coupling capacitor for isolation between output and speaker connection points. A total of 58 transistors are called out on the schematic which is found tucked into an envelope stapled to the underside of the wood cover. (Why frighten consumers with a schematic before servicing is ever needed?). Parts layout above and below chassis is such that access to any part is readily available when and if servicing should ever be required and a total of seven major and minor PC boards are used in constructing the model 4000.

FM Performance

Bang and Olufsen have obviously not had time to translate their tuner specifications to the newly approved standards now being used by other manufacturers. Even based upon older standards, however, the specifications supplied to consumers omit many important tuner performance figures and tend to confuse the reader with others. For example, IHF sensitivity is quoted in microvolts for a 75-ohm input as better than 2.0 μ V. The knowledgeable FM fan will at once realize that this is equivalent to a 4.0 micro-volt figure if the 300-ohm input is used.

TABLE II RADIO-ELECTRONICS PRODUCT TEST REPORT

Manufacturer: **Bang & Olufsen**

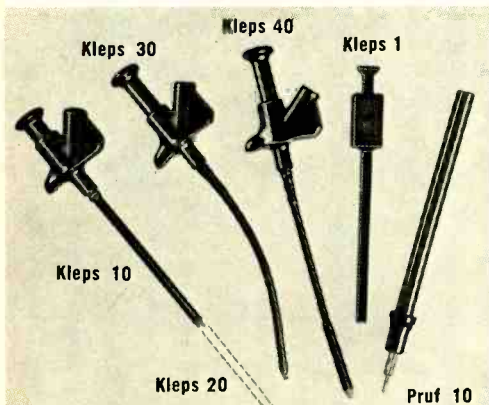
Model: **4000**

OVERALL PRODUCT ANALYSIS

Retail price	\$595.00
Price category	Medium/high
Price/performance ratio	Poor
Styling and appearance	Excellent
Sound quality	Good
Mechanical performance	Excellent

Comments: The B & O Model 4000 stereo FM receiver presents a series of curious contradictions. From a human engineering and aesthetic point of view, it is a veritable masterpiece, in the Danish tradition of clean styling and functionalism. Yet, as you examine its performance specifications (aside from its high power rating) it looks not much better than a "compact" receiver that you can buy for much less (and which no spec-minded audiophile would consider seriously). The surprising thing about this "Beomaster" (as they call it) is that when you actually hook it up to a pair of decent speakers it doesn't sound as bad as those less-than-superb measured specs would have you believe. All of which raises the question (again) of how closely do measured specs correlate with what we hear under actual music listening conditions? This comment certainly applies to the amplifier portion, which delivered clean power—and plenty of it—to our relatively low-efficiency speaker systems (the B & O Model M-70 units, used for cable compatibility). Unfortunately, we cannot be as kind when it comes to the tuner. The sophisticated dual-light center-of-channel tuning indicator gave us different results for stereo and mono—neither of which correspond to lowest distortion tuning point. We even tried touch-up alignment but could never get the "equal brightness" point of the two lights to agree with the best tuning of mono and stereo stations for one dial setting. Each required retuning. Clearly, the 60-watt rating per channel at 4 ohms is given as a primary rating because B & O probably expect to sell this unit with their own speakers having that nominal impedance rating, but U.S. consumers have a right to know the 8-ohm power output capability, too, since so many speakers with which the unit will be used have that impedance.

This is one of the reasons why the new power (dBf) notations were adopted in the new standards. Regardless of impedance, this spec turns out to be 17.4 dBf.



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TABLE III
RADIO-ELECTRONICS PRODUCT TEST REPORT

Manufacturer: **Bang & Olufsen**

Model: 4000

AMPLIFIER PERFORMANCE MEASUREMENTS

	R-E Measurement	R-E Evaluation
POWER OUTPUT CAPABILITY		
RMS power/channel, 8-ohms, 1 kHz (watts)	48.0	No rating given
RMS power/channel, 8-ohms, 20 Hz (watts)	40.0	No rating given
RMS power/channel, 8-ohms, 20 kHz (watts)	42.0	No rating given
RMS power/channel, 4-ohms, 1 kHz (watts)	69.0	Very good
RMS power/channel, 4-ohms, 20 Hz (watts)	44.0	Fair (see text)
RMS power/channel, 4-ohms, 20 kHz (watts)	60.0	Fair
Frequency limits for rated output (Hz-kHz)	40-20	Poor
DISTORTION MEASUREMENTS		
Harmonic distortion at rated output, 1 kHz (%)	0.16	Good
Intermodulation distortion, rated output (%)	2.00	Poor
Harmonic distortion at 1 watt output, 1 kHz (%)	0.065	Very good
Intermodulation distortion at 1 watt output (%)	0.190	Good
DAMPING FACTOR, AT 8 OHMS	24	Good
PHONO PREAMPLIFIER MEASUREMENTS		
Frequency response (RIAA \pm ___ dB)	0.6	Very good
Maximum input before overload (mV)	50.0	Poor
Hum/noise referred to full output (dB) (at rated input sensitivity)	67.0	Excellent
HIGH LEVEL INPUT MEASUREMENTS		
Frequency response (Hz-kHz, \pm ___ dB)	10-57, 1.0	Excellent
Hum/noise referred to full output (dB)	90	Excellent
Residual hum/noise (min. volume) (dB)	95	Very good
TONAL COMPENSATION MEASUREMENTS		
Action of bass and treble controls	See Fig. 8	Very good
Action of secondary tone controls		—
Action of low frequency filter(s)	See Fig. 9	Very good
Action of high frequency filter(s)	See Fig. 9	Fair
COMPONENT MATCHING MEASUREMENTS		
Input sensitivity, phono 1/phono 2 (mV)	2.87/	
Input sensitivity, auxiliary input(s) (mV)	N/A	
Input sensitivity, tape input(s) (mV)	230	
Output level, tape output(s) (mV)	200	
Output level, headphone jack(s) (V or mW)	0.37V @ 8 ohms	
EVALUATION OF CONTROLS, CONSTRUCTION AND DESIGN		
Adequacy of program source and monitor switching		Fair
Adequacy of input facilities		Good
Arrangement of controls (panel layout)		Excellent
Action of controls and switches		Very good
Design and construction		Superb
Ease of servicing		Very good
OVERALL AMPLIFIER PERFORMANCE RATING		Fair

Our sample did better, measuring 3.5 μ V (16.3 dBf) for sensitivity in mono and 4.0 μ V (17.4 dBf) in stereo (see Table I), but these are hardly "state-of-the-art" sensitivity figures.

The two tuning lights on the front panel are supposed to glow equally when correct center channel tuning has been accomplished. Try as we might, we could never get agreement between these lights when we tuned for minimum distortion of received audio signals during our tests. We tried to align the IF system but if indicator correspondence was achieved for mono it was wrong for stereo and vice versa. Since we are equipped with a distortion analyzer we were able to tune for lowest distortion and to ignore the light indicators, but what would a poor consumer do in this case? Other measured results tabulated in Table I speak for themselves and ranged from poor to very good, taking the price of this receiver into account. For some inexplicable reason, some of the THD readings in stereo actually turned out to be better than in

mono. Stereo separation figures were typical of those observed from circuits of this type which have so many critical alignment points, though they were certainly adequate for obtaining a good stereo effect from two-channel FM broadcasts.

Amplifier measurements

B & O evidently did have time to alter their statement of audio output power so that it more or less conforms with FTC requirements in this country. Quoting power only a 4-ohm output impedance levels seems a bit deceptive, however, even if B & O's own speakers recommended for use with this receiver have that nominal impedance. If we had to rate the power capability of the 4000 operating into 8-ohm loads, based on the limited power band of 40 Hz to 20,000 Hz that they use for their 60 watt/channel 4-ohm specification, the receiver turns out to be a 40 watt/channel unit, as tabulated in Table III. Note, too, that even with 4-ohm loads the 20 Hz capability of the 4000 is only 44 watts for the rated THD

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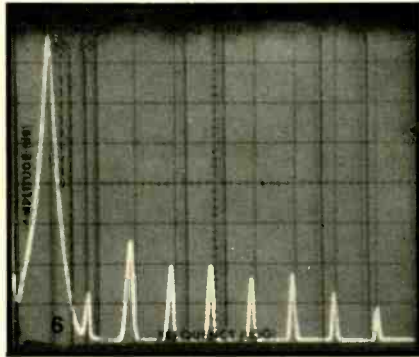
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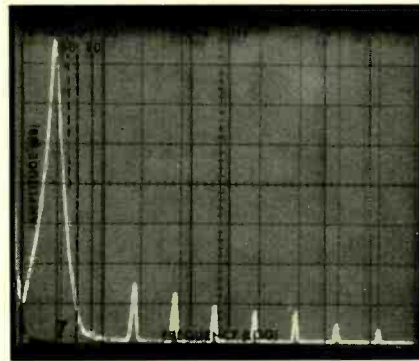
of 0.4%. The 2.0% IM distortion that we measured should not be regarded by readers with all that much criticism, for remember that IM measurements are made using 60 Hz and 7000 Hz frequencies. Evidently, the low-frequency power output limitation of this receiver accounts for the inordinately high IM figure. Reducing equivalent output to just a couple of watts below the "rated" 60 watt output level brings the IM figure into line with published claims.

The excellent conformity of the phono preamp section to standard RIAA equalization and its superior signal-to-noise ratio (measured unweighted and with reference to the 3.0 mV input sensitivity) is, unfortunately, offset by the rather low overload capability (50 mV) of the phono



input section. Thus, dynamic range of the phono section is limited not so much at the "quiet" end, as at the "loud" end,

since peak velocities recorded on modern records might well drive high-output cartridges into audible levels of distortion. We would have expected at least 6 dB more of overload capability in a receiver costing nearly \$600.00.



Referring once more to amplifier performance, Fig. 6 is a spectrum analysis of harmonic distortion components when the amplifier is delivering rated THD for a 1000-Hz signal (this occurs at an output of 69 watts into 4-ohm loads). Sweep in this 'scope presentation and that of Fig. 7 is linear, so that harmonics are evenly spaced. In Fig. 7, output was reduced to nominal rated value (60 watts) and the spectrum analysis shows that second harmonic contribution has all but disappeared while third harmonic content is some 60-dB below the reference 1-kHz fundamental at the left of the display.

Maximum boost and cut range of the bass and treble controls is shown in the multiple sweep frequency scope photo of

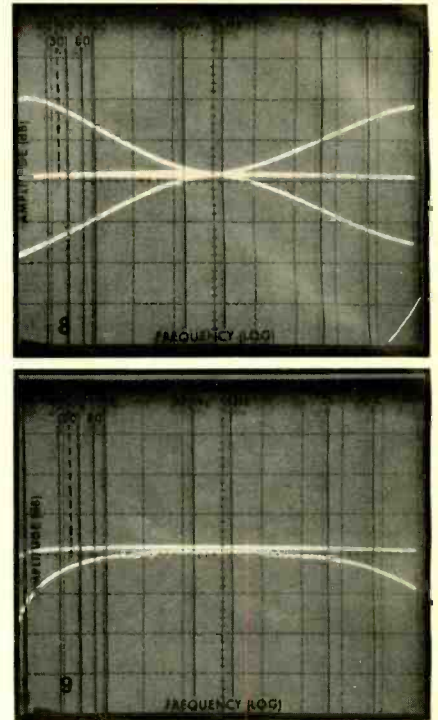


Fig. 8, while action of the high- and low-frequency filters is similarly presented in the scope photo of Fig. 9. Note that in the case of Figs. 8 and 9, sweep is logarithmic



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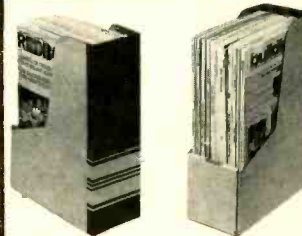
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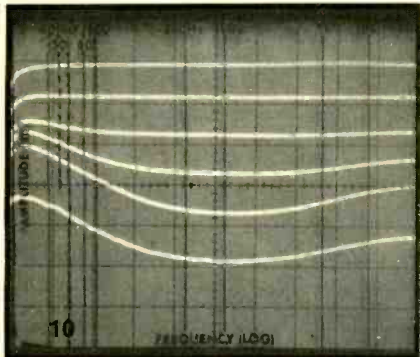
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in order to present a more conventional display of "frequency response" graphs. Filter action is seen to be minimal, with starting points extending too far into the important mid-range musical portion of the audio spectrum and with slope rates at only 6 dB per octave. The filters, therefore, are not much more effective than the normal tone controls would be in reducing rumble or high-frequency noise.



Loudness control action at various levels is shown in Fig. 10.

Conclusion

Our overall product analysis will be found in Table II, together with comments concerning the use and listenability of the B & O 4000. For sheer beauty and styling, B & O deserves the recognition afforded to them, but we can only hope that future electronic components distributed by them in this country will cater more to the perfectionist who craves top performance as well as top styling in a high-fidelity receiver. **R-E**

Electronic tickets to replace subway tokens and hotel-room keys

Ticket-activated turnstiles are being tested at a New York City subway station under a contract between the New York Transit Authority and Kenilworth Research and Development Corp. A patent for a "static reader" of cards and tickets has just been issued to that company.

Magnetic tickets are already in use in some European subway systems, some of which charge different amounts for different distances and therefore cannot use the same "message" on all tickets.

Kenilworth is also developing a coded-card system for hotels or motels. When a guest checks in, he gets a coded card to use as a room key. When he checks out, the room clerk changes the room lock combination by remote control from his desk. The next guests gets a card to match the new combination, randomly selected from a possible several million.

MDA...

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next month

SEPTEMBER 1976

■ CB Antenna Roundup

Selecting the best possible mobile antenna is vital for obtaining reliable communications in a moving vehicle.

■ 555-Timer Applications

More about this versatile IC and the things you can do with it.

■ MATV Antennas

What you should look for and how to install them properly.

■ Digital Time-Delay System

A look at a prototype instrument used in hi-fi research. The system can create a concert hall of any size or shape in an ordinary listening room.

PLUS

Mindpower: Alpha
2 Hi-Fi Test Reports
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And much more

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ONE!

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Address _____

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- I am a former MTI student.
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MTI

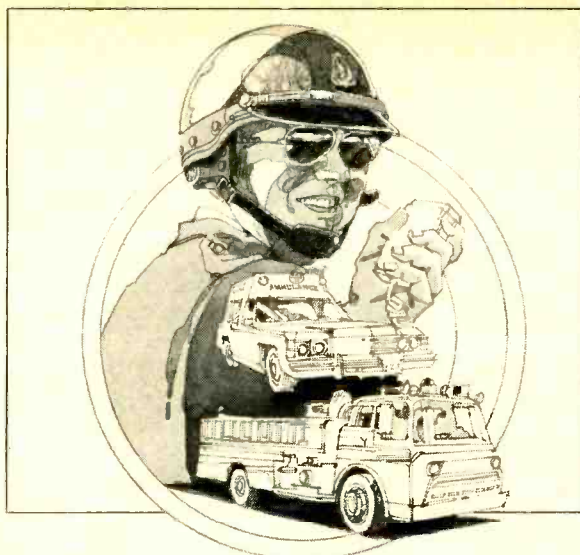
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- Tests Predetermined Frequencies 25 to 1000 MHz
- Extended Range Covers 950 MHz Band
- Pin Diode Attenuator for Full Range Coverage as Signal Generator
- Measures FM Deviation

The **FM-2400CH** provides an accurate frequency standard for testing and adjustment of mobile transmitters and receivers at predetermined frequencies.

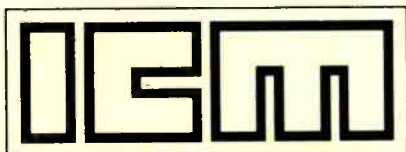
The FM-2400CH with its extended range covers 25 to 1000 MHz. The frequencies can be those of the radio frequency channels of operation and/or the intermediate frequencies of the receiver between 5 MHz and 40 MHz.

Frequency Stability: $\pm .0005\%$ from $+50^\circ$ to $+104^\circ\text{F}$.

Frequency stability with built-in thermometer and temperature corrected charts: $\pm .00025\%$ from $+25^\circ$ to $+125^\circ$ (.000125% special 450 MHz crystals available).

Self-contained in small portable case. Complete solid state circuitry. Rechargeable batteries.

FM-2400CH (meter only) \$595.00
RF crystals (with temperature correction) ... 24.00 ea.
RF crystals (less temperature correction) 18.00 ea.
IF crystals catalog price



International Crystal Manufacturing Company, Inc.

10 North Lee, Oklahoma City, Oklahoma 73102

Circle 8 on reader service card

CB TRANSCEIVER ROUNDUP

(continued from page 42)

phone, chassis-mount CB antenna, AM/FM telescoping antenna and polarity inverter.



—**Trans-Comm Manufacturing Co.**, 8885 Bond St., Overland Park, KN 66214.

Unimetrics Porpoise I
 Base unit that covers all 23 CB channels plus one VHF/FM crystal-controlled channel for



monitoring NOAA weather. Has volume and squelch controls, delta fine-tuning circuit, 455-kHz filter for adjacent-channel rejection, S/RF meter. Rugged watertight construction and corrosion-resistant materials for possible marine use. 117 VAC only. $8" \times 9" \times 2\frac{1}{2}"$.—**Unimetrics, Inc.**, 123 Jericho Tpk., Syosset, NY 11791.

UTAC Studio 4000
 Base unit with dual power-supply for 117 VAC and 12 VDC operation. It can serve as a 5-watt PA system, has detach-



able mike and power cords, circuit-breaker protection, accessory 117 VAC outlet on rear panel and external speaker jack. Additional features are digital readout channel indicators, on-air/standby indicators, switchable ANL, separate AF, RF and IF gain controls, delta tune, dual-conversion receiver with headphone jack. Wood cabinet $18" \text{W} \times 7\frac{1}{2}" \text{H}$.—**I. A. Sales Co. of California, Inc.**, 766 Lakefield Rd., Suite H, Westlake Village, CA 91361.

Westport CB9000
 State-of-the-art transceiver with features that include a multi-purpose meter that dis-

plays incoming signal strength, transmitter power output and SWR when tuning transmitter to antenna, a three-position delta tuning switch and ANL switch to disable the noise limiter when listening to extremely weak signals. $6" \text{W} \times$



$8" \text{D} \times 2" \text{H}$.—**Westland International**, 1658 10th St., Santa Monica, CA 90404.

XTAL XCB-7
 Solid-state frequency-synthesized 23-channel transceiver for mobile installations. Has sensitive dual-conversion receiver, S/RF meter, transmit and receive indicator lamps, switchable ANL, delta tuning,



PA function and 5 watts audio output. There is an auxiliary volume control on the microphone for mobile operating convenience. $7.5" \times 2.4" \times 8.5"$.—**Far Eastern Research Laboratories, Inc.**, 8749 Shirley Ave., Northridge, CA 91324.

Zodiac M-5026
 Mobile, synthesized solid-state transceiver originally designed for use on boats but its rugged construction makes it applicable to all mobile and base installations. It is prepared for



optional plug-in selective call modules (one for receive and one for transmit) and a scanning module for automatically scanning two optional channels. A jack for an 8-ohm external speaker is on the rear panel. The connecting plug can be inserted in two positions. In one of these positions, the internal speaker is automatically disconnected. Power supply 11.4–14.5 VDC, positive or negative ground, and 6 VDC to 24 VDC or 117/220 VAC with appropriate DC voltage converter and AC line adapter.—**Zodiac Communications Corp.**, Chrysler Building, New York, NY 10017. **R-E**

CLOCK KIT ROUNDUP

(continued from page 37)

Caringella LDC-1, a 7-inch high hexagon with one single large digit displayed! Also unique in appearance is the Babylon Space Age Clock whose case is a black-anodized 3/4-inch length of aluminum extrusion with a "far-out" cross-section.

Assembly

Some of the assembly and instruction "manuals" were one sheet of paper with a schematic and a parts list. Others were elaborate (such as the unexcelled Heathkit manuals), with many drawings and specific step-by-step instructions. Only the Heath manuals went to the extent of describing the physical appearance of each part, so a gross beginner in electronics could identify the components; others seemed to assume the builder could identify resistors, capacitors, diodes, etc., and could put the kit together with minimum instruction. This is unfortunate, since many of the kits were really simple enough for a beginner to tackle if they only had more detailed instructions.

Clock kits that should take the average electronic hobbyist less than an hour for electronic assembly (not including case installation and checkout) are rated "Easy"; "Medium" is from 1 to 3 hours, with over 3 hours rated "Hard." Despite the excellent instructions, the Heathkits, with many wires between sub-assemblies, appear to be the toughest to assemble of this group. The easiest of the group to assemble is, without reservation, the EC-2000. It was also the only clock built by the author from a kit that required no trouble-shooting!

Building the kits

Before attempting to build any of these clock kits, be sure you have the right equipment. You'll need a 25 to 50-watt soldering iron with a *small* tip (1/8 inch diameter), fine longnose pliers, 20-gage stranded, insulated wire, wire cutter and stripper (a finger-nail clipper works great for small wire), and some small-diameter solder (if the kit doesn't include it). Digital Concepts include "solder wick" with their kits; it uses capillary action to soak up solder from unwanted points—very handy for some of the close work on these clocks. Patience is required, as well as careful soldering. Most of the problems encountered by the author in constructing these kits were traced to soldering—either bad joints, or "bridges" between circuit paths.

A circuit trick you might want to add to most clocks using the MM5314 clock chip is one used in the Formula International MM5314 Clock. It is a characteristic of the display output of this chip that the number "six" is without a top—segment A is not activated. To remedy this, add one 1N4001 or similar rectifier-diode from segment D or E to segment A (marked cathode end to A). This will add the top segment to *all* the sixes as they appear in the display, since they are multiplexed.

You may encounter some difficulty getting the clock to work properly after it's completed. The display, if it's lighted at all, will give you the best clues. Use a magnifying glass or jeweler's loupe to inspect all suspect (and non-suspect) solder joints—it's amazing how a connection that looks perfect to the naked eye is a mess under 7-power magnification! Also look for solder bridges or "jumpers" across printed circuit paths or display or IC pins. If a common segment is "missing" from all the digits, check back through the segment driver circuitry to the IC. If a single digit doesn't light, check the digit-driver circuit back to the IC. If a particular segment of a single digit is dark, check the connection of that digit pin to the circuit—it could be a dead segment in the digit itself, which means a new digit! If the clock doesn't count, operate the time-setting controls—some clocks won't start until then. Be sure the HOLD switch isn't shorted. Also, be sure the AC is getting to the IC (pin 16 in Fig. 1). If the display doesn't light at all, check the power supply section. A voltage check across the power supply filter (220 μ F in Fig. 1) will quickly tell you if you have DC voltage.

For a better understanding of digital clocks and watches, including details on circuitry, an excellent book is "Electronic Clocks and Watches," by Michael S. Robbins (Howard W. Sams, Cat. No. 21162. \$6.50).

Setting your clock

The time on these clocks is set with pushbutton, slide or toggle switches. Clocks using the MM5314 IC have the simplest time setting: the FAST switch moves the hours ahead once per second, *turn page*

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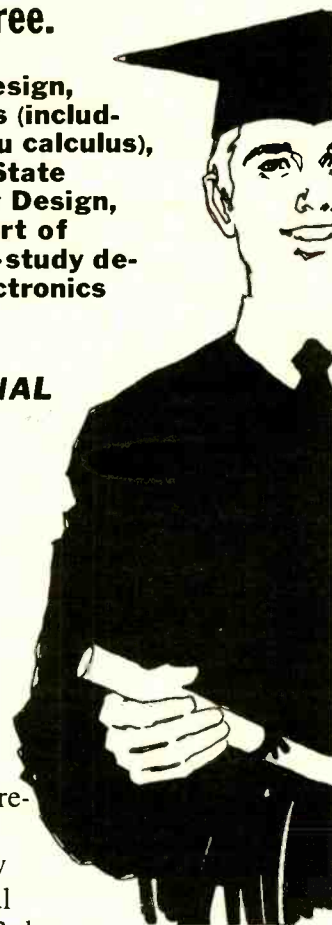
I have been in electronics for _____ years. Please mail me your free bulletin which gives details concerning your electronics degree programs.

Name _____ Age _____

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City _____ State _____ Zip _____

Circle 6 on reader service card



the SLOW switch moves the minutes ahead once per second, and the HOLD switch stops all counting. By simply setting the display time ahead of the real time, and then putting the count on HOLD until the real time catches up, you can set your clock to within a fraction of a second of whatever time standard you're using. Other IC's use various control arrangements to set time, some advancing tens of minutes, others changing twice-per-second instead of once, and some use two switches in combination to provide a third function. Calendar and alarm controls are the most confusing at first. Three of the 4-digit clocks that normally display hours and minutes can be switched to show minutes and seconds. Of all the clocks tested, only the Altaj 4-Digit Alarm Clock had

no means of synchronizing to the second.

Some sort of time standard is necessary to set these clocks accurately. The phone company offers the most available and least expensive method—look up the number for "time" in your local directory. A short-wave receiver that can tune in WWV or CHU time broadcasts gives more accurate time information. Caringella Electronics offers a specially-designed *Standard Time Receiver* kit (STR-1 \$79.95, assembled \$99.95) that receives these broadcasts on three crystal-controlled receiving frequencies.

Going mobile

You may want to use your digital clock in your car, trailer, camper or dune-buggy. Only the Heath GC1093 and Nexus clocks

are specially designed for car use, but at least three of the other kits included in this article could be adapted readily for car use. The Godbout *Son-of-a-Cheap-Clock* instructions specifically describe car operation using their optional *Crystal-Controlled Timebase* kit (\$10.50) that provides 60 Hz from 12 volts DC. Actually, all the MM5314 kits, and all the others that don't require boosted display voltages, can operate from DC supplied by a 12-volt car battery if a timebase is added. S.D. Sales offers a timebase kit for \$5.95 that uses a 3.58 MHz color-TV crystal and a National Semiconductor MM5369 IC to count down directly to 60 Hz. You might even consider using a timebase in your AC-powered clock. This eliminates power line "glitches" (transient peak voltages) that can literally "knock your clock off" in terms of accuracy. The author has found the MM5314 chip particularly vulnerable to this problem, sometimes advancing hours or minutes for no apparent reason when powered by certain wall-sockets or near other electrical appliances.

Simply power the timebase by connecting it across the clock's power supply filter capacitor, observing polarity, and feed the 60-Hz output of the time base to the 60-Hz input pin of the clock IC (disconnect the existing input). This could increase the accuracy as well, since the power-line frequency can be "uncorrected" as much as 2 seconds in a 24-hour period. Bear in mind, however, that crystal-controlled circuits are temperature-sensitive, and will probably need trimmer adjustment initially to put them "on the money." Claimed accuracy is typically 0.01%, or about 9 seconds per day.

concluded next month

Harry Nyquist, Bell scientist and inventor, dies at 87

Harry Nyquist, former Bell Labs scientist, possibly most widely known to readers of this magazine for the famous Nyquist diagram, died April 4 in Harlingen, Texas. He was 87 years old. Many of his inventions and theories are now widely accepted as fundamental to voice, picture and data transmission. He was awarded 138 patents during his 37 years with the Bell System.

His discovery of the conditions necessary to keep feedback circuits stable, called the Nyquist criterion, is used not only in the study of electronic devices such as amplifiers, but even in the study of human regulating processes.

Through theoretical analysis he determined the minimum band of frequencies required to transmit various kinds of communication signals.

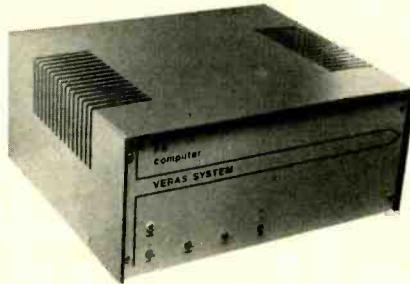
Nyquist was the first to supply a quantitative explanation of thermal noise. He also invented methods of TV transmission and of correcting delay distortion in TV.

Among the many honors he received are the Institute of Radio Engineers Medal of Honor and the Stuart Ballantine Medal of the Franklin Institute (both in 1960), the Mervin J. Kelly Award of the American Institute of Electrical Engineers, 1961, the National Academy Founders Medal, 1969, and the Rufus Oldenburger medal of the American Society of Mechanical Engineers in 1975.

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Our regulated power supply is rated at 10 amps $\pm 5V$ and $\pm 12V$, with local regulators which is more than adequate to power our basic computer kit and extra RAM boards.

All boards are high quality G-10, double sided, solder plated with gold plated edge connector.

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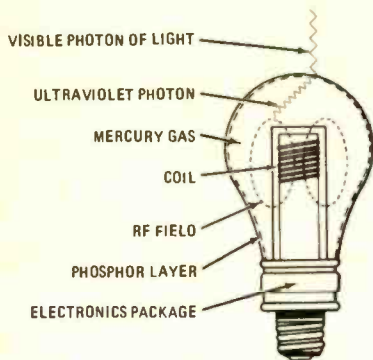
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New fluorescent long-life lamp may fit ordinary lamp socket

A fluorescent lamp now under a development contract between the Energy Research and Development Administration (ERDA) and its inventor, Donald D. Hollister of California, will screw into an ordinary electric light socket, use only one-third the energy of present incandescent lamps and may last ten years without burning out.

The principle is the same as that of today's fluorescent lamps. These are usually long tubes with a phosphor coating on the inside surface and containing mercury vapor. The phosphor emits visible light when struck by photons of ultraviolet light, produced by exciting the mercury atoms with an electric discharge. In the household type of light,



comparatively bulky starters and ballasts are needed to initiate and control the discharge—in the larger industrial "cold-cathode" lamps, high voltages are necessary.

The Hollister *Litek* lamp looks much like an ordinary "inside-frosted" bulb. The mercury vapor is excited by radio frequency rather than the 60-Hz house current. Transistor circuitry in the base of the bulb produces the RF current. Part of the circuit is a small coil in the center of the bulb. The RF field set up around this coil excites the mercury vapor atoms producing the ultraviolet rays.

Much of the developmental work will be aimed at bringing down the initial high cost of the lamps (which would now be about \$10 each) to a point where they will sell competitively with ordinary lamps.

Second 24-channel satellite launched by RCA

Satcom II—second in a series of high-capacity domestic communications satellites—was launched March 26 from Cape Canaveral. Like Satcom I—launched December 12 (*Radio-Electronics*, April 1976, page 6)—it has 24 channels, twice the number of any previous satellite.

The new satellite, like its older companion, gets its greater capacity by frequency interleaving and polarization diversity—alternate transmission of signals on vertically and horizontally polarized antennas—to get 24 independent 34-MHz channels within the allotted band of 500 MHz.

One of the four reflector antennas of Satcom II has been aimed at a point near Anchorage, Alaska, to concentrate six channels on the country's largest state.

Another six-channel reflector antenna is directed to center its beam over Kansas, to provide concentrated coverage of the 48 contiguous states and Puerto Rico. (Satcom I has 12 of its channels beamed on Hawaii.) Satcom II's other 12 channels are for general coverage of the U.S. mainland, Alaska and Hawaii.

FCC to simplify rules covering TV games

The Federal Communications Commission is reviewing the regulations that deal with video games, with the idea of simplifying them, states the chief of the FCC division that oversees approval of these games.

All TV games must be submitted to the FCC for testing and approval before they can be sold. The games are tested for radiation, energy emission and interference, among other characteristics.

TV games are not all alike. A few operate on video frequencies and must be connected into the video circuitry of the receiver or use an independent monitor to display the game board. These are classed by the FCC as low-power devices, under Part-15 of the Regulations, which covers devices that emit radio-frequency radiation.

Most home TV-games have a control panel connected to the antenna of the TV set and operate on an unused channel frequency—often Channel 6 or one of a number of UHF channels. These are considered as "Class-1 TV devices" by the FCC.



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have it
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Sensitive easy-to-read 4 1/2" 200 scale amp meter. Zero center position. Includes 200 ohm shunt. Comprises FET transistor, 2 diodes, 2 resistors, 2 diodes. Meter at 100 ohms protected against burnout. Panel for durability. High-impact plastic case with handle useable as a mounting stand. Kit has simplified step assembly instructions. Both factory-wired versions shipped with batteries and test leads. 6 3/4" W x 2 7/8" D. 3 lbs.



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REPLACEMENT FOR PIX TUBE?

I need a replacement picture tube for a Sears TV. This is a 12DCP22. They quoted me a price of \$200.00 on it! Do you know of another tube that will replace this?—A.C., Penns Grove, NJ.

From the replacement picture tube manual, it looks as if either an 11SP22 or 11WP22 might do. Also, a 13JP22, (which will be so close to the same size that it wouldn't make any difference!). The electrical parameters are all close.

VERTICAL PROBLEM

I see two pictures on this Sylvania DO5. One's rolling slowly down and behind it another one upside down! I can twiddle the controls and get one picture, but it's only about an inch high. I've changed the tube; no luck. Any ideas?—A.N., Lake Geneva, WI.

You've got what looks like a tremendous foldover. Check your vertical height and vertical linearity controls; one of them may be open. If they're not, then you have probably got a shorted capacitor in the feedback loop. One that has caused this kind of problem is C318, the .0056 μF from the red wire of the vertical output transformer to the junction of R326 and C320. If this one is OK, check all the rest, especially the .1 μF coupling capacitor C314.

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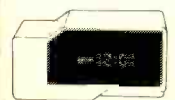
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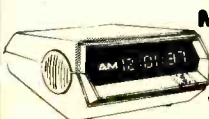
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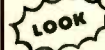


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use 7473 I.C.
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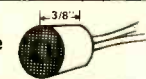
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Time Display	12 Hour	X	X	X	X	X	X	X
Duplicate Register	Alarm Counter	X	X	X	X	X	X	X
Alarm Signal	Alarm Output	X	X	X	X	X	X	X
Alarm of Power Failure	On	X	X	X	X	X	X	X
Segment Out put Polarity	Vis for Display	X	X	X	X	X	X	X
AM or PM Indication	Diff during time display	X	X	X	X	X	X	X
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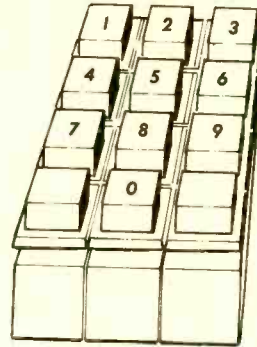
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THE KIT INCLUDES:

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- 2 Switches for time set
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- 1 .01 Disc Cap
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60 Hz. Crystal Time Base

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Factory Prime!

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DL33MMB 3 MAN-3 Size Readouts in one package. These are factory prime, not retested rejects as sold by others. compare this price! 75c 3 for \$2.

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Kit Includes: Rockwell A4001 IC
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Complete Keyboard with Case
PC Board with all Electronic Parts
Instructions and Batteries



Dimension: 32.5mm(H) x77mm(W) 145mm (L)
1 9/32 in (H) x 3 1/32 in (W) x 5 23/32 in (L)

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SPECIFICATION

- * 9-digit HP Red Led Displays
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- * Full floating point
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BASIC FUNCTION

- * Algebraic mode operation
- * Constant operations
- * Repeat Operations
- * Chain operations
- * Change sign operation
- * Display and Y-register exchangeable
- * One accumulating memory
- * Display and memory exchangeable

SPECIAL FUNCTION

- * Trigonometric functions (sin, cos, tan)
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Plus handling & shipping \$1.50

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This is a unit featuring a true "state of the art" design. It is something you will be proud to show your friends.

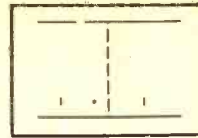
With a basic knowledge of electronic circuitry, this kit can be assembled and playing in just a few hours. If you have trouble, test facilities are available at nominal cost to remedy the problem.

FEATURES

1. Unique curve button adds extra thrill and skill to game.
2. Disappearing score - allows full vision of playing field when ball is in action.
3. 16 different angles of deflection for the ball compared to 3 with most competitive designs.
4. Fast action paddles.
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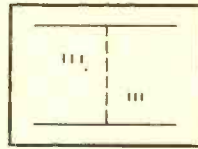
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GAME 1

Let's start with a Tennis "MATCH". Fun for all, particularly beginners. This is the game that started the craze.

Scores to 12 points



GAME 2

Then go to the "PRO MATCH". You'll need 3 paddles to return the ball on this one, almost as fast as a Hockey Puck. A challenge for the 2 players this is designed for.

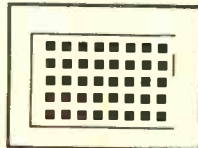
Scores to 12 points.



GAME 3

Now to deflate the ego's of the "Pros" put them to a "GRAVITY MATCH". A bouncing ball adds more fun and excitement plus it plays havoc with the skill of the 2 players.

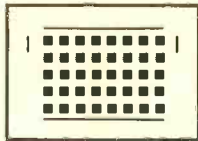
Scores to 12 points.



GAME 4

WIPE OUT I

A game for a single player. Test your reflexes and see how many squares you can knock out. As your score increases so does the speed of the ball. Top Score is 2400 points in 6 tries.



GAME 5

WIPE OUT II

If you can't beat the machine by yourself, get someone to help you. Together you can (that is it is possible to) score 2800 points in 6 tries.

All games have sound.

LINEAR IC's

309K	1.25
323K	6.00
339N	1.00
531H	2.75
739N	1.00
741M	3/1.25
760N	4.25
1303N	2/1.75
3900N	2/1.00
3905N	1.25
3909N	1.25
4136N	2.00

C-MOS

34001 FSC	1.00
4000	4/1.00
4001	4/1.00
4011	4/1.00
4012	4/1.00
4013	3/1.25
4016	3/1.25
4024	1.00
4033	2.00
4081	1.00
4512	1.50
4528	1.50

MICROPROCESSOR

CPU'S

8008	19.95
8080A	34.00

PROMS

1702A	12.00
1702AL	12.00
8223B	3.00

COMPONENTS

KITS

F-8	95.00
MEK6800DI	125.00

ROMS

7488	3.50
74186	4.99

SMOKE DETECTOR KIT \$29.95

TRANSISTORS

2N718A	3/1.00
2N1302	3/1.00
2N3054	2/1.25
2N3055	2/1.50
2N3563	5/1.00
2N3903	5/1.00
2N3906	5/1.00
2N3772	2.00
2N5400	5/1.00
2N5447	4/1.00
2N5550	3/1.00
2N6027	2/1.00

DIODES

Prices for any one number

1N746A through 1N759A	7/1.00	100/11.00
1N4728A through 1N4764A	5/1.00	100/15.00
1N5221B through 1N5267B	7/1.00	100/11.00
1N4007		
	10/1.00	100/8.00

IC SOCKETS

8 Pin	LoPro	4/1.00
10 Pin	Trans	10/1.00
14 Pin	LoPro	3/1.00
14 Pin	W.W.	3/1.00
16 Pin	Std.	3/1.00
24 Pin	Std.	3/1.25
28 Pin	Std. & W.W.	3/1.25

CLOCK KIT \$12.95

Complete with display except case.

CLOCK CHIPS

MM5311	4.95
MM5312	4.95
MM5313	4.95
MM5314	4.95
MM5316	6.75
CT7001	6.75

P.C. Bd. Edge Connector

22 Pin .156 Center double readout/solder2.25

CALCULATOR CHIPS

MM5725	2.95
MM5736	2.50

LED'S

FND500	1.50
FND507	1.50
MAN 4	2/1.50
MTC 2	2/1.50

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or your Money Refunded.

Give us your name & address. We will send our catalogue.

Circle 47 on reader service card

7400N TTL

SN7400N	16	SN74453N	27	SN74150N	100
SN7401N	21	SN74454N	20	SN74151N	7.9
SN7402N	16	SN74455N	20	SN74152N	8.8
SN7403N	16	SN74456N	22	SN74153N	1.25
SN7404N	18	SN74457N	45	SN74154N	9.9
SN7405N	24	SN74458N	63	SN74155N	9.9
SN7406N	20	SN74459N	39	SN74156N	9.9
SN7407N	29	SN74460N	37	SN74157N	1.25
SN7408N	25	SN74461N	32	SN74158N	9.9
SN7409N	25	SN74462N	50	SN74159N	9.9
SN7410N	18	SN74463N	32	SN74160N	1.10
SN7411N	20	SN74464N	50	SN74161N	1.10
SN7412N	33	SN74465N	50	SN74162N	1.25
SN7413N	45	SN74466N	98	SN74163N	5.90
SN7414N	35	SN74467N	98	SN74164N	2.10
SN7415N	35	SN74468N	39	SN74165N	1.25
SN7416N	25	SN74469N	39	SN74166N	1.25
SN7417N	21	SN74470N	3.50	SN74167N	1.50
SN7418N	33	SN74471N	45	SN74168N	9.9
SN7419N	49	SN74472N	75	SN74169N	9.9
SN7420N	37	SN74473N	49	SN74170N	2.49
SN7421N	33	SN74474N	49	SN74171N	2.49
SN7422N	49	SN74475N	49	SN74172N	9.9
SN7423N	29	SN74476N	79	SN74173N	9.9
SN7424N	29	SN74477N	79	SN74174N	2.20
SN7425N	29	SN74478N	89	SN74175N	2.20
SN7426N	29	SN74479N	4.00	SN74176N	5.00
SN7427N	27	SN74480N	1.00	SN74177N	6.00
SN7428N	27	SN74481N	1.00	SN74178N	1.19
SN7429N	27	SN74482N	3.9	SN74179N	1.75
SN7430N	26	SN74483N	3.9	SN74180N	1.75
SN7431N	31	SN74484N	4.00	SN74181N	5.00
SN7432N	27	SN74485N	1.00	SN74182N	6.00
SN7433N	27	SN74486N	1.00	SN74183N	1.19
SN7434N	27	SN74487N	3.9	SN74184N	1.75
SN7435N	27	SN74488N	3.9	SN74185N	1.75
SN7436N	27	SN74489N	3.9	SN74186N	1.75
SN7437N	27	SN74490N	3.9	SN74187N	1.75
SN7438N	27	SN74491N	3.9	SN74188N	1.75
SN7439N	27	SN74492N	3.9	SN74189N	1.75
SN7440N	16	SN74493N	3.9	SN74190N	1.75
SN7441N	89	SN74494N	70	SN74191N	1.75
SN7442N	59	SN74495N	60	SN74192N	1.75
SN7443N	75	SN74496N	50	SN74193N	1.75
SN7444N	75	SN74497N	1.09	SN74194N	1.75
SN7445N	75	SN74498N	95	SN74195N	1.25
SN7446N	61	SN74499N	1.15	SN74196N	1.75
SN7447N	69	SN74500N	4.00	SN74197N	1.75
SN7448N	79	SN74501N	4.50	SN74198N	5.59
SN7449N	26	SN74502N	4.50	SN74199N	1.79
SN7450N	26	SN74503N	4.50	SN74200N	6.00
SN7451N	27	SN74504N	1.15	SN74201N	6.00
SN7452N	27	SN74505N	2.35	SN74202N	6.00
SN7453N	27	SN74506N	2.00	SN74203N	6.00

CONSUMER ELECTRONICS

exelar

DIGITAL WATCH
This watch is manufactured by National Semiconductor. It provides 5 functions: hours, minutes, seconds; date, A.M. Indicator dot. Accuracy is assured to 5 seconds per month by precision quartz crystal. If something should go wrong with the watch, repair is assured within 48 hours after it is received. Complete with steel black leather band.

ES4-Y5
3 MICRON GOLD PLATE BEZEL
\$29.95
NOT A KIT

Novus

DIGITAL ALARM CLOCK
This 4 digit Novus Alarm Clock is a very reliable and smartly styled unit. It provides such features as an alarm settable to any minute of the day, a 7 minutes snooze alarm, a power failure indicator, and even an A.M., P.M. Indicator.

\$19.95
NOT A KIT

XCITON LITRONIX MONSANTO

OPTO ELECTRONICS DISCRETE LEDS

R - RED
G - GREEN
Y - YELLOW
O - ORANGE

125" dia.	185" dia.	190" dia.
200" dia.	200" dia.	.085" dia.

KC209R	5/51	KC256R	5/51	KC111R	5/51
KC209S	4/51	KC256G	4/51	KC111G	4/51
KC209Y	4/51	KC256B	4/51	KC111Y	4/51
KC209O	4/51	KC256O	4/51	KC111O	4/51

DISPLAY LEDS

FN0503	FN070	DL707	DL747	DL338
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TYPE	POLARITY	HT	TYPE	POLARITY	HT
MAN 1	COMMON ANODE	270	MAN 74	COMMON CATHODE	300
MAN 2	5 x 7 DOT MATRIX	300	DL707	COMMON ANODE	300
MAN 3	COMMON CATHODE	270	DL747	COMMON ANODE	600
MAN 4	COMMON CATHODE	187	DL338	COMMON CATHODE	600
MAN 7	COMMON CATHODE	300	FN070	COMMON CATHODE	110
MAN 7G	COMMON ANODE-GREEN	300	FN070	COMMON CATHODE	250
MAN 7Y	COMMON ANODE-YELLOW	300	FN070	COMMON CATHODE	500
MAN 7Z	COMMON ANODE	300	FN070	COMMON ANODE	500

IC SOLDERTAIL - LOW PROFILE (TIN) SOCKETS

8 pin	1.24	25.49	50-100	1.24	25.49	50-100
14 pin	1.17	16	15	24 pin	1.38	37
14 pin	20	19	18	28 pin	45	44
16 pin	22	21	20	36 pin	60	59
16 pin	29	28	27	40 pin	63	62
22 pin	37	36	35			

SOLDERTAIL STANDARD (TIN)

14 pin	5.27	25	24	28 pin	5.99	90
16 pin	30	27	25	36 pin	1.39	1.26
16 pin	35	32	30	40 pin	1.59	1.45
24 pin	49	45	42			

SOLDERTAIL STANDARD (GOLD)

8 pin	5.30	27	24	24 pin	5.70	63
14 pin	39	38	37	28 pin	11.00	1.00
16 pin	43	42	41	36 pin	1.59	1.45
16 pin	75	68	62	40 pin	1.75	1.59

WIRE WRAP SOCKETS (GOLD) LEVEL #3

10 pin	5.45	41	37	24 pin	5.05	95
14 pin	39	38	37	28 pin	1.40	1.25
16 pin	43	42	41	36 pin	1.59	1.45
16 pin	75	68	62	40 pin	1.75	1.59

50 PCS. RESISTOR ASSORTMENTS \$1.25 PER ASST.

ASST. 1	5 ea.	10 OHM	12 OHM	15 OHM	18 OHM	22 OHM	27 OHM	33 OHM	39 OHM	47 OHM	56 OHM	1/4 WATT 5% - 50 PCS.
ASST. 2	5 ea.	88 OHM	82 OHM	100 OHM	120 OHM	150 OHM	180 OHM	220 OHM	270 OHM	330 OHM	390 OHM	1/4 WATT 5% - 50 PCS.
ASST. 3	5 ea.	1.2K	1.5K	1.8K	2.2K	2.7K	3.3K	3.9K	4.7K	5.6K	6.8K	1/4 WATT 5% - 50 PCS.
ASST. 4	5 ea.	8.2K	10K	12K	15K	18K	22K	27K	33K	39K	47K	1/4 WATT 5% - 50 PCS.
ASST. 5	5 ea.	56K	68K	82K	100K	120K	150K	180K	220K	270K	330K	1/4 WATT 5% - 50 PCS.
ASST. 6	5 ea.	390K	470K	560K	680K	820K	1.0M	1.2M	1.5M	1.8M	2.2M	1/4 WATT 5% - 50 PCS.
ASST. 7	5 ea.	2.7M	3.3M	3.9M	4.7M	5.6M	6.8M	8.2M	10M	12M	15M	1/4 WATT 5% - 50 PCS.

ALL OTHER RESISTORS FROM 2.2 OHMS 5.6M AVAILABLE IN MULTIPLES OF 5 ea

5.25 PCS. 05 ea. 30.95 PCS. 04 ea. 100.495 PCS. 03 ea. 500.995 0275 ea.

14 PCS. POTENTIOMETER ASSORTMENTS

ASST. A 2 ea. 10 OHM-20 OHM-50 OHM-100 OHM-200 OHM-500 OHM-500 OHM

ASST. B 2 ea. 1K, 2K, 5K, 10K, 20K, 50K

ASST. C 2 ea. 50K, 100K, 200K, 250K, 500K, 1M, 2M

\$9.95 Per Asst.

Each assortment contains 14 pcs of 10 turn pots. All pots are available in single unit quantities. \$9.95 ea.

74LS00 TTL

74LS00	39	74LS55	39	74LS151	1.55
74LS01	39	74LS56	39	74LS152	1.89
74LS02	39	74LS57	65	74LS153	1.55
74LS03	45	74LS58	65	74LS154	2.25
74LS04	45	74LS59	75	74LS155	2.25
74LS05	45	74LS60	8.19	74LS156	2.25
74LS06	39	74LS61	65	74LS157	2.85
74LS07	79	74LS62	1.25	74LS158	2.85
74LS08	2.19	74LS63	1.25	74LS159	2.85
74LS09	49	74LS64	1.25	74LS160	2.85
74LS10	49	74LS65	1.89	74LS161	2.25
74LS11	49	74LS66	1.89	74LS162	2.25
74LS12	45	74LS67	65	74LS163	2.25
74LS13	49	74LS68	65	74LS164	2.25
74LS14	49	74LS69	65	74LS165	2.25
74LS15	49	74LS70	65	74LS166	2.25
74LS16	49	74LS71	65	74LS167	2.25
74LS17	49	74LS72	65	74LS168	2.25
74LS18	49	74LS73	65	74LS169	2.25
74LS19	49	74LS74	65	74LS170	2.25
74LS20	49	74LS75	65	74LS171	2.25
74LS21	49	74LS76	65	74LS172	2.25
74LS22	49	74LS77	65	74LS173	2.25
74LS23	49	74LS78	65	74LS174	2.25
74LS24	49	74LS79	65	74LS175	2.25
74LS25	49	74LS80	65	74LS176	2.25
74LS26	49	74LS81	65	74LS177	2.25
74LS27	49	74LS82	65	74LS178	2.25
74LS28	49	74LS83	65	74LS179	2.25
74LS29	49	74LS84	65	74LS180	2.25
74LS30	49	74LS85	65	74LS181	2.25
74LS31	49	74LS86	65	74LS182	2.25
74LS32	49	74LS87	65	74LS183	2.25
74LS33	49	74LS88	65	74LS184	2.25
74LS34	49	74LS89	65	74LS185	2.25
74LS35	49	74LS90	65	74LS186	2.25
74LS36	49	74LS91	65	74LS187	2.25
74LS37	49	74LS92	65	74LS188	2.25
74LS38	49	74LS93	65	74LS189	2.25
74LS39	49	74LS94	65	74LS190	2.25
74LS40	49	74LS95	65	74LS191	2.25
74LS41	49	74LS96	65	74LS192	2.25
74LS42	49	74LS97	65	74LS193	2.25
74LS43	49	74LS98	65	74LS194	2.25
74LS44	49	74LS99	65	74LS195	2.25
74LS45	49	74LS100	65	74LS196	2.25
74LS46	49	74LS101	65	74LS197	2.25
74LS47	49	74LS102	65	74LS198	2.25
74LS48	49	74LS103	65	74LS199	2.25
74LS49	49	74LS104	65	74LS200	2.25

THIS MONTH ONLY!! DL728

The DL728 is a dual 0.5" common cathode red display. It is ideal for use with clock chips, as segments are already multiplexed.

\$1.95

DPDT	ON	OFF	ON	201	3.06	2.08	1.87	1.78
	ON	OFF	ON	223	2.88	2.76	1.80	1.81
	ON	OFF	ON	121	2.35	1.95	1.43	1.30
	ON	OFF	ON	123	2.05	1.65	1.21	1.10

MINIATURE TOGGLE

SPDT - SERIES PB, P01	Model	1	Quantity net prices
Maintained Action Switch	Number	Each	2.99 10.29 30.99
Non-Maintained Action Switch	Model	PB-123	\$2.35 \$1.95 \$1.47 \$1.30
Non-Maintained Action Switch	Model	PB-126	\$2.35 \$1.95 \$1.47 \$1.30

5 AMP RATINGS

THUMBWHEEL SWITCHES

Part No.	Description	Price	Part No.	Description	Price
SR EP	End Plate (each)	5.50	SR EP	End Plate (each)	5.50
SR DP	Divider Plate (each)	40	SR DP	Divider Plate (each)	40
SR BB	Button Body (each)	40	SR BB	Button Body (each)	40
SR HB	Half Body (each)	40	SR HB	Half Body (each)	40

8 POSITION ROTARY SWITCH

These switches are a 7 position, one position open, rotary switch enclosed in a TO-5 can. They have a standard 8 pin configuration and will mount perfectly on printed circuit board.

2 FOR \$1.00

ZENERS - DIODES - RECTIFIERS

TYPE	VOLTS V	PRICE	TYPE	VOLTS V	PRICE
1N748	3.3	400m	1N4005	50V PIV	1.00
1N751	5.1	400m	1N4006	100V PIV	1.00
1N752	6.2	400m	1N4007	200V PIV	1.00
1N753	6.2	400m	1N4008	300V PIV	1.00
1N754	6.8	400m	1N4148	75	10m
1N955B	15	400m	1N4149	75	10m
1N5232	5.6	500m	1N4154	35	10m
1N5234	6.2	500m	1N4734	5.6	1w
1N5235	6.8	500m	1N4735	6.2	1w
1N5236	7.5	500m	1N4736	6.8	1w
1N456	25	40m	1N4737	7.2	1w
1N458	150	7m	1N4744	15	1w
1N485A	180	10m	1N1183	50 PIV	35 AMP
1N4001	50 PIV	1.00	1N1184	100 PIV	35 AMP
1N4002	100 PIV	1.0			



DELTA ELECTRONICS CO.

P.O. BOX 2, AMESBURY, MASS. 01913

CB "PLUS" POWER TRANSFORMER

This heavy duty power transformer has an output, when rectified, of 13.5v DC @ 10 amps. Ideal for CB power supplies, battery chargers, lab supply, etc. It is the voltage regulating type, with dual primaries for 115v or 230v, and taps for 20 Hz or 60 Hz. It also has secondaries for 24v @ 6A, 18v @ 5A, 6v @ 2A, and 2.5v @ 4A. 5 3/4" x 5 1/4" x 5 1/4".

STOCK NO. R9973 24 lbs. \$17.95 ea, 2/35.00



RADIATION DETECTOR

Brand new VICTOREEN Model 710 B. Reads gamma radiation from 0.1 to 50 roentgens / hour. Complete with service and instruction manual. Meter is a 20 uA movement, worth twice the price of the whole unit. Also contains matched multiplier resistors of 1000 meg., 10,000 meg. & 100,000 meg. plus VXR86 (5886) electrometer tube. Wt. 3lbs. 5" x 4" x 8 1/2".

STOCK NO. R5202 \$4.95 each, 2/9.00

AM/FM TUNER & IF STRIP

Complete AM/FM tuner and IF strip from a car radio. Needs only 12v DC and an audio amplifier to make a fine, highly selective set. Reduced from \$7.95 and sold AS-IS, because some are in need of repair. In most cases it is the AM osc. that is defective. We provide the circuit diagram. 5 1/2" x 3 3/4" x 1 1/4", 1 lb.

STOCK NO. R5255 \$5.95 ea, 2/11

13.5 volt, 2 amp transformer, ideal for small 12v DC supply. 2 lbs. STOCK NO. R9978 \$3.95 each, 2/7.00

Send for our latest free catalog. Minimum order \$5, phone orders welcome: (617) 388-4705. Include sufficient postage; excess will be refunded. BANKAMERICARD & MASTERCARD welcome, ALL numbers needed for processing. Minimum charge \$15.

Circle 33 on reader service card

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Same day shipment

First line parts only. Factory tested. Guaranteed money back. Quality IC's and other components at factory prices.

TERMS: \$5.00 min. order U.S. funds Calif. residents add 6% tax.

FREE: Send for your copy of our 1976 QUEST CATALOG.

Include .13¢ stamp.

INTEGRATED CIRCUITS

7400 TTL	17	SN74251N	1.60	LM741N	35	NB279B	2.75	10101	3.10
SN7400N	17	SN74259N	1.65	LM1303N	41	NB97B	3.25	10123	3.19
SN7402N	17	74LS00 TTL	1.34	LM2111N	1.95			10124	1.10
SN7403N	17	SN74LS00N	34	LM9300N	55			10125	1.10
SN7404N	18	SN74LS02N	39	MC1458B	59				
SN7406N	23	SN74LS04N	39	NE5504L	5.00				
SN7410N	17	SN74LS08N	39	NE5504	85				
SN7414N	63	SN74LS10N	39	NE5538	2.30				
SN7416N	34	SN74LS12N	50	NE555A	1.00				
SN7417N	39	SN74LS12N	50	NE555V	43				
SN7421N	37	SN74LS13N	59	NE567V	1.45				
SN7430N	25	SN74LS13N	59	NE568A	1.15				
SN7438N	20	SN74LS15N	1.28	NE568V	1.85				
SN7439N	65	SN74LS15N	1.28	NE568V	1.45				
SN7447N	20	SN74LS15N	1.28	NE568V	1.45				
SN7448N	78	SN74LS15N	1.28	NE568V	1.45				
SN7450N	17	SN74LS15N	1.28	NE568V	1.45				
SN7475N	42	SN74LS15N	1.28	NE568V	1.45				
SN7476N	39	SN74LS15N	1.28	NE568V	1.45				
SN7477N	39	SN74LS15N	1.28	NE568V	1.45				
SN7478N	44	SN74LS15N	1.28	NE568V	1.45				
SN7479N	44	SN74LS15N	1.28	NE568V	1.45				
SN7488N	70	SN74LS15N	1.28	NE568V	1.45				
SN7489N	200	SN74LS15N	1.28	NE568V	1.45				
SN7490N	45	SN74LS15N	1.28	NE568V	1.45				
SN7492N	45	SN74LS15N	1.28	NE568V	1.45				
SN7493N	65	SN74LS15N	1.28	NE568V	1.45				
SN7496N	75	SN74LS15N	1.28	NE568V	1.45				
SN74100N	110	SN74LS258N	2.20	CD3401	42				
SN74107N	39	SN74LS258N	2.20	CD4001	25				
SN74121N	39	SN74LS258N	2.20	CD4002	25				
SN74123N	59	SN74LS258N	2.20	CD4002	25				
SN74126N	45	SN74LS258N	2.20	CD4002	25				
SN74145N	89	SN74LS258N	2.20	CD4002	25				
SN74150N	95	SN74LS258N	2.20	CD4002	25				
SN74151N	110	SN74LS258N	2.20	CD4002	25				
SN74154N	110	SN74LS258N	2.20	CD4002	25				
SN74155N	95	SN74LS258N	2.20	CD4002	25				
SN74157N	95	SN74LS258N	2.20	CD4002	25				
SN74161N	95	SN74LS258N	2.20	CD4002	25				
SN74166N	135	SN74LS258N	2.20	CD4002	25				
SN74170N	195	SN74LS258N	2.20	CD4002	25				
SN74171N	119	SN74LS258N	2.20	CD4002	25				
SN74174N	5	SN74LS258N	2.20	CD4002	25				
SN74175N	90	SN74LS258N	2.20	CD4002	25				
SN74181N	240	SN74LS258N	2.20	CD4002	25				
SN74182N	115	SN74LS258N	2.20	CD4002	25				
SN74191N	125	SN74LS258N	2.20	CD4002	25				
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	MAN32	CA	300	1.50	6K of Memory		
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	MAN62	CA	300	1.50	10 MHz	4.25	
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	MAN112	CA	300	1.50	MM5316	6.35	
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	MAN122	CA	300	1.50	IC SOCKETS		
	MAN127	CA	300	1.50	Solder Tin		
	MAN132	CA	300	1.50	Pin 1 UP Pin 1 UP		
	MAN137	CA	300	1.50	8 15 24 36		
	MAN142	CA	300	1.50	14 18 28 43		
	MAN147	CA	300	1.50	16 20 36 56		
	MAN152	CA	300	1.50	18 27 40 61		
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7445	70	74154	1.03	75454	.61	4042	79	NE565A	1.28
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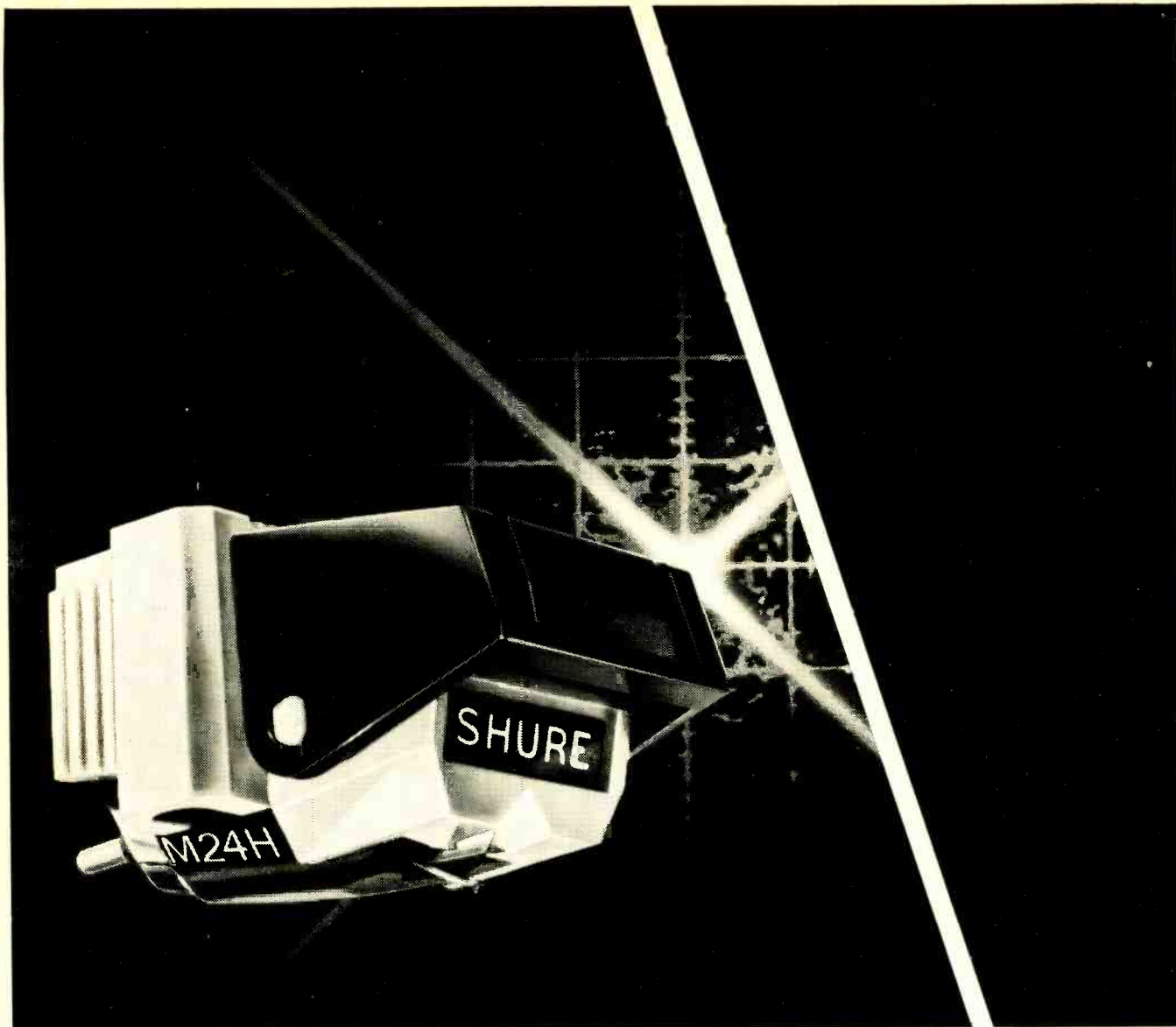
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