34140

Radio-Electronics

$1.25 ■ JULY 1979

IND

THE MAGAZINE FOR NEW IDEAS IN ELECTRONICS

VIDEODISC CIRCUITRY
What's inside

NEW DC AUDIO AMPS
Deliver ultra-wide response

PC BOARDS
How to make your own

DIGITAL THERMOMETER
°F and °C with 0.1° resolution

R.E.A.L. SOUND LAB
Yamaha top-of-the-line receiver

SWITCHING POWER SUPPLIES
How to design your own

Build this
HEART RATE MONITOR
Direct readout unit

A GERNSBACK PUBLICATION

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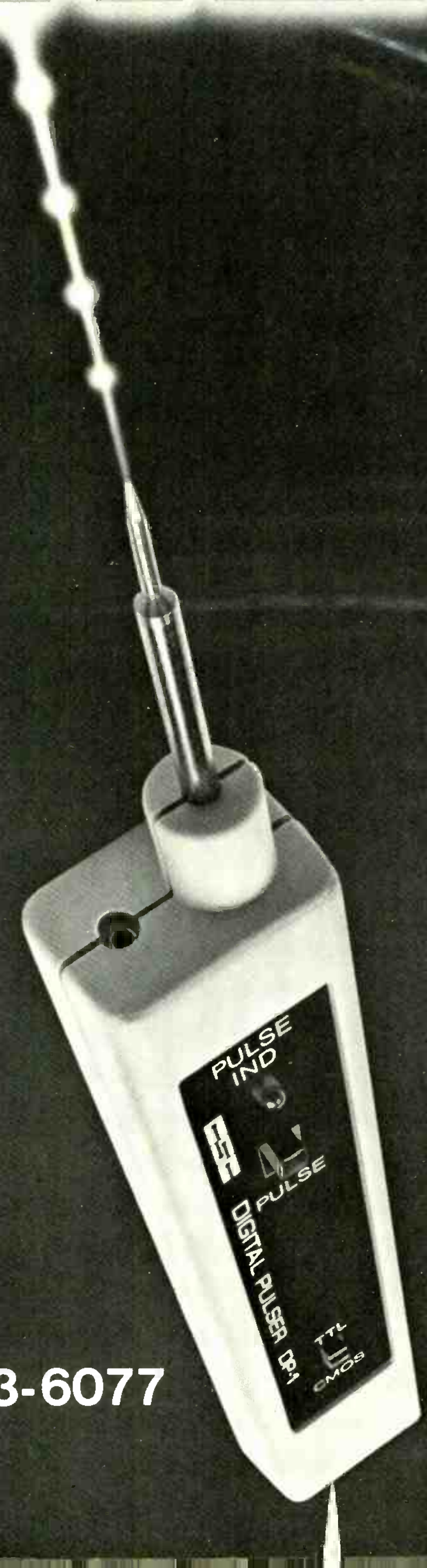
PLUS
★ **TEMP MEASUREMENT** Clue in servicing

★ **AUDIO TEST STATION**

★ **HOBBY CORNER** New twist for digital clocks

★ **SERVICE CLINIC** Beware of intermittents

PULSEMAKER



It's a digital signal injector. And it thinks for itself.

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CIRCLE 16 ON FREE INFORMATION CARD

Don't take our word for it.

"We can heartily recommend the Superboard II computer system for the beginner who wants to get into microcomputers with a minimum of cost. Moreover, this is a 'real' computer with full expandability."

Popular Electronics March, 1979

"(Their) new Challenger 1P weighs in at $279 and provides a remarkable amount of computing for this incredible price."

Kilobaud Microcomputing February, 1979

"Over the past four years we have taken delivery on over 25 computer systems. Only two have worked totally glitch free and without adjustment as they came out of the carton: The Tektronic 4051 (at $7,000 the most expensive computer we tested) and the Ohio Scientific Superboard II (at $279 the least expensive) . . . The Superboard II and companion C1P deserve your serious consideration."

Creative Computing January, 1979

"The Superboard II and its fully dressed companion the Challenger 1P series incorporate all the fundamental necessities of a personal computer at a very attractive price. With the expansion capabilities provided, this series becomes a very formidable competitor in the home computer area."

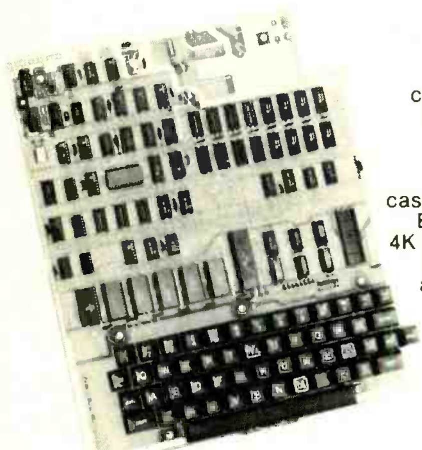
Interface Age April, 1979

"The graphics available permit some really dramatic effects and are relatively simple to program . . . The fact that the system can be easily expanded to include a floppy means that while you are starting out with a low-cost minimal system, you don't have to throw it away when you are ready to go on to more complex computer functions. Everything is there that you need; you simply build on to what you already have. You don't have to worry about trading off existing equipment to get the system that will really do what you want it to do. At $279, Superboard II is a tough act to follow."

Radio Electronics June, 1979

"The Superboard II is an excellent choice for the personal computer enthusiast on a budget."

Byte May, 1979



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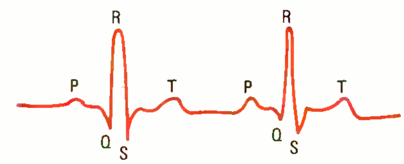
THE MAGAZINE FOR NEW IDEAS IN ELECTRONICS

Electronics publishers since 1908

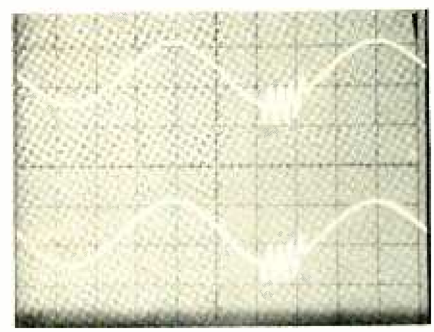
JULY 1979 Vol. 50 No. 7

ON THE COVER

Using an infrared sensor that clips to your finger, this Heart Rate Monitor provides a direct readout of your pulse rate in beats-per-minute. It also "beeps" to provide an audible indication. Sounds interesting? Read about it starting on page 35.



HEART WAVEFORM is detected by Heart Rate Monitor circuit to provide a direct readout in beats-per-minute. To see how it works, turn to page 35.



COMPLEX WAVEFORMS are needed to compare the performance of DC amplifiers. To find out why, turn to page 47.

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looking ahead

Videodisc jockeying: With one videodisc system on the market in limited quantities (Philips/MCA/Magnavision) and one promised for late 1980 or 1981, it would appear that there would be little room for additional systems. Although many different systems have been demonstrated in the past, it has been tacitly acknowledged that Philips and RCA would fight it out between themselves for the upcoming videodisc market. Of course, this left the Japanese without an entry in videodiscs, but because of their preoccupation with videotape at the present time, some knowledgeable industry sources assumed the Japanese would sit this one out and, when the proper time came, adopt either the Philips (optical) or the RCA (capacitance) system. But Japan's biggest consumer electronics manufacturer, Matsushita, apparently feels the stakes are too high to wait passively. Matsushita's earlier videodisc system, called "Visc," could easily have been brought into compatibility with RCA's capacitance system, and most observers thought it would be.

It was surprising, therefore, when, at a very late stage in the game, Matsushita introduced a new videodisc system and pointedly said it was ready for production. The new "Visc-O-Pac" is a variable-speed disc that can store at least two hours on two sides of a 9-inch-diameter record. The speed varies from 300 rpm at the outside of the disc to 700 near the center. Like the original Visc, the new system uses grooved discs and reads them out mechanically with a "twist stylus" that translates the discs's hills and dales to variations in torque. The new disc is packed in a transparent case that is automatically removed when the record is played and restored when playing is complete. RCA's SelectaVision discs are 12 inches in diameter and revolve at a constant 450 rpm. Each one is packed in a plastic caddy, which is slid into the changer and pulled out.

An RCA spokesman says SelectaVision's design is "frozen" and won't be changed to compromise with the new Matsushita system. If Matsushita really intends to introduce a third "standard," it could have a rough road since both RCA and MCA have been lining up programming for the capacitance and optical systems, respectively, and Matsushita would appear to be well behind in this activity. Matshushita would be a formidable ally for either proponent, and both the Philips/MCA and RCA camps are trying to determine whether it really will seriously pursue a third system or whether Matshushita is using Visc-O-Pac to improve its bargaining position or is trying to delay the videodisc market to avoid cutting into the videocassette boom.

Eight shows, one channel: Borrowing liberally from other people's inventions, RCA Americom, which operates Satcom satellites, is proposing a new transmission system to the Armed Forces Radio & Television Service that will make possible simultaneous reception of TV shows. AFRTS, which operates about 150 TV stations at U.S. military bases on foreign soil, currently does most of its programming by videocassettes shipped from the U.S. RCA proposes to supply two TV channels, five full 15-kHz audio channels and an on-screen teletext channel, carrying them all on a single satellite channel. They would be beamed directly via Satcom to U.S. bases in the Western Hemisphere and relayed to Intelsat to serve U.S. troops elsewhere.

The two-channels-in-one are derived from an invention by CBS and Thomson-CSF called STRAP, or Vidiplex, which interweaves two separate TV pictures using alternate fields of each picture. The missing fields are reconstructed at the receiving end from information contained in adjacent fields. Four of the five audio channels are digitally encoded into the television picture by a process called DATE (digital audio for TV) developed by the Public Broadcasting System. The teletext channel is carried in the TV signal's vertical interval.

Pocket 'brains': The successor to the pocket calculator almost certainly will be the hand-held memory or microcomputer or whatever you want to call it—it's so new there's no generic name for it yet. The trend started with the pocket "memo pad" that could store about 30 phone numbers or whatever you wanted to store in it. Now memories have been sharply expanded, and two hand-held "language translators" have come on the market at almost exactly the same time. Called the Lexicon and the Craig M100, they are made by different companies but both are presumably based on the same Mostek IC. They both sell in the $200 range and contain alphanumeric keyboards, doing double duty as calculators and metric converters.

Although there are differences between the two, let's discuss the Craig as probably "typical" of this new type of device. Initially, finger-sized program cartridges are available for English, French, German, Spanish and Japanese. Three cartridges can be loaded into the battery-operated unit at one time, and translations can be made from any one to any other. Each cartridge has a "vocabulary" of 1,500 words or phrases. In addition, 50 commonly used phrases are listed on the back of the translator, with a code number for each. You just type the code number on the translator and the foreign equivalent appears on the fluorescent display that holds up to 16 letters but can accommodate more with a right-to-left crawl similar to that on a movie theater marquee display. Any of 1,500 words may be entered on the keyboard for translation to any language whose cartridge is inserted in the machine. In addition, the unit helps correct spelling, works as a language quiz machine and fulfills other language-learning functions.

While the first generation of these machines helps accomplish the obviously important function of language translation, future cartridges will fulfill other needs. Recipe storage, dictionary synonyms and calorie counting come to mind immediately—and undoubtedly there will be more. According to Craig, a near-future generation of the machine will be programmable, making it an important device for storage of personal information.

DAVID LACHENBRUCH
CONTRIBUTING EDITOR

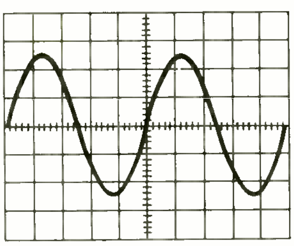
LOW TIM MAKES THE LISTENING DIFFERENT.

COMPARABLE AMPLIFIERS DO SOUND DIFFERENT

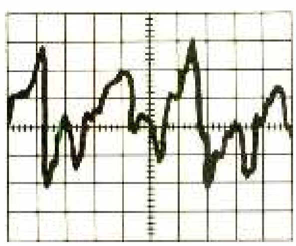
Choosing the best amplifier for your audio system involves comparing specs, features and, of course, price. But ultimately, if you love music, you should base your decision on the way an amplifier sounds when reproducing music.

Two amplifiers may have identical power ratings and virtually no Total Harmonic Distortion, but can sound very different: one clean and clear, the other harsh and metallic. The difference you hear is Transient Intermodulation Distortion (TIM, for short). The real effects of TIM on music, however, have only recently been recognized, since TIM does not show up in even the most accurate traditional laboratory measurements.

Measurements for THD are made with smooth, repetitive signals (sine waves). Music, on the other hand, presents an amplifier with a series of non-repeating, pulsive, "transient" signals, as illustrated below.



SINE WAVES



DYNAMIC MUSIC SIGNALS

An amplifier that cannot faithfully follow the sharp transients demanded by music may have very low THD, but very high TIM.

WHAT CAUSES TIM?

It has been discovered that TIM distortion in an amplifier is caused by an insufficient slew rate — the engineer's term for an amplifier's ability to handle the high power, high frequency signals a musical transient presents. Poor slew rate in conventional amplifiers is most often caused by the very mechanism used to reduce THD, namely, the addition of negative feedback. Put more simply, in conventionally-designed power amplifiers, the more negative feedback you use, the lower will be the THD (which is good), but the higher will be the TIM (which is not so good).

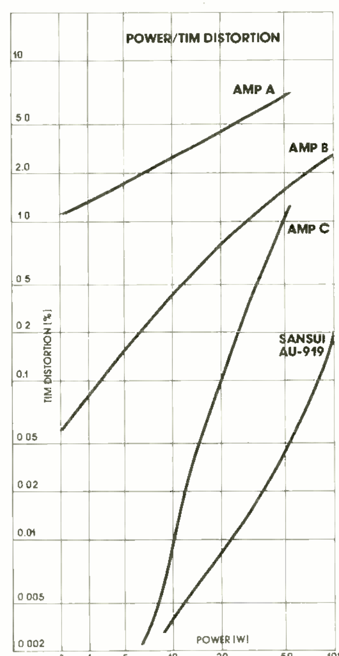
It took Sansui, and a whole new approach to amplifier design, to solve the high-frequency slew-rate problems of TIM without compromising our superbly low THD specifications.

THE SANSUI SOLUTION

The most important step in the solution was to "speed up" (increase the frequency response of) the basic amplifier — even before negative feedback is applied — by using Sansui's own patent-pending DD/DC (Diamond Differential/Direct-Coupled) circuit. The DD/DC circuitry includes a sophisticated "lag + lag-lead" dual compensation system, more often found in instrumentation amplifiers than hi-fi products, which maintains stability without decreasing frequency response. With DD/DC, the amplifier can instantly supply the enormous negative feedback current demanded by transients, without restricting the slew rate, so without introducing TIM.

AU-919 DD/DC AMPLIFIER

How well our unique circuitry succeeds in eliminating TIM, while maintaining extraordinarily-low levels of THD is shown in these comparative curves. The Sansui AU-919 amplifier (bottom curve) is rated at 110 watts per channel, min. RMS, both channels into 8 ohms from 10Hz to 20,000Hz, with no more than 0.008% total harmonic distortion.



Power output vs. TIM distortion curves for the Sansui AU-919 and competitive amplifiers. Derived using the TIM measurement method described in a paper presented at the 63rd Convention of the AES May, 1979; available from Sansui on request.

LET YOUR EARS BE THE JUDGE

Instruments and circuit-design analysis are fine in their place, which is the laboratory. But you listen to music in your home; and we're confident that you will hear the difference in musical clarity that a Sansui amplifier makes. Your local Sansui authorized dealer can demonstrate all the convincing reasons for choosing Sansui.

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editorial

A Call For New Ideas

Every magazine has an editorial policy. It provides the guidance that determines the subject matter that is covered on a monthly basis.

The editorial policy of **Radio-Electronics** is quite basic. We sum it up in one sentence and place it on the front cover each and every month, right below our logo. It reads: *"The Magazine for New Ideas in Electronics."*

Simple? Sure, but oh how difficult to achieve. It means that we maintain contact with the engineering departments of the semiconductor houses, research labs, key manufacturers as well as various industry sources. We go right to the source, then sift out the best ideas and present them in the best way we know how, either as an application note, a construction or tutorial article, etc.

Certainly a percentage of the new ideas come from you, our reader. But the percentage is small. Too small. This could be interpreted to mean that our readers are basically idealess. This is surprising, as it has been our contention for many years that you, our reader, the electronics activist, are a vast untapped reservoir of new ideas. Why then, haven't we seen more of your ideas? We feel that the problem comes down to the fact that it is just too much of a pain to write an article about the ideas that you have. Let's face it; writing a three- or four-page article is downright difficult.

We now think we've found a solution. It's a new column and you guessed it, it's called New Ideas. It will consist of just about anything innovative. It could be a new circuit, IC application, gadget, or even an innovative use for a new component, a new way to hook up your test equipment, or a new or faster way to lay out or etch your PC boards.

Submitting your idea is easy, but it must include an illustration. If it is a new application of a component or a better circuit approach to something that has already been done, include a schematic or a pictorial drawing. You can draw it freehand, but be sure that it is legible. If we use it we'll have it redrawn by our illustrators. Otherwise, a photograph (black and white and in focus, please) will suffice.

The written description is also a lot easier than a full-length article; a maximum of four and a minimum of two typewritten pages, double-spaced. The first paragraph should describe your New Idea. Next, explain why it is innovative. The rest of the text should be a detailed explanation that includes any necessary information your fellow readers will need to be able to actually use it. Keep the words simple.

Submitting the idea is a matter of snipping out the coupon, filling it out, signing it and mailing it with your idea to us. The coupon contains some legal copyright jargon which gives us your permission to publish it. If we don't publish it we'll return all of the material to you.

If we do publish your New Idea, you'll see your name in print and we'll send you a check for $25. So now what's your excuse? We know you have the ideas. Get up off your . . . er . . . laurels and write them up.

Art Kleiman

ART KLEIMAN
Managing Editor

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NEW IDEAS

All published entries will earn $25 upon publication. Selections will be made at the sole discretion of the editorial staff of **Radio-Electronics.**

I agree to the above terms and grant **Radio-Electronics** Magazine the right to publish my idea. I declare that the attached idea is my own original material and that its publication does not violate any other copyright. I also declare that this material had not been previously published.

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All in all, we cut over $100- worth of corners! But not a single one that affected the quality and performance of our new DMM.

Don't let our low price fool you!

Because Sabtronics sells factory-direct – without all the hidden charges a dealer would track on – we can offer the superior 2010A DMM kit for a surprisingly low $69.95. Surprising because you get the accuracy, features and performance you'd expect from the high priced units.

The 2010A offers you the long-term accuracy of a laser-trimmed resistor network, an ultra-stable band-gap reference element and single chip LSI circuitry – all in a compact, rugged, human-engineered housing. With 31 ranges and 6 functions, you can measure AC and DC volts from 100 µV to 1000V; AC and DC current from 0.1 µA to a surprisingly high 10A; resistance from 0.1Ω to 20 MΩ. Typical DCV and Ohms accuracy is 0.1% ±1 digit. And you see these precise readings on a bright, 3½-digit LED display with automatic decimal placement and large, 9mm numerals.

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And, although designed for benchtop use, the sleek, compact 2010A is powered by 4 "C" cells (not included), bringing wide-range lab performance to the field when you need it.

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Your 2010A DMM kit comes complete with easy-to-follow assembly instructions, all parts (including high-impact case), and test leads. You can complete assembly in a single evening However, for a slight additional fee, Sabtronics will ship your 2010A factory-assembled and calibrated: at $99.50 it's still an incomparable value!

Whether you're a professional or hobbyist, if quality and accuracy are important – and padded prices aren't – you should inspect the 2010A DMM for yourself. If you're not completely satisfied, return it in its original condition within 10 days for a prompt and courteous refund of purchase price. Call us with your MasterCharge or Visa order today, or simply fill out the convenient order form.

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Telephone 214/783-0994

Brief Specifications

DC Volts: 100µV to 1000V in 5 ranges
AC Volts: 100µV to 1000V in 5 ranges
DC Current: 0.1µA to 10 A in 6 ranges
AC Current: 0.1µA to 10 A in 6 ranges
Resistance: 0.1Ω to 20 MΩ in 6 ranges
Diode Test Current: 0.1µA, 10µA, 1mA
ACV Frequency Response: 40Hz to 40kHz
Input Impedance: 10 MΩ on ACV and DCV
Overload Protection: 1200 VDC or RMS on all voltage ranges except 250 VDC or RMS on 200mV and 2V AC ranges. Fuse protected on ohms and mA ranges.
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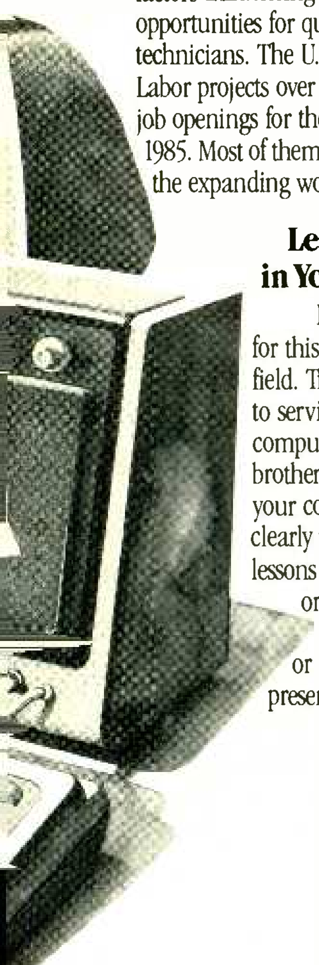
Using this new technology, the industry is offering compact, affordable computers that will handle things like payrolls, billing, inventory, and other jobs for businesses of every size...perform household functions including budgeting, environmental systems control, indexing recipes, and more. And thousands of hobbyists are already owners, experimenting and developing their own programs.

Growing Demand for Computer Technicians

This is only one of the growth factors influencing the increasing opportunities for qualified computer technicians. The U.S. Department of Labor projects over a 100% increase in job openings for the decade through 1985. Most of them *new* jobs created by the expanding world of the computer.



Learn at Home in Your Spare Time

NRI can train you for this exciting, rewarding field. Train you at home to service not only microcomputers, but their larger brothers, too. Train you at your convenience, with clearly written "bite-size" lessons that you do evenings or weekends, without going to classes or quitting your present job.

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NRI training goes far beyond theory. It includes practical experience, too. As you progress, you perform meaningful experiments building and studying electronic circuits on the NRI Discovery Lab.® You assemble test instruments that include a transistorized volt-ohm meter and a CMOS digital frequency counter...instruments you learn on, use later in your work.

And you build your own microcomputer. Each step of construction advances your knowledge, gives you deeper insights into this amazing world that's upon us.

This is the only microcomputer designed for learning. It looks, operates, and performs just like the finest of its kind...actually does more than many commercial units. But NRI engineers have designed components and planned the assembly procedure so it demonstrates important principles, gives you working experience in detecting and correcting problems. And that's what NRI training is all about.

Other Opportunities in Electronics

Since 1914, before commercial radio was even on the air, NRI has been the way to learn new electronics skills. Today's modern offerings include, in addition to three different computer courses, TV/Audio/Video Systems Servicing, with training on the only designed-for-learning 25" diagonal color TV, with state-of-the-art computer programming. Or, check out our Complete Communications Course, preparing you to enter this booming field servicing, installing, and repairing equipment like microwave, broadcast, CB, shortwave radio, paging, radar, and more.

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SOLVING THE ENERGY CRISIS?

It seems to me that the big challenge for electronics in the immediate future is—energy. So, here's an impossible idea:

High school physics taught us that matter and energy are interchangeable. More to the point, one gram of matter is interchangeable with an enormous quantity of energy . . . in other words, if you could convert one gram of matter into energy with *100% efficiency* you could light up New York for a year.

For practical purposes, 100% conversion does not exist. The most efficient conversion process to date (atomic reaction) involves huge quantities of energy from very little fuel. The problem, then, is to come up with a way to produce a technique of matter-to-energy conversion which is almost completely efficient, controllable and suitable for use with abundant and cheap materials.

We have all learned that matter must occupy volume. Clearly then, it must become something other than matter, and all that is left is energy. Therefore, let's postulate that if you squeeze something hard enough it will interchange its volume for an equivalent quantity of energy.

The problem lies in squeezing hard enough. You obviously also don't want to squeeze too much matter at a time or the energy produced becomes difficult to control. Therefore, perhaps sufficient pressure could be obtained by two rapidly moving, very small particles colliding with each other.

The machinery necessary to do this could be based on the particle accelerator, a device that uses switched magnetic fields to accelerate atomic particles. The device could be toroidal, but a linear setup would be more practical since it would not involve changing the direction of the particles we wish to impact. In other words, build a junior-sized atom smasher.

It would be shaped as a tube several miles long so that it can achieve the velocities required for the densities being used. It will be airtight because you want to evacuate the atmosphere from inside it so that the rapidly moving particle will not encounter friction from the gas molecules and incinerate itself. Induction coils will be spaced out along the length of the tube; their magnetic fields will move the matter around. Also used will be sensing coils and some deflection coils (their function will be described later on).

To derive the flux densities required to do the job, some heavy currents will have to flow through the induction coils. To do this without generating excessive heat, the coil resistance must be negligible. The tube must be encased in a jacket inside which a supercoolant can be injected.

At the terminal end of the accelerator will be a structure containing a black-bodied oven, the walls of which contain pipes through which water or some other heat-exchanging liquid can pass to extract the heat of the impact and remove it so it can be converted to electricity. Beyond the oven structure is a second accelerator

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tube, the mirror image of the first.

Here's the procedure: Place a particle of matter at each end of the tube, suck out all the air and cool everything down with liquid nitrogen, helium or some other coolant. Switch the power on and off for each of the inductance coils in sequence so as to cause the particles to accelerate toward each other. They enter the black-bodied oven via two small ports and collide. If the acceleration is sufficient to produce the required pressure to cause the particles to become greater than their greatest possible density (to interchange themselves with energy) what results is a very small, very hot ball of raw power. Those elements that can radiate through a vacuum (i.e., light) will do so and will be converted to heat upon reaching the oven. The rest will be contained in the ball. It can then be tapped by allowing a measured air pressure into the oven. The heat can be used to produce steam.

Now, here come the electronics. We need a humdinger of a real fast computer to determine when the coils are to be switched on and off, or the particles will not accelerate sufficiently. It must also keep both particles in the dead center of the tubes or they won't intercept each other. To do this, it will have to sense the position of the particle and adjust it with the deflection yokes. Furthermore, the computer will have to adjust for any differences in the relative velocities of the two approaching particles, so that they collide dead center in the black-bodied oven. Perhaps the logic of this computer could be created with LSI tunnel diodes because tunnel diodes can switch very fast and the LSI techniques can reduce the distances the pulse must travel, and thus the delay.

You'll also need a new semiconductor device—a mega-thyristor, perhaps—that can switch thousands of amps at thousands of volts extremely quickly. Printed circuit boards for the control circuitry will be available shortly (!); check your local dealers for a few miles of surplus reinforced 9-inch glass pipe and a couple of hundred gallons of liquid helium. The coils can be hand-wound with No. 000 magnet wire.

STEVE RIMMER
Markham, Canada

TUNER TEST COMPARISONS

The June 1978 issue of **Radio-Electronics** contained a test on the Luxman *model R-1120* receiver. The same model was tested by *Stereo Review* (another reputable hi-fi magazine). The results were published in *Stereo Review*'s September 1978 issue. However, the results between the two tests were quite different in some respects.

The greatest difference appeared in the channel separation readings of the tuner section. According to **Radio-Electronics'** stereo performance measurements, the channel separation at 100 Hz was a very high 60 dB (superb), while Hirsch-Houck Labs obtained only something like 42 dB up to 500 Hz. Furthermore, their description of the channel separation vs. frequency makes me think that they have been testing a downright different receiver.

Also, there is a difference (I am not saying error) between their readings of the harmonic distortion of the amplifier section. At 1 watt and 1 kHz, **Radio-Electronics** gives 0.03%, while Hirsch-Houck Labs offer only 0.01%. As someone who works in this field, it is hard for me to believe that the results of these two tests represent both extremes of the performance tolerances of this particular Luxman receiver. If this is so (in spite of my disbelief), there is no point in claiming channel separation or anything else with an accuracy of decibels (sometimes even tenths of dB's). The same applies to all measurements. A more obvious reason why Hirsch-Houck Labs received lower separation readings is that the stereo decoder adjustments were not tuned to their optimum, as they were in the unit tested by **Radio-Electronics**.

You may have noted that, in bringing up the issue of the discrepancies between test results published by the two magazines, I have based everything on the fact that both tests are completely valid. Should a test report reveal the very best readings or the worst? Or something in between? Which would be most useful to the consumer who is thinking of buying the Luxman *model R-1120* since the particular unit he gets can have a low-frequency channel separation anywhere between (or outside of) 42 dB and 60 dB?

I don't know which one of the two tests was made first, but **Radio-Electronics** published its results in the June issue, whereas *Stereo Review* included its report in the September issue, thereby being the

continued on page 16

later of the two. Anyway, I think that *Stereo Review* failed to give the correct information by publishing the test results of the receiver, the tuner circuits of which were not correctly adjusted. **Radio-Electronics** published its results several months earlier, from which *Stereo Review* could have noticed there was something wrong with its test results. Nobody has commented on this matter—neither the readers nor the magazine's editorial staff to date.

Returning to the question of what is best and most useful for the consumer, it is clear that such a discrepancy between the tests of the same product is nothing but confusing. Anyone can find a somewhat similar case by comparing the test reports of the Harman/Kardon *Citation 16*, published in both magazines.

The problems associated with modern FM tuner measurements are not unknown to me. The quality of tuners seems to outperform their test equipment to a greater and greater extent. One such aspect is the measurement of the channel separation. I assume that in both tests, the Sound Technology *model 1000A* stereo signal generator was used for the channel-separation measurement. This fine equipment, however, is claimed to give a separation of 50 dB from 50 Hz to 8 kHz, so a separation of 60 dB at 100 Hz achieved by the Luxman *model R-1120* receiver should be very near the limit of the test signal itself.

Some of the newest stereo decoder IC's using the PLL (*Phase-Locked Loop*) technique are capable of maintaining a separation of around 60 dB throughout the audio frequency band, so it can be expected that the present stereo signal generators are inadequate for the stereo separation measurement of tuners in the very near future. Because I am faced with this problem so often, I came to think, why not measure the separation with the dynamic signals instead of the static sinewave as a modulating signal? It could be done by tone bursts, for instance. A dynamic test signal could reveal some deficiencies of the tuner circuits that are not readily detected by using the static signals. Furthermore, since the music signal to be received contains transients and is dynamic in nature, the use of a dynamic test signal in the tests is highly justified.

If for any reason it would be more appropriate to go on testing the stereo performance in an ordinary manner, then it might be a good idea to shift from using a so-called switching-type multiplex generator (which the Sound Generator *model 1000A* is) to a matrix-type generator. Then, test signal separation values of 55 dB or more from 20 Hz–15 kHz are available.

LEO BACKMAN
Helsinki, Finland

If you will examine the actual separation response curve of the FM section of the model R-1120 *stereo receiver as shown in the test report, you will note that maximum separation of this particular sample receiver occurred almost exactly at 100 Hz. Admittedly, this is most unusual since in most receivers and tuners we test, maximum separation occurs at mid-frequencies and tends to decrease as one approaches the low- and high-frequency extremes. Nevertheless, our policy is to report our readings as we find them in the specific sample tested. In fact, the results obtained by Hirsch-Houck Laboratories and published in* Stereo Review *are probably more typical of an* average *receiver.*

As for your more philosophical questions, may I say that stereo separation in excess of 30–35 dB is rather academic in any case. The "high" numbers that we report and that many manufacturers boast about are largely an exercise in engineering perfection and will not audibly improve the stereo image. My own feeling is that "superb specs" are an indirect indication of serious engineering efforts and do have an indirect (if not an audible) relationship to the quality of a given piece of equipment. I am sure that as a practitioner in this field you are also aware that especially *at low frequencies, actual channel separation becomes even less important since bass tones, as reproduced in a listening room, are largely nondirectional.*

As for the test equipment both Hirsch-Houck Labs and we use, you are correct that the guaranteed separation capability of the Sound Technology model 1000A *is 50 dB, but my own unit is known to be capable of providing an FM stereo signal that has separation in excess of 60 dB across the audio frequency band. Just as home audio equipment varies slightly in specs, so do individual pieces of test equipment.*

continued on page 22

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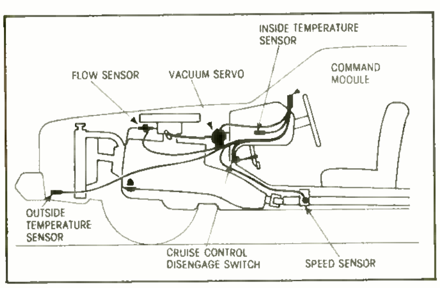

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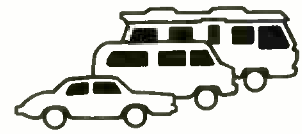

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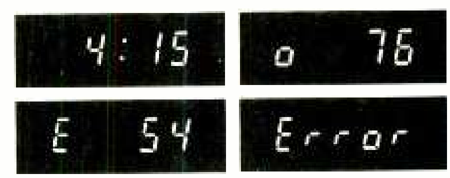

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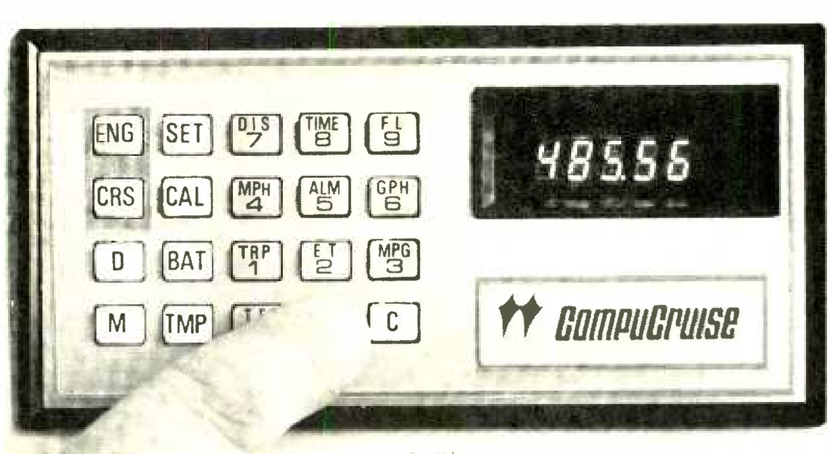

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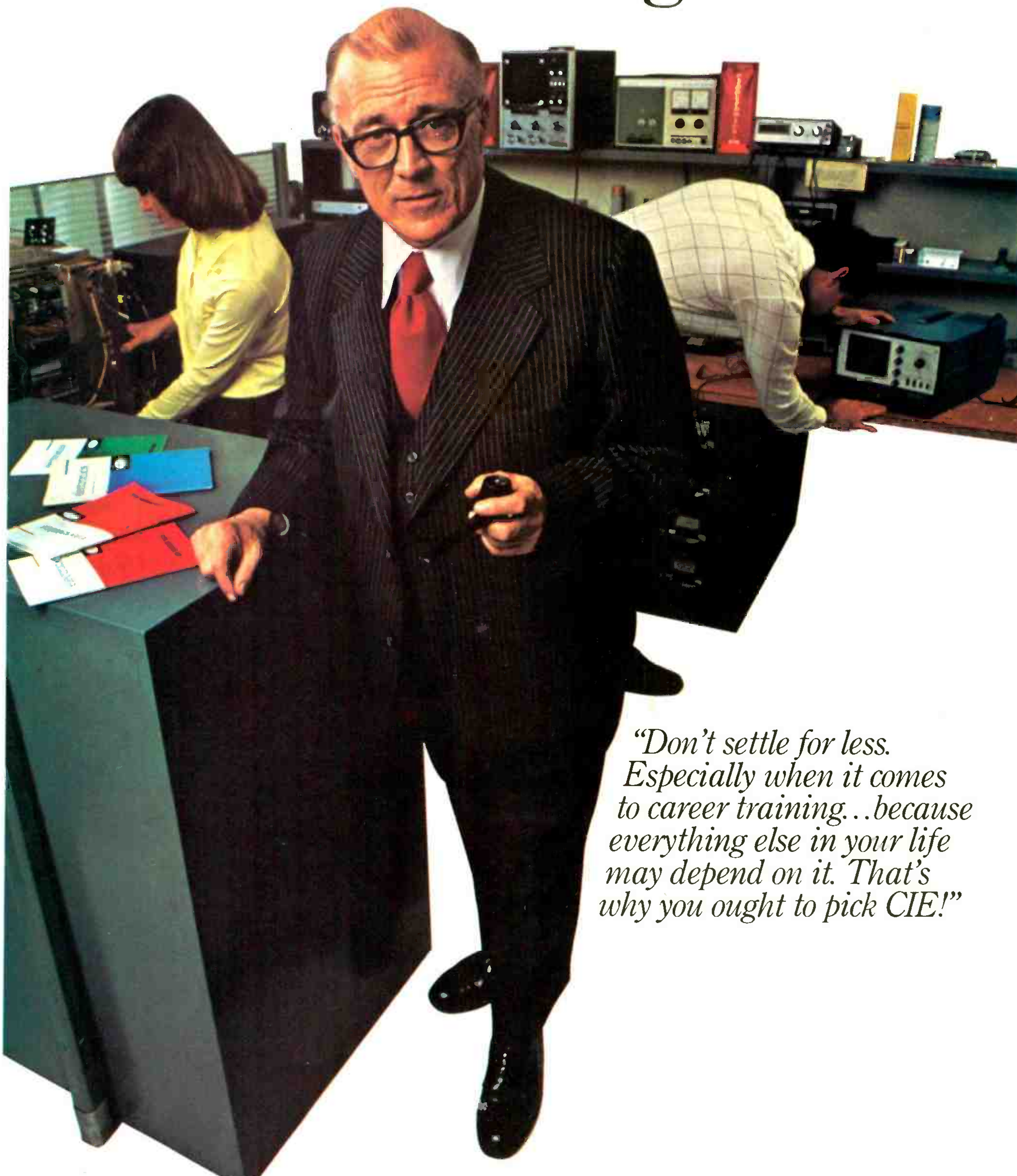

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LETTERS
continued from page 16

The importance of all these test reports is not so much the actual numbers obtained upon the test bench, but the overall impression that the reviewer is able to impart to the reader regarding the particu-

SUPERCONDUCTING COIL

It's too bad Mr. Ecklin (Letters, October, 1978) didn't elaborate on how charging and discharging a superconducting coil (or any coil for that matter) is going to solve the energy crisis.

While a superconducting coil is useful for *storing* energy, it does not *create* it. The statement that...

permanent magnets and some kind of magnetic shielding. A magnetic field is a conservative force field, like gravity. Energy cannot be extracted from it, only transformed. For example, mechanical energy, turning an armature of a generator whose coils are in a magnetic field, will be converted to electrical energy. But the electri-

equipment reports

Graymark Model 540 Binary Clock

CIRCLE 101 ON FREE INFORMATION CARD

IF YOU ARE TECHNICALLY ORIENTED AND would like to have a conversation piece with a purpose, the Graymark *model 540* Binary Clock Kit should fit the bill. The clock is in an attractive simulated wood-grain plastic case measuring 7 W × 3 H × 4½ inches D, with a black and chrome-trimmed front panel. It contains 11 integrated circuits (10 TTL IC's and 1 voltage regulator), 24 resistors, 6 capacitors, 2 power diodes, 1 signal diode, 18 light-emitting diodes (LED's), 2 transistors and a power transformer assembled to three PC boards. Three pushbutton switches on the back panel are used to set the time display.

The front PC board holds the 18 LED's arranged in five vertical columns, with either 3 or 4 LED's in each column, depending on the required count for that column. Each column indicates a measure of time, in a binary-coded-decimal (BCD) format. In each column the bottom LED represents the decimal count of 1; the next LED above it represents a count of 2; the next one above is 4; and the next one above (in three columns that have one) represents 8. Suppose the time is 11:05:29 (11 hours, 5 minutes, 29 seconds) as shown in the photograph. Since a lighted LED represents the decimal number just described, the five rows, reading from left to right, have the following LED's on during that second: column 1 (hours) 1, 2 & 8; column 2 (10's of minutes) none; column 3 (minutes) 1 & 4; column 4 (10's of seconds) 2; column 5 (seconds) 8 & 1. It's fascinating to watch the seconds count in this unconventional manner, with the minutes advancing right on cue up to 11:59:59 and then repeating. (This clock does *not* display in a 24-hour format).

This may sound very complex to those of you who are unfamiliar with digital electronics; however, the Graymark instruction manual guides you through each stage step-by-step. This manual was written by George F. Martin, Graymark's director of engineering, and R.L. Kall of the engineering staff, and reflects considerable teaching experience. Those wanting the full value of an education in binary counting and TTL theory can assemble a small section of the kit, then test it (using a multimeter and oscilloscope), with the manual explaining how everything works. This is called Mode I. For those who just want to build the kit and don't have any particular interest in TTL theory, Mode II is provided. In Mode I, you perform *all* the printed steps; in

Mode II, you only read and perform the steps that are printed in red.

The manual is printed throughout in two colors, has over 100 explicit illustrations and diagrams and contains virtually no errors. (Exceptions: On page 34, step 5 refers to Fig. 49, but should refer to the foil side of the PC board; and on page 41, step 35 should be printed in red.) The operational theory of the clock is extremely detailed, and is accompanied by many block diagrams, charts, timing diagrams and even IC data sheets. A complete parts list and a schematic diagram of the clock are also included.

The PC boards and parts are all new and of top quality. The LED's seem to be graded for equal brightness, and an assembly aid is provided for their proper positioning and alignment. Every single component needed is included—even a nylon cable tie and solder. The PC boards are masked to avoid solder bridges, and parts locations are silk-screened on the component side of the boards to insure proper assembly. The only tools you'll need are a 20- to 30-watt soldering iron, a wire stripper, diagonal cutters, a Phillips-head screwdriver and long-nose pliers.

Constructing the kit is simple following the detailed step-by-step instructions, but it is time consuming. There are over 350 solder connections, 21 jumpers and 29 board-interconnecting wires. It took four hours to assemble (following the Mode II red instructions), and working slowly and carefully to avoid later problems. This care was rewarded by the clock working perfectly when plugged into the 110-VAC line. Time-setting is accomplished easily with the SLOW, FAST and HOLD switches once the time-readout format is understood. Counting is controlled by the line frequency (either 50 Hz or 60 Hz, jumper-selected), so this clock provides long-term accuracy, since power companies keep a close tolerance on the average output frequency.

The *model 540* Binary Clock sells for $39.95 in kit form including the manual (postpaid in the United States) from Graymark International, Inc., 1751 McGraw Ave., Dept. RE, Irvine, CA 92714. Foreign orders add $6 postage and handling. California residents add state and local taxes as applicable. The manual is available separately for $2. **R-E**

BSR System X10 AC Remote Control

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HERE IS A REMOTE-CONTROL SYSTEM THAT gives you, at your fingertips, complete control of the lights and appliances in your home without getting involved in any special wiring. You use the house wiring as the signal-carrying system. For example, if you suddenly hear a strange noise downstairs, you push a button on the control unit and it turns on the lights. With the BSR *System X10* light and appliance command console by your bedside or chairside, you can turn lights on and off, dim or brighten them at the touch of a button. You can even use the *System X10* to trigger a simple alarm device.

Using this system, you can literally operate almost every light and electrical appliance in your home without leaving your easy chair. That means you can turn air conditioners on and off, as well as TV's, stereos or lights. The basic system comes with a command console, appliance module and a couple of lamp modules. For less than $100 it is possible to buy a *System X10*, including enough modules to control lights and appliances at up to four different locations. The command console, *model SC-311*, through its keyboard, permits remote control operation of lights or appliances in up to 16 separate locations. (By rotating a bottom of the control switch, more groups of 16 controlled switches can be provided.) It plugs into any AC wall outlet in the house and transmits FM command signals over the electrical wiring. Optionally available is a cordless controller, *model CC401*. It transmits signals to the ultrasonic command console over distances of as much as 30 feet. All functions of the command console are duplicated on the cordless controller.

The lamp module, *model LM501*, will control any incandescent lamp rated up to 300 watts. Functions include on and off, bright and dim.

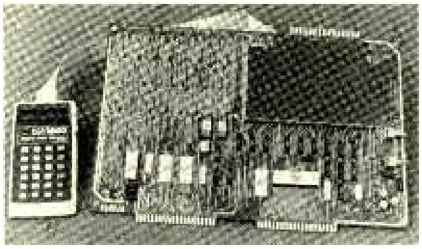
The appliance module, *model AM601*, turns an appliance on or off; a TV, stereo, fan, etc. Maximum appliance ratings on a resistive load are 15 amp; motorload, 1/3 horsepower; incandescent lamp, 500 watts. A wall-switch module is also available. It looks like an ordinary wall switch, operates like one, installs like one, but can also be remotely controlled.

When we first looked at the unit, we wondered what would happen if we had one, an upstairs neighbor had one, or the guy next door had one; if his units would turn mine on, and if my units would turn his on. Obviously, if our signal gets into his apartment, it will. But BSR is just one little step ahead of us. There are 16 separate ranges that will automatically prevent overlap. A simple dial selector on the unit codes the letters A through P for those noninterfering signals.

I can't think of an easier way to remotely control electrical functions in anyone's home or apartment, and the price is surprisingly reasonable for what the equipment can do. This is one of those products among the many we've tested that I am going to want for myself.

The *System X10* is available from Advanced Electronics, 54 W. 45 St., New York, NY 10036. **R-E**

RCA CDP18S020 COSMAC Evaluation Kit



CIRCLE 103 ON FREE INFORMATION CARD

THE RCA 1800 SERIES COSMAC MICROPROCESSOR and its associated family of devices have a couple of unique characteristics. First, because they are COS/MOS devices, the power drain is low, starting at the milliwatt level. Single-IC standby memory power is also in the low milliwatt range.

Second, the 1800 family tolerates an unusually wide power supply range—3 to 12 volts for the CDP1802 with a 3.2-MHz clock. And the operating temperature range for the full-speed processor and certain memory products covers the full −55 to 125°C temperature range. This is important if your microprocessor-controlled gadget will form part of an automotive system.

The processor instruction set is based on a 16- × 16-bit scratch-pad organization that provides good programming flexibility.

The RCA CDP18S020 Evaluation Kit is a relatively inexpensive tool with which to learn about the RCA 1802, prototype a microcomputer system, or develop software. A 20-mA loop or RS232C terminal is normally required to use the Evaluation Kit, although a simple keyboard or switch interface can be designed. Board dimensions are 14 × 9.7 inches, including fully decoded prewired locations for expansion to 4096 bytes of random-access memory (RAM), and a 6- × 4-inch user area wired to accept standard DIP packages.

Three edge connectors provide access to the microprocessor pins and the user input-output (I/O) area, and connect to external power sources and peripheral devices. The kit comes with a 2-MHz crystal which, for the 16- and 24-clock-period instructions, calculates to 8-μs or 12-μs execution times. A 6.4- MHz oscillator reduces these values to 2.5 and 3.75 μs.

A 512-byte ROM is assigned address space from 8000 to 81FF and permanently stores the UT4 monitor program. A 32-word RAM starting at 8C00 is used by the utility program to store register contents. Two supplied RAM IC's fit into the first two locations in the 4K memory area for an initial 256-word user programming space.

System operation is controlled by three pushbuttons and a toggle switch. The RESET pushbutton intializes the CPU and control logic: RUN U (*R*un *U*tility) gives control to the ROM monitor program by starting execution at 8000. The RUN P (*R*un *P*rogram) pushbutton starts program execution at 0000, where the first user's program instruction is usually entered. The CONTINUOUS/STEP toggle switch lets the user choose between the normal clocked mode or single-cycle operation, where individual program steps can be dissected down to 2 machine or 3 machine cycles-per-instruction.

A series of 29 LED's display the status of the 16-bit memory address bus, the 8-bit data bus, the S0 and S1 processor state codes, the $\overline{\text{CLEAR}}$ and $\overline{\text{WAIT}}$ control signals, and the processor's Q flip-flop.

Bidirectional communications to a data terminal are provided by interface circuits that use the Q flip-flop for output and the $\overline{\text{EF4}}$ flag to input the serial data. Detailed instructions show how to hook up to current loop terminals such as *Teletypes*, and to EIA RS232C interfaces such as Texas Instruments' *Silent 700* terminal. Parallel 8-bit input and output ports are included in the kit.

External power supplies are required—of 5

```
*M0 112233445566778899AABBCCDDEEFF;

100020 123456789ABCDE,
1029384756;
000F AFBECD
*?M0 30
0000 1122 3344 5566 7788 99AA BBCC DDEE FFAF;
0010 BECD 0000 0000 0000 0000 0000 0000 0000;
0020 1234 5678 9ABC DE10 2938 4756 0000 0000
*?M20 10
0020 1234 5678 9ABC DE10 2938 4756 0000 0000
*?M8C00 20
8C00 D0D0 8C02 FF00 814F 9401 804A BD00 EF82;
8C10 FA24 FF66 FF02 7F00 80EF 0000 2800 8000
*$P

*$P0100
```

FIG. 1

volts at 600 mA, or 10 volts at 200 mA with a separate 5-volt 400-mA supply for the LED's.

Assembly

Kit assembly was pleasantly uneventful with the help of a high-quality, double-sided PC board with plated-through holes. Close PC runs are necessity on microcomputer boards, and careful soldering and inspection techniques are a must. Sockets are provided for the microprocessor and utility ROM IC's, but, as always, I recommend using additional sockets or *Molex* pins to mount some or all of the remaining 22 circuits.

The checkout procedures consists of measuring the resistance of the supply input leads, and loading and executing a four-instruction program that sets and resets flip-flop Q.

Figure 1 demonstrates the writing of data to memory, the reading of data from memory, and starting programs. The UT4 program recognizes three commands corresponding to each of these functions.

After pressing the RESET and RUN U pushbuttons, type either a carriage return or a line feed depending on whether your terminal is connected for full-duplex or half-duplex operation. Full-duplex operation requires the computer to echo back characters typed on the keyboard to the printer, since the two terminal functions are completely isolated. Based on the first character typed, the utility program sets up to echo or not, and calculates the bit timing necessary to talk and listen to the terminal.

Figure 1 shows how the three-command repertoire works. First, you enter a program either from the keyboard or from punched paper or magnetic tape. The command !M is the write-memory command, which is immediately followed by the address where the input should be entered—in this case, 0 or 0000. The space after the 0 separates the address from the data. Next, the program instructions or data are entered in hexadecimal format, with each two characters accounting for a single memory word. In hexadecimal or base 16 format, additional symbols are needed for numbers between 10 to 15. Letters from A through F are used to represent 10 through 15 with a single symbol.

Spaces can be imbedded between words if desired. At the end of the line, you have a number of choices. In Fig. 1 the first line is terminated by a semicolon. This told the machine I wasn't finished yet, and that I will give a new address and more input. Everything else was ignored until the next hexadecimal digit. I then added an extra line feed to make the printout more legible. On the second line I started to type 10 but decided I really wanted to enter more data starting at address 20. The system (being forgiving) only pays attention to the last four numbers entered, so I typed 0020 (or I could have typed 020 since one 0 was already there from the 10). I then hit the space bar and typed in the data.

This time I hit a comma at the end of the line that told the machine I still had more data to enter but wanted to continue on the next line. With the comma the data continues in sequence and a new address is not given.

At the end of the third line I decided to go back and fill in data starting at 000F; so I used the semicolon again.

Finally, at the end of line 4, I simply used a

continued on page 32

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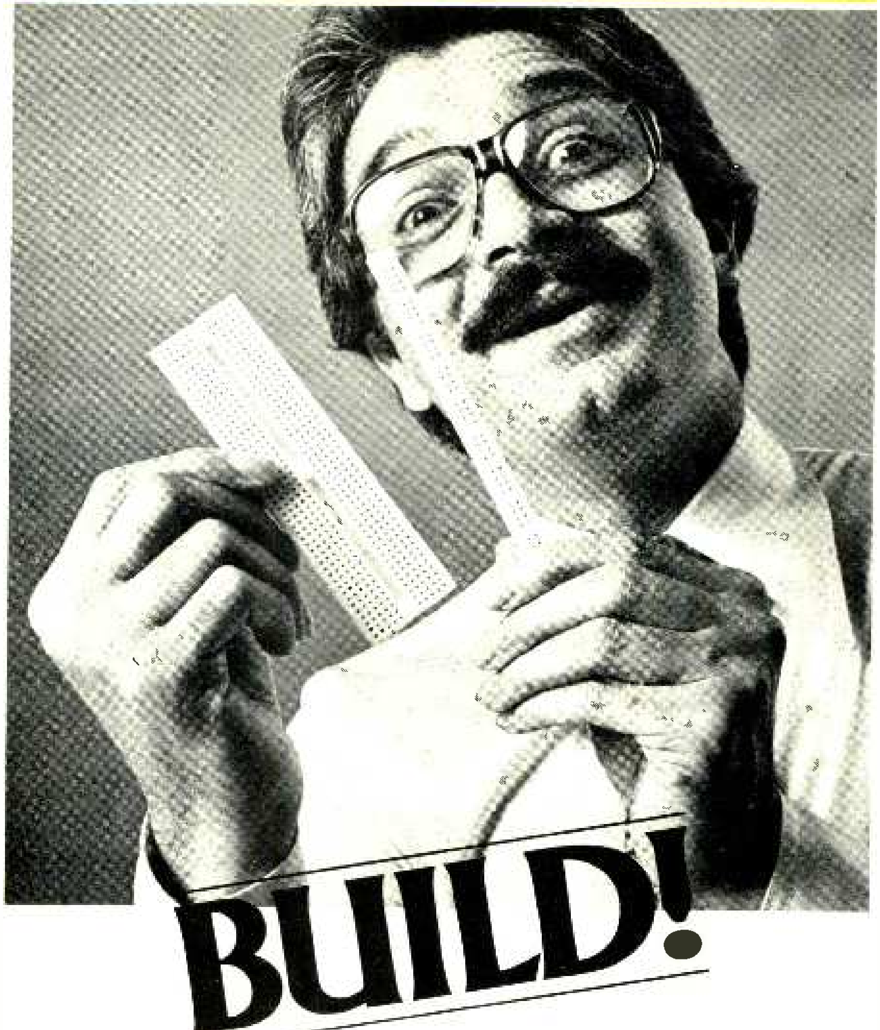

EQUIPMENT REPORTS

continued from page 27

carriage return, indicating I was through, and the machine responded with the prompt asterisk on the following line.

At this point, you're ready to check by reading out memory contents with the ?M command. Again, you use 0 as the starting address; however, the 30 is not data but the number of words in hexadecimal format to be typed out—$30_{16} = 3 \times 16 = 48_{10}$ words. The next three lines represent the response to that command. The first four columns display the starting address for each line followed by 16 words grouped by two's. The last byte on the 0000 line is the AF that I inserted at address 000F on line 4.

Note the format that the machine uses to output memory contents. The first two lines begin with addresses and end with semicolons, and the third line starts with an address (0020) and ends with a carriage return. This allows the data to be stored on tape in this format and then later be read back in using the compatible !M command.

The next group of lines demonstrate a memory dump of 10_{16} or 16_{10} words starting at 0020.

The UT4 monitor program uses a 32-byte RAM starting at 8C00 to store the 16 scratchpad microprocessor registers. This feature is helpful in troubleshooting, but care must be used since certain registers are modified by the system. The program cannot be restarted from an intermediate point after being interrupted by inserting an idle instruction unless the registers are restored.

The next three lines in Fig. 1 show how the register RAM is printed out with the ?M8C00 20 command. Characters R0 and R7 are displayed on the line prefixed by 8C00, and R8 through RF on the line starting with 8C10.

Command $P starts program execution. If no address is given, execution begins wherever the program counter is set, usually at 0000. Otherwise, the program is started at the address typed immediately after $P.

A large loose-leaf binder comes with the kit. It includes detailed sections on kit assembly, design and operation of the system, the utility program (including listing), application notes on I/O and control, software and memory.

The CDP18S20 evaluation Kit is priced at $249 and is available from RCA Solid State Division, Somerville, NJ 08876, or from RCA Solid State distributors. **R-E**

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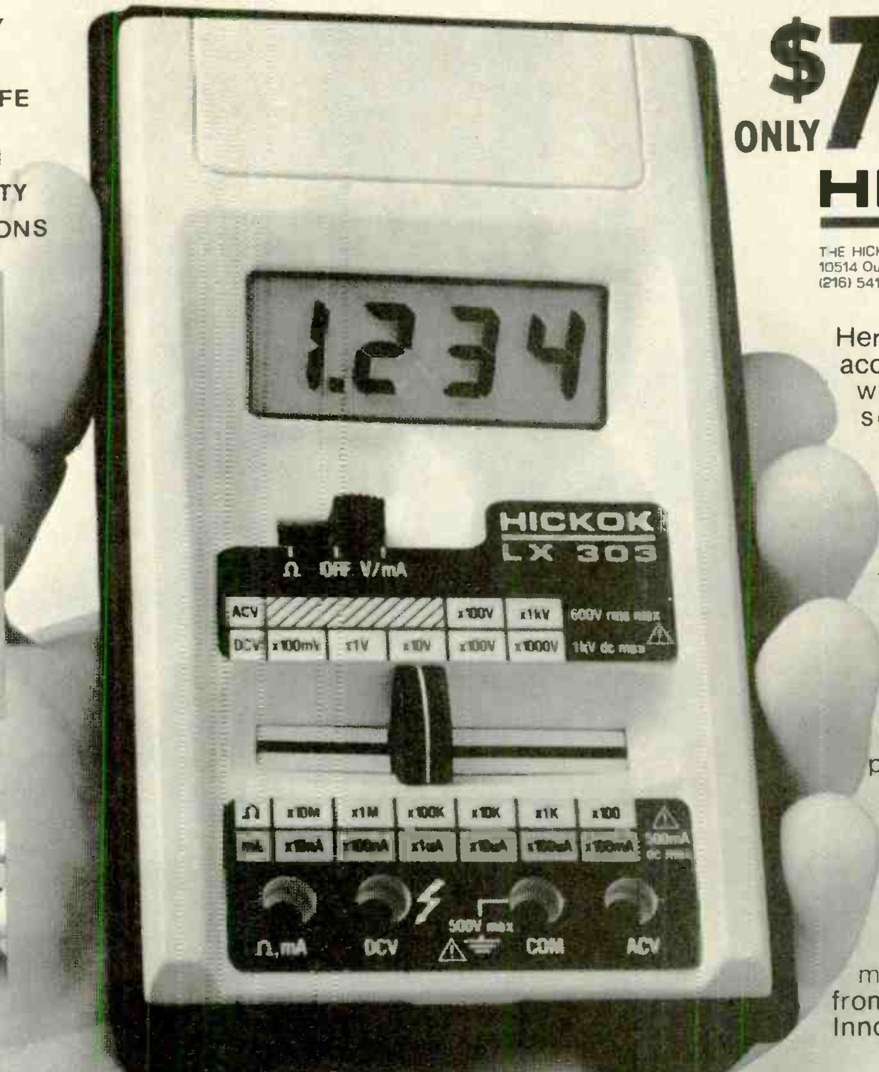


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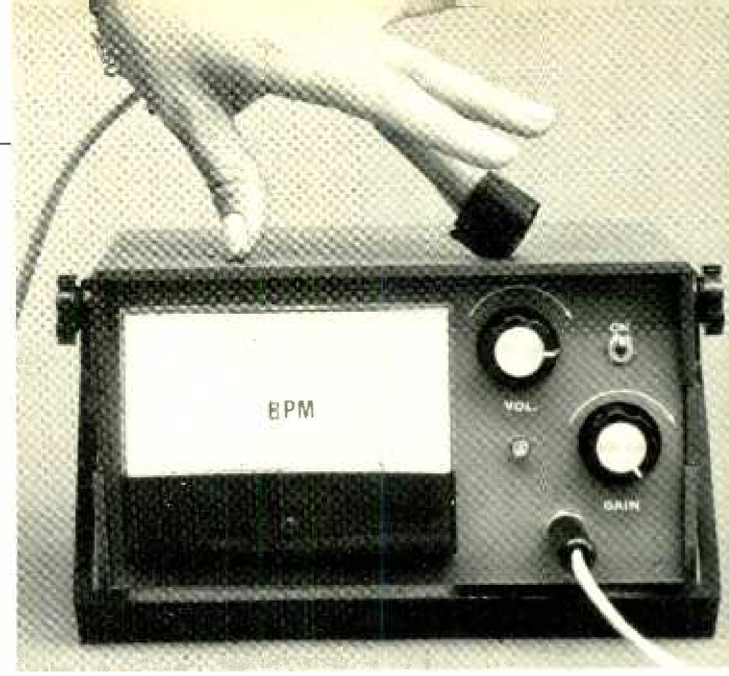


Heart Rate MONITOR

An instantenous check on heart-rate activity is essential when engaging in meditation, Yoga or an exercise program for health and physical fitness. This cardiotach provides a direct readout of your heart rate.

MARK C. WORLEY

THE CARDIOTACH IS AN ADVANCED, SOLID-state design useful for experimental or clinical monitoring of the human heart rate. The term "cardiotach" is derived from the Greek word *kardia*, meaning heart, and the Greek word *takhos*, meaning speed. Thus, *cardiotach* literally means heart speed or heart rate.

Research has shown that the heart rate is generally proportional to the body's level of tension, excitement or anxiety; therefore, a slower heart rate can be used as an indicator of the degree of relaxation. For those practicing various methods of meditation or tension-reducing relaxation, the Cardiotach can be useful for displaying the relative degree of calmness.

Experimenters and clinical technicians can use it as a response indicator of anxiety states or relaxation responses to such external stimuli as words, music, odors, visual displays, etc. The pulse rate increase is usually quite rapid in response to anxiety-producing stimuli and can be a more accurate indicator of the body's state than verbal responses. This is one reason why a heart rate monitor usually forms part of a polygraph or "lie detector."

Often, during relaxation-training sessions, an aural indicator can disturb the state of relaxation for the participants. The Cardiotach has a front panel meter that provides a visual indication of the heart rate.

For those physical fitness enthusiasts who might want to monitor heart rate in relation to physical stress, the Cardiotach could be useful, too. It is not, however, a portable (battery-operated) instrument, and is subject to false readings from muscle and sensor movements. Therefore, its best application might be as a before-and-after measurement while comfortably seated or otherwise stationary.

In addition, it's fun and satisfies your curiosity to know your heart rate and see the meter display it directly in BPM (*B*eats *P*er *M*inute).

Design objectives in devising the Cardiotach were to use inexpensive, readily available components, provide an accuracy of at least ±5% and avoid potential shock hazard. All these criteria were met far beyond expectations. The accuracy of the instrument, depending upon meter linearity, is better than 5%, the unit costs less than $100 to build, and all the components, except for the sensor, can be obtained from mail-order distributors.

Circuit description

The circuit senses each heartbeat via an infrared optocoupler/sensor and triggers on the "R"-wave, which is the largest-amplitude signal found in the heartbeat waveform (see Fig. 1). Because of this, it was decided to simply use amplitude discrimination in order to have the R-wave trigger the tachometer circuit. Thus, the circuit directly displays the R-wave repetition rate.

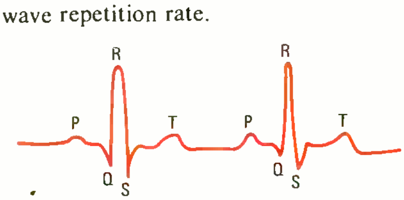


FIG. 1—HIGH AMPLITUDE PULSE of the heartbeat waveform.

Figure 2 is the block diagram of the Cardiotach circuit; Fig. 3 is the complete schematic diagram. The circuit is divided into eight basic sections: sensor, bandpass amplifier, Schmitt trigger, charge pump, meter circuit, beep-tone generator, calibrator and power supply. We'll consider the operation of each section in turn and see how they all combine into one instrument.

1. The sensor is an infrared reflective sensor (manufactured by Optron, Inc., 1201 Tappan Circle, Carrollton, TX 75006) containing an infrared emitting diode and an infrared sensitive phototransistor that are shielded from each other

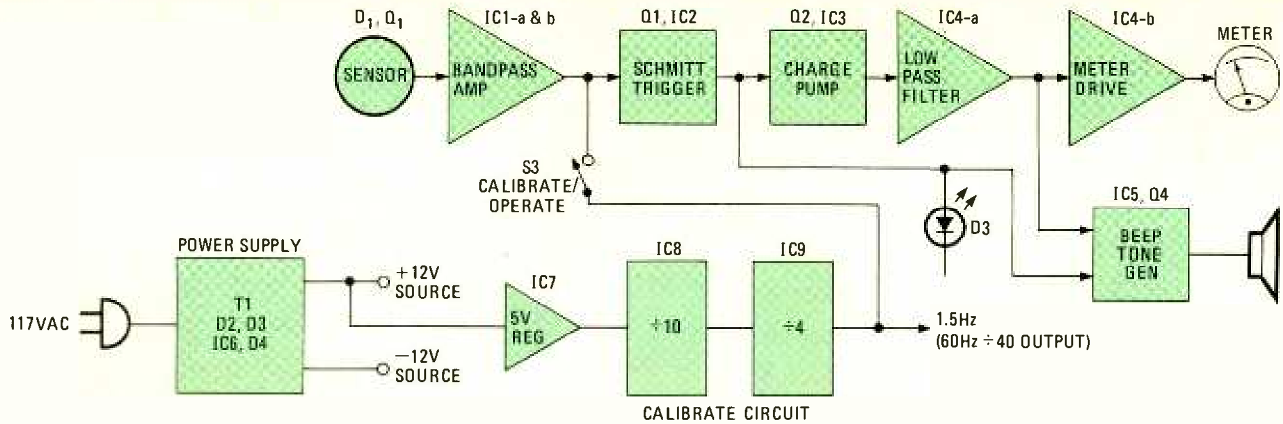


FIG. 2—BLOCK DIAGRAM of the cardiotach. Infrared optoelectronic sensor detects pulses in blood flowing close to the skin surface and interprets each pulse as a heartbeat.

by a barrier (see Fig. 4). The transparent cover allows the infrared emission to be coupled back to the transistor via reflection or conduction from a nearby surface. In this application the transparent face of the optocoupler is held against the skin. As blood pulses through the body, the infrared-sensitive phototransistor responds to the varying levels of infrared skin transmissivity caused by the changing blood volume with each heartbeat. The phototransistor, Q1, senses and amplifies the signal for further amplification by IC1.

2. The bandpass amplifier, IC1, amplifies the signal within the range of about 0.5 Hz to 6 Hz to reduce 60-Hz hum and other noise-source problems. It is a non-inverting amplifier with the variable gain controlled by sensitivity potentiometer R9. Resistor R10 is an end-mounted resistor that is used as a scope test point for the electrocardiogram signal.

3. The Schmitt trigger, IC2, is trig-

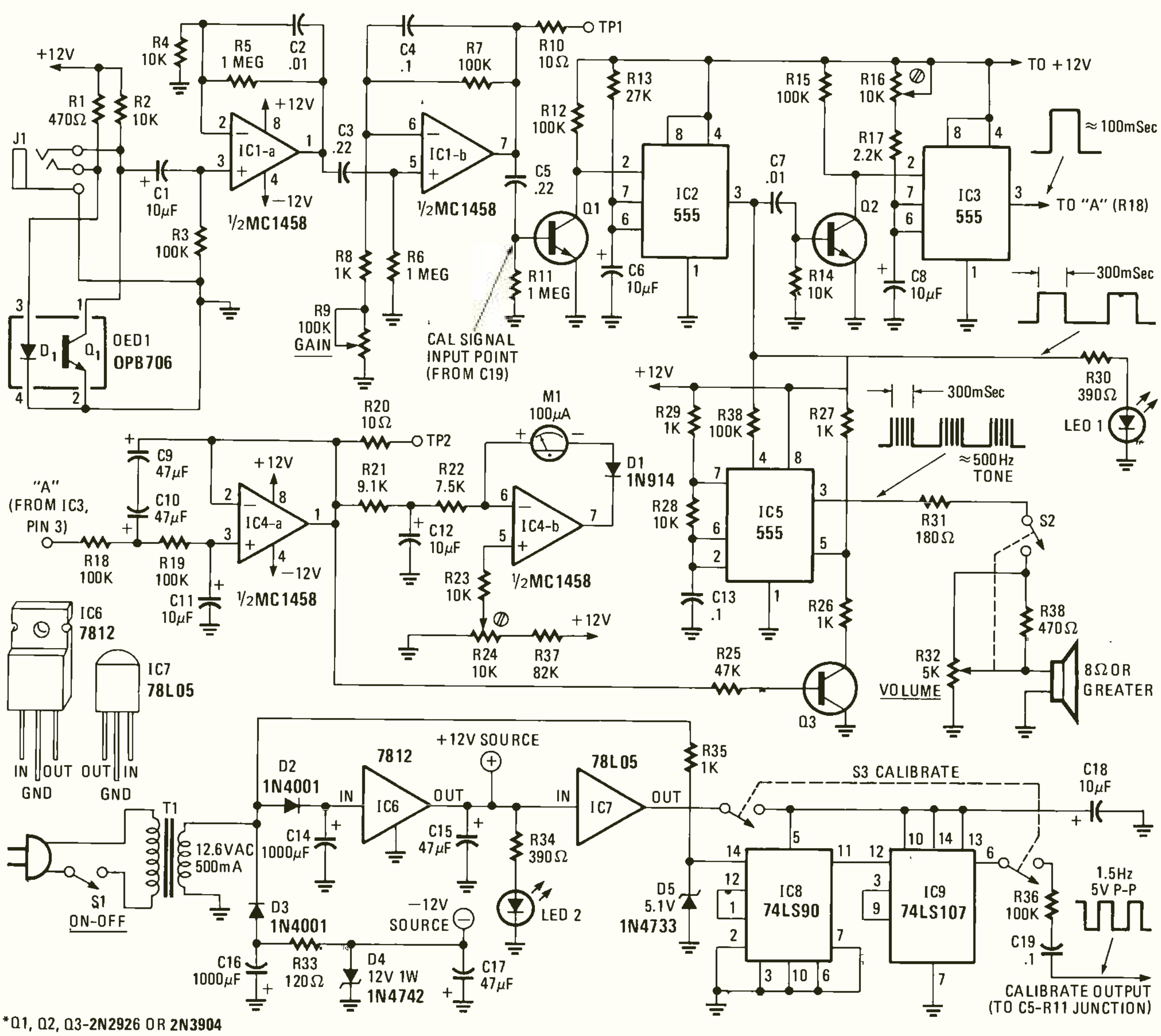


FIG. 3—SCHEMATIC of the Heart Rate Monitor. If you desire, rather than hardwiring opto-sensor OED1 to front-panel jack J1 as shown in the diagram, you can add a male plug to the opto-sensor cable and plug it into J1. If you opt to leave the cable hardwired, you can eliminate jack J1.

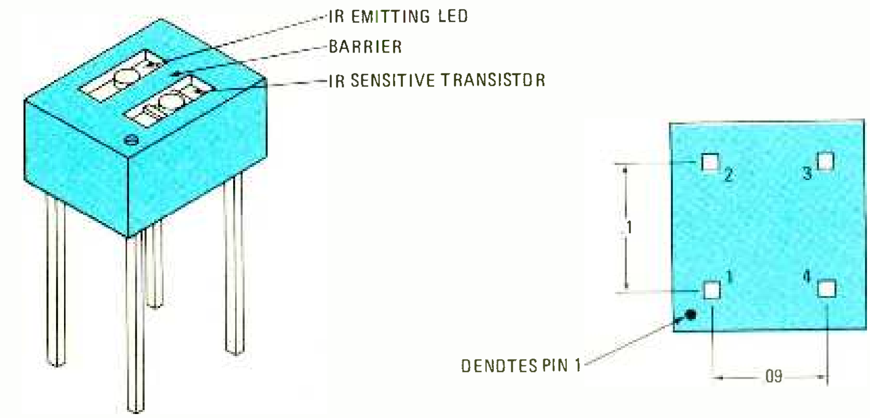


FIG. 4—CONSTRUCTION and pinout for the OPB-706 infrared reflective sensor.

gered by a negative pulse from Q2 to produce a 300-μs squarewave that helps eliminate multiple triggering on both the R- and T-waveforms. The pulse is also used to light LED1 and trigger the beep generator IC.

4. The charge pump, IC3, produces a 100-μs pulse each time it's triggered by a heartbeat signal from IC2. Resistor R17 is an internal calibration potentiometer that adjusts the width of the pulse. The actual pulse width is dependent upon the circuit values and tolerances in the low-pass filter circuit. Quality components are a must in this part of the circuit in order to maintain stability.

5. The low-pass filter, IC4, is used to smooth the 100-ms pulses into a DC voltage that is proportional to the heart rate. This voltage can be measured at R20, which is an end-mounted resistor used as a test point during calibration. Integrated circuit 4-b is a voltage-to-current converter used to drive meter M1. Input resistors R21 and R22 filter and scale the meter drive circuit to produce a 60-μA current for a 1-volt input. Since the meter is in the feedback path of IC4-b, its internal resistance and any thermal resistance changes will have no effect upon the current through it. Diode D1 prevents reverse meter current, and since it also is in the feedback path, it has no other effect on the meter. Resistor R24 is used to cancel offset voltages and to position the meter needle during calibration. Resistors R21 and R22 are selected for a series resistance of 16,660 ohms, resulting in a 60-μA-per-volt scaling of IC4-b's meter drive circuit. (The meter is intended to be calibrated with 0μA as 50 BPM, 20 μA as 70 BPM and so on, with 100 μA as 150 BPM. If a 50-μA meter is used, R21 and R22 must be doubled in value to equal a total resistance of 33, 330 ohms.)

The charge pump and filter circuit are designed to provide 1-volt DC to IC4-b at 60 BPM (or 1 Hz) and to increase that voltage linearly with an increase in frequency. This results in a 60-μA change through the meter when the heart rate increases from 60 BPM to 120 BPM.

6. The beep-tone generator, IC5, produces a 300-ms beep with each heartbeat. The generator operates in a keyed and modulated mode controlled by IC2 and Q3. As long as pin 4 is kept low, IC5 does not oscillate. When IC2 pin 3 goes high, it allows IC5 to produce a tone for the duration of the pulse of IC2. The frequency, or pitch, of the tone from IC5 increases with an increased heart rate and vice versa. The voltage on pin 1 of IC4-a varies the conduction of Q3, which, in turn, varies the trip point of IC5 and its operating frequency. The response of Q3 is not linear, but it does vary noticeably with the heart rate. If this feature is not desired, eliminate R25–R27 and Q3. No jumper connections are needed; just leave IC5 pin 5 disconnected.

7. The calibrator circuit, IC7–IC9, generates a 1.5-Hz (or 90-BPM) squarewave that is derived from the 60-Hz line frequency. It is used to initially calibrate the Cardiotach and for later recalibration

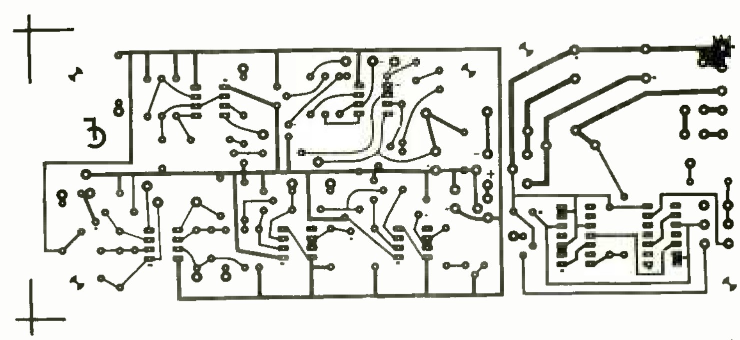


FIG. 5—FOIL PATTERN for the printed-circuit board used in making the cardiotach. The board may be cut in two and the pieces wired separately. Pattern is shown half-size.

PARTS LIST

Resistors ¼ watt, 10%, unless otherwise specified

Resistors

R1—470 ohms, ½ watt
R2,R4,R14,R23,R28—10,000 ohms
R3,R7,R12,R15,R18,R19,R36,R38—100,000 ohms
R5,R6,R11—1 megohm
R8,R26,R27,R29,R35—1000 ohms
R9—100,000-ohm linear pot (sensitivity control)
R10,R20—10 ohms, ½ watt (test points 1 & 2)
R13—27,000 ohms
R16,R24—10,000-ohm trimmer
R17—2200 ohms
R21—9100 ohms, 1%
R22—7500 ohms, 1%
R25—47,000 ohms
R30—390 ohms
R31—180 ohms
R32—5000-ohm, audio taper pot with switch
R33—120 ohms, ½ watt
R34—390 ohms, ½ watt
R37—82,000 ohms
R38—470 ohms

Capacitors

C1,C6,C11,C12,C18—10 μF, 16 volts, electrolytic
C2, C7—.01 μF, ceramic
C3, C5—.22 μF, 50 volts, Mylar
C4, C13, C19—0.1 μF, 50 volts, Mylar
C8—10 μF, tantalum
C9,C10,C15,C17—47 μF, 16 volts, electrolytic
C14, C16—1000 μF, 16 volts, electrolytic

Miscellaneous

OED1—OPB706 (Optron)
D1—1N914
D2, D3—1N4001
D4—1N4742, 12-volt, 1-watt Zener diode
LED1, LED2—Visible red LED (LED 2 not used in prototype)
D5—1N4733, 5.1-volt, 1-watt Zener diode
Q1, Q2, Q3—2N2926, 2N3904, or equal
IC1, IC4—MC1458 or 5558
IC2, IC3, IC5—NE555
IC6—7812 or LM340T-12
IC7—78L05
IC8—74LS90
IC9—74LS107
S1—SPST toggle on/off switch
S2—SPST switch (forms part of R32)
S3—DPDT mini PC-mount slide switch
M1—100-μA, 4¼-inch meter
T1—12.6 VAC at 500 mA, or greater
Cabinet plus assorted hardward, knobs, etc.

The author, Mark C. Worley, 3504 Minerva, Flint, MI 48504, has the following available: Meter with separate dial overlay $22.50; G-10 etched and drilled PC board $12.00; Optron type OPB706 sensor only, not complete assembly, $6.50. A kit of the three items listed here is $37.50. All prices are postpaid.

The enclosure is available from Tracewell Enclosures, Inc., 7032 Worthington-Galena Road, Columbus, OH 43058. Model H457, $18.95 plus $2.00 shipping and handling. Will be shipped UPS collect upon request. For further details call 1-800-848-4525.

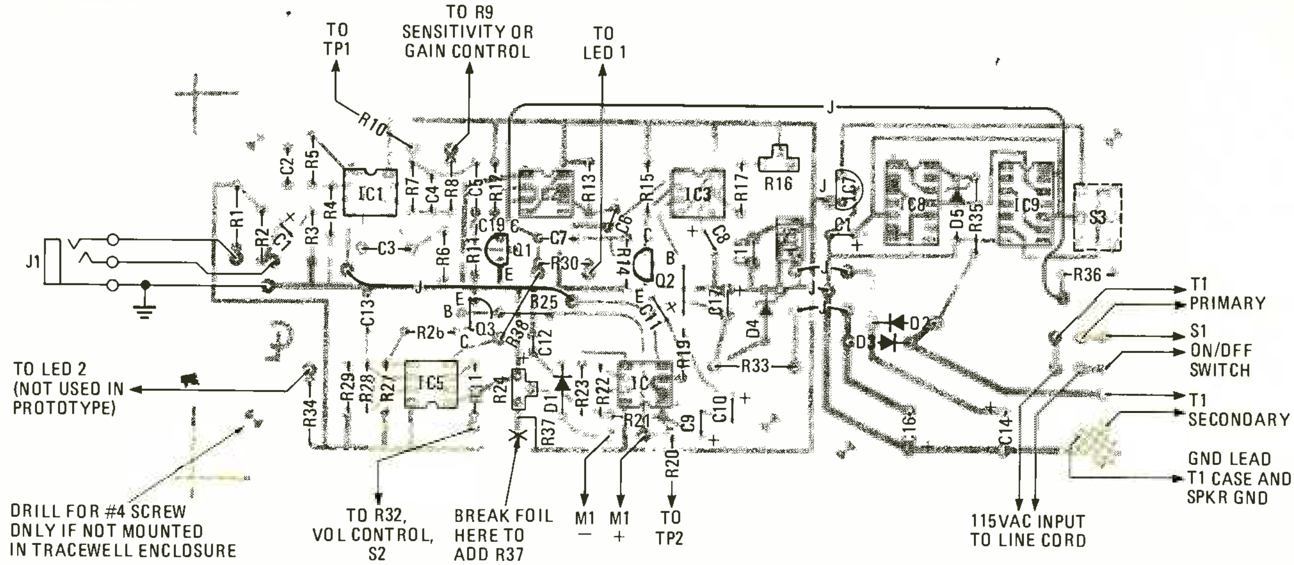


FIG. 6—HOW PARTS ARE PLACED on the PC board. Note pads that are used for making connections to meter and other parts that are not mounted directly on the board.

checks. Regulator IC7 is a low-current 5-volt regulator used to power the circuit; IC8 and IC9 together divide the 60-Hz frequency by 40 to yield a 1.5-Hz output; and R35 and D5 limit and square the 60-Hz sinewave into suitable digital levels for TTL IC's. Standard TTL IC's can be used instead of L or LS TTL types, but at an increased current drain from the nominal 10 to 12 mA.

8. The power supply is a straightforward, half-wave, dual-polarity supply. The +12-volt current drain is less than 100 mA, while the −12-volt drain is less than 10 mA, thus eliminating the need for more elaborate rectification or filtering. Voltage regulator IC6 is a standard, three-terminal unit, and D6 is a 500-mW or 1-watt, 12-volt Zener diode.

Circuit assembly

Assembling the Cardiotach is straightforward and easy with a printed-circuit board. Assembly can be done on perforated board, but it is not recommended because of the numerous circuit connections to be made. Figure 5 shows the foil pattern of the PC board. Figure 6 shows where parts are positioned.

The PC board is designed to be versatile. It can be left at its full size of 7½ × 3 inches, or cut into two boards, 5 × 3 inches and 2½ × 3 inches. The larger size is designed to fit into an enclosure that has built-in PC board slots to hold the board. I used the case manufactured by Tracewell Enclosures, Inc., described in the Parts List, but any enclosure that can accommodate the PC boards and transformer should work all right.

Begin by installing the two jumpers located near the middle of the board (so you won't forget them). The remainder of the components can be installed in any order you prefer. IC sockets are optional but a good idea. Make sure to install all diodes, capacitors, etc., with the proper polarity. A dot on the PC board is adjacent to pin 1 of the IC's and the positive end of all polarized capacitors. If you use the full-sized board, also install short jumpers from positive to positive (+ to +), from negative to negative (− to −), and the ground between the main board and the calibrator/power-supply board. If the PC board is cut in two and mounted separately, the jumpers will of course have to be longer. Additionally, run a jumper between the output of the calibrator, R36, and the junction of C5 and R11.

Install the board (or boards) with the necessary connections to the input jack, gain potentiometer, meter, etc., in the enclosure.

Assemble the sensor as shown in Fig. 7, using a small piece of perforated board measuring ¾ × ⅜ inch. Note that pins 2 and 4 (Fig. 4) of the sensor are jumpered. Use shielded two-conductor cable or jacketed, flexible three-conductor cable; a 3- to 4-foot-long section is sufficient. Connect a stereo phone plug to one end of the piece of cable and the sensor assembly to the other end. A piece of conductive foam plastic of the type used to protect MOS devices can act as a cushion and as a

continued on page 82

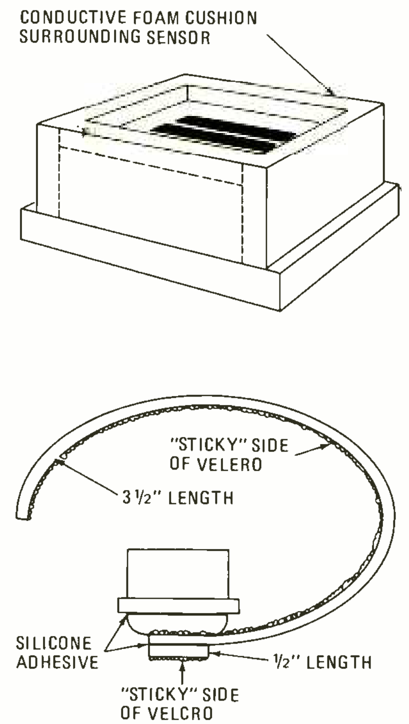


FIG. 7—HOW THE SENSOR IS ASSEMBLED. Connecting circuit leads are not shown.

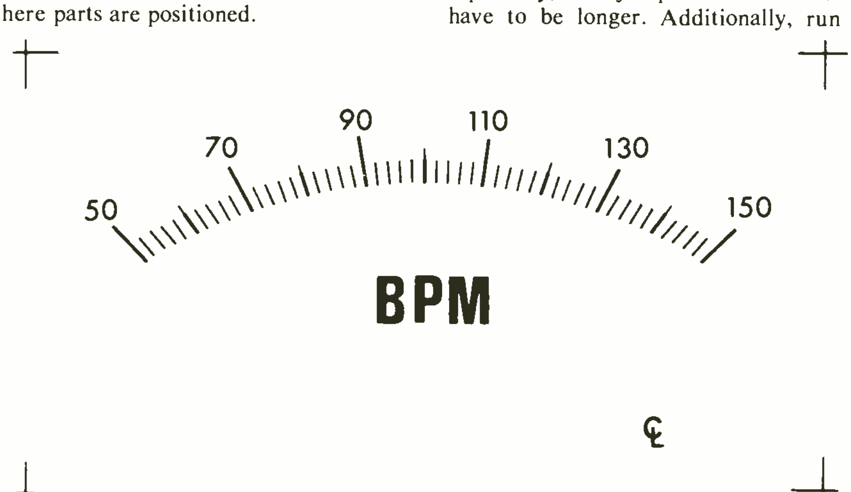
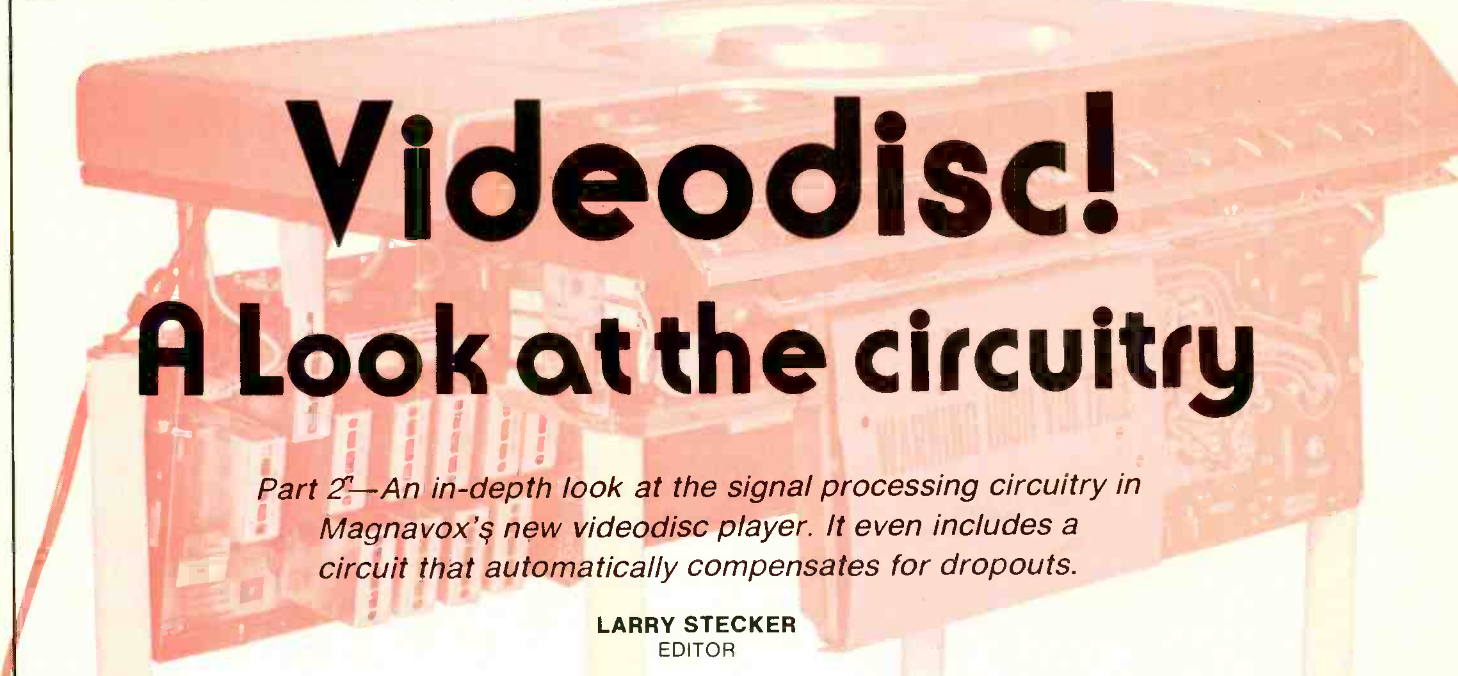


FIG. 8—METER SCALE can be photographed full-size or cut from the pages of this magazine and cemented directly onto the face of a 4½-inch 100μA meter.



Videodisc!
A Look at the circuitry

Part 2—An in-depth look at the signal processing circuitry in Magnavox's new videodisc player. It even includes a circuit that automatically compensates for dropouts.

LARRY STECKER
EDITOR

WHEN YOU GET STARTED LOOKING INTO A VIDEODISC PLAYER, you are suddenly shocked by the kinds of circuits you've never seen before. The more interesting ones, we'll run through here. Let's start by taking a look at the signal processing circuits.

As described in our introductory article last month, a laser beam scans the surface of the videodisc in the Magnavision player. To keep that beam following the right program track, three photodiodes are arranged to detect proper orientation of the laser beam. These photodiodes and their associated preamp module are physically located on the slide assembly. A block diagram of this circuit is in Fig. 1.

The preamp provides reverse bias to all the diodes. The output from diodes A, B, C and D are applied to a summing circuit where A + B and C + D are produced. These two signals are now applied to still another summing circuit and amplifier to create the total FM signal: (A + B) + (C + D). The pairs are also fed to a different circuit to produce the focus error voltage: (A + B) − (C + D).

The output from photodiodes E and F is applied to another amplifier. It produces the true radial error voltage. This voltage is high-frequency emphasized to create another radial error voltage called "radial error with high-frequency compensation." We'll look at how both of these signals are used when we examine the servo circuitry, but, for now, we will continue to look at the total FM signal from the photodiodes.

This signal is passed on to the signal-processing circuits on the video/servo panel. A block diagram of this circuit is shown in Fig. 2. A high-frequency amplifier splitter separates the sound FM from the video FM. The sound FM is fed to two frequency-sensitive stages: the 2.8-MHz sound II demodulator, and the 2.3-MHz sound I demodulator. These stages serve as FM detectors and retrieve the audio signals from their respective carriers. The two resulting audio signals are applied to an electronic switch network that applies either one or both of the signals to the VHF modulator. The sound button on the front panel of the player determines which audio signals are used.

The video FM, an 8-MHz signal, is applied to video demodulator I. The demodulator extracts the composite video signal from the carrier. This signal is then amplified by the video amplifier and applied to the VHF modulator. The digital logic for the picture number is removed from the composite video signal by the clipper/decoder circuit. Here the logic is decoded and converted to the picture number video signal. This signal is also amplified by the video amplifier and applied to the VHF modulator. The VHF modulator takes both the audio and video and impresses them onto the required channel 3 or channel 4 RF frequencies. The resulting RF signal is connected to the antenna terminals of the TV set through an antenna switch box.

The video circuitry creates a DC voltage that is proportional

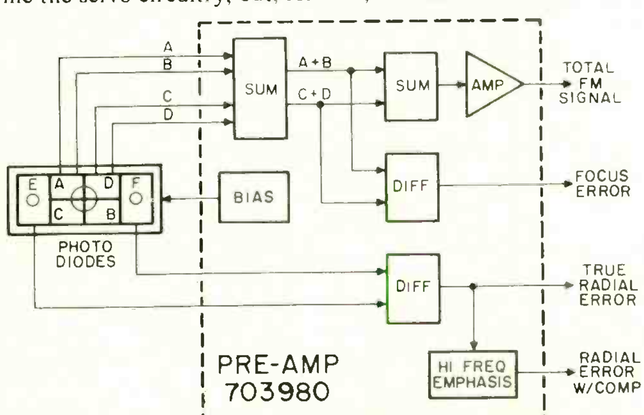


FIG. 1—PHOTODIODES AND PREAMP MODULE are located on the slide assembly. The preamp provides reverse bias to all diodes.

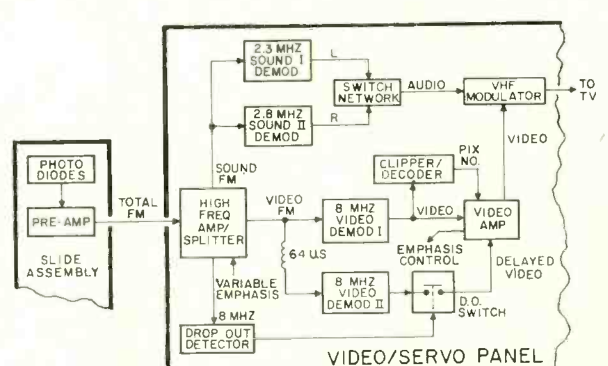


FIG. 2—SIGNAL PROCESSING. Simple block diagram shows all of the circuit elements involved.

to burst amplitude. This voltage is called emphasis control because it is applied to the high-frequency amplifier to emphasize the high frequencies when playing the tracks that are near the inner diameter of the videodisc. The high-frequency emphasis effect decreases as the program progresses toward the outer diameter. This control is required because the pits are more closely spaced at the inner diameter and, therefore, result in reduced high-frequency response. This circuit compensates for that reduced response.

The 8-MHz FM signal is applied to a dropout detector circuit. When a bad spot on the videodisc is encountered, the 8-MHz signal disappears and the dropout detector senses its absence. The 8-MHz signal is also applied through the 64-μs delay line (the time period of one horizontal line) to video demodulator II. When a dropout occurs, the dropout detector activates the electronic dropout switch. It then applies the previous horizontal line in place of the one that was dropped out. The result on the screen is two successive horizontal scan lines with the same video information.

All signal-processing circuitry is located on the video/servo board. The total FM signal from the preamp module is applied to the high-frequency processor module as shown in Fig. 3. The RF amplifier amplifies the entire signal. Gain control R3002 sets the correct amplitude output. The output from the RF amplifier is fed to the input of the sound FM amplifier. This input is tuned and, therefore, passes only the 2.3-MHz and 2.8-MHz sound carriers. Both of the amplified sound carriers

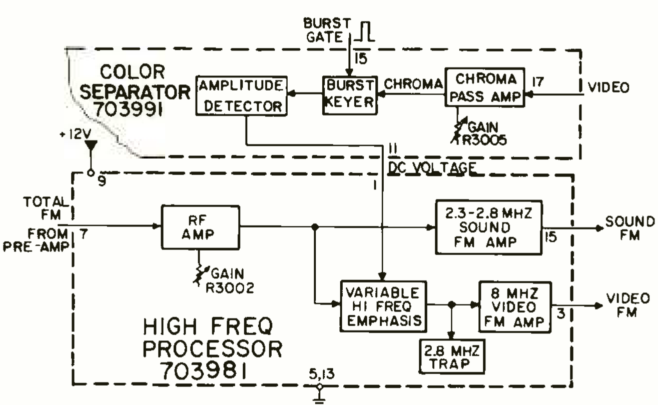


FIG. 3—FM SIGNAL PROCESSING CIRCUIT uses the signals provided by the preamp.

appear at pin 15 of the FM amplifier.

As we pointed out earlier, the high-frequency portion of the RF signal taken off the videodisc has less amplitude at the inside of the videodisc than the same signal taken off at the outer diameters. The variable high-frequency emphasis network is used to level out the high-frequency response over the entire surface of the videodisc. This circuit is controlled by a DC voltage at pin 1. The control voltage at pin 1 is directly proportional to the 3.58-MHz burst amplitude of the composite video signal. The color separator module removes the burst from the video signal by keying the burst separator with the horizontal rate burst gate pulse at pin 15. The amplitude detector creates a DC voltage that is proportional to the burst amplitude.

As the DC voltage at pin 1 decreases, the high-frequency response increases. The net effect is to boost the high frequencies at the inside of the videodisc. The video FM amplifier boosts the 8-MHz video FM signal and applies it to pin 3 of the module. The 2.8-MHz trap removes any remaining channel II sound carrier at this point.

The sound circuits

The sound FM signal is processed in two modules as shown in Fig. 4. It is applied to the 2.3-MHz FM demodulator on the sound demodulator I module. The demodulator output is the left-channel audio signal. This left-channel signal is applied to the electronic switch on the sound demodulator I module.

The 2.8-MHz FM demodulator on sound demodulator II also receives the sound FM signal. The resulting right-channel audio signal from the demodulator is also applied to a switch.

The switches are controlled by DC voltages at pin 15. In the diagram they are shown in their normal position with neither channel muted. The left-channel audio from the demodulator passes through the electronic switch and out through the left audio-output jack. It also passes through pin 7 of the modules and into the adder stage on the sound demodulator II module. The right-channel audio signal from the 2.8-MHz FM demodu-

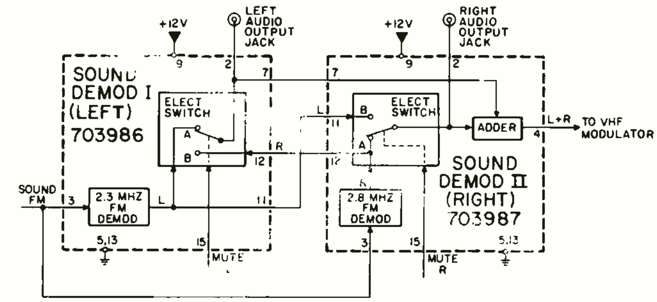


FIG. 4—SOUND SIGNAL PROCESSING CIRCUIT consists of two sound demodulator modules.

lator is also applied to the adder as well as to the right audio-output jack through its electronic switch. Thus, the output of the adder is L + R audio. This sum signal is applied to the VHF modulator to produce the sound carrier.

If the left channel is muted by the user depressing the front panel sound I button, the voltage on pin 15 of the sound demodulator I module goes high (+ 5 volts) and switches the electronic switch to position B. The left audio is now disconnected and goes nowhere. The right audio signal is routed to the left audio-output jack and also through pin 7 to the adder. Therefore, the right audio signal appears at both adder inputs and at both rear-panel audio-output jacks. The output of the adder is right channel only and the TV will now produce only right-channel sound.

Video circuits

The 8-MHz video FM signal from the high-frequency-processor module is applied to the 8-MHz video FM amplifier through pin 3 on the dropout detector, as shown in Fig. 5. The trap removes any 2.3-MHz sound carrier still present at this point. The amplifier delivers two outputs—one at pin 15 and one at pin 17. The output at pin 17 is passed through a 64-μs delay line. It delays the signal by one horizontal scan line.

The undelayed video FM is applied to the dropout detector. The output of this stage is a voltage at pin 7. As long as the dropout detector senses the 8-MHz signal, it maintains an output of about 1 VDC at pin 7. If the high-frequency signal should "drop out" momentarily (caused by a videodisc defect),

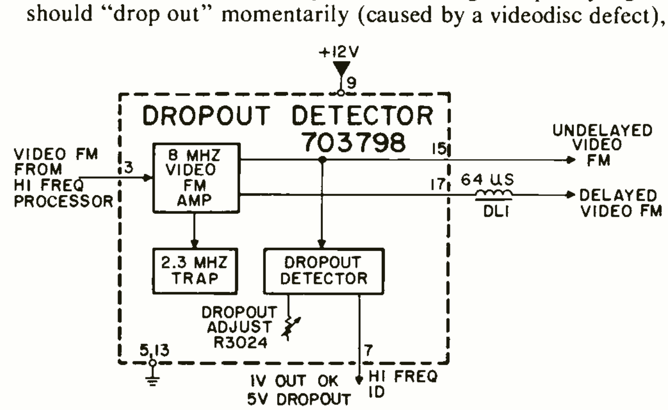


FIG. 5—DROPOUT DETECTION CIRCUIT spots signal dropouts and automatically fills those gaps.

the output at pin 7 goes high to about 5 VDC. The DROPOUT ADJUST potentiometer, R3024, sets the actual amount of time the high frequency must be absent before the dropout detector responds. The output at pin 7 is the high-frequency identification voltage. It will be used later in other circuits.

The video FM and the delayed video FM signals are both applied to a demodulator module, as shown in Fig. 6. The video demodulator I module receives the undelayed video FM signal and applies it to the FM demodulator stage at pin 15. The composite video output of the demodulator appears at a test point on pin 1 and is applied to the video amplifier. This amplifier has a frequency response extending to 4.2 MHz.

The amplifier's gain is controlled by R3013. The output from pin 4 is applied through DL3, a 540-ns delay line, to pin 4 of the video demodulator II module. Here the composite video signal is applied to point A of the electronic dropout switch.

The 64-μs delayed video FM signal is applied through pin 17 to the FM demodulator stage on the video demodulator II module. Its composite video output appears at a test point on pin 1 and applied to the video amplifier. The frequency response of this amplifier is rolled off at 2.6 MHz because the 64-μs delay line cannot pass signals above that frequency. As a result, dropout corrections are in black and white. The effect is not noticeable on the screen however.

Resistor R3013 controls the gain of the video amplifier. The video output is applied to point B of the electronic dropout

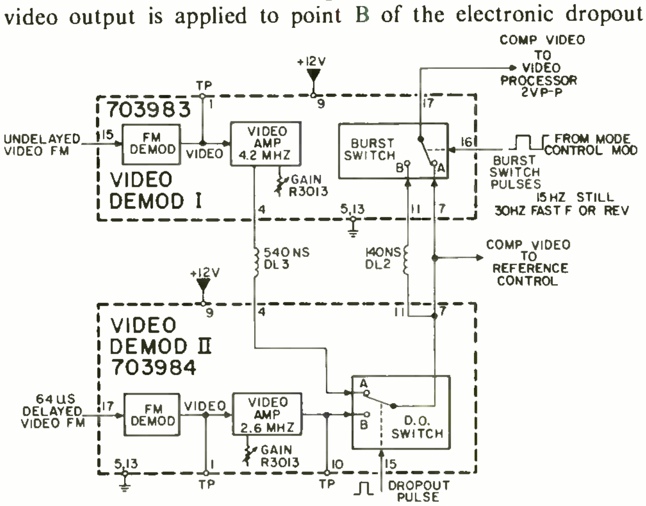


FIG. 6—VIDEO FM SIGNAL PROCESSING CIRCUIT is made up of two separate video demodulator circuit modules.

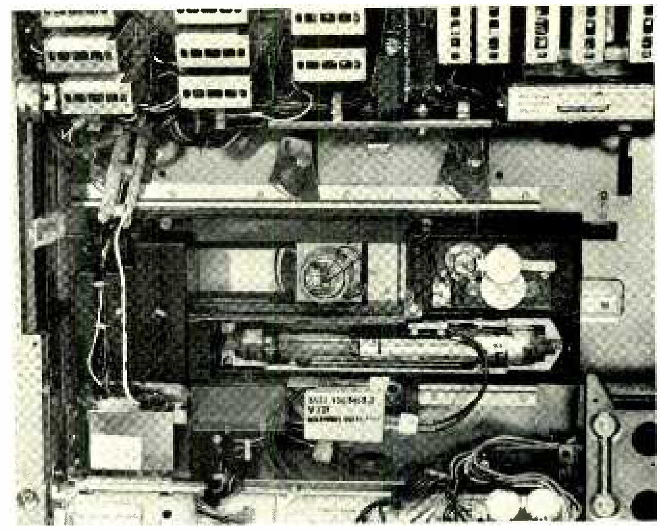
switch and can be monitored at the test point on pin 10.

The electronic dropout switch receives 540-ns delayed video on point A and one line delayed (64 μs) composite video on point B. The voltage at pin 15 determines which of these signals is applied to the electronic burst switch. The voltage at pin 15 is the high-frequency identification voltage from the dropout detector module. When a dropout occurs, the voltage goes high and creates a dropout pulse for the duration of the dropout. The dropout switch is normally in position A and receives the undelayed video (540 ns). However, when a dropout pulse is present, the dropout switch moves to position B and receives the delayed video (64 μs). The selected signal leaves at pins 7 and 11.

The 540-ns delay line compensates for the dropout response time. About 540 ns is required for the dropout circuitry to respond to the actual dropout. Thus, the "undelayed" video is actually delayed by 540 ns. When a dropout occurs the undelayed video remains present at position A of the dropout switch for 540 ns and gives the dropout circuit time to switch in the delayed video. The actual time difference between the two video signals is 64 μs minus 540 ns. This equals about 63.5 μs.

The electronic burst switch on the video demodulator II module is used to maintain the 180° phase difference in the 3.58-MHz chroma signal from frame to frame during special modes of operation, such as still picture, reverse, fast forward and slow motion. The chroma signal is normally 180° out of phase from track to track on the videodisc. This chroma relationship is also true from frame to frame on normal TV broadcasts since it is standard NTSC format. The purpose is to cancel 3.58-MHz interference in the picture.

However, when the same track (frame) is being played over



INSIDE THE VIDEODISC PLAYER. The laser tube is visible in the center of the photo. At the top are some of the many plug-in modules.

and over, such as during still-picture operation, the chroma signal would not be 180° out of phase from frame to frame. To introduce this phase difference, the signal is delayed by 140 ns every other revolution during still picture. The 140-ns delay line, DL2, is equivalent to ½ of a 3.58-MHz period.

The electronic burst switches delay line DL2 in or out depending on the burst switch pulses at pin 16. These pulses come from the mode control module. During normal play, no pulses are present, the burst switch remains in position A, and the 140-ns delay line is not in the circuit. During still picture, the burst switch pulses are at a 15-Hz rate. As a result, the burst switch is in position B for 1/30th of a second (one frame) and in position A for 1/30th of a second. During reverse play and fast forward, the burst switch pulses are at 30 Hz because only one half of each track is read at a time. The burst switch is then in position B for ½ revolution (1/60th of a second) and position A for the other half revolution.

The resultant composite video signal is coupled out of the module at pin 17 where it is sent to the video processor module. The composite video at pin 7 is identical to the signal at pin 17 except it lacks the burst switch correction. This signal is sent to the reference control module.

The video signal from the electronic burst switch is coupled to the first video amplifier in the video processor module at pin 17, as shown in Fig. 7. The video blanking input at pin 16 blanks the video signal during the return of the light beam to the inside of the videodisc and also during initial turn-on. The video signal from the amplifier is processed by the DC clamp circuit. It clamps the video signal to the correct DC level. The clamp adjust control, R3029, can vary this DC level. The DC clamp is driven by a horizontal rate clamp-gate pulse at pin 15. The DC level is corrected during each horizontal blanking interval.

Composite video is clipped in the reference control module by the amp/clipper stage. The resultant clipped video contains the digital code that represents the picture number. This code is applied to a decoder on the mode control module. The video generator actually creates the video signal for the picture number. A video signal is also generated that provides the grey background behind the picture numbers on the screen.

These video signals are applied to the second video amplifer and then to the VHF modulator. The composite video signal is also applied to the rear-panel monitor jack.

The VHF modulator, Fig. 8, receives the composite video signal and the audio signal. These signals modulate the RF carrier in the RF modulator stage. The RF modulator is an oscillator that delivers an RF signal on VHF TV channel 3 or 4. If the channel selector switch connects to ground, channel 3 is generated. If the switch connects to 12V, channel 4 is generated.

A simplified diagram of the antenna switch box is shown in

continued on page 89

Precision Digital Thermometer

BILL OWEN*

THE PRECISION DIGITAL THERMOMETER described in this article uses large-scale integrated circuitry and laser-trimmed temperature transducers to achieve state-of-the-art temperature-sensing capabilities. The two switch-selectable probes can be connected through hundreds of feet of cable to provide accurate temperature sensing in remote areas. Celsius or Fahrenheit measurement is switch-selectable with 0.1° resolution, with an accuracy better than ±0.5 °C (1.2 °F) over a −50° to +150°C range (−60° to 200 °F). Table 1 shows the digital thermometer specifications.

The digital thermometer can operate from a 117-volt to 9-volt plug transformer, 12-volt automotive or marine battery systems or from internal rechargeable NiCad batteries for portable operation.

This thermometer has the range, flexibity and accuracy necessary for many useful applications, including

- A weather station with indoor/outdoor monitoring capability
- In a ham installation to report local temperature
- Medical or veterinary use
- Troubleshooting air conditioning and heating systems
- Aquarium monitoring
- Hothouse/greenhouse monitoring
- Monitoring solar-energy collectors
- Monitoring incubators
- Fresh and salt water fishing
- On the electronics bench to check semiconductor case temperature; measure crystal oven temperature; etc.
- Glass-fiber mixing
- General laboratory use, setting water baths, ovens, etc.
- Photographic and darkroom use

There are many more applications where this digital thermometer can replace mechanical thermometers and provide better resolution, accuracy and readability.

The heart of the thermometer is the AD590K temperature sensor. This sensor is an IC that, when connected to a voltage source, produces an output current proportional to temperature. The output current is equal to 1 μA per-degree-Kelvin. The Kelvin degree is equal in size to the Celsius degree; however, the Kelvin temperature scale is offset 273.2° higher than the Celsius scale, with 0°K (−273.2°C) called absolute zero. Absolute zero is the coldest possible temperature where molecular motion is at a minimum. The relationship between the Kelvin, Celsius and Fahrenheit scales is as follows:

$$T°C = T°K - 273.2°$$

$$T°F = \tfrac{9}{5}(T°C) + 32°$$

$$T°F = \tfrac{9}{5}(T°K - 273.2) + 32°$$

There is also a little-used Rankine temperature scale that starts at absolute zero with Fahrenheit-size degrees and is offset 459.7° from the Fahrenheit scale. Rankine-to-Fahrenheit conversion is as follows:

$$T°F = T°R - 459.7°$$

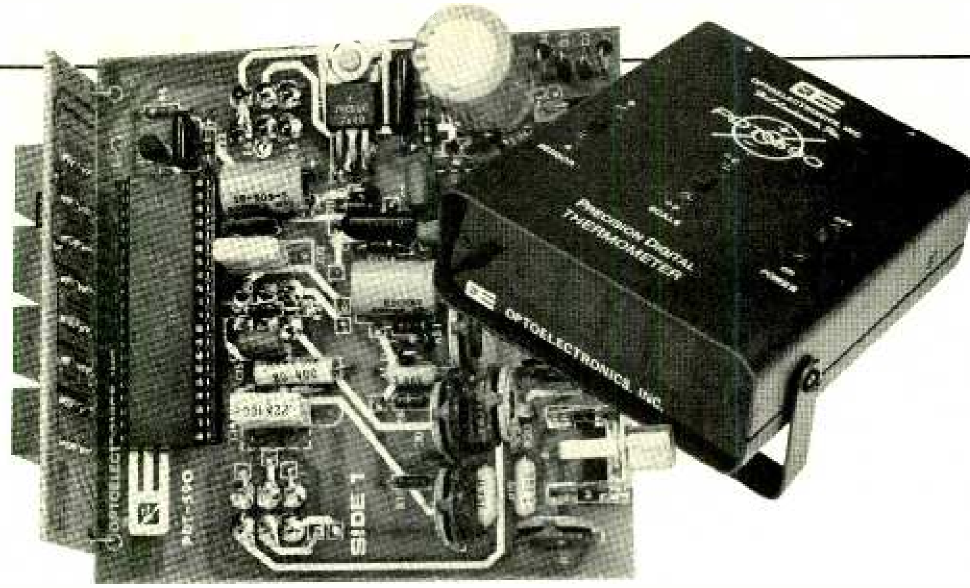
When the output current of the AD590K is passed through the appropriate value-scaling resistor, the resulting output voltage is proportional to the Kelvin or Rankine temperature, as shown in Fig. 1. The scaling resistors can be combined as shown in Fig. 2 so that °K or °R can be switch-selectable and read from a voltmeter. To generate an output voltage that is proportional to the more common Celsius and Fahrenheit scales, we need to subtract 2.732 volts from the °K output

TABLE 1—DIGITAL THERMOMETER SPECIFICATIONS

Range	−50°—+150°Celsius −60°—+200°Fahrenheit
Resolution	0.1°C 0.1°F
Sensor Linearity	±0.5°C, from −55° to +150°C
Meter Error	±1 count = ±0.1°C or F
Accuracy	Linearity error + calibration error + meter error
Probe Inputs	Two, switch-selectable
Sensor Probe	Number: 2 Type: temperature-dependent current source Response time: 3.4 seconds to reach 63.2% of step change in temperature in stirred liquid bath Voltage standoff: ±200V from sensor case to either active lead Cable length: 10 feet (can be extended to several hundred feet) Connector type: RCA phono plug
Meter Operating Temperature Range	0°—50°C
Display	3½, 0.43-inch-high, high-intensity red LED digits
Size	1¾ H × 4¼ W × 5¼ inches D
Weight	14 oz. (20 oz. with batteries and charger)
Input Power	9-14 volts AC or DC, 175 mA, 1.7 watts

*Product Engineer, Optoelectronics, Inc.

This easy-to-build electronic thermometer provides a resolution of 0.1 degree with unusually rapid response time. Two switch selectable sensor probes can be used for accurate measurements from remote areas.



and 4.597 volts from the °R output, as shown in Fig. 2. This is accomplished by having the voltmeter measure the difference between the scaled output voltage and the appropriate reference voltage.

The reference voltages must be very stable, so a 6.9-volt-precision, integrated-circuit Zener (IC7, LM329DZ) is used with appropriate resistor dividers. Figure 3 shows the complete temperature-to-voltage circuit with Celsius-to-Fahrenheit and sensor switches. Trimmer resistors are used to calibrate the temperature sensors and to precisely adjust the reference voltages.

The selected temperature sensor's Celsius or Fahrenheit output voltage is measured by a 3½-digit digital voltmeter (DVM). The DVM has a −1,999-volt to +1.999-volt range, and so when the scaled output voltage falls below the reference voltage, a negative temperature is indicated. Because the input voltage is 10 mV-per-degree Celsius or Fahrenheit, the decimal point is placed between the 1-mV and 10-mV digits to obtain a degree C or degree F readout.

The complete schematic is shown in Fig. 4. The DVM is built around Intersil's 7107 analog-to-digital (A/D) converter IC. The 7107 uses the dual-slope integration method of conversion, and has autozero and a true differential input (it measures the net difference between voltages applied to its input-high and input-low terminals).

The A/D converter contains amplifiers, buffers, analog switches, a comparator, a clock oscillator, counters, latches and LED segment drivers. In the first part of a measurement cycle, the A/D converter internally shorts the inputs and charges autozero capacitor C15 to compensate for the amplifier and integrator offset voltages. In the next phase, the integrator output voltage increases at a rate that is proportional to the unknown input voltage for a fixed number of clock pulses. In the final phase, the integrator

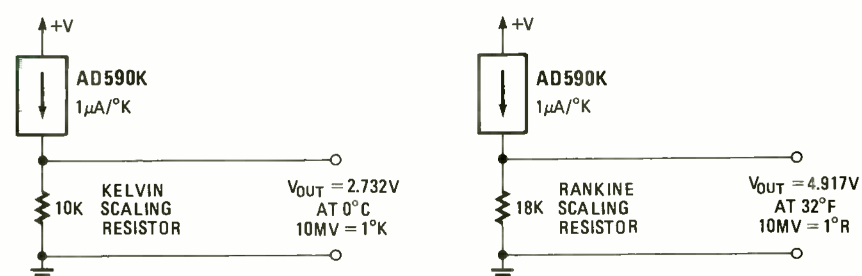


FIG. 1—TEMPERATURE-DERIVED CURRENT flows through scaling resistors to develop voltages proportional to Rankine and Kelvin temperatures.

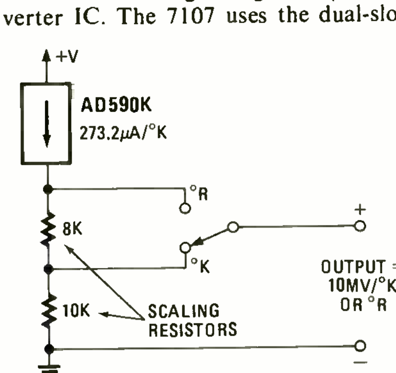


FIG. 2—SCALING RESISTOR adjusted to give Kelvin- and Rankine-proportional voltages.

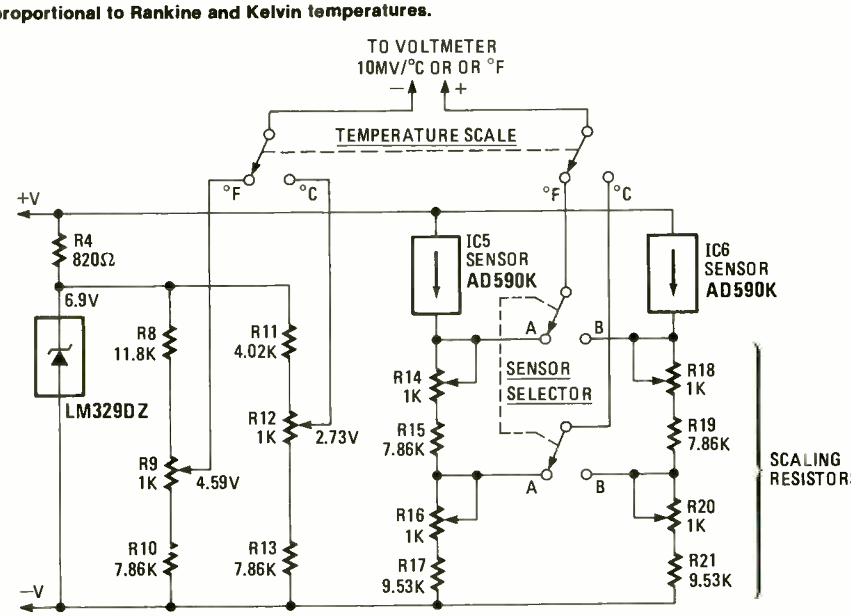


FIG. 3—REFERENCE VOLTAGES, derived from a 6.9-volt precision source, are used to produce temperature-dependent voltages corresponding to Centigrade and Fahrenheit scales.

output voltage is decreased at a rate that is proportional to the reference voltage stored on reference capacitor C12. The number of clock pulses required for the integrator to reach 0 volt is counted and displayed. If the unknown voltage is integrated for 1000 counts, and if it requires 1000 counts during the final phase to reach 0 (using a 1-volt reference), then 1000 is displayed corresponding to 1.000 volt.

Resistor R22 and capacitor C13 are connected to the internal oscillator to generate a frequency of 48 kHz, which is divided by 4 before being used. Maximum 60-Hz rejection is achieved by having the integration period be an integral multiple of the line frequency. Three conversions-per-second are performed with the 48-kHz clock frequency.

Accuracy with the dual-slope A/D converter is achieved without using precision resistors or capacitors. Integration capacitor C14, autozero capacitor C15 and reference capacitor C12 must have low leakage characteristics as well as low dielectric adsorption. Polypropylene film, Mylar and polycarbonate capacitors are recommended for their excellent dielectric properties.

Although the A/D converter has an on-chip voltage reference, the LM329DZ reference voltage is more stable because it is not subject to internal heating caused by the LED segment drivers. The 1-volt reference is externally supplied from a resistive divider across the LM329DZ precision Zener.

The circuit requires a +5.6- as well as a −5-volt power supply. The 9 to 14 volts AC or DC input supply is rectified and filtered by D1–D4 and C1. The 7805 voltage regulator supplies the +5 volts. The 555 timer (IC2) operates the astable mode and generates a 2-kHz squarewave

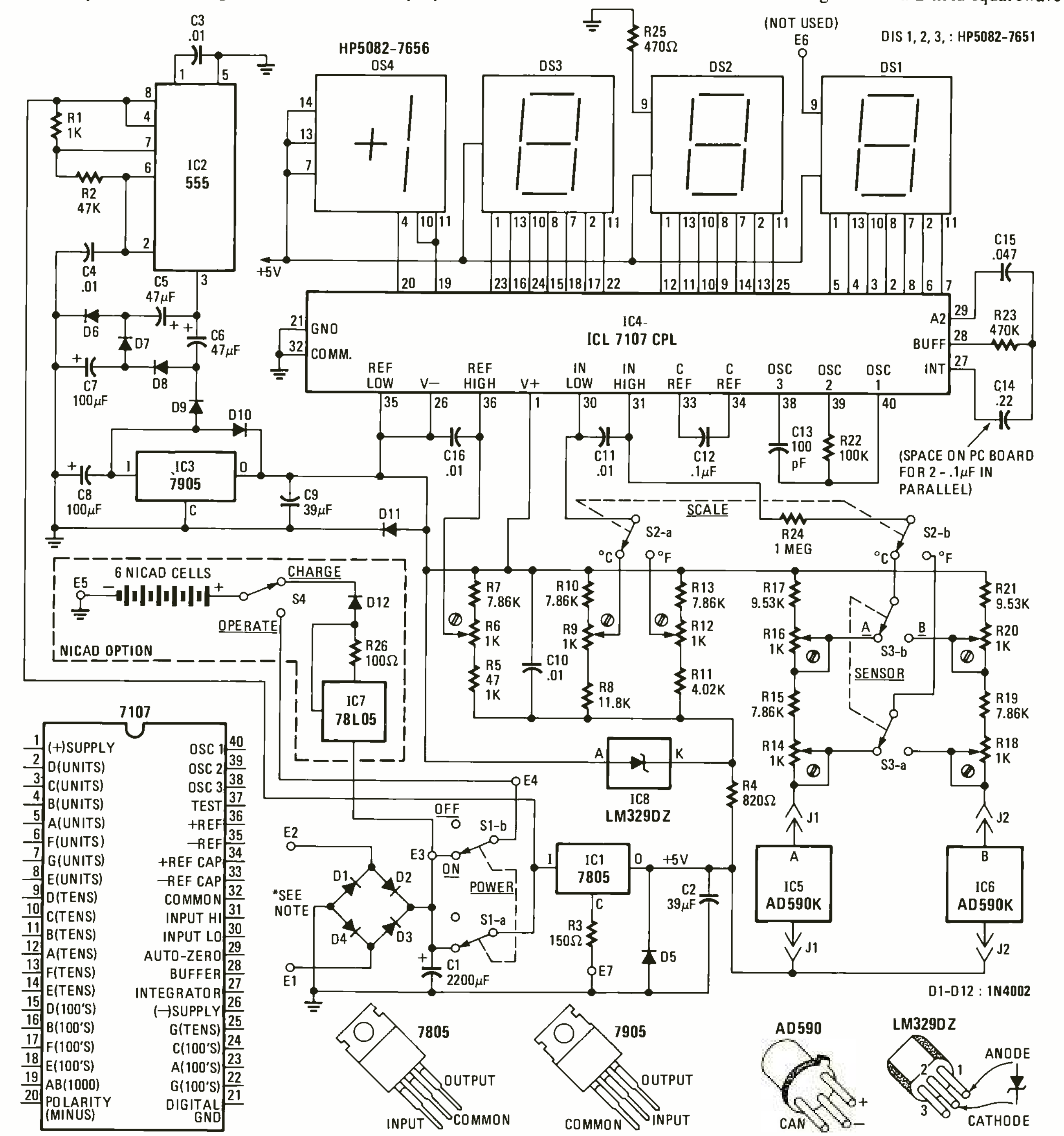


FIG. 4—THE DIGITAL THERMOMETER is designed around a 3½-digit A/D converter. The 555 timer IC generates a pulse train that is voltage-doubled and rectified for the negative supply.

that is voltage-doubled and clamped to produce the negative supply voltage that is regulated by 7905 regulator IC3.

Construction

Assembly is simple and straightforward; the PC foil patterns are shown in Figs. 5, 6 and 7, and parts placement is shown in Figs. 8, 9 and 10. Insert and solder all components referring to the parts list and Fig. 8. Start with the resistors and diodes, working your way up to the larger items. Note that some components are installed on the side of the main PC board opposite the other components, as in Fig. 9. Many components are top-soldered or soldered on both sides of the PC board wherever the PC foil surrounds a component lead. There are several feed-through locations (indicated by a □ in the parts layout) where a short piece of wire clipped from a component lead is inserted through a hole and soldered to the PC foil on both sides of the board.

The 7905 voltage regulator is installed on side 1 of the main PC board, and the 7805 voltage regulator is installed on side 2, using mica insulators and an insulating *nylon machine screw*. The three 7805 leads must be bent straight down about ¼ inch away from the regulator body, and soldered and clipped before the 7905 leads are soldered. Clip the excess 7805 leads close to the PC board so that they do not touch the 7905 leads.

The LED digits are soldered to the display board as shown in Fig. 10. After completing the PC boards, place a ¾-inch piece of excess resistor lead in main PC board locations b and e, and solder them in place so that one-half the lead length extends from each side of the board. Bend these wires forward and insert the ends of wire b into locations a and c, and insert wire e into locations d and f on the display board. Solder the wires after carefully aligning the two PC boards so that they are at right angles, with all foil fingers exactly matching. There are two sets of foil semicircles that can be used as indicators to check the alignment. After rechecking alignment, solder the 26 mating foil fingers together.

Secure the three slide switches to the cabinet top with small flat-head screws. Put the main PC board on the switch lugs and check the positioning with the rear panel, front panel and cabinet top in place. Solder the 18 slide-switch lugs to the main PC board.

Power-input jack J3 is mounted on the rear panel using shoulder washers and nylon spacers. Check to make sure that there is no continuity between the power jack and the rear panel. Use stranded hookup wire to connect the power-jack bracket and center pin to PC board locations E1 and E2.

Probe construction

Remove the case leads from the AD590K temperature sensors. Cut the

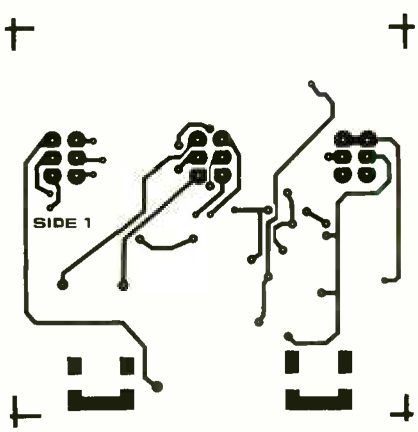


FIG. 5—FOIL PATTERN for the components side of the PC board. Approximately half size.

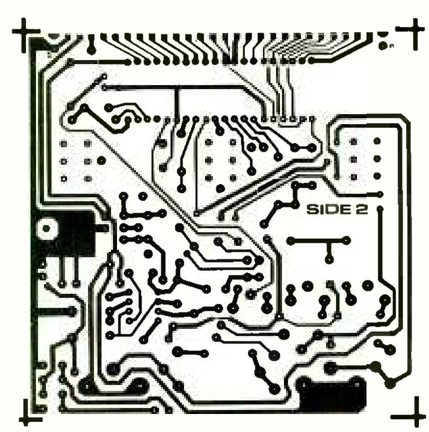


FIG. 6—PATTERN for side-2 of the board. Only a few parts are mounted on this side.

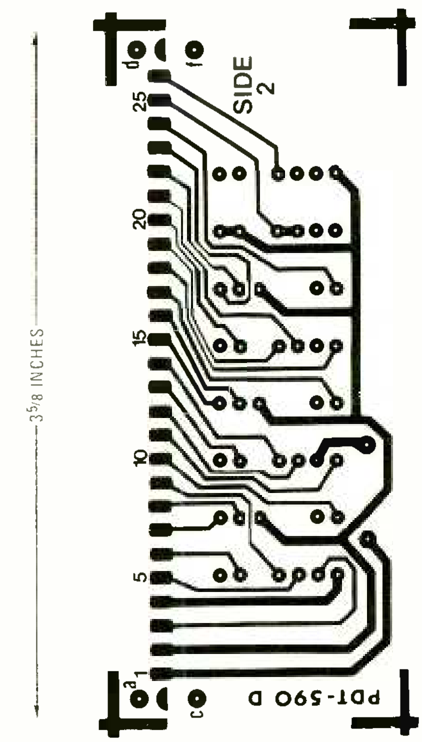


FIG. 7—DISPLAY BOARD uses this pattern with edge pads to mate with those on main board.

PARTS LIST

Resistors, ¼ Watt, 5% unless otherwise noted
R1—1000 ohms
R2, R5—47,000 ohms
R3—150 ohms
R4—820 ohms
R6, R9, R12, R14, R16, R18, R20—1000 ohms, vertical-mount, trimmer potentiometer
R7, R10, R13, R15, R19—7860 ohms, 1%
R8—11,800 ohms, 1%
R11—4020 ohms, 1%
R17, R21—9530 ohms, 1%
R22—100,000 ohms
R23—470,000 ohms
R24—1 megohm
R25—470 ohms
R26—100 ohms

Capacitors
C1—2200 μF, 16 volts, electrolytic
C2, C9—39 μF, 10 volts, tantalum
C3, C10, C16—.01 μF, ceramic disc
C4, C11—.01 μF polyester
C5, C6—47 μF, 16 volts, electrolytic
C7, C8—100μF, 25 volts, electrolytic
C12—0.1 μF, Mylar
C13—100 pF, dipped mica
C14—0.22 μF, polyester
C15—.047 μF, polypropylene

Semiconductors
D1-D13—1N4002
DIS1-DIS3—HP5082-7651, 7-segment LED display, common anode, right-hand decimal point, high-efficiency RED
DIS4—HP5082-7656 universal overflow display, ± 1, right-hand decimal point
IC1—7805, +5-volt regulator
IC2—NE555 timer
IC3—7905,—5-volt regulator
IC4—ICL7107CPL, 3½-digit CMOS A/D converter (Intersil)
IC5, IC6—AD590K, temperature sensor (Analog Devices)
IC7—LM329DZ precision Zener, 6.9 volts

Miscellaneous
S1-S3—miniature slide switch, DPDT
S4—miniature toggle switch, SPDT
Power transformer, 9 volts AC, 300 mA, plug-type with molded plug
Socket, 40 pins, DIP
Socket, 8 pins, DIP
J1, J2—phono jacks, PC mount
J3—pin-type power receptacle to match power transformer
Case, assorted hardware

The following kits for the digital thermometer are available from Optoelectronics, Inc., 5821 N.E. 14th Ave., Ft. Lauderdale, FL 33334:

The complete kit for the PDT-590 digital thermometer (includes cabinet, power supply, two probes and all parts except optional NiCad battery and charger) $99.95. The PDT-590/WT, wired and tested $159.95.

Rechargeable battery option NI-CAD-590 includes batteries, holder, mounting hardware, switch and charging circuit (used in kit and factory-wired models) $25.00. Set of PC boards and switches PCB-590 $19.95. Extra probe kit P-590K $12.00; extra assembled probe P-590 $15.00.

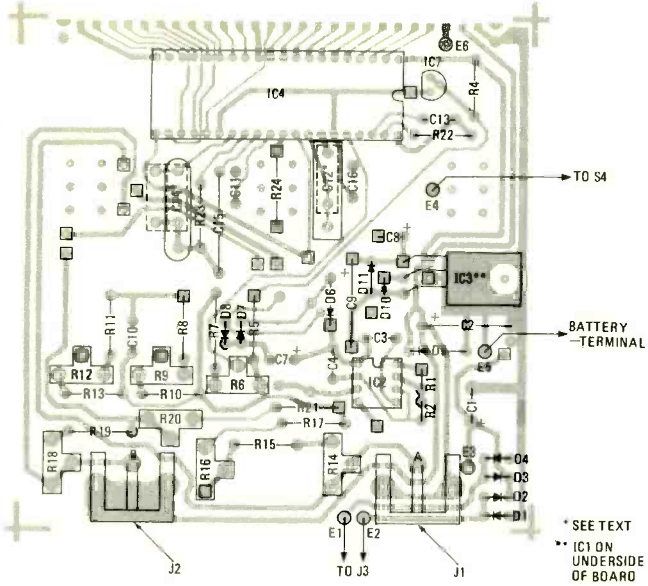


FIG. 8—PARTS PLACEMENT DIAGRAM showing locations of most of the components. Note that IC3 and IC1 are back-to-back.

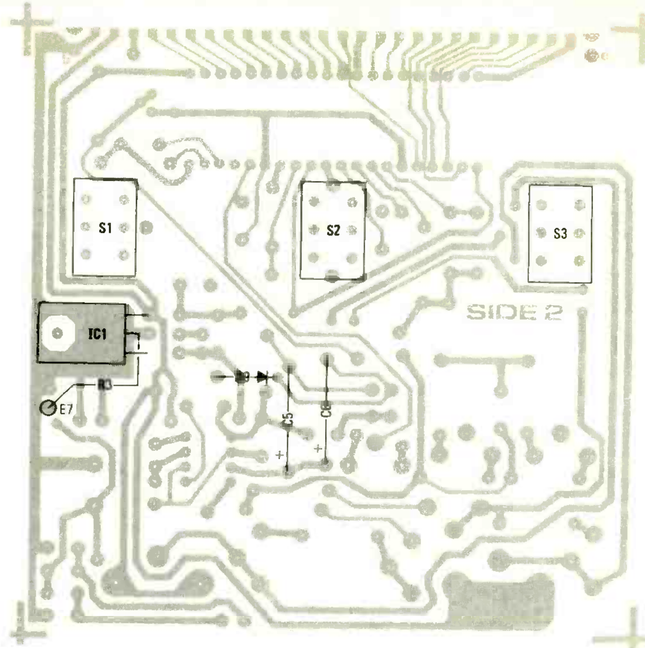


FIG. 9—SLIDE SWITCHES and a few other parts are mounted on side-2 of the main PC board.

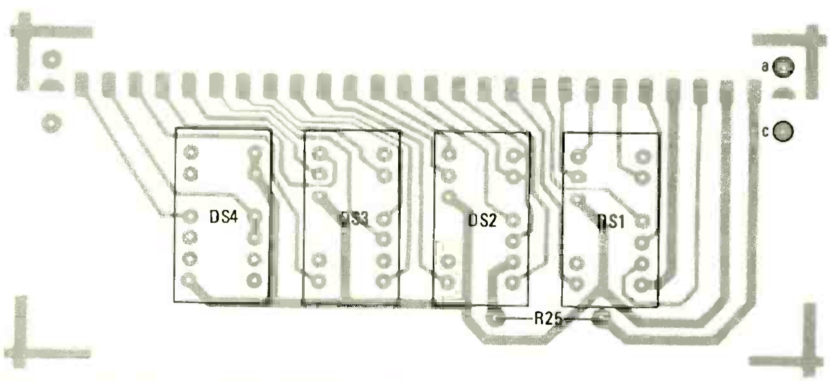


FIG. 10—PLACEMENT OF SEVEN-SEGMENT READOUTS on the display PC board. Be sure that the readouts are right-side up and that DS4 is in correct position.

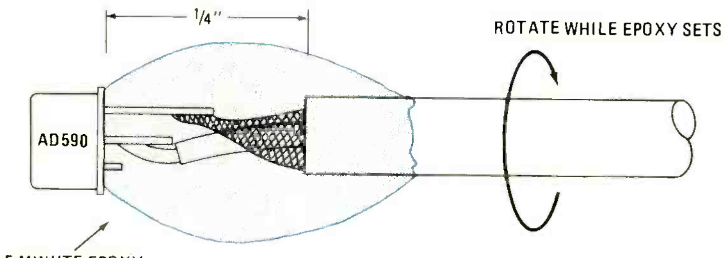


FIG. 11—HOW TEMPERATURE PROBES ARE CONSTRUCTED. Note that clear quick-setting epoxy cement is used to insulate and seal the sensor connections.

positive and negative leads back to ¼ inch in length and tin them. Remove ¼ inch of insulation from the end of the probe cable, and twist and tin the shield and the center conductor wires. Solder the shield to the sensor's positive lead and the center conductor to its negative lead.

Clear-drying five-minute epoxy cement should be used to waterproof the sensors. Thoroughly mix some epoxy and apply it around the solder connections on the sensor while rotating the cable (see Fig. 11) while the epoxy sets.

Calibration

After completing the sensor probes, plug them into the instrument and apply power to the circuit. Even without calibration the display count should increase as the sensor responds to the heat from your hand. Label one probe "Sensor A" and the other "Sensor B," and do not unplug or interchange them during calibration.

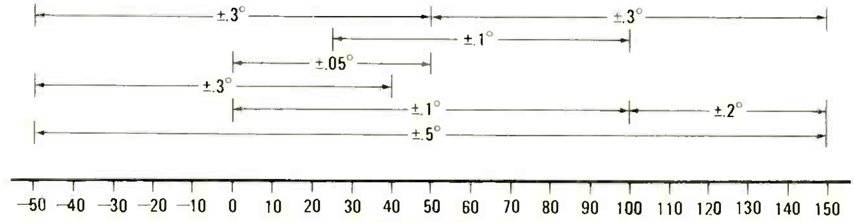


FIG. 12—SENSOR NONLINEARITY of the PDT-590 digital thermometer improves over reduced temperature ranges. Note that linearity is as good as ±0.05° between 0° and 50° C.

Calibration requires a DVM to set the reference voltages. Connect the negative DVM lead to pin 2 of the 7905 voltage regulator (IC3) and the positive lead to ground, and then check for 5 volts ±0.25 volt. Next, connect the positive DVM lead to pin 2 of the 7805 regulator and check for 10.6 volts to 11 volts. If the voltage is below 10.6 then increase R3 to 180 ohms or 200 ohms to raise the positive supply voltage.

With the negative DVM lead on pin 2 of the 7905 voltage regulator, connect the positive lead to the center lug of trimmer resistor R6 and adjust R6 for 1.000 volt. Next, connect the positive lead to the center lug of trimmer R9 and adjust R9 for a 2.73-volt measurement. Then, connect the positive lead to the center lug of R12, and adjust R12 for 4.59 volts.

The sensor probes are easily calibrated using the boiling point and freezing point of water for reference. To achieve ±0.6°C accuracy (or better), the sensor probes should be calibrated at both points and the error should be evenly split between them. For instance, if the meter is adjusted to read 0.0°C at the freezing point of water and 101.0° at the boiling point of water, then the error will be +1°C. The error would be ±0.5°C if the meter were readjusted to read −0.5°C at the freezing point and 100.5°C at the

continued on page 83

Understanding DC Amplifiers

Ultra-wide frequency response and reduced harmonic and transient intermodulation distortion are some of the advantages of DC amplifiers. Here's a look at how these relatively new amplifiers work

LEN FELDMAN
CONTRIBUTING HI-FI EDITOR

DURING THE PAST TWO YEARS OR SO, SEVeral manufacturers of audio amplifiers have been offering so-called DC amplifiers to demanding audiophiles. The choice of "DC" as a name for this new type of audio amplifier is perhaps unfortunate. In earlier days, that abbreviation, at least as it applied to audio equipment, meant direct-coupled.

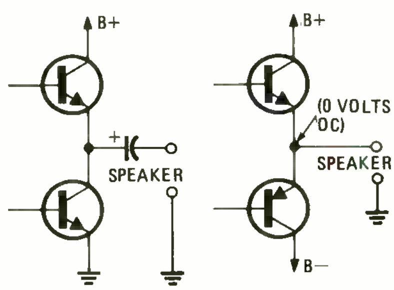


FIG. 1—CAPACITOR-COUPLED OUTPUT stage is shown in *a*. DC amplifier output stage eliminates coupling capacitor by using a dual power supply and complimentary NPN and PNP output transistors.

The transition from capacitor-coupled output circuitry (Fig. 1-a) to audio output stages that could be connected directly to the loudspeaker load (Fig. 1-b) was made relatively simple by using suitable complementary NPN and PNP high-powered output transistors and dual-polarity power supplies. By establishing a 0 DC volts condition at the junction of the two output transistors, it was possible to deliver AC power to the load without applying DC voltage. Such a DC voltage would, of course, damage speaker voice coils if appreciable direct current flowed. At the very least, the presence of a small amount of DC voltage would offset the position of the speaker cone and cause nonlinear operation.

Nowadays, when audio manufacturers refer to DC amplifiers, they mean a new type of amplifier capable of amplifying signals of extremely low frequency—theoretically, down to 0 hertz or DC. It can be argued that since there is no musical content in any program source that goes to 0 hertz, there is no point in designing an amplifier that actually can amplify DC signals. After all, even the lowest note on a giant pipe organ is a relatively high 16 Hz, and attempts to capture the sound of that low note deliver it as more of a vibration that we feel rather than hear.

Indeed, some manufacturers define a DC amplifier not so much as one that can amplify "down to 0 hertz," but rather one that has no low-frequency time constants in any of its negative-feedback circuits. Figure 2-a shows a conventional negative-feedback loop; while Fig. 2-b shows how negative feedback is applied in so-called DC amplifiers. While the capacitor in the feedback network is eliminated, there may still be coupling capacitors elsewhere in the signal path.

Generally, an integrated amplifier (consisting of a preamplifier/equalizer stage, a tone control section and a power amplifier section) may have one or all of its sections designed in a DC configuration, and manufacturers would still label the product as a DC amplifier.

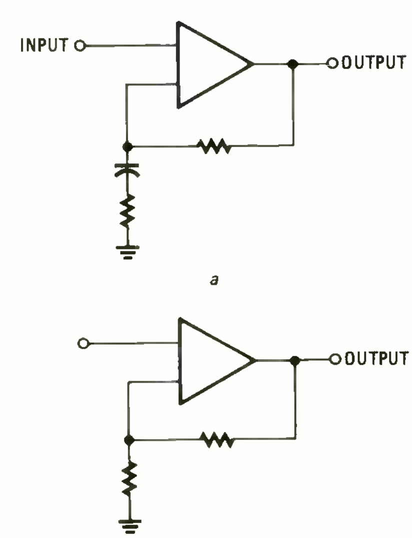


FIG. 2—CONVENTIONAL AMPLIFIER uses capacitor in feedback loop as shown in *a*. DC amplifier eliminates capacitor as shown in *b*.

Why design a DC amplifier?

Amplification of direct-current signals is not required in the reproduction of musical signals. The purposes of designing a DC amplifier are threefold:

1. To establish a constant driving

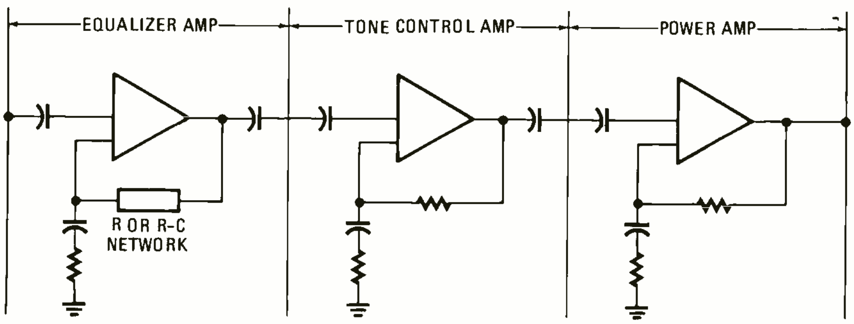


FIG. 3—INTEGRATED DC AMPLIFIER may still have capacitors in the signal path.

power-versus-frequency relationship between the amplifier and its loudspeakers, or between the phono cartridge and the preamplifier/equalizer section over a very wide frequency range.

2. To eliminate capacitors, which can generate their own harmonic distortion components, from all signal paths, including the negative-feedback loop, as much as possible.
3. To improve the waveform transmission characteristics of the amplifier, including the phase and time relationships inherent in complex signals and, thereby, to also reduce transient intermodulation distortion (TIM).

Eliminating capacitors

In an integrated amplifier without output capacitors there may still be as many as eight capacitors in the signal path, as shown in Fig. 3. The large-capacitance electrolytics used previously in output stages are the most likely to degrade sound quality since they can behave as nonlinear impedances even when properly polarized. Such capacitors are likely to affect the coupling between speakers and cartridges and the amplifier. It is no wonder, then, that they were the first to be eliminated in modern amplifiers.

In theory, it is possible to design an amplifier having no capacitors at all. However, in practice this may be difficult and, in some cases, undesirable. If a very small amount of direct current is produced by a signal source (for instance, a tuner having a slightly leaky output capacitor, or a tape deck having the same problem), this current will be amplified by the gain factor of the entire integrated amplifier (often by 30 dB or more) and appears as a DC voltage at the speakers, which could easily destroy an expensive loudspeaker system. For this reason, a few coupling capacitors remain necessary in integrated amplifier design.

Different companies have approached the DC amplifier design problem in different ways. Figure 4 shows some of these approaches. In Fig. 4-a, only the power amplifier uses a pure, capacitor-less "DC design." Using such a DC design in the power amplifier has the advantage of providing excellent damping factors at low frequencies, which, in turn, provides well-defined and tight bass reproduction. For optimum overall sound reproduction, this design approach requires a fairly heavy-duty power supply. This design approach is incorporated in Sansui's *model AU-707, model AU-607, model AU-717* and *model AU-515* amplifiers, as well as *Technics* by Panasonic, *models SU-8080* and *SU-8075*.

Figure 4-b shows another approach that involves a DC power amplifier, plus a preamplifier/equalizer in which the input capacitor has also been eliminated. This method permits extremely low-level, low-frequency signals to be applied directly from the phono cartridge into the first preamplifier stage without passing through a coupling capacitor. Since a cartridge can be considered to be a voltage generator, the preamplifier/equalizer usually uses an FET because of its voltage-amplifying capability. Using an FET as a first stage has the advantage of not requiring any bias voltage. Although there is a difference in the signal-to-noise ratio between an FET and a conventional bipolar transistor phono-input circuit when it is measured under short-circuit input conditions, the FET circuit provides an excellent signal-to-noise ratio during actual operation when a phono cartridge is connected. This anomaly, incidentally, prompted the IHF committee, which was involved in producing new standards of amplifier measurement, to specify a more realistic termination of the phono inputs of an amplifier or preamplifier when making signal-to-noise measurements. The phono input termination specified in the new standards consists of a 500-mH, ±10% inductor in series with a 1000-ohm, ±10% resistor and a 125-pF, ±10% capacitor in parallel with the L–C circuit.

Amplifiers using the design approach

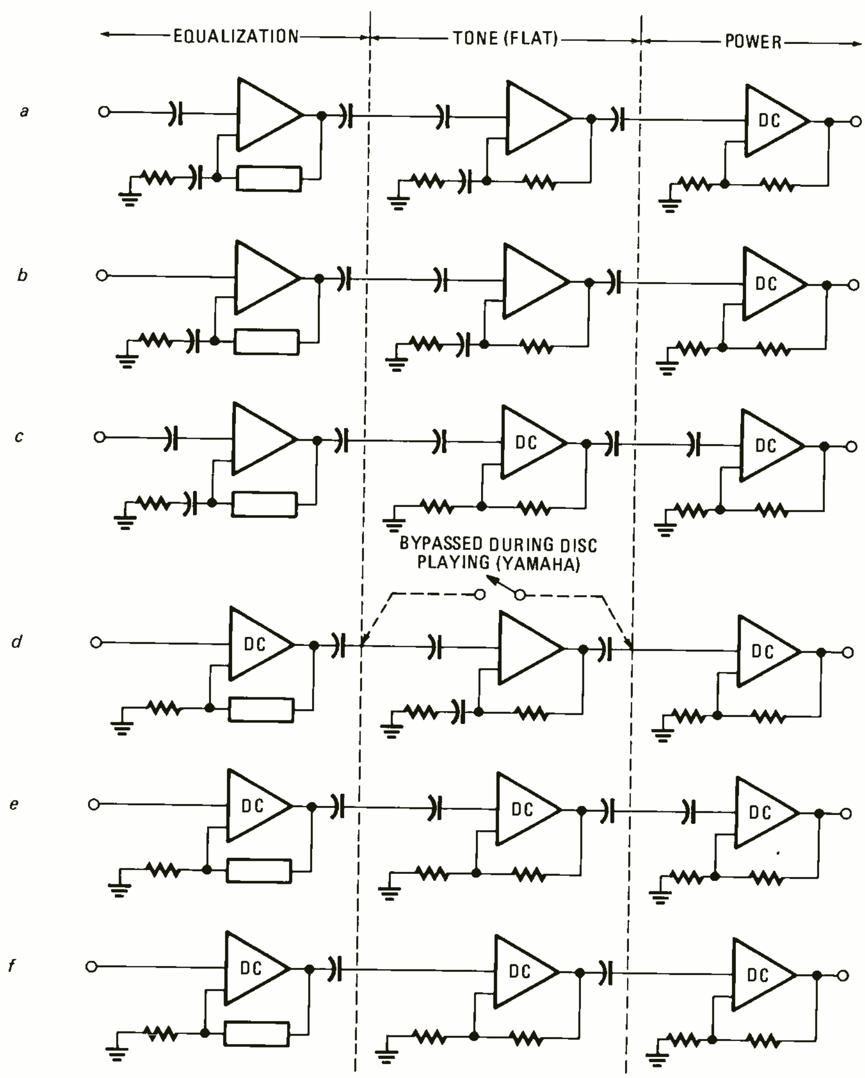


FIG. 4—DESIGN VARIATIONS in DC amplifiers that are currently being produced by different manufacturers.

shown in Fig. 4-b include Kenwood's *model KA-7300D, model KA-7100D* and *model KA-8100,* except that the input capacitor to the tone-control section is eliminated.

In Fig. 4-c, both the power and the tone-control amplifier stages have eliminated the capacitor in the feedback loop, and, while the output capacitor has been eliminated from the power stage, input and output capacitors are still present in each of the separate sections, forming a low-frequency time-constant circuit. This design approach is used in Pioneer's *model A-004* integrated amplifier.

Figure 4-d shows both the preamplifier/equalizer and power amplifier stages are DC-designed and have eliminated input-capacitor coupling. The design emphasis is on optimum input coupling for the phono cartridge and optimum output coupling to the loudspeakers. Amplifiers from different manufacturers using this approach show variations, which may result from different views regarding sound quality, physical performance and cost-vs.-performance considerations.

For example, the Onkyo *model A-708* and *model A-705* use an equalizer circuit that is divided into two sections, as shown in Fig. 5. A negative-feedback circuit is used for equalizing low frequencies, while an R–C circuit is used to rolloff the high frequencies in accordance with RIAA equalization requirements.

In the Yamaha *model A-1,* power-amplifier gain is increased during the record playing, and the input-capacitor-less, DC-designed equalizer is directly coupled to the power section, as shown by the dotted lines in Fig. 4-d. In this instance, only one coupling capacitor is introduced into the signal path. On the other hand, when the tone-control amplifier is introduced into the circuit, the signals pass through a capacitor-coupled tone-control section.

In the case of Sony's variation of this design (as presented in their *model TA-F6B*), when the DC equalizer is used, the amount of feedback in the DC range is partially restricted to obtain additional stability. A small-value capacitor remains in the negative-feedback loop. This design is often referred to as a "DC feedback type." Similarly, in the case of JVC's *model JA-S41*, a capacitor remains in the negative-feedback loop of the preamplifier/equalizer for shunting the DC feedback.

In Fig. 4-e, all stages DC-designed in their feedback networks, but coupling capacitors are still used in the tone-control and power-amplifier stages. An example of this design is Pioneer's *model A-006*.

Finally, Fig. 4-f shows a design in which all the stages have eliminated capacitors in the feedback loops, and all input capacitors to the various sections have also been eliminated. According to JVC (whose *model JA-S77* and *model JA-S55* use this approach), this represents the best compromise short of totally removing all capacitors in the signal path. The output capacitors remaining in the circuit (between the equalizer and flat amplifier and between the flat amplifier and the power amplifier) are designed for a minimum low-frequency time constant.

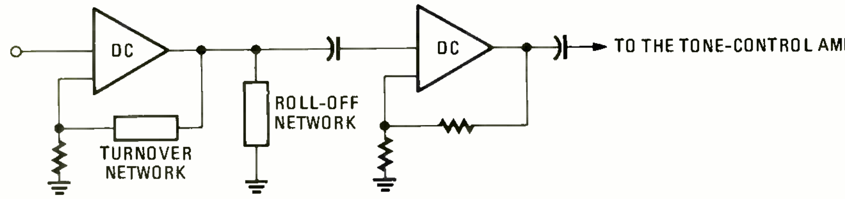


FIG. 5—TWO-STAGE EQUALIZER circuit is used by Onkyo in their *model A-708* and *A-705*.

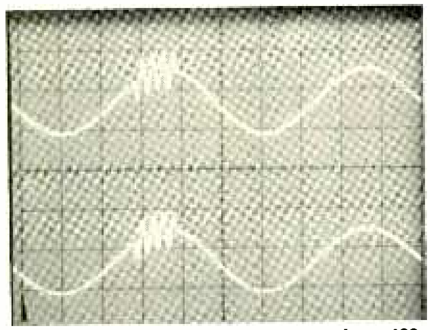


FIG. 6—DC AMPLIFIER is evaluated using a 400-Hz tone-burst riding on a 20-Hz sinewave (upper trace) as the input signal. Output from DC amplifier (lower trace) shows little phase shift.

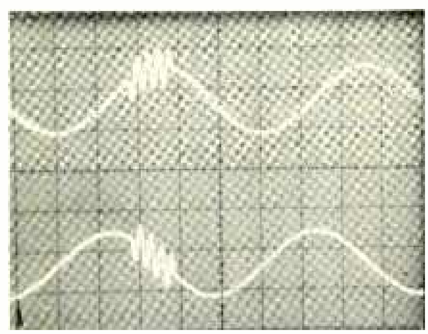


FIG. 7—DC AMPLIFIER with different design scheme than the amplifier in Fig. 6 is evaluated using the same input waveform (upper trace). Output waveform shows phase-shift of 400-Hz component.

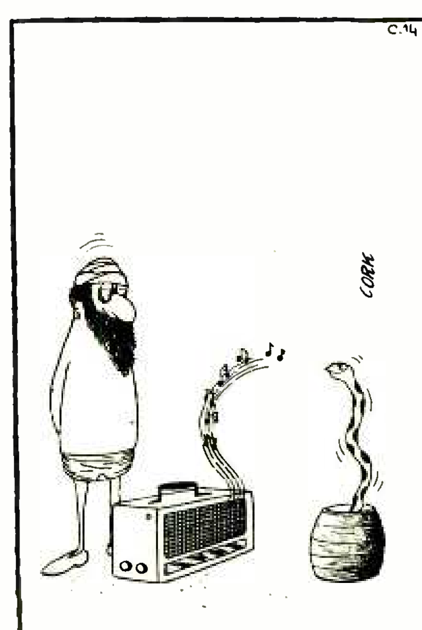
Comparing waveforms

When comparing a DC amplifier (or, more correctly, a fully DC-coupled section of such an amplifier) with an AC-coupled amplifier, it is easy to note differences in the output by using a squarewave input signal. The "tilt" of the output squarewave delivered by the AC amplifier indicates the amount of phase shift in the amplifier's low-frequency range.

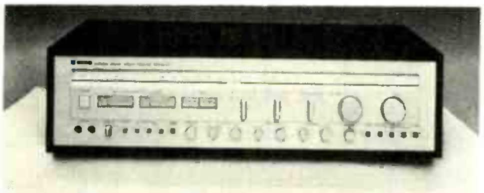
In comparing different DC amplifier designs, however, using a simple squarewave input signal may not show such obvious output differences at all. Accordingly, more complex input waveforms more easily show up these minor differences. For example, imagine that a 400-Hz tone burst were superimposed upon a 20-Hz sinewave. When using such a waveform to compare two DC amplifier designs such as those shown in Fig. 4-b and Fig. 4-f, such differences are easily found. (See Figs. 6 and 7.)

The scope photo of Fig. 6 shows that when the Fig. 4-f design is used, the 400-Hz burst appears at the same relative position in the output waveform with respect to the 20-Hz low-frequency component in the composite signal. Using another amplifier which is designed according to the scheme shown in Fig. 4-b and using the same input waveform (shown by the upper trace in both Figs. 6 and 7), the scope photo of Fig. 7 shows that the 20-Hz component in the output (lower) trace has been displaced in time with respect to the 400-Hz tone burst.

Many audio theorists suggest that such subtle differences in time-phase relationships are detectable by the human ear, even though all frequencies are ultimately reproduced at their correct relative amplitudes. Others argue just as vehemently that such phase differences are undetectable by the human ear. Nevertheless, early reactions to the new breed of DC amplifiers seem to indicate that they do sound audibly better during critical listening tests. Each manufacturer will undoubtedly approach the DC design problem from his own point of view, and it is still up to the consumer to decide which of all these new amplifiers sounds best and reproduces sound that most closely approximates the original live music performance. **R-E**



Radio-Electronics Audio Lab Tests



1

CIRCLE 106 ON FREE INFORMATION CARD

Yamaha Model CR-2040 AM/FM Receiver

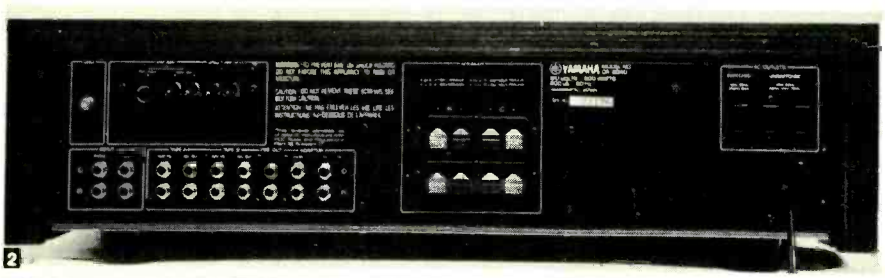
LEN FELDMAN
CONTRIBUTING HI-FI EDITOR

A SENSIBLY ORGANIZED, ELEGANTLY STYLED and sleekly proportioned front panel is what impresses you first about Yamaha's 1979–1980 top-of-the-line receiver, the *model CR-2040*.

The receiver is housed in an ebony wood-grained cabinet (included in the retail price). A horizontally oriented mid-section of the front panel (shown in Fig. 1) protrudes slightly for a three-dimensional effect, and contains a square-shaped POWER switch, three VU meters, a recording output selector switch, input and phono selector switches, a master volume control and a tuning knob. The center meter serves a dual function: It acts as a signal-strength meter or as a power-output meter for the right-hand channel, complementing its companion meter on the left, which indicates left-channel power in watts. The meter on the right is used for FM center-channel tuning.

The fully independent RECORD SELECTOR and INPUT SELECTOR switches enable you to feed any program source to the tape-output jacks, while the INPUT SELECTOR switch chooses the program source that will be connected to the speakers. The PHONO SELECTOR switch chooses any of four load-resistance values for the cartridge, and, in addition, selects a moving-coil (MC) preamplifier circuit that lets you use low-output cartridges without having to add a matching transformer or pre-preamplifier ("head amp").

RADIO-ELECTRONICS AUDIO LAB
R.E.A.L. SOUND
RATES
YAMAHA CR-2040 RECEIVER
EXCELLENT



2

MANUFACTURER'S PUBLISHED SPECIFICATIONS:

FM TUNER:
Usable Sensitivity (mono): 1.6 μV (9.8 dBf). **50-dB Quieting:** mono, 3.2 μV (15.3 dBf); stereo, 35 μV (36.1 dBf). **S/N Ratio:** mono, 90 dB; stereo, 84 dB. **Capture Ratio:** 1.5 dB. **Selectivity** (DX/local): 82/48 dB. **IF and Spurious Rejection:** 100 dB. **Image Rejection:** 80 dB. **AM Rejection:** 60 dB. **Frequency Response:** 30 Hz to 15 kHz, +0.4, −1.0 dB. **THD** (mono): 0.07% at 100 Hz & 1 kHz; 0.1% at 6 kHz. **THD** (stereo): 0.09% at 100 Hz & 1 kHz; 0.15% at 6 kHz. **Stereo Separation:** 50 dB at 1 kHz and 100 Hz; 45 dB at 10 kHz. **Subcarrier Rejection:** 70 dB. **Muting Sensitivity:** 5 μV (19.2 dBf). **Auto/DX Switching Sensitivity:** 35 μV (39.2 dBf).

AM TUNER:
Usable Sensitivity: 15 μV. **Selectivity:** 30 dB. **S/N Ratio:** 50 dB. **THD:** 0.4%. **Image Rejection:** 40 dB. **IF Rejection:** 35 dB. **Spurious Rejection:** 60 dB.

AMPLIFIER:
Power Output: 120 watts-per-channel, 8 ohms (140 watts-per-channel, 4 ohms), 20 Hz to 20 kHz. **Rated THD:** 0.02%. **Damping Factor:** 40. **IM Distortion:** 0.02%. **Frequency Response** (all inputs): 20 Hz to 20 kHz, ±0.2 dB. **Input Sensitivity:** MC phono, 100 μV; MM phono, 2.5 mV; high level, 120 mV. **S/N Ratio:** ("A"-weighted, referenced to full output): phono MC, 88 dB, referenced to 500 μV; phono MM, 95 dB, referenced to 10 mV; high level, 100 dB. **Bass and Treble Range** (see text): ±10 dB. **Midrange Control:** ±6 dB. **Low Filter Cutoff:** −3 dB at 25 Hz. **High Filter Cutoff:** −3 dB at 6 kHz or 10 kHz. **Loudness Control Range:** 20 dB. **Audio Muting:** 20 dB.

GENERAL SPECIFICATIONS:
Power Consumption: 600 watts, 120 volts 60 Hz. **Dimensions:** $22\frac{3}{16}$ W × $6\frac{9}{16}$ H × 16 inches D. **Weight:** 44 lbs., 14 oz. **Suggested (Approximate) Retail Price:** $850.

The top of the panel contains a softly illuminated pair of frequency AM and FM scales, to the left of which are a red power-on light, a green half-power light, and a red overload light that illuminates whenever the amplifier is driven beyond its rated output capability. Six small indicator lights to the right of the frequency scales illuminate to show AM reception, stereo FM reception, activation of an automatic FM-blend circuit, local or DX FM operation, and activation of Yamaha's special OTS (*O*ptimum *T*uning *S*ystem) tuning circuit.

All the less-used controls are placed along the bottom edge of the panel. These controls include two phone jacks, a speaker selector switch, eight small rotary knobs and ten pushbuttons. The five pushbuttons on the left select the center-meter functions (power or signal strength), low-cut or high-cut filtering, and a 20-dB audio muting feature. Five pushbuttons on the lower right select mono/stereo modes, interpose an adaptor circuit interruption point, choose either of two FM IF modes (local or auto-local), activate or defeat the muting and OTS feature, and select FM or AM reception. Outermost of the eight remaining rotary controls handle loudness and balance. The loudness control alters the gain settings by 20 dB, is continuously variable (introducing loudness compensation as the control is rotated) and is entirely independent of the master volume control. In using these controls, the listener adjusts any program source to "life-like" loudness levels using the *master* volume control. Then, if softer-than-lifelike levels are desired, you simply reduce the setting on the *loudness* control, which then introduces precise loudness compensation over the available 20-dB range. Thus, proper loudness is obtained regardless of speaker efficiency, room acoustics, program-source level or any of the other variables that usually make conventional tapped-volume-control loudness systems all but useless.

The six remaining rotary controls take care of bass, treble and mid-range tone adjustments. Here also, Yamaha has gone far beyond what is normally found on most receivers. Each tone control has a companion control that determines its turnover frequency (in the case of the BASS and TREBLE controls) or its center frequency (in the case of the midrange or PRESENCE control).

The turnover point of the treble control may be varied from 2 kHz to 10 kHz, while that of the BASS control may range from 100 Hz to 500 Hz, and the center frequency of the midrange control can be varied from 1 kHz to 6 kHz. This control versatility comes very close to that of a true parametric equalizer, and, as far as we know, is not found on any other integrated receivers to date.

The rear panel of the *model CR-2040* contains spring-loaded, color-coded terminals for speaker connections. Also included are the usual phono and high-level input jacks, tape-input and tape-output jacks, a pair of preamplifier-out jacks, and jacks for the adaptor circuit to connect noise-reduction units, expanders, time-delay devices, etc. It is also possible to connect a tape deck to the preamplifier-out terminals if you want to pre-equalize (tone-control) signals for recording. A view of the rear panel is shown in Fig. 2.

Balanced 300-ohm FM antenna terminals plus an AM antenna and ground terminal are also provided, as is an unusual "indoor" AM antenna, shown in Fig. 3. This true loop antenna proved to be somewhat more sensitive than the usual straight "stick" type, and it can be mounted on the rear panel or on any convenient nearby surface since its bracket is coated with self-adhesive material. While a 75-ohm coaxial connector is provided for unbalanced FM transmission lines, the connector is a nonstandard unit. Yamaha supplies a mating male connector that can be easily attached to incoming coaxial cable without any soldering. Three convenience AC receptacles are also included; one switched, two unswitched. Figure 4 shows how additional high-fidelity components could be combined with the Yamaha *model CR-2040*.


3

Construction and circuitry

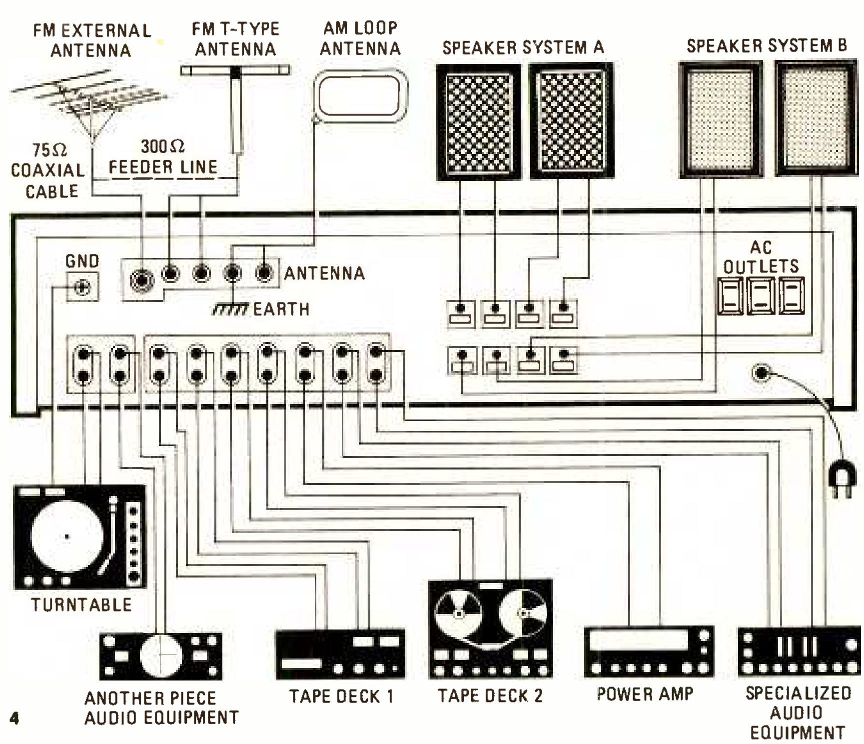
An internal view of the chassis is shown in Fig. 5. An unusual feature of the layout is the use of flexible cables that couple several of the front-panel controls to multiple-position slide switches that are physically close to the circuits they handle, thereby reducing the possibility of hum-and-noise pickup. A substantial section of the chassis contains large heat-sink structures housing the power transistors, while

TABLE 1
RADIO-ELECTRONICS PRODUCT TEST REPORT

Manufacturer: **Yamaha** Model: **CR-2040**

FM PERFORMANCE MEASUREMENTS

	R-E Measurement	R-E Evaluation
SENSITIVITY, NOISE AND FREEDOM FROM INTERFERENCE		
IHF sensitivity, mono: (μV) (dBf)	1.9 (10.8)	Good
Sensitivity, stereo (μV) (dBf)	4.2 (17.7)	Very good
50-dB quieting signal, mono (μV) (dBf)	2.4 (12.8)	Excellent
50-dB quieting signal, stereo (μV) (dBf)	33.0 (35.6)	Excellent
Maximum S/N ratio, mono (dB)	86	Superb
Maximum S/N ratio, stereo (dB)	75 (See text)	Superb
Capture ratio (dB)	1.4	Good
AM suppression (dB)	61	Very good
Image rejection (dB)	80	Very good
IF rejection (dB)	100+	Superb
Spurious rejection (dB)	100+	Superb
Alternate channel selectivity (dB)	83/50 (local)	Excellent
FIDELITY AND DISTORTION MEASUREMENTS		
Frequency response, 50 Hz to 15 kHz (±dB)	0.3	Excellent
Harmonic distortion, 1 kHz, mono (%)	0.045	Superb
Harmonic distortion, 1 kHz, stereo (%)	0.045	Superb
Harmonic distortion, 100 Hz, mono (%)	0.055	Superb
Harmonic distortion, 100 Hz, stereo (%)	0.055	Superb
Harmonic distortion, 6 kHz, mono (%)	0.12	Excellent
Harmonic distortion, 6 kHz, stereo (%)	0.12	Excellent
Distortion at 50-dB quieting, mono (%)	0.75	Good
Distortion at 50-dB quieting, stereo (%)	0.28	Very good
STEREO PERFORMANCE MEASUREMENTS		
Stereo threshold (μV) (dBf)	3.0 (14.7)	Very good
Separation, 1 kHz (dB)	55	Superb
Separation, 100 Hz (dB)	53	Superb
Separation, 10 kHz (dB)	44	Superb
MISCELLANEOUS MEASUREMENTS		
Muting threshold (μV) (dBf)	5.0 (19.2)	Very good
Dial calibration accuracy (±kHz at MHz)	50 at 108	Excellent
EVALUATION OF CONTROLS, DESIGN, CONSTRUCTION		
Control layout		Superb
Ease of tuning		Very good
Accuracy of meters or other tuning aids		Excellent
Usefulness of other controls		Excellent
Construction and internal layout		Excellent
Ease of servicing		Good
Evaluation of extra features, if any		Excellent
OVERALL FM PERFORMANCE RATING		Excellent

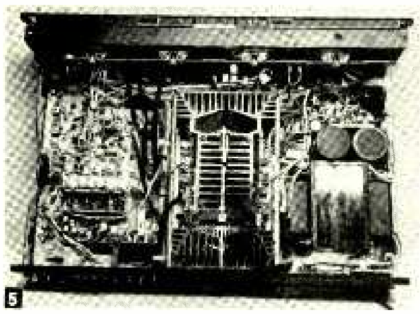


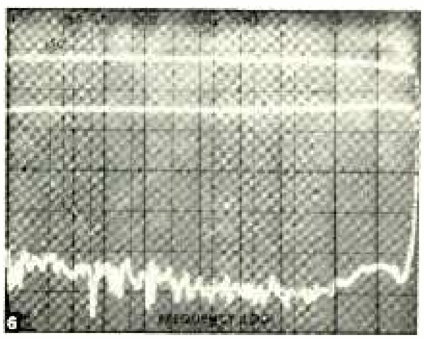
4

tuner circuits and preamplifier stages are as far removed from the power transformer as possible.

The FM front end uses a four-section tuning capacitor and is equipped with a juntion FET for the RF amplifier stage. The IF section operates in two modes (the "local" or wide-band mode and the "DX" or narrow-band mode for high selectivity). Three uniresonance ceramic filters, one discrete transistor stage and a six-stage differential IC amplifier with current limiter are used in the local mode, while two additional ceramic filters and a second differential amplifier are used in the DX mode.

An auto-DX circuit activates the IF operat-





ing mode, depending upon the amount of noise and interference present in the received signal. In addition, if stereo signal strength is low, a multiplexed blend circuit automatically reduces noise while sacrificing stereo FM separation. The AFC circuitry (OTS) is defeated when the tuning knob is touched during tuning, but it locks the local oscillator "on frequency" once the desired signal is tuned in and the knob is released. When the OTS is activated, this also activates the muting circuit to eliminate interstation noise when tuning.

The stereo decoder contains a phase-locked-loop demodulator plus a tracking pilot-signal canceller that removes residual 19-kHz signal before it reaches the demodulator. This special circuit even takes into consideration any minor variations in the 19-kHz level that are transmitted by the station (pilot signals may legally range from 8% to 10% of total modulation), thus tracking both the level and the phase of the incoming pilot signal. This canceller circuit makes it possible to achieve excellent high-frequency response in stereo FM, since "brute force" filtering of the 19-kHz signal (which often degrades response in the 10-kHz to 15-kHz range) is not required after decoding.

The elaborate tone controls use low-noise IC's with "gyrator," or simulated L–C circuits that are immune to hum pickup. The phono section uses five low-noise transistors-per-channel, and the equalization-feedback resistors have a 1% tolerance, while the equivalent

TABLE 2

RADIO-ELECTRONICS PRODUCT TEST REPORT

Manufacturer: **Yamaha** Model: **CR-2040**

AMPLIFIER PERFORMANCE MEASUREMENTS

	R-E Measurement	R-E Evaluation
POWER OUTPUT CAPABILITY		
RMS power/channel, 8-ohms, 1 kHz (watts)	145.3	**Excellent**
RMS power/channel, 8-ohms, 20 Hz (watts)	140.0	**Superb**
RMS power/channel, 8-ohms, 20 kHz (watts)	148.7	**Excellent**
RMS power/channel, 4-ohms, 1 kHz (watts)	205.0	**Excellent**
RMS power/channel, 4-ohms, 20 Hz (watts)	N/A	**N/A**
RMS power/channel, 4-ohms, 20 kHz (watts)	N/A	**N/A**
Frequency limits for rated output (Hz-kHz)	10–40	**Excellent**
Dynamic headroom (dB)	1.2	**Nonrated**
DISTORTION MEASUREMENTS		
Harmonic distortion at rated output, 1 kHz (%)	0.0029	**Superb**
Intermodulation distortion, rated output (%)	0.0025	**Superb**
Harmonic distortion at 1-watt output, 1 kHz (%)	0.008	**Excellent**
Intermodulation distortion at 1-watt output (%)	0.01	**Excellent**
DAMPING FACTOR AT 8 OHMS, 50 Hz	50	**Very good**
PHONO PREAMPLIFIER MEASUREMENTS		
Frequency response (RIAA ±dB)	+0, −0.2	**Excellent**
Maximum input before overload (mV)	275 (33 for MC)	**Superb**
Hum/noise, "A"-weighted, referenced to 1-watt or 0.5-volt output, for 5-mV input (dB)	81.5 (73 for MC)	**Excellent**
HIGH LEVEL INPUT MEASUREMENTS		
Frequency response (Hz-kHz, ±dB)	3.5–80, 3	**Excellent**
Hum/noise ("A"-weighted) referenced to 0.5-volt or 1-watt output, 0.5-volt input (dB)	83	**Excellent**
Residual noise ("A"-weighted) minimum volume, referenced to 1-watt output	84	**Very good**
TONAL COMPENSATION MEASUREMENTS		
Action of bass and treble controls	See Fig. 8	**Superb**
Action of secondary tone controls	See Fig. 9	**Superb**
Action of high- and low-cut filters	See Fig. 10	**Fair**
COMPONENT MATCHING MEASUREMENTS		
Input sensitivity, phono 1/phono 2, referenced to 1-watt or 0.5-volt output (mV)	0.19/7.6 μV	
Input sensitivity, high level, referenced to 1-watt or 0.5-volt output (mV)	12.0	
Output level, tape outputs, at rated output (mV)	120	
Output level, headphone jack, at rated output (mV or mW)	N/A	
EVALUATION OF CONTROLS, CONSTRUCTION AND DESIGN		
Adequacy of program source and monitor switching		**Excellent**
Adequacy of input facilities		**Excellent**
Front panel layout		**Superb**
Action of controls and switches		**Very good**
Design and construction		**Excellent**
Ease of servicing		**Good**
OVERALL AMPLIFIER PERFORMANCE RATING		**Excellent**

capacitors have a 2% tolerance. The extra head amplifier stage uses an additional low-noise IC for the required additional gain.

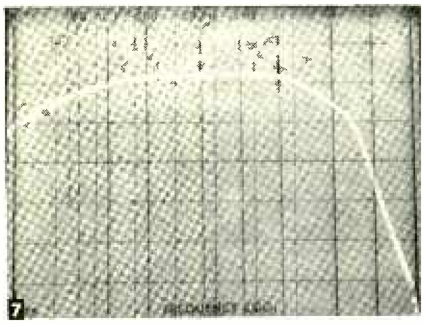
The entire power amplifier is direct-current, direct-coupled. It contains three stages: the first consists of a current-mirror differential amplifier; the second is a Darlington-connected, constant-current-loaded predriver stage; and the third, the output, comprises three-stage Darlington-connected complementary push-pull stages.

FM measurements

Table 1 summarizes measurements made for the FM tuner. Aside from the fact that the tuner did not quite meet its monophonic usable-sensitivity specifications (of minor importance) all remaining measurements were as good or considerably better than claimed. Because our test equipment is not able to measure a 90-dB signal-to-noise ratio in mono or an 84-dB signal-to-noise ratio in stereo, we will have to take Yamaha's word on those claims. The S/N readings we did obtain were superb and were no doubt limited by our equipment.

Figure 6 shows the FM stereo frequency response and separation (shown in the lower trace). The center trace shows what happens when the multiplex-blend circuit is automatically introduced because of low stereo-signal strengths. Under those circumstances, separation across the entire frequency band decreases to not much more than 10 dB. Such a low separation level still manages to offer some degree of stereo effect, but the advantage is that noise is vastly reduced, making it possible to listen to such signals *in stereo* without having to endure unbearable background noise levels. In our listening tests we discovered that many of the stereo signals that would have had to be switched to the monophonic mode on sets not provided with the multiplex-blend feature were quite listenable with this circuit operating. The vertical scale in the scope photo of Fig. 6 (and in all other scope photos in this report) is 10 dB-per-division. Both mono and stereo FM distortion levels are so low that we wonder whether again our measurement capability was limited by the test equipment instead of the receiver itself. For all we know, the actual THD values for the Yamaha *model CR-2040* may even be a bit better than those shown in Table 1.

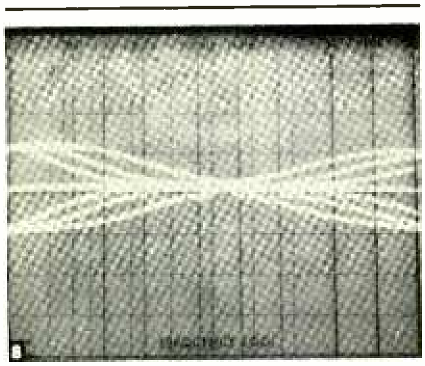
The AM section uses minimal circuitry (only a two-section tuning capacitor), and the frequency response (shown in Fig. 7) is about as poor as that found in most high-fidelity receivers. Sensitivity, when we used the supplied antenna loop, was quite good, however, as were the signal-to-noise ratio (50 dB as claimed) and the distortion reading (it measured 0.5% for 30% modulation).



Amplifier measurements

Table 2 shows the results of measurements on the power amplifier and control sections. Yamaha has been extremely conservative in rating the power output at 120 watts-per-channel. The unit could easily have been rated as a 140-watt-per-channel unit (into 8 ohms) and have still complied fully with the Federal Trade Commission Rule on power disclosure for audio amplifiers. Note also that the referenced or rated harmonic distortion level is a mere 0.02%.

The input-sensitivity and signal-to-noise values shown in Table 2 cannot be compared directly with published claims, since we now use IHF Standard reference levels and weighting networks. Nonetheless, a comparison with other top-quality units using IHF standards shows that the noise levels of the *model CR-2040* are extremely low, even when the higher-gain moving-coil phono inputs are used. If you want to use an MC cartridge, the savings that accrue from having a built-in "head amp" are quite substantial. The high phono-overload capability of the preamplifier (for both the MM and MC modes) is particularly worthwhile if you plan to play some of the new direct-to-disc recordings that typically contain higher groove velocities (i.e., modulation levels) than commercially mass-produced discs.



Figures 8 and 9 show the flexible six-control tone setup. We have plotted only three possible turnover frequency settings for each control (for the BASS and TREBLE controls in Fig. 8; for the midrange in Fig. 9). But a limitless number of intermediate settings could have been achieved for each of these controls.

TABLE 3
RADIO-ELECTRONICS PRODUCT TEST REPORT

Manufacturer: **Yamaha** Model: **CR-2040**

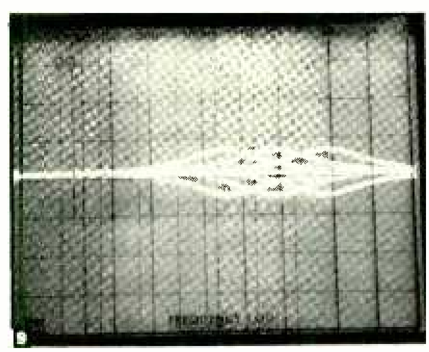
OVERALL PRODUCT ANALYSIS

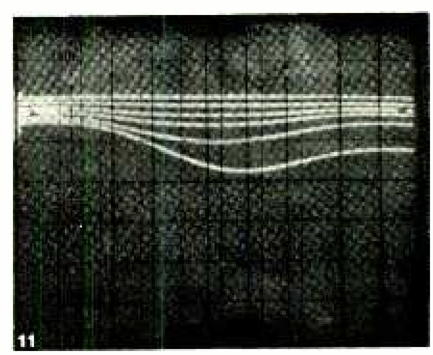
Retail price	**$850 (approximate)**
Price category	**High**
Price/performance ratio	**Excellent**
Styling and appearance	**Superb**
Sound quality	**Excellent**
Mechanical performance	**Excellent**

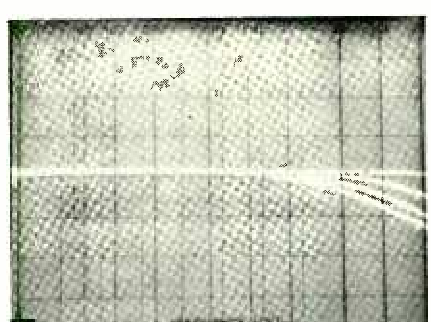
Comments: There is no technical reason why an all-in-one stereo receiver should not perform fully as well as separate components, and there is no better proof of this than the measured and listened-to results of the Yamaha *model CR-2040*. The controls are extremely sophisticated, and the tone controls, in particular, are more flexible and precise than those found on most of the costlier separate preamplifiers and integrated amplifiers. We believe that its power-output rating is about as high as anyone would want in an all-in-one component, and Yamaha's emphasis on performance and versatility as opposed to ever-greater power ratings makes a lot of sense. The emphasis on actual-user specifications (such as the NDCR ratings) is also a progressive step forward, though with the new IHF Amplifier Standards now in force, we hope that the company will "adjust" their various reference levels to fit the new standards.

The sound quality delivered by a pair of high-quality speakers hooked up to the receiver is audibly better than that produced by Yamaha's earlier receivers, and that's saying quite a lot. The introduction of an all-DC-coupled power amplifier has resulted in improved sound. The distortion levels of the FM tuner rival those of the amplifier and place severe limits on our otherwise state-of-the-art lab-test equipment. Yamaha has borrowed some of the circuit designs from their separate tuners and integrated amplifiers to achieve this level of performance. We have been impressed with Yamaha's philosophy of carrying major features on all their units, from the most expensive to the lower-powered receivers. We hope that they will follow this approach in the rest of the 1979–1980 line since increasing speaker efficiencies are prompting consumers to select lower-powered receivers as central components of their stereo systems. Because the *model CR-2040* is the "flagship" of Yamaha's new receiver line, they have spared no effort in equipping it with every imaginable feature.

At its suggested retail price, the new Yamaha receiver performs as well or better than many of last year's models (including their own) that retail for as much or even more. The *model CR-2040* is as close to a dream receiver as the high-fi industry has achieved to date.







High-cut filter response is shown in Fig. 10, in which three traces (in addition to flat response) are shown, since both filter pushbuttons can be depressed either simultaneously or individually.

Figure 11 shows overall frequency response as the separate loudness control is varied over its entire range (approximately 20 dB). Note that this variation in loudness level and tonal response is achieved without changing the master volume control setting.

Summary

Table 3 contains an overall product evaluation along with our summary comments regarding the listening and handling qualities.

Yamaha obviously believes that today, those who purchase a higher-powered receiver are no longer casual listeners but require every bit as much flexibility and versatility in an integrated component as do audiophiles selecting separate components. In the past such versatility has often meant compromises in the sound. That is definitely not the case with the *model CR-2040*. You will probably agree with us that it is difficult if not impossible to detect any difference in sound between this receiver and much higher-priced separate components having an amplifier with an equivalent power-output.

When we first began testing and using the *CR-2040*, we were asked to guess its suggested retail price (the final price had not yet been fixed). We ventured a guess that turned out to be $200 more than Yamaha's final suggested retail price. Need we say more? **R-E**

Audio Test Station

PART 5—The utility and overall accuracy of the Audio Test Station will depend on the skill and care used in its calibration. This article "walks you, step-by-step," through the calibration process.

RAY DAVISON

IF YOU HAVE COMPLETED THE AUDIO TEST System, your next step is proper calibration so you can take full advantage of its many features. Calibration steps will be performed stage-by-stage so the precision of the sections calibrated during the initial stages can be used in later procedures. Figure 16 shows the locations of the various trimmers that you will be adjusting.

Timebase calibration

Connect a reasonably well calibrated scope to jack J1. (The scope is the only calibration standard that we will be using and it is assumed that amplitude calibrations are not critical for most applications.)

Set the scope input to DC.
Set all trimmer resistors to their center positions. See Fig. 16.
Turn on power switches S1 and S2.
Set R5 to TRIANGLE and S8 to NOT INVERT.
Set R3 to maximum and R4 to 0.
Set S3 to 1 kHz.
Set S4 to SYMMETRICAL and R1 to its lower position.

The scope should show a clean triangle wave at about 1 kHz.

Set R8 to 0—make sure R4 is still at 0.
Adjust R232 for zero offset.
Set R3 to maximum.
Adjust R227 for 16 volts P-P.
Adjust R240 for zero offset.
Switch S5 to SQUAREWAVE.
Adjust R223 for approximately 16 volts P-P and R222 for approximately zero offset. These two controls will be readjusted later.
Switch the scope input to AC.
Adjust R212 for slight clipping.
Adjust R213 for a symmetrical waveform.

When the scope is set to AC, adjusting R213 will cause the average level of the waveform to shift. Symmetry is reached when the positive-going and negative-going peaks are *exactly* the same distance from the center line on the scope.

Adjust R212 for minimum sinewave distortion.

A sinewave plotted on the face of the scope screen is a valuable aid in completing this step in the calibration. (An 8 × 8 cm clear plastic overlay (Fig. 17) is available from Fidelity Sound.) Naturally, if you have access to a harmonic distortion analyzer, you can use it in adjusting for minimum distortion.

Adjust R223 for 16 volts P-P output.
Switch the scope to DC input.
Adjust R222 for zero offset.
Set S5 to TRIANGLE.

Check the waveform quality at each position of S3. At the 10K position the waveform will be distorted; however, this is not too important because this position is used only to trigger the pulse generator.

For initial checks on the low-frequency ranges, set R1 to 100F. Any deviation from strict linearity indicates capacitor leakage. A slight curvature of the waveform is acceptable for most applications. However, if curving is severe, the circuit may not oscillate at all at low currents.

For testing at the lowest positions of S3, set the scope's horizontal timebase for external sweep. This will produce just a vertical trace. Follow the oscillator through a couple of cycles to insure that there is no excessive leakage. At the .002 position of S3 a single cycle takes approximately 8 minutes. If the scope beam stops while approaching one peak, increase R1 slightly to increase the charging current. The beam should advance slightly. This action indicates excessive leakage in the capacitor involved. Increasing R1 beyond some point should cause oscillations to resume. **Replace the faulty capacitor.**

Set R3 to maximum.
Set S9 to MANUAL.
Set R4 to 0.
Set R206 to 0 output.
Move R4 to +5 volts.
Set R209 for +8 volts output.
Move R4 to −5 volts.

The output should be approximately −8 volts. This is simply a functional check. Trimmers R206 and R209 will be fine-tuned later.

Sweep generator calibration

Waveforms: Most of the circuitry is identical to that used in the timebase section and the same calibration procedure applies. The output levels and symmetry proceeds from the output (J4) back. That is, set R7 to zero and adjust R534 for 0 volts DC level. Now, set R7 to maximum, S13 to NOT BLANK, and adjust the trimmers between oscillator IC502 and switch S14.

The only difference in this area is that R513 must be adjusted; whereas its counterpart in the timebase is fixed. Interaction between R510 and R513 is rather subtle. It is not enough to adjust each independently for minimum distortion. Often, by actually increasing the distortion with one of these pots, readjustment of the other pot results in lower distortion.

The optimum calibration procedure requires a harmonic distortion analyzer and a dual-trace scope. First, a sinewave is

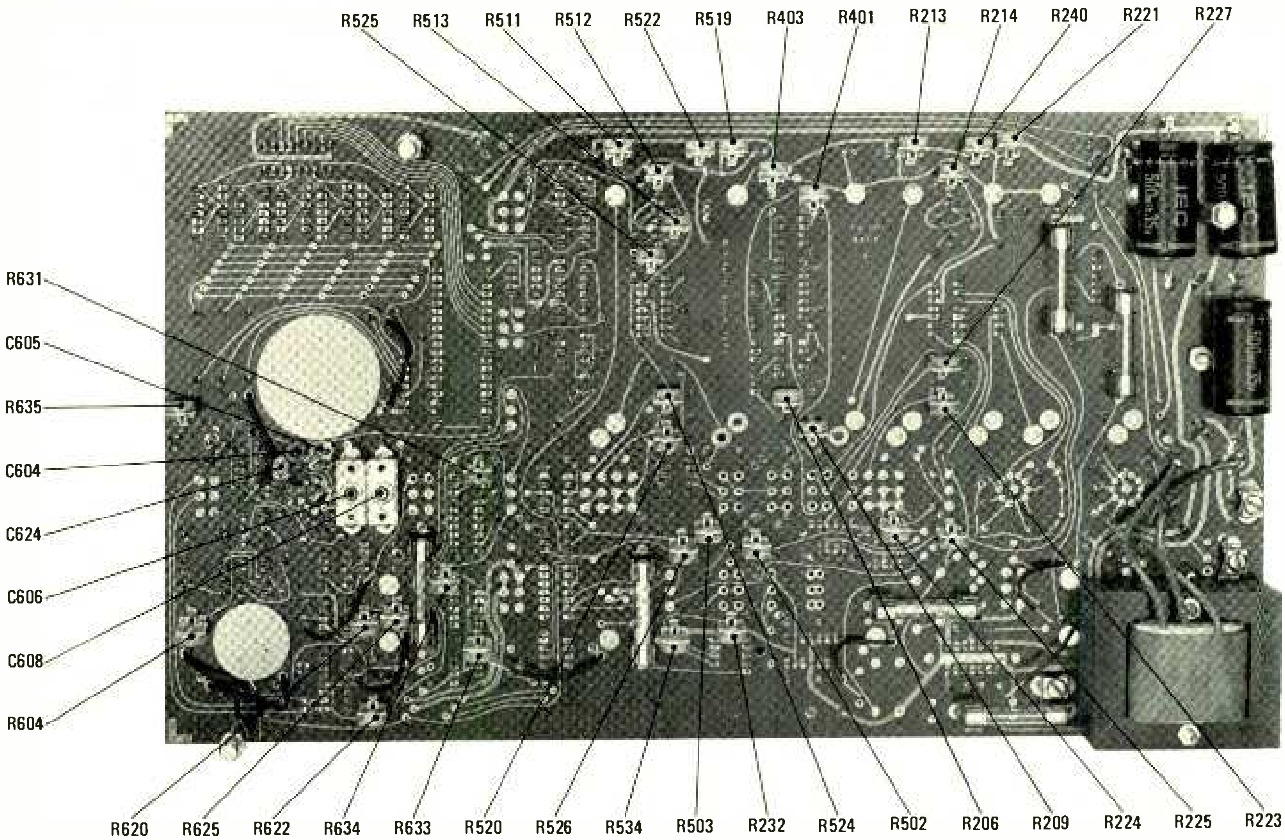


FIG. 16—VIEW OF THE BACK SIDE OF THE PC BOARD showing the locations of the fuses, a couple of large capacitors and, most important of all, the locations of the trimmer capacitors and trimmer resistors. Their placement simplifies calibration.

mathematically plotted on the face of the scope tube (the sinewave pattern (Fig. 17) available from Fidelity Sound may be fastened to the tube screen) and the output of the AF sweep generator is adjusted so that the period and amplitude correspond to the peaks and zero-crossings of the plotted sinewave.

This same signal is simultaneously fed to the input of the distortion analyzer. The output of the distortion analyzer is applied to the second trace of the scope.

The first adjustments are made with a screwdriver in each hand. Simultaneously, adjust R510 and R513 to provide the best visual fit between the generator waveform and the plotted pattern. Watching the output of the distortion analyzer as you make the adjustments will help you understand the interaction of these two controls. The final adjustments are made while watching the meter on the distortion analyzer. However, if there is a noticeable deviation between the generator output and the reference waveform, it indicates that a further improvement is possible.

A simpler, but less precise, test is to use a single-trace scope with a sinewave pattern superimposed on the screen. A visual match between the plotted and generated waveforms will produce a signal having distortion components that are low enough to be insignificant in frequency-response measurements.

Calibrating the manual frequency sweep involves both the timebase and audio sweep generator sections since either can be used to provide a manual frequency sweep of the audio sweep generator. Earlier, we set aside fine-tuning of the manual timebase. We will take that up now.

This procedure uses the frequency counter as the calibration standard for the sweep circuit. It is the voltage levels that will be calibrated so the frequency counter can be considered as being a digital voltmeter. Proceed as follows:

Set S11 to MANUAL.
Sweep R6 through its maximum travel and check the end-point frequencies.
Adjust R502 and R503 for the desired end-points.
R503 sets the total sweep width; R502 affects mainly the low-frequency end-point.
Connect the scope to the output of IC501.
Set the vertical amplifier for 1 volt-per-division and adjust the trace for one division from the top of the screen with no input.
Run R6 through its full range and note the end-point voltage levels.
Set the timebase frequency to 1 kHz.
Set S4 to SYMMETRICAL and S9 to SWEEP.
Set S12 to LINEAR and S11 to SWEEP.

You should now see a triangle wave that can be positioned and scaled by R10 and R11 so its peaks correspond to the end-point voltages developed by sweeping R6 through its full travel.

Switch S12 to LOG.
Run R8—the front panel HIGH LOG set control—to the end of its travel at maximum sweep width. Now back off 3 turns.

Plot an antilog function (Fig. 18) on the scope screen and align the generated waveforms with the pattern. To provide a stable overlap of the generated and plotted patterns, you will find it helpful to sync the scope from the triangle output of the timebase generator. Use the manual trigger level rather than auto. Also, try switching S8 to INVERT. If your scope has a dual-trace feature, try it. The peak of the antilog function is easy to locate; the low point of the valley is not. The method used here makes it easy to establish the end-points of the antilog function.

Adjust R401 and R403 so that the antilog waveform has approximately the same span as that provided by R11 sweep voltage without clipping at the peaks.
Use the scope's vertical attenuator to fit the generated waveform to the plotted antilog function.
Adjust R401 and R403 for the best visual match between the generated and plotted waveforms. Note the effect each movement of each pot has on the generated waveform.

This completes the rough adjustment of the antilog waveform. Fine-tuning comes later.

At this point, everything is at least approximately calibrated so that the timebase will sweep the audio sweep generator either manually or automatically in linear and logarithmic modes. Now, to calibrate the manual sweep control.

Set S3 to 100 and R1 to its lowest position.
Set S4 to the SYMMETRICAL (upper) position.
Set S9 to SWEEP.

At this point we will use the audio sweep generator and the counter as a digital voltmeter. The sweep generator then acts as a voltage-to-frequency converter. This will be used to match the manual and sweep modes of the timebase. The log sweep has the greatest resolution at low frequencies and the linear sweep has the greatest resolution at the high end; so this is the way we will set them up.

Set the scope horizontal amplifier to EXTERNAL INPUT.

Apply the timebase triangle waveform to the scope's vertical and horizontal inputs simultaneously. If a line is traced from lower left to upper left across the screen, this indicates that a *positive* voltage drives the scope beam toward the *right*. Similarly, a line from upper left to lower right shows that a positive horizontal input voltage drives the beam toward the *left*. In this case, throw S8 to INVERT so the trace extends across the screen from lower left to upper right. This insures that frequency-response plots will have the low-frequency end at the left and the high-frequency end on the right.

Set R4 to 0.
Switch S3 to 10 Hz. Use R3 to establish a 10-cm sweep. (It may be necessary to use the scope's expanded-sweep mode.)
Switch S3 to .002.
Set S22 to ½ SEC.

With the beam traveling left-to-right and the counter increasing in frequency and with S12 set for linear operation, note the end-points of the beam and the highest frequency attained.

As the beam is returning to the left side of the screen and the frequency of the audo sweep generator is decreasing (S12 in the LOG position), note the turn-around point of the beam and the lowest frequency reached on the frequency counter. Note that it is possible to interpolate fractions of a hertz by observing the "bobble" of the counter between two frequencies. If, for instance, it "bobbles" between 20 and 21 Hz every time the counter refreshes (every half second) the frequency is 20.5 Hz. Or, if the reading stays on one number longer than the other, the frequency is closest to that figure.

Repeat the slow sweep a couple of times to confirm the end-point frequencies. (Remember to switch S12 as the trace switches directions.)

Set S9 to MANUAL.
Sweep R4 through its full travel. The frequency of the audio sweep generator should track R4.
Set S12 to LOG and drop R4 to its lowest position. Note the frequency of the audio generator.
Adjust R206 and R209, in the timebase section, so that R4, as it is moved through its travel range and S12 is switched, produces the same end-point frequencies as those produced during the automatic-sweep mode. Trimmer R209 establishes the total sweep width and R206 sets the center point. When these trimmers are properly set, R4, with S9 in the MANUAL position, will produce the same sweep as the triangle timebase did with S9 and the sweep mode.
Set S9 to MANUAL.

Sweep the scope horizontal amplifier by running R4 through its full range. Make sure that when R4 is at its endpoints, the beam is on an end vertical line.

Switch S12 to LINEAR.
Set R4 to 0.
Adjust R11 for the desired center frequency.
Move R4 to its lowest position.
Set R10—through the front panel—for the desired low-frequency limit.
Move R4 to its upper position. Check for the desired high-frequency limits. Several readjustments of R10 and R11 may be necessary.
Adjust R9 to the extreme low-frequency end and then back off 3 turns.
Run R4 through its full travel.

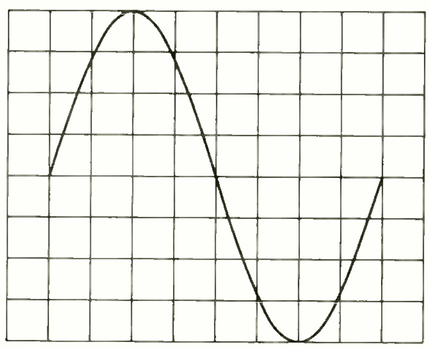


FIG. 17—SINE FUNCTION can be plotted on the CRT screen and used to adjust the sweep generator for minimum distortion.

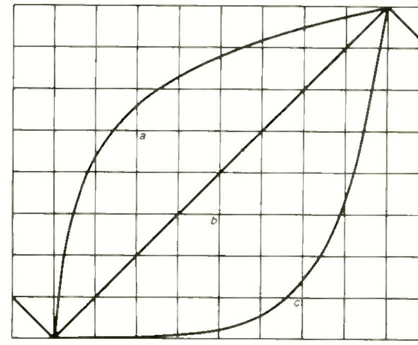


FIG. 18—CALIBRATION WAVEFORMS. Log function is shown in *a*, triangular wave is shown in *b* and antilog function is shown in *c*.

Watch the beam as it moves horizontally across the scope screen. Stop at each vertical centimeter division and note the frequency. A perfect log sweep will have the frequencies indicated in Table 1.

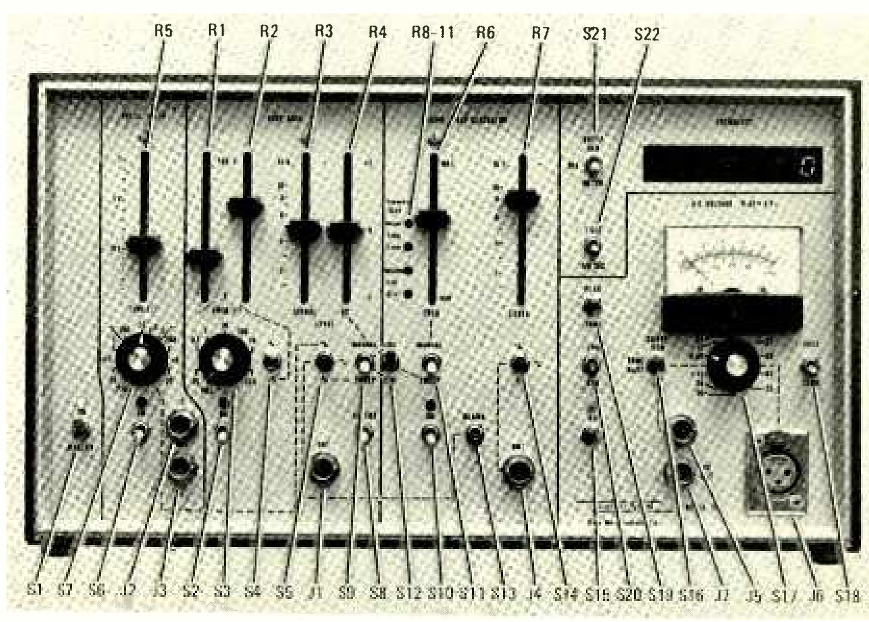
Adjust R401 and R403 for the best fit at the frequencies listed.

It is important to be able to occasionally look at the waveform at the output of

TABLE 1

cm	Hz
0	20
1	40
2	80
3	160
4	320
5	640
6	1280
7	2560
8	5120
9	10240
10	20480

IC501 as was done when the first approximate adjustments of R401 and R403 were made. This is because it is easy to grossly misadjust R401 and R403 and keeping an eye on the waveform at the



LOCATIONS AND DESIGNATIONS of the controls mounted on the front panel.

output of IC501 will make fine adjustments more precise.

With S9 on SWEEP, run R4 to its lowest position. Set the desired low-frequency end-point by adjusting R9.

Move R4 to its upper position and set the upper frequency end-point with R8.

Recheck the lower end-point.

Voltmeter adjustments

Start by calibrating the input attenuator.

Set S16 to TIMEBASE.

Set S3 to 1K.

Set S5 to SINEWAVE.

Set METER RANGE switch S17 to −24 dB.

Monitor the output of IC610 with the scope.

Set R4 to 0.

Set R3 to produce 3 to 4 volts peak at the output of IC610.

Move R1 through its full travel.

Adjust trimmer capacitor C604 for minimum deviation from the 1-kHz level.

Repeat the steps outlined above to adjust the appropriate compensating capacitors for the −12 through +24 dB positions of S17.

Apply a 1-kHz sinewave simultaneously to pins 2 and 3 of mike jack J6.

Set S17 to −72dB.

Monitor the output of IC610 while adjusting trimmer resistor R604 for minimum output. This adjusts the common-mode rejection for the mike preamp.

AC to DC converter

The following procedure is for setting up the AC-to-DC converters:

Set the METER RANGE switch (S17) to 0 dB.

Set S16 to TIMEBASE.

Adjust the timebase section for a 1-kHz 4-volt peak sinewave at the output of IC610.

Set S19 to PEAK.

Monitor the output of IC605 with the scope. It should display a full-wave rectified sinewave.

Adjust R620 for equal amplitude in both halves of the waveform.

Adjust R625 for approximately 4 volts peak.

Check to be sure that it is possible for each half of the waveform to reach at least 4 volts peak without clipping.

Increase the timebase frequency to 100 kHz while checking the rectified sinewave. Some degradation of the valleys is acceptable; however, the peaks should not be affected.

Reduce R3 to 0.

Adjust R622 for 0 volt at the output of IC609.

Adjust R3 so the output of IC609 is exactly 4 volts peak.

Adjust R625 so the output of IC609 is 4 volts DC.

Monitor the signal at the arm of S19.

Place S19 in the TRMS (true RMS).

The DC voltage should drop to approximately 2.8 volts. Now, reduce the timebase frequency to around 20 Hz.

With S18 in the FAST position, a definite droop should be noted when S19 is at PEAK. An approximately equal amount of ripple should be noted when S19 is set returned to TRMS.

Placing S18 in the SLOW position should significantly reduce both the droop and the ripple.

Log converter

The procedure for calibrating the log converter is as follows:

Set the timebase for a 1-kHz triangle waveform.

Set R3 for 4 volts P-P (peak to peak).

Set R4 to +2 volts. This will produce a triangle wave between 0 and 4 volts.

Set S16 to EXTERNAL with nothing connected to jack J5. There should be 0 volt at the output of S19.

Connect the output of J1 through a 10K resistor to the output end of R628, the input of IC607.

Set the scope timebase so that half of the triangle wave cuts diagonally across an 8 × 8 centimeter grid.

Monitor the output at J7. If possible, use a dual-trace scope so the input and output of the log converter can be observed simultaneously.

Plot an 8 × 8 centimeter log function on the face of the scope screen (see Fig. 18) or use the preplotted transparency mentioned earlier.

Adjust trimmer resistors R631, R633, R634 and R636 for the best fit of the output at J7 to the plotted log pattern.

Trimmer R631 adjusts the total range of the log function as evident by the sharpness of the knee. Trimmer R633 adjusts the DC offset so that a zero volt input produces a zero volt output. Trimmer R634 is used to adjust the overall gain so a 4-volt input produces a 4-volt output.

Remove the timebase signal and the 10K resistor.

Turn off the timebase generator.

Set S16 to SWEEP GEN.

Set S11 to MANUAL.

Set R6 to approximately 1 kHz.

Set S19 to PEAK.

Set S20 to LINEAR.

Set R7 for 8 volts P-P.

The signal at J7 should read 4 volts.

Set R7 for 0 volt.

The voltage at J7 should read 0.

Set S20 to LOG.

Adjust R633, if necessary, to keep the voltage reading at J7 at zero.

Switch S20 to LINEAR.

The output of J7 should be 4 volts. If it is not, touch up R634.

Adjust R635 for 100% meter deflection.

Well, that wraps up the calibration procedure. Next month we will conclude this series with some hints and application notes on using the Audio Test System. **R-E**

NEW TECHNICIANS ASSOCIATION

The Board of Directors of the new Electronics Technicians Association (ETA) has appointed Dick Glass of Indianapolis as President of the not-for-profit professional association. Dick Glass has been deeply involved in association activities in the consumer electronics field in the past, having served as Executive Vice President of NEA and NESDA; President of NEA three times; President of the Indianapolis Television Technicians Association; director of the Certified Electronics Technician program; Director of Training for the NEA/U.S. Labor Dept. Apprenticeship Training program in 1967-68; publisher of *ServiceShop* magazine; and an instructor in the PSM business management schools of NESDA.

Mr. Glass resigned from his position with NESDA in 1977 and has since operated his own service management consulting firm; authored numerous trade publication articles and has taught electronics technology at ITT Technical Institute.

DICK GLASS

Dick stated that ETA is a national association of electronics technicians. Membership is open to all of the technicians engaged in this profession.

Ron Crow, former ISCET executive, is a native of Iowa and now the chairman of the ETA division for educators: the Electronics Educators Association. He holds a BS degree from Iowa State University in Electrical Engineering. In addition to his work as executive director of ISCET from 1971 to 1978, he has worked at Gulliver's in Des Moines, Iowa, as a service technician; at G.E. in Utica, New York, and at St. Paul, Minnesota, as a design engineer. He is presently also an instructor and department head at Iowa State University. He is a member of the Iowa Association of Lifelong Learning. He is also co-author of the Howard W. Sams publication: "Study Guide for Associate CET Exams." **R-E**

HOW TO

Make Your Own PC Boards

Whether you design your own circuits and printed-circuit boards or fabricate the boards using patterns published in magazine articles, here are some hints that'll help with your next project.

JAMES E. TEMPLE

ARE YOU STILL BUILDING YOUR PROJECTS BY USING THE OLD rats-nest type of point-to-point wiring? Are you still reluctant to tackle construction projects when a commercial printed circuit board is not available? If the answer to both questions is yes, then you seem to lack the skill to make your own PC boards from scratch.

By now you have certainly discovered the method of photocopying directly from a magazine page, and transferring the foil pattern to the board. This method makes it easy to form your own boards for the project. It is an excellent method if you have the time and patience to use it but it only works if the projects you want to build are the ones from magazine articles. But what if you want to design your own projects, or add improvements to the preprinted foil patterns? If you don't know how to make your own PC boards or to lay out the PC board itself, you are limited.

Over the past several years, I have developed PC construction skills to make my own project boards. All my PC construction is accomplished on a one-to-one basis. That is, in most cases you will only require one or two printed circuit boards. You are probably not going to offer the boards for sale. What you're looking for is a reliable and sturdy base for your project, and if repairs are necessary, the circuit board will not fall apart. Besides if your pet project is a good one, you may want to write an article on it for publication. Submitting the project built around PC boards is far better than a point-to-point wiring method that is hard to copy and show in an article.

I want to emphasize that designing your own boards is not a difficult skill to master. And with a PC board, the project is reliable, repairs are easier to handle and tracing problems is much simpler too. If you've ever tried to troubleshoot a rats-nest project, you know this is in itself a major headache. After all, you must build it right the first time or you won't get it right at all. With PC boards, troubleshooting is easier, and you can make changes if the circuit requires it. Once you have developed board-making skills, photocopying methods are just a step away.

Printed circuit etchants

Perhaps one reason that many hobbyists do not attempt to make their own PC boards is because they are afraid of the etchant chemicals. Ferric chloride is the only safe etchant to use on the hobby level. It is a mild acid that works well on copper, but it can leave terrible stains if spilled onto the floor or on your clothes. The solution is to do your etching in a work area where it won't matter if a spill happens, and wear old clothes. Plus, make sure you read the instructions.

Important: Never use metal trays to do your etching in, particularly aluminum. Always use glass or heavy plastic etching trays. These specialty trays are not expensive. When you consider that many household chemicals (lye, cleaning solutions, etc.) must also be handled in a similar manner, the ferric chloride etchant is no more dangerous than any of them when treated properly. When small children are around, the chemicals should be locked up securely. The safe handling of any chemical results from understanding what the chemical is and how it is used.

When you work with ferric-chloride etchant (and stay away from others unless you know what you are doing) cover the floor with old newspapers. Keep a plastic pail filled with water nearby to wash off the PC board after etching is finished, and to wash out the etching trays. Immediately after etching a board, take the time to pour the etchant into a second plastic bottle. Do not mix the used and unused etchant. Clean and dry the etchant tray. Secure the chemicals and lock them up if necessary.

What about the disposal of the final used-up etchant? If you have copper pipes in your home, **do not dump them into the plumbing system.** Store the used-up etchant in an old plastic or glass container and check in your community for chemical disposal areas. If you must dispose of the etchant in your plumbing system, be sure to dilute the etchant extremely well. Several gallons of water to about a pint of etchant will dilute the etchant safely for disposal. Also, flush the pipe system with several gallons more of water. It is completely safe to dispose of etchant in this manner; the solution is extremely diluted and harmless to plumbing. Other than these two safety precautions, using, storing and disposing of the chemical should offer no problems.

Etch-resist lacquer paint and the lacquer remover (solvent) are the chemicals used to apply etch-resist to copper boards. Safety measures are the same as for any other type of solvent used around the house. Make sure your work area has adequate ventilation when finished boards are cleaned. And again store the solvent away where it is safe from small hands.

The chemicals used in photocopying your designs are a spray to sensitize the boards and the developing solutions. You must read the instructions for these materials. Spraying your own boards requires a dark, well-ventilated area. The fumes from these sensitizing sprays are about as heavy as any lacquer spray, and except for the odors of the fumes, there should be no unusual problems.

Commercial presensitized boards are available for photocopying techniques. Only glass or metal trays should be used with the developing solution for an exposed board. Other than working in a well-ventilated area, you should have no problems in handling the developers used in the process.

THE TYPE 650 PHOTO-ETCH KIT by Injectorall contains all materials needed to layout and etch boards up to 3 by 4 inches.

PRINTED-CIRCUIT KIT NO. 22-297, from GC Electronics is what you need to make PC boards using the negative method.

Basic tools

The first consideration in PC board techniques are the tools you will need for working quickly and accurately. A drill is required to drill the boards—not the ¼-inch handyman's type of drill but a quality hobby drill. The Dremel drill with its many accessories is the best. This drill has a built-in speed control. Low speeds are preferable when using quality carbide bits for drilling fine holes into the board. You should also consider purchasing only the better-quality accessories—cutters, buffers, reamers, etc. They pay for themselves over a period of time because you won't need to buy replacements as often. The Dremel line is excellent and readily available.

Carbide drill bits, rather than steel drill bits, are a better choice for doing PC work because they outlast steel bits. They have a higher initial cost, but really save money over a period of time. The best bit sizes are the No. 58 for holes to mount sockets into, and the No. 65 for direct-mounting and soldering DIP IC packages. Other sizes also come in handy: the 1/32 and the 1/16 are good to have.

The carbide bits tend to be brittle when compared with steel bits. So, do not use excessive pressure on the tool or bit when drilling the board. Let the bit do the work, making sure to guide it in a straight downward motion. I've used one bit for over several months, that translates into several thousand PC board holes. The bits do last if handled correctly. If you are not sure of your skill at first, perhaps you should use the steel bits until you develop confidence.

Steel bits don't break as readily as the carbide bits, but they do become dull quickly from the PC boards. A steel bit also leaves copper burrs that must be cleaned up before you can use the board. The rule here is to use the steel bits until you have developed the feel for board drilling. Then, switch to the carbide bits for future work. Dremel has a special chuck for the numbered drill bit sizes; make sure to obtain this chuck along with your drill.

You will find that some type of PC board magnification is useful when drilling or applying the etch resistant. Hobby magnifiers are readily available. There is a type of magnifier that is placed over the head similar to a pair of glasses. What appears as a very small hole to the naked eye becomes quite large when you use a hobby magnifier.

A good close light on the work area is needed when working with the head-type magnifiers. If your budget allows, obtain the type of fluorescent light fixture that has a built-in 4-inch-diameter magnifying surface. This is a standard fixture; art and hobby stores carry it, or you can buy it from Lafayette Stores. It represents an expense of about $50, but if you are serious about doing your own PC work, this type of hobby light cannot be measured in terms of dollars. For beginners, try the headset from Radio Shack (about $7), then consider a fluorescent magnifying light fixture at a future date. A magnifying type of hobby fixture does make a major difference in the long run.

Along with the hand hobby drill, the numbered bits and the magnifier as basic tools, you must consider your work surface for drilling the PC boards. I recommend using a 12-inch by 12-inch, tightly pressed cork board, about ⅜-inch thick. Lumber suppliers carry these boards. When drilling, place the PC board flat on the cork surface. When you drill through the PC board, the bit will not have a hard surface to come in contact with, and there is less chance of breaking the bit.

You should also have the ordinary hobby tools for your electronic work. A small vise, a hobby anvil, tack hammers, center punches, reamers, pliers, etc. Don't skimp on quality in the tools you collect.

An excellent addition to your tool collection is an *Xacto* knife set, usually sold with three holders and an assortment of knife blades. The No. 5 and No. 17 blades are handy for PC board work. There's also an *Xacto* hobby sawblade. This is a fine-toothed saw that cuts a 1/32-inch width and can be used to cut the PC boards apart. The *Xacto* hobby sand block also comes in handy for smoothing an edge of a board.

Art supplies

Once you have started your hobby tool collection, and have added the basic drill, bits, knives, and lighting instruments, you should give some thought to the art supplies that are needed.

Of course, the basic necessities are a drawing board and drafting instruments. Here's a tip that can save money and allows you to have an excellent drawing table. Let's assume that you do have a desk of some sort to hold your drawing supplies. This desk should be separate from your basic work area. It should have several drawers to hold your supplies. To this desk you can add your drawing board for all the schematics and logic diagrams you will be making. Consider a drawing board with a metal-edge guide, about 25 inches wide to 30 or 36 inches long. Costs will be around $20 to $25 for the drawing board.

Obtain a pair of hinges, not too large, with a removable type of pin. Insert the hinges into the bottom of the drawing board, and line them up with the edge of the desk. Screw the hinges into the desk edge. Taking out the hinge pins permits the drawing board to be removed from the desk surface. You can replace the board when you make your drawings. You can use a box beneath the back edge of the board to angle it to suit your needs. You have not only saved the costs of a separate drawing table and boards, you have created a convertible drawing table or desk work area.

In the area of drafting and art supplies, it is possible to skimp somewhat. A wooden T-square is just as good as a $15 steel one, and costs about $2. A drafting pencil costs about $2 and uses a fine .005-inch-thick lead. Why bother with standard wooden drawing pencils and sharpeners with a lead this fine? Angles, templates and other drafting tools can be standard, rather than fancy, instruments. Quality erasers should be used, and a brush is useful to clean up the work area.

If you are going to make ink drawings of your own positives or negatives for PC copy work, then get the best pens. *Pelikan* pen sets with various nibs are best, and can be used with a China-type of permanent ink. This China ink, by the way, adheres to plastic film and Mylar film; it is permanent and extremely dense.

You should also have quality bond paper and drawing paper. Layout bond paper is good and holds ink well. For fine layout work use vellum papers. A supply of clear plastic film is handy for overlays. On these clear films, the permanent-type marker pens work well, but I find the lines a little thick. Use various colors (red, black, green) for overlay work.

POSITIVE PHOTORESIST etched circuit kit, Vector Electronics 32XA-1, includes photo-sensitized copper-clad boards, artwork patterns and all other materials needed to make seven PC boards.

For those who want to specialize in photocopy work, Mylar film is the best-quality (albeit expensive) film to work with. Once the layout is placed on Mylar film, photocopies are easily obtained. To date I have used clear film, but I understand that the opaque film is invisible to a black ultraviolet light for copy work. Films with grid lines, with a 0.1-inch spacing, are available but costs are high.

Graph paper can be used for the initial layout; use 10 lines to the inch, and you will have a perfect layout for all the IC components for your board. Transferring this layout to a film overlay (if a two-sided board is contemplated) gives you a permanent basic drawing, with an overlay film for the top and bottom sides to check against your PC board lines.

I suggest that you visit a good art and drafting supply store and ask if they have inexpensive starter sets. If you do not have drafting experience, consider a do-it-yourself book on the subject. Try your hand at your own drawings. These drawing skills come naturally. Even the cavemen learned to draw; so can you. It's just a matter of doing it, and good materials can only help.

Drafting aids

Many manufacturers offer electronic drafting aids—from templates of symbols to IC pad layouts; these come in ×1, ×2 and ×4 sizes. For your hobby work, the ×1 size can be used. Direct drawings of a ×4 size are for military specifications but require photoreduction to a ×1 size; this is too costly for hobby work. Direct dry transfers from letters, numbers, electronic symbols, IC pads, etc., are also available.

Bishop Graphics is a major supplier of drawing and drafting aids. The Digi-Key Corporation catalog shows that there are over 16,000 different Bishop Drafting supplies. The 14-lead and 16-lead IC pads are a handy item, but they tend to be expensive if a lot of IC pads are needed in the layout drawing. The 0.10 lines of a draftsman ruler provide the centers of the IC leads, and you can draw the IC pads directly. A ×1 template does provide the pad for copying directly to the drawing, but a fine-lead pencil must be used to draw the lines.

As for the supplies needed for the actual PC board itself, a good etch-resist lacquer is important. The Radio Shack resist lacquer is good, but you may have to thin it out with some solvent. Use a fine artist's brush—the 00000 size for very fine lines and a 000 brush for general PC lines. When these brushes are used with the lacquer resist, they will wear out, so have several on hand; lacquer is rough on the bristles. Also brushes as fine as this do not hold a great deal of resist on them, and a line of about ½ inch is usually the longest line you can draw directly. A 2-inch-long line will then be applied in four strokes. Merely drawing a pencil guideline also helps.

When you consider any PC board layout, you will note that most of the lines are straight and very few curves are involved. The IC DIP packages permit a layout using straight lines, which are merely the connecting lines between the various IC pads. By getting the feel of the brush and the resist lacquer and applying the resist in short strokes, any size line can be made. Remember, you have laid out the interconnecting lines on paper, and you are only copying these lines on the PC board by using the resist paint. This is why a film overlay comes in handy—to check on the line drawings made on the copper board.

Using a brush and resist paint is not the only way that you can draw in the pads and the lines. Bishop Graphics also offers direct transfer of etch-resist pads, plus a fine line that comes in tape form. It is applied between the contact points, cut and pressed firmly to the board. These direct resist-material transfers are fine for a one-shot PC board but are not reusable. They are not expensive to use, but some skill should be developed in handling them. The trick is to have a dry, clean copper PC board. If the material does not stick firmly to the board, it is useless.

Radio Shack has a resist-type of pen that can apply a fine line to the copper PC board. In a pinch you can use a black pen to make the resist line to the board, but I find these lines tend to undercut. Of all three methods for direct transfer to a PC board, I recommend using the brush and resist method.

The brush and resist method allows you to apply very fine lines to the PC boards. If a line is too thick, you can easily thin it down by cutting the dried lacquer paint with an *Xacto* knife blade. Lines as thin as 1/64 hold up well in the etchant, and undercutting of these lines has been minimal for me.

The whole point of the PC board method you choose is that the lines on the copper board must resist the etchant and not be undercut or etched away during the time that the board is exposed to the ferric-chloride etchant. If the etch-resist is not holding up to the etching of the board and the foil is being etched away under the resist material, you must develop another method or perfect the one you have chosen to work with.

From the drawing stage to the laying-in of the PC board resist material to the finished board, you should encounter no major problems once you have practiced your skills. And as soon as you have mastered these skills, you should be able to make circuits of any size or complexity. By starting small, making small circuit boards and adding to your skills, you can master the methods you have chosen. I use the brush and resist direct-application method, but it took a period of time to master. I will try to pass on some of the techniques and time savers I use in future article but the skills you will have to master yourself. You can do it! **R-E** conductor (see Fig. 1). This can be represented as the circuit shown in Fig. 2, with the heat source as a voltage generator, and the temperature probe as a high-impedance voltmeter.

The substrate on which the semiconductor is mounted is a good insulator and is represented by a high resistance. Heat losses through radiation from the enclosure are represented by a resistance, and the heat capacitance of the enclosure by a capacitor. The temperature probe has similar losses; the object is to reduce these losses to a minimum. Figure 1 also shows the design of a typical probe, with a temperature element mounted in a metal tip, isolated thermally from the rest of the probe.

Again there are heat capacitance and resistive heat losses, and a resistance attributable to the temperature gradient across the tip. One further problem is trying to make a good thermal contact with the object being measured, so contact resistance also has to be noted.

An efficient design

The design of a probe has to take all these points into account. The probe tip must be as small as possible to reduce heat resistance and capacitance to a minimum, and it must be well insulated from the rest of the probe, to reduce heat losses. The probe wires should be good conductors, and very thin to prevent internal heat losses.

The response time of a probe is usually specified as the time taken to reach 66% of the measured temperature—typical figures would be 5 to 20 seconds. A more useful figure is the time taken to reach 99% of the final temperature, which for digital instruments should be fast, and should be less than 10 seconds, or better than 1 second for 66%.

To get this speed there must be low contact resistance between probe and object, low probe-tip heat capacitance, minimum tip volume, low connection resistance between tip surface and the temperature element, low capacitance of the temperature element, and the insulation between tip and probe must be very good to avoid heat leakage. In other words the requirements for good temperature reproduction and fast response are similar.

AN ACCURATE TEMPERATURE CHECK is necessary when servicing household appliances such as a clothes dryer

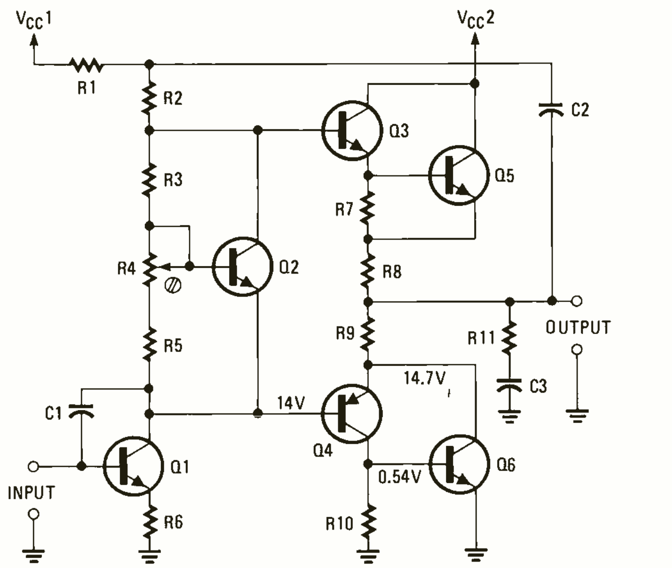


FIG. 3—TEMPERATURE PROBES can locate the area of a fault in a circuit, but other measurements are then necessary to pinpoint the malfunctioning component.

An example of an instrument that meets these requirements is a digital multimeter from Philips—the *model PM 2513*—which includes a temperature measuring facility that checks temperatures from −60 to +200 degrees Celsius. High accuracy and the advantages of custom design in the LSI circuits have meant that modern digital multimeters have a place in engineering circles similar to that of an electronic calculator in general use.

The LSI circuitry in the multimeter controls both the analog-to-digital conversion and the numeric display, as well as being able to measure current. voltage and resistance. The temperature sensor in the probe is a resistive element varying in value from approximately 27 ohms at −60°C to approximately 62 ohms at +200°C.

Temperature checking

Temperature checking is necessary in general servicing for any appliance where temperature is a target—high or low. Freezers, refrigerators, air conditioning, washing machines and dishwashers all need temperature regulation. In more general electrical servicing fields, temperature checks are necessary on motors, bearings and power switch contacts to locate problems before they become serious—thus insuring long life.

A design and service tool

Many equipment faults are due to overheating. An amplifier producing 1 watt of useful power consumes several watts. This extra power has to be dissipated as heat. Most components have a limited temperature range, so temperature checking is essential to locate and remove unwanted hot spots. Some form of temperature measurement is essential in the design stage, to insure the correct rating of components, heat sinks and ventilation.

Temperature measurement is also useful in servicing, as mentioned earlier. But in this case the temperature information is indirect. A component overheating—be it transistor, resistor, or any other circuit element—is not always a direct indication of which component is at fault.

Take the amplifier circuit in Fig. 3. The correct bias voltages for transistor Q4 are as shown. Any variations in the bias voltages can lead to overheating, but the cause could be anything from a simple fault in the transistor, through a fault in resistors R8, R9 or R10, to faults in components Q1, Q2 or Q3.

The temperature probe will locate only the area of the fault. Measurements of voltage levels, current and resistance are then necessary for accurate fault location. The combination of temperature measurement and the other functions of a normal multimeter make the *model PM 2513* a flexible tool. **R-E**

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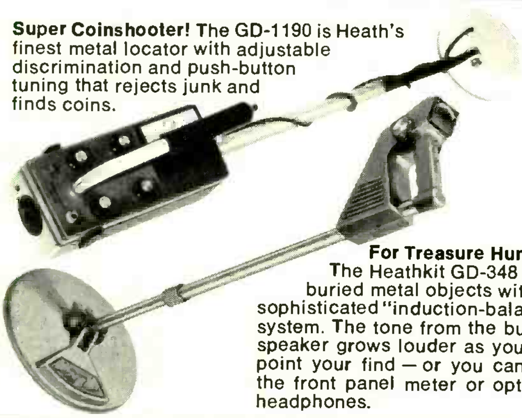

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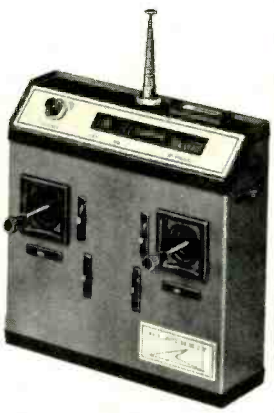

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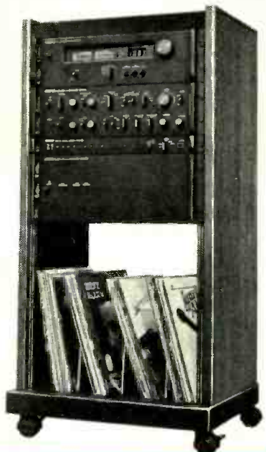

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service clinic

Be aware of intermittents: they can cause some strange symptoms.

JACK DARR, SERVICE EDITOR

EVER SINCE TECHNICIANS GOT INTO THE service business they have been plagued by problems. Probably the most annoying is the intermittent. Anyone who claims never to have had any trouble with an intermittent just opened the shop that morning and hasn't had any business yet!

Over the years, I have tried to find and identify as many types of intermittents as possible (via reports from the field), and bring them to your attention. As we all know, there are quite a few of them that are chronic. This means that the same symptom shows up in several chassis of a given make and model. And I'm sure you can all think of some dandy examples.

I've just heard of a new one that sounds very interesting. A friend and fellow technician, Leon Caldwell (Caldwell TV, Mena, AR) found the identical problem in three sets of the same make and model. We therefore felt justified in calling the trouble chronic! (And since this article was written, Leon has found a fourth set.)

Troubles

The symptom is a bright horizontal line in the raster, about one-third of the way down from the top of the screen. This results from several scanning lines being piled on top of each other; there is a blank space above and below the bright line.

On set No. 1, my friend tried replacing the vertical IC—IC302. This "fixed" it. Back in the shop, he found another set (set No. 2) with the same problem. He tried putting in the IC he had taken out of set No. 1, and it worked! On set No. 3, the next day, because he was getting suspicious he simply pulled IC302 out of the socket and pushed it back. This cleared up the problem.

Further investigation on set No. 3 showed that moving the convergence plug/socket would cause the symptom to appear and disappear, as would pushing on the PC board. When he took the chassis out, he saw quite a few suspicious-looking solder joints. Repairing all these joints cleared up the problem. Back at the shop again, the set No. 2 chassis was pulled to reveal the same problem.

There seemed to be enough solder on the joints. In some cases, the component leads hadn't been pushed far enough through the board to make a good joint. A (voluntary) callback to set No. 1 revealed the same problem, which was "redone."

According to my friend Leon, the worst offenders are the four long rectangular ground lances going through the PC board on the right-hand side (from the top). The foil used on these boards is quite thin and the board is flexible. Pushing and pulling on the board showed up more bad joints. We decided that the reason for the reaction in set No. 1 was that pulling IC302 out of the socket and putting it back had exerted enough pressure on the board to "make" some of the bad joints (at least temporarily).

The sets described here are Wards Airlines, chassis Nos. GGY-16218A, GGY-16218B and GGY-16231A and B. They are stamped or labelled "Made in Juarez, Mexico." If you experience this problem or any others in any of these chassis, it would be a good idea to examine all the solder joints on the underside of the board, especially around those ground lances.

Not long ago, I received a letter asking about a completely unknown TV set, manufactured in Singapore or somewhere in the Far East. This set was sold by a New Orleans discount distributor. No data could be located on it at all. Several months later, the technician wrote saying, "I got tired looking at the thing on my bench and jerked it out of the cabinet. Looking it over, there were bad solder joints all over the place! So many that I kept track; finally remade 47 of them! Now the blankety-blank thing is working!" A warning note on this appeared in "Reader Questions" a while ago, but repetition never hurts.

Another difficulty that turns up regularly is contact problems in modular sets. If this happens, make sure to check *all contacts* on the module involved. Try taking the module out and putting it back. If doing this clears up your symptom or changes the symptoms at all, check those contacts. Clean and tighten all contact springs, etc. If you suspect a certain module and replacing the module clears up the trouble, always try putting the old one back and see what happens. I believe this is why factory service people complain that technicians are sending back perfectly good modules!

One manufacturer (whose name I've forgotten, luckily) sent out a bulletin on a certain chassis with a contact problem. The recommended fix was to *solder* that contact!

I hope that this will help somewhat in alerting you to some of these problems so that you can do something about it. Knowing these things can save both you and your customers money. **R-E**

service questions

ERRATIC SYNC

The syncs were quite erratic in this GE CD chassis. It looked like a defective sync separator was causing the problem. When the picture locked in, there was a slight shift to the right in sync. After some checking, the 39K resistor R251 was found to have greatly increased in value. This reduced the amplitude of the horizontal-sync pulse to the AFC unit. This in turn caused sync and AGC problems.

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

CORRECTION NOTED

I recently wrote J. G. of Tucson, AZ, that I couldn't find a substitute for Ambassador flyback No. A-29056-A. At the time, this was correct.

Mr. William J. Utterbach, Cupertino, CA, sent me a Thordarson flyer, in which the A-29056-A Ambassador flyback is listed as a FLY-265 Thordarson. Thanks very much; I am always happy to be corrected in cases like this.

LOW DC VOLTAGES

The DC voltages in this Magnavox model T991 are all very low, except for the +150-volt source. Is this a scan-derived DC power supply? There's no picture and no sound.—J. R., Detroit, MI.

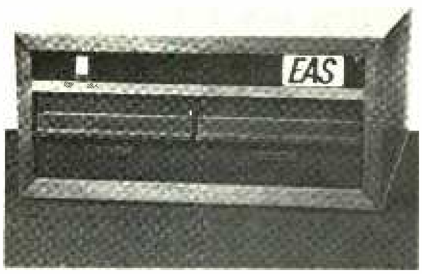
The DC power supply on this set *does* use scan-derived voltages. From the readings you're getting it seems that the hori-

continued on page 84

computer products

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

DISC DRIVE SYSTEM is a dual-drive floppy-disc system that comes assembled and is S-100, Z-80, 8080 and IBM-compatible. System consists of



CIRCLE 121 ON FREE INFORMATION CARD

two 8-inch drives; a Tarbell controller with 4-drive capability and on-board PROM bootstrap loader for *CP/M* assembler; power supply; interface; cables; and cooling fan. The drives offer full 250K-byte storage-per-drive, 3.3K bytes-per-track, 8-ms track-to-track access time and 211-ms average access time. Recommended for use with DOS *CP/M* assembler, text editor and debugger. System sells for $1995.—**Electro Analytic Systems, Inc.,** Box 102, Ledgewood, NJ 07852.

S-100 BUS ADAPTER/MOTHERBOARD, *model 8100,* is available as a kit or assembled, and allows interfacing S-100 based devices to a TRS-80 computer to provide memory expansion and extended I/O capabilities. Built-in 6-slot motherboard can be set on a tabletop and is connected to the TRS-80 via a ribbon cable; optional on-board support circuitry and sockets are available for 16K dynamic RAM. Also available are optional on-board I/O interfaces for serial and parallel I/O; serial interface provides RS232 or 20-mA current loop with software-programmable baud rate, model control lines, word length, stop bits, etc., to on-board D8-25 connector. Jumpers can be used to drive printers or to interface to larger computers or modems. The board contains 2

CIRCLE 122 ON FREE INFORMATION CARD

latched 8-bit parallel input and output ports with standard 22/44 pin-edge connector. Prices: basic unit including S-100 bus interface and edge connector/card guide, manual, cable—$185, kit; $245, assembled; other connectors and card guides $45, kit; $75 assembled; RAM support option, $45, kit; $75, assembled; I/O option, $85, kit; $115, assembled.—**HUH Electronics,** 1429 Maple St., San Mateo, CA 94402. **R-E**

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With System X-10 at your side, you can operate almost every light and electrical appliance in your home without leaving the comfort of your easy chair. Imagine turning on a TV set or stereo; even dimming a light in the next room without moving from your chair.

It may sound like one of those electronic devices found in a spy thriller, but you can have one today.

And how many times have you left a light or an electrical appliance on overnight simply because you were too tired or too lazy to turn it off? Think of the money you can save on electric bills with System X-10. Turn off heaters or appliances from any location in your home without a lot of running around.

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Each module will control any incandescent lamp rated up to 300 watts from control signals received from the Command Console. Functions include on and off, brighten and dim. UL listed.

APPLIANCE MODULE

Each module receives signals from the Command Console to turn appliances on and off; such as TV, stereo, fan, etc. Maximum appliance ratings: Resistive load—15 amps., Motor load—1/3 HP, Incandescent Lamp—500 wats. UL listed.

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new products

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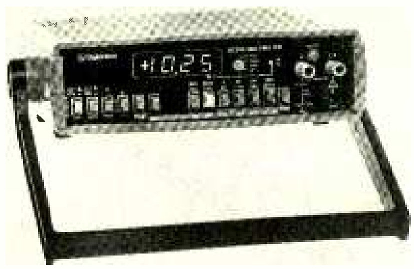
DIGITAL MULTIMETER, *model 3030A*, is a 7-function, 3½-digit instrument that offers true RMS response over a 20-Hz–50-kHz bandwidth, plus 10-milliohm, 10-mV and 10-nA resolution. The unit measures AC/DC voltages from 20 mV to 1200 volts; AC/DC current from 20 μA to 2 A; resistance from 20 ohms to 20 megohms; and has a 60-dB level range. Features include EMI shielding, ohmmeter circuit functions on all ranges; front-panel zero-adjust control; and bright orange 0.43-inch LED display. All ranges are overload-protected. An optional rechargeable battery pack is available; other options include 100/120/220/240-volt operation and BCD output, probes, carrying case and rack-mounting. The *model 303A* comes in a rugged plastic case, weighs 3 lb., 8 oz., measures 8⅛ W × 8¹¹⁄₁₆ D × 2⅜-inches H. Prices: *model 3030A*, $365; battery pack, $45.—**Ballantine Laboratories, Inc.**, Box 97, Boonton, NJ 07005.



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MULTIPLE-OUTPUT POWER SUPPLY, *model 1650*, is designed for solid-state equipment, and provides three isolated outputs: 5 VDC, 5A, and two 25 VDC (A and B supplies) at 0.5A. Automatic-tracking feature controls supply B when supply A output is varied; is PWM-controlled via an opto-isolator. Other features include automatic current limiting and complete overload protection on all ranges and outputs. Suggested retail price: $275.—**B&K-PRECISION,** Dynascan Corp., 6460 W. Cortland St., Chicago, IL 60635.

CIRCLE 152 ON FREE INFORMATION CARD

ELECTRONIC IGNITION SYSTEM, *Mark 10 model Z*, is designed specifically for 4-cycle engines and provides a capacitive discharge pulse both in front of and in addition to regular spark pulse. Reduces need for tuneups, improves spark-plug life, acceleration and idle. Weather-, shock- and vibration-proof, the completely assembled *model Z* installs easily. Price: $69.95.—**Delta Products, Inc.**, Box 1147, Grand Junction, CO 81501.

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NYLON TIE & WIRE CONNECTORS, *"E" Pak Merchandiser*, is an assortment of nylon ties and wire connectors packed in see-through bags and mounted on a 24 × 28-inch panel. Display contains 5 packs each of 4 nylon-tie sizes, reusable ties, two assortment packs, and 5 each of 3 sizes of wire connectors, color-coded for size. Stock numbers are listed on the back of each pack.—**Vaco Products Co.**, 1510 Skokie Blvd., Northbrook, IL 60062. **R-E**

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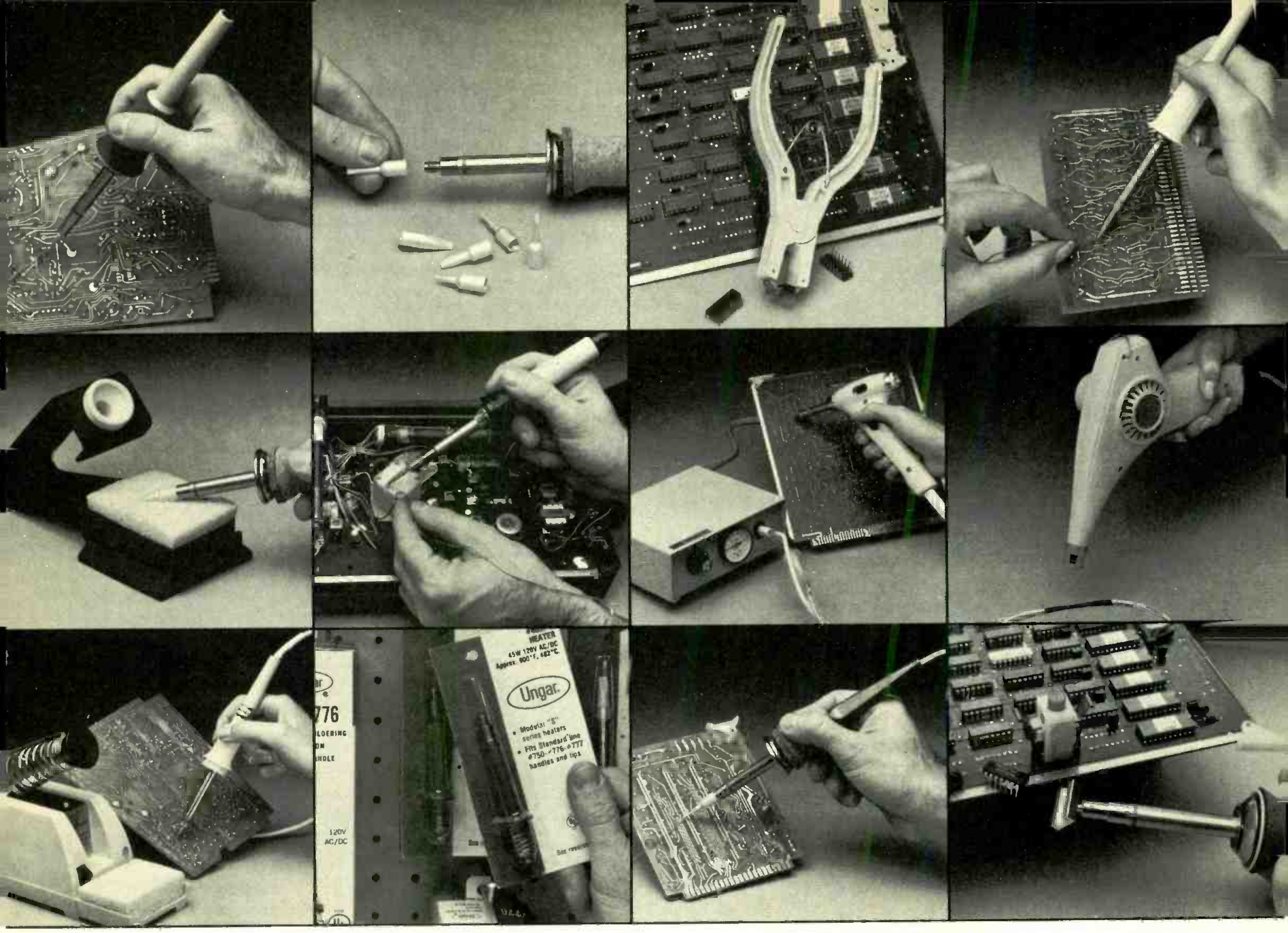

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STATE OF SOLID STATE
continued from page 68

changes, each comparator responds and produces an output signal indicating whether that particular voltage sample is above or below its respective reference voltage. The 255 comparators produce a unique digital 255-bit output word corresponding to each of the possible 256 input levels. For example, when the input voltage is at −1 volt, midway in the input range, the top 128 comparators are switched off and the lower ones are switched on, producing a code of 128 zeroes and 127 ones. This coded information is compacted into an 8-bit word by the 255-to-8-bit encoder. Reduction of the digital word length is possible since 256 (2^8) levels can be completely distinguished by 8 bits.

The TDC1007J digitizes an analog signal at clock rates from DC to 30 megasamples-per-second (MSPS). It accurately samples signals up to 7 MHz without an external sample-and-hold amplifier. The comparator 3-dB bandwidth is 40 MHz. The system clock is applied to the convert strobe terminal and samples the input during positive clock transitions. Two additional control leads, NMINV and NLINV, permit the selection of binary, complemented binary, offset 2's complement and inverted 2's complement.

The maximum input capacitance of the converter is 300 pF, which although it is similar to that provided by 75-ohm coaxial cable, should be driven from a low-impedance source follower because of the capacitance's nonlinearity and DC bias. Both ends of the reference-voltage divider are brought out to pins to give you a choice of operating level. It is possible to run the converter with less than 1 volt across the divider, but some performance specifications may be degraded as a result. Reference voltages V_{RT} and V_{RB} are selected to set the first and 255th threshold levels. Center tap resistor R_T is provided so that the upper or lower divider half can be trimmed with an external resistor to permit linearity compensation for the extended-temperature version. Compensation is not necessary over the 0 to 70°C temperature range.

The TDC1007PCB video A/D converter edge-connected evaluation board is designed for easy set-up and hands-on experience. Included with the board are the TDC1007J A/D converter IC, voltage regulators and an analog input buffer amplifier with a gain of −2 and a 1000-ohm input impedance. The evaluation board accepts and digitizes a 1-volt, peak-to-peak, 75-ohm signal. Complete layouts and schematic diagrams are given in the preliminary data sheet.

The TDC1007J is packaged in a 64-pin DIP rated for 2 watts power dissipation. For information, write TRW LSI Products, P.O. Box 1125, Redondo Beach, CA 90278. **R-E**

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HEART RATE MONITOR

continued from page 38

convenient means of grounding your finger to circuit ground. This is accomplished by connecting a short, bare wire to pins 2 and 4, bending it around and pushing it into the conductive foam after it has been glued to the perforated board. This ground connection will considerably reduce the capacitive coupling of AC hum into the sensor assembly. Now attach some self-stick *Velcro* material as shown in Fig. 7 with silicone adhesive and allow to dry thoroughly.

If you use a 4$\frac{1}{4}$-inch meter as suggested, the meter overlay (Fig. 8) can be cut out and glued with rubber cement to the face of the meter. This will result in a neat, professional-appearing project. Use extreme care when disassembling the meter to prevent damage to the delicate meter movement and needle.

In the prototype Cardiotach, the on/off indicator LED, D7, was not used; this LED is optional and can be omitted if you wish. If the LED is not used, eliminate R34 from the PC board.

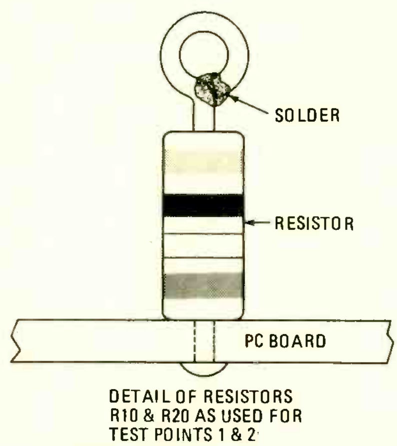


FIG. 9—TEST POINTS consist of 10-ohm, $\frac{1}{2}$-watt resistors soldered upright on the board.

(An experienced builder **NEVER** marks or covers a meter scale. Instead, he turns the dial plate over and cements the new scale on the back.—*Editor*)

Resistors R10 and R20 are end-mounted, $\frac{1}{2}$-watt resistors at test points 1 and 2. Cut the lead on one end of each resistor to $\frac{1}{2}$ inch and form it into a loop, then solder the other end of the resistor snugly against the PC board as in Fig. 9. Any low-value resistor can be used or even a piece of bare wire; however, a resistor tends to be a sturdier test point.

Resistor R37 was added after the PC board was designed. You will have to break the foil between the +12V supply and trimmer R24 to add the resistor. You can omit R37, but then it becomes a little tricky to adjust R24 properly.

A DPDT switch and calibration resistor could be added to the meter to connect it to test point 2 during calibration. This would eliminate the need for a separate meter during calibration. An 18K resistor, plus the internal meter resistance, would roughly allow the meter to read 2 volts full scale. Using an additional meter, you could determine where to place the calibration mark on the meter face.

After assembly is complete and all connections are carefully checked, the unit can be calibrated.

Calibration and check-out

With the cover off, apply power to the Cardiotach, but don't plug in the sensor assembly. Place switch S3 in the calibrate position. LED1 should start flashing, and the beep tone should be heard if it is turned on. Connect a voltmeter to TP2 and adjust R16 to exactly 1.5 volts DC. The filtering action of IC4-a will slow down the action of R16. Adjust the control a little at a time and wait for the meter to reach its final value before readjusting the control. Now adjust R24 so that the meter reads 90 BPM. The Cardiotach is now calibrated. Set S3 back into the operate position and plug in the sensor assembly.

Attach the sensor to your index or middle finger, placing it against the finger pad, and wrap the self-stick straps around your finger moderately tightly. Your finger should not feel uncomfortable or cold due to excessive tightness, nor should the sensor be loose enough to slip around. Adjust the sensitivity control upward from the minimum until the LED starts flashing and beep tones are heard, then set the control a little beyond that point. After from four to six heartbeats, the meter should begin to move upward. It will overshoot, then settle back down to the correct measurement. Double triggering, and the resulting high meter reading, is usually caused by the excessive gain that results from an improperly set sensitivity control and from 60-Hz hum. If the sensitivity control doesn't seem to be causing the problem, shield the sensor from any direct AC-operated light source. Multiple triggering can also result if the power supply goes out of regulation. This can be caused by an underrated transformer or too much beep-tone volume. The beep tone is intended to be low in volume so it won't be obtrusive. Changing the value of R31 for higher volume may result in too much current drain from the +12V supply and feedback into the rest of the circuitry.

Some people with chronically cold, dry fingers may have difficulty using the Cardiotach. In these cases the sensor can be used on the earlobe, or on the back of the hand, arm or other surface that has better circulation. Adhesive tape can be used to hold the sensor in place.

One final word. The Cardiotach is a useful instrument for biofeedback and simple heart-rate monitoring. It is *NOT* a diagnostic device, nor is it designed to effect any cures. Medical problems are best left to the professionals. **R-E**

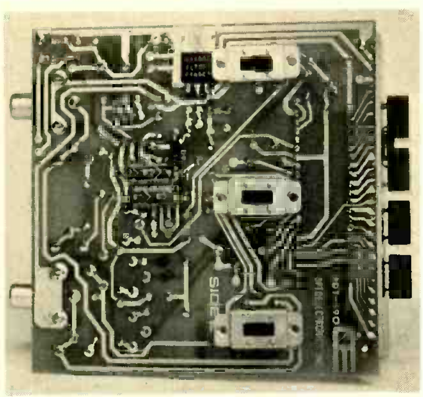
DIGITAL THERMOMETER

Continued from page 46

boiling point. This method of equalizing the error over the temperature range is sometimes referred to as "splitting the rock."

Place both sensors in a pot of mineral-free water (distilled if necessary), and after it is freely boiling, adjust R16 for Sensor A and R20 for Sensor B for 100.0°C. (R14 and R18 should be set at mid-range.) If you are very far above sea level, then it may be necessary to make an altitude correction.

For the freezing point of water, mix crushed ice with an equal amount of cold water. Stir the mixture for several minutes; you should observe the temperature reach a low point and stabilize for several minutes when equilibrium is reached. If it measures right on 0.0°C, then you are finished with calibration. If the temperature is below 0.0°C, then adjust trimmers R16 and R20 until the amount of error is reduced by a half—"splitting the rock."



SWITCHES are mounted on Side 2 of the PC board and protrude through top of the case.

Next, place the sensors in tap water and allow them to come to equilibrium at room temperature. Use the conversion equations and calculate the Fahrenheit temperature from the indicated Celsius temperature. Adjust R14 and R18 for the correct Fahrenheit temperature.

Figure 12 shows the sensor linearity error over several different temperature spans. In order to achieve these accuracies over reduced spans, an accurate thermometer with 0.1°C resolution must be used to calibrate the sensors at each end of the selected span. An accurate clinical thermometer can be used over the clinical range; however, note that it tends to integrate the temperature from the tissue with which it is in contact along its length, while the AD590K measures the temperature of the point it contacts.

Accurate glass thermometers with 0.1° resolution are available from most laboratory supply distributors for under $25; however, they are very fragile and require that a specific length of thermometer be immersed for accurate measurements. The glass thermometer should be used in a well-stirred water bath in order to calibrate the sensor probes. **R-E**

SERVICE QUESTIONS

continued from page 74

zontal *oscillator* is not running, which means no DC voltages can be developed. There's a starter circuit in this oscillator that applies a DC pulse on the oscillator until it starts.

In this chassis, the circuit is in the +159-volt line (activated when the switch is turned on) which is dropped through the 12K resistor, R229, to pin 10 of the horizontal module. This voltage feeds the oscillator. When the oscillator starts, diode D1, connected to the +24-volt line from the scan-derived supply, is reverse-biased. The oscillator is fed from the flyback circuit, just as soon as it conducts. Check all components in this area, as well as the oscillator itself, which could be bad.

MORE DOUBLE TROUBLE

I enjoyed the "Double-Trouble" story in the July 1978 Service Clinic.

I had a similar problem a long time ago on a 1960 Zenith black-and-white set. The customer complaint was there was no video, no sound. The B+ line and high voltage are both OK. There was a 2.0-volt signal at the video detector test point. A signal on the video-amplifier grid; nothing on the plate. Hmm . . . there was no DC voltage on video-amplifier screen. The B+ was good; so was the dropping resistor (but hot). The screen read ground. I clipped the connections but it still read ground on the lead from the dropping resistor.

Finally, I traced this to one stud on a terminal strip (the kind of strip with the studs on top of the chasis). I looked on top of the chassis and . . . someone had dropped a ring into the set. It had hit the terminal strip and the B+ line had welded it to ground. So I removed the ring; the set now plays!

DC VOLTAGE PROBLEMS

I have an Admiral T3L6 chassis with a blown fuse. When I changed the fuse, I got +159 volts but none of the other DC voltages. I do not know where to go from here.—T. T., Brooklyn, NY.

Go to the horizontal-output stage. All the low DC voltages in this chassis are developed by rectifying pulses from the flyback. Check the horizontal-output and oscillator/driver transistors, and all the diodes connected to the flybacks for shorts. This set may have been hit by lightning. Check it over carefully for signs of other damage, such as blown resistors or PC conductors.

HEIGHT/LINEARITY PROBLEM

I'm losing about an inch of raster from the top and bottom on this Admiral model 6K1668-3. I thought this would be easy. But, after checking the circuit thoroughly and finding all OK, I'm not so sure any more! The cathode and grid voltages are slightly off. There must be something I'm missing! What is it?—E. D., Tappan, NY.

In a typical vertical output tube circuit for many color sets, there is a little 50-μF electrolytic capacitor in the output stage cathode. If it goes bad it can cause all different kinds of trouble.

The big headache is that in this chassis the capacitor itself is not *on* the chassis, it's over on the convergence board! Because even the schematic shows it's apparently not there, we overlook it. As this capacitor seems to be the only component you *haven't* changed, try testing it.

OHMMETER CAN TEST SCR'S

Several readers have written to ask if an SCR can be tested with an ohmmeter the same way that transistors can. Trying this test out showed that you can use an ohmmeter, at least with smaller SCR's. First, measure the SCR from the anode to the cathode. This should show an open circuit in both directions. Now, connect the positive lead of the ohmmeter to the anode and short the gate terminal to the anode (where the positive lead is located) This should turn the SCR on. The larger SCR's won't latch on but will conduct (either polarity) when the gate is shorted to the anode.

You can definitely check SCR's for shorts, just as you'd check a diode. **R-E**

new lit

More information on new lit is available from the manufacturers of items identified by a Free Information number. Use the Free Information Card inside the back cover of this issue.

COMPUTER GUIDE, *Getting Started with Computers,* lists 25 resources, books and periodicals to help the personal computer owner learn about his system. It is designed for the novice as well as experienced programmers and electronics engineers, with separate sections devoted to each level of proficiency. The booklet also includes an up-to-date buyers guide, and surveys and recommends computer systems tailored to individual needs.—**NCE/CompuMart, Inc.,** P.O. Box 8610, Ann Arbor, MI 48107.

CIRCLE 141 ON FREE INFORMATION CARD

ELECTRONIC PRODUCTS CATALOG contains 48 pages of new and useful electronic products, components and equipment, all at bargain prices. Includes such items as special phone equipment, a laminating machine, a digital clock, a solid-state color TV chassis, a radar detector, plus hundreds of other discounted items. The catalog features a special 16-page insert offering quantity discounts to and volume users.—**ETCO Electronics Corp.,** Dept. 077, North Country Shopping Center, Plattsburgh, NY 12901.

CIRCLE 142 ON FREE INFORMATION CARD

TOOLS & HARDWARE CATALOG, *Catalog 179,* contains 196 pages of hand and power tools for the hobbyist and technician. Also included among the items listed are voltmeters, radar detectors, wire and cable strippers, TV antennas, CB radios and accessories, telephone amplifiers, and many, many more. Order form and handy index are included. $1 refundable with first order.—**U.S. General Supply Corp.,** Dept. R.E., 100 General Place, Jericho, NY 17753.

DIGITAL STORAGE SCOPES, *Bulletin 449-5,* contains 6 illustrated pages covering two dual-trace oscilloscopes providing infinite storage time. The *model OS4000* is a 10-MHz dual-trace scope; the *model OS41000* offers X-Y capability. Complete specs are given.—**Gould, Inc.,** Instruments Div., 3631 Perkins Ave., Cleveland, OH 44114.

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ELECTRONIC PRODUCTS BROCHURE, *1979 Distributor Short Form Catalog,* contains 12 pages summarizing technical specs and order information for resistor networks, trimmer pots, turns-counting dials, LCD's and planar gas discharge displays. Complete list of manufacturer's distributors is included.—**Beckman Instruments, Inc.,** Technical Information Dept., 2500 Harbor Blvd., Fullerton, CA 92634.

CIRCLE 144 ON FREE INFORMATION CARD

MICROCOMPUTER BOOK CATALOG lists 150 books designed to help users understand and operate their personal computer systems, and includes material geared to both the neophyte and the experienced computer operator.—**BITS, INC.,** Dept. 41, 25 Route 101 West, Peterborough, NH 03458. **R-E**

CIRCLE 145 ON FREE INFORMATION CARD

VIDEODISC
continued from page 41

Fig. 9. The signal from the VHF modulator rides a 10 VDC level. When the player is switched on, the 10 VDC appears and switches on diode D1 through R1. The signal is thus coupled through C2 and the balun to the TV set's antenna terminal of the TV.

In addition, relay K1 is energized and the normally closed contacts are held open, thereby disconnecting the external VHF antenna. When the player is off, the 10 VDC is absent, K1 is de-energized and its contacts close. The external VHF antenna

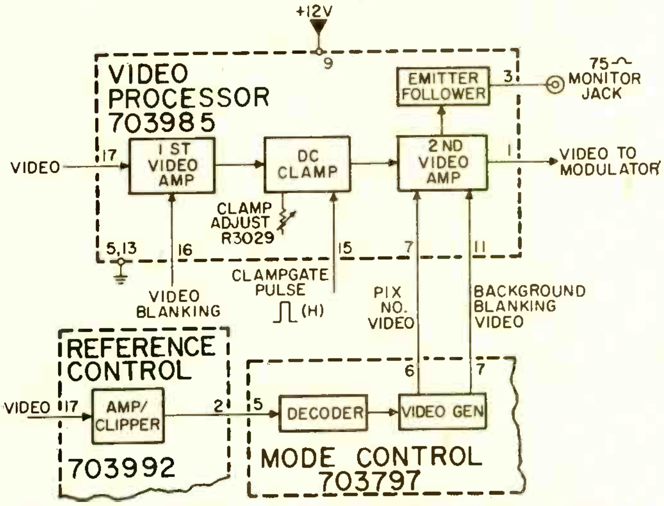

FIG. 7—COMPOSITE VIDEO SIGNAL PROCESSING CIRCUIT is made up of a video processor, mode control and reference control modules.

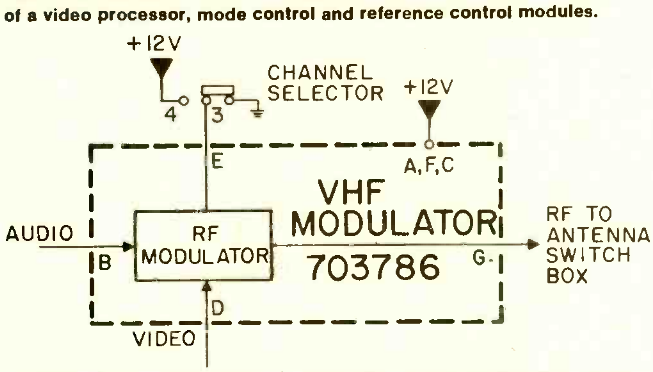

FIG. 8—RF SIGNAL MODULATOR takes the signal from the player, modulates a channel 3 or 4 RF signal and feeds that signal to the TV set's antenna terminals through an antenna switch box.

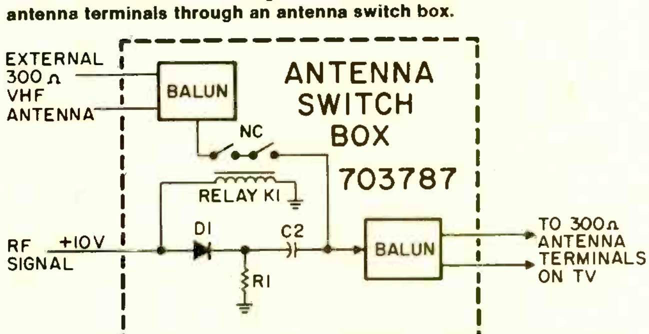

FIG. 9—ANTENNA SWITCH BOX connects videodisc player to TV antenna terminals. It acts automatically and prevents videodisc signals from getting to the TV antenna.

is now coupled through both baluns to the TV set.

Relay K1 uses two contacts in series to maintain proper isolation, a minimum of 60 dB. The player will operate properly on channel 3 or 4 even if a medium-strength signal is already present at the external VHF antenna on those channels.

That's the end of our coverage of the Magnavision videodisc player. A complete Magnavision manual for the *model VH8000* can be purchased from Magnavox, Service Training Department, Fort Wayne, IN 46804. **R-E**

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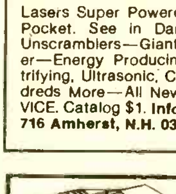

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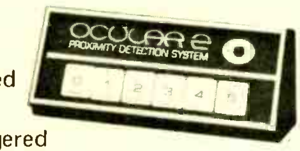

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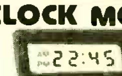

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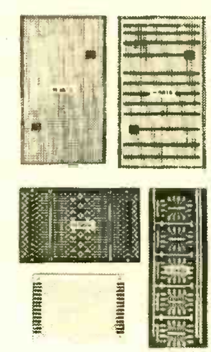

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U.S.P. 725	3.7" x 5.5"	1500	4.89	1.38
U.S.P. 728	7" x 9.6"	6240	19.50	10.40
H-5612	3½" x 6"			1.70
H-5616	3½" x 6"			1.70
H-5606	3½" x 5"			1.50
H-5602	2½" x 6½"			1.50

NEW MARK III LED VU

9 Steps 4 Colors

Stereo level indicator kit with arc-shape display panel!! This Mark III LED level indicator is a new design PC board with an arc-shape 4 colors LED display (change color from red, yellow, green and the peak output indicated by rose red). The power range is very large, from -30dB to +5dB. The Mark III indicator is applicable to 1 watt – 200 watts amplifier operating voltage is 3V – 9V DC at max 400 MA. The circuit uses 10 LEDs per channel. It is very easy to connect to the amplifier. Just hook up with the speaker output!

IN KIT FORM $18.50

HICKOK LX303 DIGITAL LCD MULTIMETER

- 3½ digits display
- 200 hours 9V battery life
- Auto zero; polarity; overrange indication
- 100MV DC F.S. sensitivity
- 19 ranges and functions
- D.C. volt: 0.1 MV to 1000 V
- A.C. volt: 0.1 V to 600 V
- Resistance: 0.1Ω to 20 MΩ
- D.C. current: 0.01 A to 100 MA

OUR PRICE $71.45

ELECTRONIC DUAL SPEAKER PROTECTOR

Cut off when circuit is shorted or overload to protect your amplifier as well as your speakers. A must for OCL circuits.

KIT FORM $8.75 EA.

60W + 60W STEREO AMPLIFIER

COMPLETED UNIT—NOT A KIT!

OCL pre amp. & power stereo amp. with bass, middle, treble 3-way tone control. Fully assembled and tested, ready to work. Total harmonic distortion less than 0.5% at full power. Output maximum is 60 watts per channel at 8Ω. Power supply is 24 - 36V AC or DC. Complete unit

Assembled $49.50 ea.
Power transformer $ 8.50 ea.

FM WIRELESS MIC KIT

It is not a pack of cigarettes. It is a new FM wireless mic kit! New design PC board fits into a plastic cigarette box (case included). Uses a condensor microphone to allow you to have a better response in sound pick-up. Transmits up to 350 ft.! With an LED indicator to signal the unit is on.

#FMM2 KIT FORM $7.95

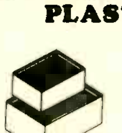
BUTTON CELL

NI-CD RECHARGEABLE BATTERIES
225MA/hr 1.2V per cell
7/8"x3/8"

Single Cell 1.2V	$1.20
4 cells stack 4.8V	$4.80
5 cells stack 6V	$6.00

special voltage order accepted at $1.30 per cell rate

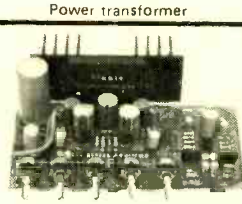
PLASTIC PROJECT BOX



The popular low-cost way to house your ex electronic experiments. With a copper-clad PC board cover, it allows you to have the circuits made right on top of the box.

Small size 2 7/8"x2 1/4"x1 3/8"	0.80 EACH
Large size 4"x3"x1 5/8"	1.25 EACH

22W + 22W STEREO HYBRID AMPLIFIER KIT



POWER TRANSFORMER $6.50 EACH

It Works in 12V D.C. As Well! Kit includes 1 PC SANYO STK-024 stereo power amp. IC LM 1458 as pre amp, all other electronic parts, PC Board, all control pots and special heat sink for hybrid. Power transformer not included. It produces ultra hi-fi output up to 44 watts (22 watts per channel) yet gives out less than 0.1% total harmonic distortion between 100Mz and 10KHz.

$32.50 PER KIT

CIRCLE 12 ON FREE INFORMATION CARD

SUPER 15 WATT AUDIO AMP KIT

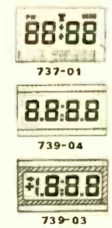
Uses STK-015 Hybrid Power Amp

Kit includes: STK-015 Hybrid IC, power supply with power transformer, front Amp with tone control, all electronic parts as well as PC Board. Less than 0.5% harmonic distortion at full power 1/2dB response from 20—100,000 Hz. This amplifier has QUASI—Complimentary class B output. Output max is watt (10 watt RMS) at 4Ω.

ONLY $23.50 each

BECKMAN FET LIQUID CRYSTAL DISPLAY

Overall size 2" x 1.2" 0-5" characters reflective type



Model 737-01 — for clock 4 digits with PM, alarm, snooze, colen indicators.

Model 739-04 — for panel meter 4 digits.

Model 739-03 — for panel meter 3½ digits with ± sign and over range indicator.

All displays include zeber connectors and front bezel. With data sheets.

Your choice—any model $7.50 EACH

MINI ELECTRONIC ORGAN KIT

PET-102 (25 KEYS)

The kit contains all electronic and mechanical parts, key boards, speaker, switches and PC Board as well as the wooden cabinet. Ideal for school project or gift to children interested in electronics. Uses 6V C size x 4 battery (not included). $38.50

PROFESSIONAL CASE

for our 0-30V Power Supply. It is a nice looking metal cast case with giant 4" volt/amp meter; output blinding post and fuse holder, on/off switch and line cord! ONLY $21.50 EA.

CASE 030

FLUORESCENT LIGHT DRIVER KIT

12V DC POWERED

Lights up 8 ~ 15 Watt Fluorescent Light Tubes

Ideal for camper, outdoor Auto or Boat

Kit includes high voltage coil, power transistor, heat sink, all other electronic parts and PC Board, light tube not included!

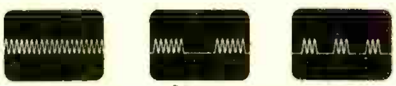
WITH CASE ONLY $6.50 PER KIT

MANY SOUND DECISIONS!

Solid state sound Indicator operating voltage 6V DC 30μ A. Small size approximately 3/4" X 1 1/4".

Model EB2116 (Continuous)
Model EB2126 (Slow Pulse)
Model EB2136 (Fast Pulse)

$3.60 EACH



Continuous · Slow pulse · Fast pulse

POWER SUPPLY KIT

0-30V D.C. REGULATED

Uses UA723 and ZN3055 Power TR output can be adjusted from 0-30V, 2 AMP. Complete with PC board and all electronic parts.

0-30 POWER SUPPLY $10.50 each

Transformer for Power Supply, 2AMP 24V x 2 $8.50

12V DC MINI RELAY

6V	SPDT	2AMP	1.30
12V	SPDT	3AMP	1.60
12V	DPDT	2AMP	2.50
12V	4PDT	3AMP	3.50

5 AMP 5VDC

3 Terminals Positive Voltage Regulator Hard to find! Fairchild 78HO5To-3 Package, Input 8.5 - 20V DC Output +5V DC 5AMP Load Regulation 1%.

Only $8.75 ea

HEAVY DUTY CLIP LEADS

10 pairs — 5 colors Alligator clips on a 22" long lead. Ideal for any testing.

$2.20/pack

1Watt AUDIO AMP

All parts are pre assembled on a mini PC Board

Supply Voltage 6 ~ 9V D.C.

SPECIAL PRICE $1.95 ea.

ELECTRONIC SWITCH KIT

CONDENSER TYPE

Touch On Touch Off uses 7473 I.C. and 12V relay

$5.50 each

MINI-SIZED I.C. AM RADIO

Size smaller than a box of matches! Receives all AM stations Batteries and ear phone Included

Only $10.50

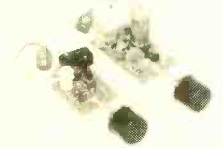
"FISHER" 30 WATT STEREO AMP

MAIN AMP (15W X 2)

Kit includes 2 pcs. Fisher PA 301 Hybrid IC all electronic parts with PC Board. Power supply ± 16V DC (not included). Power band with (KF 1% ± 3dB). Voltage gain 33dB. 20Hz — 20KHz.

Super Buy Only $18.50

ULTRA SONIC SWITCH KIT



Kit includes the Ultra Sonic Transducers, 2 PC Boards for transmitter and receiver. All electronic parts and instructions. Easy to build and a lot of uses such as remote control for TV, garage door, alarm system or counter. Unit operated by 9—12 DC.

$15.50

SOUND GENERATOR I.C.

TI76477

Creates almost any type of sound—gun shot, explosion, train, car crash, star war, birds, organ ext. A built-in audio amplifier provides high level output. Operates from one 9V battery, 28 pin dip; we supply the datas. $2.90 EACH

5W AUDIO AMP KIT

2 LM 380 with Volume Control

Power Supply 6 ~ 18V DC

ONLY $6.00 EACH

WE FOUND THE CASE FOR THE FM MIC!

Small nice looking aluminum case size like a pack of cigarettes. It is an intercom. Audio amp inside with a mic jack, a mini toggle sw on top, can be used for many projects. We give you the circuit data as well.

VERY SPECIAL PRICE 2 for $4.99

Sub Mini Size PANEL METER

500 UA

ONLY $1.20 ea

NUMERIC AND HEXADECIMAL LED DISPLAY WITH LOGIC

HP 5082 - 7300

- 4 x 7 Dot Matrix 0.4" Digit
- With On Board Decoder/ Driver and Memory.
- TTL Compatible
- BCD Input

SPECIAL $9.90 Each

Sub-Mini Size CONDENSER MICROPHONE

FET Transistor Built-in $2.50 each

HARD TO FIND!! 12V 4PDT RELAY

3 Amp Contact

$3.50 Each

ELECTRONIC ALARM SIREN

AU—999

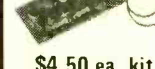
COMPLETE UNIT

Ideal for use as an Alarm Unit or hookup to your car back up to make a reverse indicator. Light Output up to 130dB

Voltage Supply 6 ~ 12V $7.50

CDS LIGHT CONTROL SWITCH KIT

High Sensitivity Darlington Circuit, operated with a 9V D.C. supply to control lights or use it for burglar alarm, shooting game, visitor buzzer, product counting, flash-light slave unit or automatic door opener and many more. The potentiometer is to adjust the sensitivity and the relay in the circuit can handle up to 200 watts.



$4.50 ea. kit

TRANSFORMERS

ALL 117 VOLT INPUT

30V	4AMP	$7.50 EA.
36V CT	3AMP	$8.50 EA.
48V CT	3AMP	$8.50 EA.
24V CT	3AMP	$6.50 EA.
24V CT	0.8AMP	$1.80 EA.
12V CT	0.5AMP	$1.80 EA.
12V CT	120MA	$1.25 EA.

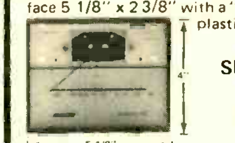
AC POWER SUPPLY

Wall Type Transformer

12V AC	Output	200MA	$2.75 EA.
16V CT AC	Output	100MA	$2.10 EA.
6V DC	Output	120MA	$1.90 EA.
12V DC	Output	100MA	$1.90 EA.

GIANT SIZE VU METER

1MA movement 3 1/2" scale length. Scale in VU -20db to +3db. Meter face 5 1/8" x 2 3/8" with a "smoke" plastic cover.



SPECIAL

$8.50 Each

SOUND ACTIVATED SWITCH

All parts completed on a PC Board

SCR will turn on relay, buzzer or trigger other circuit for 2 - 10 sec. (adjustable)

Ideal for use as door alarm, sound controlled toys and many other projects

Supply voltage 4.5V ~ 9V D.C.

$1.75 ea./2 for $3.00

LINEAR SLIDE POT

500KΩ SINGLE

Metal Case 3" Long

2 FOR $1.20

FLASHER LED

Unique design combines a jumbo red LED with an IC flasher chip in one package. Operates directly from 5V-7V DC. No dropping resistor needed Pulse rate 3Hz @ 5V 20 MA.

2 for $2.20

PROFESSIONAL PANEL METERS

A. 0-50UA	8.50 ea
B. 0-30VDC	8.50 ea
C. 0-50VDC	8.50 ea
D. 0-3ADC	9.00 ea
E. 0-100VDC	9.00 ea

Type MU-52E

All meters white face with black scales. Plastic cover.

PUSH-BUTTON SWITCH

N/Open Contact

Color: Red, White, Blue, Green, Black. 3/$1.00

N/Close also Available 50¢ ea.

LARGE QTY. AVAILABLE

Rechargeable NI-CD Batteries Pak

6AA NI-CD in a flat pack gives you a total of 7.2V 450MA output

$5.25 PER PACK

I.C. TEST CLIPS

Same as the E Z clips With 20" Long Leads In Black and Red Colors

$2.75 per pair

SOLID STATE ELECTRONIC BUZZER

Mini size 1" x 3/4" x 3/4"

Supply voltage 1.5V 12V

Ideal for Alarm or Tone Indicator

$1.50 each

BATTERY POWERED FLUORESCENT LANTERN

FEATURES

- Circuitry designed for operation by high efficient, high power silicon transistor which enable illumination maintain in a standard level even the battery supply drops to a certain low voltage
- 9" 6W cool/daylight miniature flourescent tube.
- 8 x 1.5V UM-1 (size D) dry cell battery.
- Easy sliding door for changing batteries.
- Stainless reflector with wide angle increasing lumination of the lantern

$10.50 EACH
MODEL 888 R

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7/79

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BEST PRICE IN THE COUNTRY!
RCA 1000 OHMS PER VOLT MULTIMETER

$7.88

WV-539A

- EASY TO READ COLOR-CODED METER
- POCKET SIZED - GOES ANYWHERE
- PRECISION PARTS USED TO INSURE ACCURACY
- COMPLETE WITH TEST LEADS

DIGITAL CALENDAR CLOCK
COMPLETE WITH MOTOR AND TIMER

$4.95

120 V 5 WATTS

DISPLAYS
HOURS
MINUTES
DAY
DATE

AP POWERACE ALL-CIRCUIT EVALUATORS WITH POWER

POWERACE 101 General purpose model for prototyping all types of circuits. $84.95

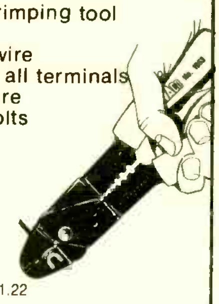
POWERACE 102 Complete digital prototyping lab w/FREE built-in logic probe. $114.95

POWERACE 103 Triple output power supply for prototyping both linear and digital circuits. $124.95

- ***Breadboard elements accept all DIP sizes***
- 1680 Solderless, plug-in tie points
- Short-circuit proof fused power supplies

VACO ®
wiring & crimping tool does it all

- Strips wire
- Crimps all terminals
- Cuts wire
- Cuts bolts



$5.49

1963

REGULAR $11.22

This is the Wiring and Crimping Tool that does it all. It slices 6 sizes of bolts (4-40, 5-40, 6-32, 8-32, 10-32, and 10-24). It strips wire (22-10 guage). It crimps all terminals (both insulated and non-insulated). Conveniently located wire cutter at tip of jaws, cuts wire percisely, easily.

BELL & HOWELL PARABOLIC MICROPHONE
Complete with Stand and Plug

Tape office conferences and school lectures

$5.95

SOLD FOR $23.95

LENS-LIGHT ILLUMINATING MAGNIFIER $1.99
A must for PC work.

GENERAL ELECTRIC TIMER
FEATURES HOUR AND MINUTE DISPLAY

WITH ALUMINUM FRONT PANEL COMPLETE WITH RELAYS AND AC MOTOR

PROTECT YOUR ELECTRONIC EQUIPMENT WITH THIS AUTOMATIC TURN-OFF TIMER

$4.95

MODEL 3AS

120 V 60 cy.

SAVE ON BATTERIES
MULTI-VOLTAGE AC ADAPTOR
300 mA 3, 4.5, 6, 7.5, 9, 12 V

4-WAY PLUG $3.99

2 WATT SOLID-STATE AMPLIFIER
all parts pre-assembled on a mini PC board

ITC EXCLUSIVE! 99¢

WELLER 25 WATT FEATHERWEIGHT SOLDERING IRON WITH REPLACEABLE TIPS.
Designed for hobbyists and technicians

SLASHED TO $5.99

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ELECTRONIC SUPERMARKET

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Los Angeles, CA 90006
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Minimum Order $5.00
Please add $2.00 postage and handling.
California residents add 6% Sales Tax
VISA/Mastercharge: state number, expiration date, and signature
OEM and Institutional inquiries invited.

CIRCLE 33 ON FREE INFORMATION CARD

FAIRCHILD RED LED LAMPS
#FLV5057. Medium Size. Clear Case. RED EMITTING. These are not retested off-spec units as sold by some of our competition. These are factory prime, first quality, new units.

10 FOR $1.19
50 FOR $4.95

"WE BOUGHT 250,000 PCS."

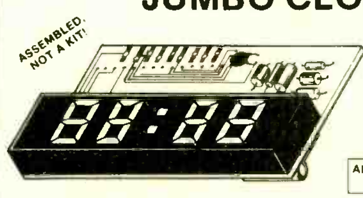
"THE COLOSSUS"
FAIRCHILD SUPER JUMBO LED READOUT
A full .80 inch character. The biggest readout we have ever sold! Super efficient. Compare at up to $2.95 each from others!

YOUR CHOICE **$1.49 EA**

FND 847 Common Anode
FND 850 Common Cathode **(6 for $6.95)**

NATIONAL SEMICONDUCTOR JUMBO CLOCK MODULE
MILITARY TIME FORMAT!

MA1008D BRAND NEW!



$4.95 ~~$7.95~~

REG. $9.95

ADD $1.95 FOR AC XFMR

FEATURES:
- FOUR JUMBO ½ INCH LED DISPLAYS
- 24 HR REAL TIME FORMAT
- 24 HR ALARM SIGNAL OUTPUT
- 50 OR 60 Hz OPERATION
- LED BRIGHTNESS CONTROL
- POWER FAILURE INDICATOR
- SLEEP & SNOOZE TIMERS
- DIRECT LED DRIVE (LOW RFI)
- COMES WITH FULL DATA

ZULU
50% OFF SALE!

PERFECT FOR USE WITH A TIMEBASE.

COMPARE AT UP TO TWICE OUR PRICE!

MANUFACTURER'S CLOSEOUT!

16K DYNAMIC RAM CHIP
WORKS IN TRS-80 OR APPLE II

16K X 1 Bits. 16 Pin Package. Same as Mostek 4116-4. 250 NS access. 410 NS cycle time. Our best price yet for this state of the art RAM. 32K and 64K RAM boards using this chip are readily available. These are new, fully guaranteed devices by a major mfg.

VERY LIMITED STOCK!

"MAGAZINE SPECIAL" — 8 For $79.50

EXPERIMENTER'S CRYSTAL

262.144KHZ. This frequency is 2 to the 18th power. Easily divided down to any power of 2, and even to 1HZ. New by CTS-Knight. A $5 value.

$1.25 each
4.00 MHZ — $1.75

MINI PROJECT CASE
Black Molded Plastic 2⅞x1⅝x2 in. Has open front, with mounting ears so unit can be easily attached to auto dash, etc. Case has molded card guides for mounting PC Board inside. Perfect for digital clocks, car burglar alarms, or almost any electronic project. Can also be used for encapsulating circuits or modules. **75¢ each** **Super Special Purchase!**

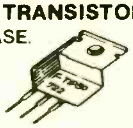
FAIRCHILD PNP "SUPER TRANSISTOR"
2N4402 TO-92 Plastic Silicon PNP Driver High Current VCEO-40 HFE-50 to 150 at 150 MA FT-150 MHZ. A super "BEEFED—UP" Version of the 2N3906.

8 FOR $1

G.I. FULL WAVE BRIDGE
4 AMP 600 PIV
3/4 In. Square
With Lugs, #LM-1
75¢ ea. 3 For $2

MOTOROLA POWER TRIAC
TO-220 CASE
15 AMP 400 PRV
SPECIAL: **89¢ each**
5 FOR $3.95

COMPLEMENTARY POWER TRANSISTORS
SILICON NPN AND PNP. TO-220 CASE.
VCEO - 40V PD - 30 WATTS
FOR AUDIO POWER AMPS, ETC.



TIP29 - NPN
TIP30 - PNP

YOUR CHOICE **3 FOR $1**

FET SALE!
2N4304. Brand New
N Channel, Junction Fet.
BVGD0-30V IDSS-15 MA Typ.
1500 uMHOS. TO-18 Plastic Case. Mfg. by Teledyne.
6 FOR $1

EXPERIMENTER'S HEATING PLATE
Large Manufacturers Surplus. 5¼x10½ In. Made of 3/8 in. tempered glass with heating element laminated on back. Works off 120 VAC. Protected by thermostat and two thermal fuses. Rated 120 Watts. Use for any heating applications. Perfect for heating ferric chloride to increase PC board etching efficiency. Units are brand new, non-submersible.

WHILE THEY LAST — $2.99 each

SONY 30 WATT AUDIO AMP MODULE
#STK-056. 30 WATTS SUPER CLEAN AUDIO. 20 HZ to 100 KHZ ± 2 DB. HYBRID, SILICON, SELF-CONTAINED MODULE. ONLY 1¾x2½ IN. WITH DATA. COMPARE AT UP TO TWICE OUR PRICE!

$9.99 EACH

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Active Electronic Sales Corp.

EPROM'S

Special of the Month

1702A-6 256 x 8 1.5 uS	~~$6.95~~	$4.45
2708 IK x 8 450 NS		$9.95

MOS Static RAM's

Part No.		Price
2101 1K 22 PIN	~~$2.45~~	$2.39
2102LFPC 1K 350NS (Low Power)	~~$1.19~~	$1.14
2102-1PC 1K 450NS	~~$.99~~	0.94
2114 4K (1K x 4) 300NS	~~$6.99~~	$6.75
2114 4K (1K x 4) 450NS		$6.50

MOS Dynamic RAM's

Part No.	Price
4K 4027 4K (4K x 1) 300NS 16 PIN	$2.95
16K 416-3 16K (16Kx1) 200NS 16PIN	$9.95
16K 416-5 16K (16Kx1) 300NS 16PIN	$7.95

UART's

Part No.		Price
AY5-1013A	~~$4.50~~	$4.25
AY3-1015	~~$5.50~~	$5.25

1K CMOS RAM

Part No.		Price
5101 450NS (Low Power)	~~$4.95~~	$4.50

MICROCOMPUTER BOARDS

SYM-1 MICROCOMPUTER BOARD

- Hardware compatibility with KIM-1
- Standard interfaces include audio cassette with remote control both 8 bytes second (KIM) and 185 bytes second (SYM-1) cassette formats TTY and RS232 system expansion bus TV KB expansion board interface four I O buffers and an oscilloscope single-line display
- Single +5V power requirements

SYM-1 $329.00

NEC MICROCOMPUTER TK-80A

- The TK 80A is a complete microcomputer on a board based on the industry standard 8080A The board has both 1K RAM and 1K Electrically Erasable PROM expandable to 4K x 8 and 8K x 8 respectively on-board It also features 300 or 1200 baud cassette interface the Kansas City type and three 8-Bit Programmable I O Ports (24 lines) Keypad with 25 real keys (not a glorified calculator keypad) and 8 big bright ½ digits for display are also included

TK-80A $299.00

Rockwell International AIM65

AIM 65 features on-board thermal printer and alphanumeric display and a terminal-style keyboard It has an addressing capability up to 65K bytes, and comes with a user-dedicated 1K RAM Two installed 4K ROMs hold a powerful Advanced Interface Monitor program, and three spare sockets are included to expand on-board ROM or PROM up to 20K bytes An application Connector provides for attaching a TTY and one or two audio cassette recorders, and gives external access to the user-dedicated general purpose I/O lines Also included as standard are a comprehensive AIM 65 User's Manual, a handy pocket reference card an R6500 Hardware Manual an R6500 Programming Manual and and an AIM 65 schematic AIM 65 is packaged on two compact modules The circuit module is 12 inches wide and 10 inches long, the keyboard module is 12 inches wide and 4 inches long They are conected by a detachable cable

AIM65 $375.00

MULTIBUS MEMORY

LARGE SCALE MULTIBUS MEMORY
MEMORY ONLY

SIZE (BYTES)	MUPRO PRODUCT NUMBER	INTEL* EQUIV PART NUMBER	PRICE
16K	MBC-016/8	SBC-016	$ 715
32K	MBC-032/8	SBC-032	1125
48K	MBC-048/8	SBC-048	1475
64K	MBC-064/8	SBC-064	1795
32K	MBC-032/16	SBC-032	1125
64K	MBC-064/16	SBC-064	1795

MICROPROCESSOR CHIPS

CPU's

Part No.	Price
8080A	5.50
8085	12.95
6800	7.95

INTERFACE SUPPORT CIRCUITS

Part No.	Price	Part No.	Price
8212	1.98	8255	4.95
8214	3.95	8257	10.95
8216	1.98	8259	14.95
8224	2.75		
8226	1.98	6810	3.95
8228	3.98 ~~4.75~~	6820	3.95
8238	3.98 ~~4.75~~	6821	3.95
8251	5.50	6850	4.95
8253	14.95	6852	4.95

Zilog

Z80-CPU	$13.60
Z80A-CPU	$16.20
Z80-PIO	$10.90
Z80A-PIO	$13.10
Z80-CTC	$10.90
Z80A-CTC	$13.10
Z80-DMA	$32.20
Z80-SIO/0	$45.00
Z80A-SIO/0	$50.00
Z80-SIO/1	$45.00
Z80A-SIO/1	$50.00
Z80-SIO/2	$45.00
Z80A-SIO/2	$50.00

Features..........

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Complete integrated circuit data selector. Master guide to the latest I.C.'s including microprocessors and consumer circuits.

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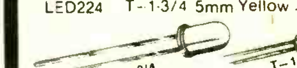
L.E.D. LAMPS

LED209	T-1 3mm Red	.09
LED211	T-1 3mm Green	.14
LED212	T-1 3mm Yellow	.13
LED220	T-1-3/4 5mm Red	.11
LED222	T-1-3/4 5mm Green	.15
LED224	T-1-3/4 5mm Yellow	.14



DISPLAYS

FND357	375"	Common Cathode	~~$1.45~~	$1.09
FND500	500"	Common Cathode	~~$1.20~~	$1.09
FND507	500"	Common Anode	~~$1.20~~	$1.09
FND567	500"	Common Anode	~~$1.40~~	$1.29
DL747	630"	Common Anode	~~$2.75~~	$2.49
DL704	300"	Common Cathode	~~$1.60~~	$1.29
DL707	300"	Common Anode	~~$1.60~~	$1.29

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TIL112	Opto Isolator 1500V	~~$0.58~~	$0.49
MCT6	Dual Opto Isolator 1500V	~~$1.39~~	$1.29

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Finest Quality Socket available in the world. Nobody can match Texas Instruments quality — a unique combination of I.C. technology and multi-metal expertise.

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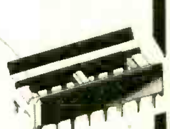
8 PIN	.08	22 PIN	.22
14 PIN	.12	24 PIN	.24
16 PIN	.14	28 PIN	.28
18 PIN	.18	40 PIN	.40
20 PIN	.20		



LINEAR I.C.'S

LM324N	.49	Quad Op Amp
LM339N	.49	Quad Comparator
LM555N-8	.29	Timer
LM556N-14	.59	Dual Timer
LM723CN	.36	Voltage Regulator
LM723CH	.39	Voltage Regulator
LM741CH	.37	Op Amp
LM741CN-8	.24	Op Amp
LM1458N-8	.49	Dual Op Amp
RC4558N-8	.45	Dual Op Amp

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CT-50

The CT-50 is a versatile and precision frequency counter which will measure frequencies to 60 mHz and up to 600 mHz with the CT-600 option. Large Scale Integration, CMOS circuitry and solid state display technology have enabled this counter to match performance found in units selling for over three times as much. Low power consumption (typically 300-400 ma) makes the CT-50 ideal for portable battery operation. Features of the CT-50 include: large 8 digit LED display, RF shielded all metal case, easy pushbutton operation, automatic decimal point, fully socketed IC chips and input protection to 50 volts to insure against accidental burnout or overload. And, the best feature of all is the easy assembly. Clear, step by step instructions guide you to a finished unit you can rely on.

Order your today!

SPECIFICATIONS:

- Frequency range: 6 Hz to 65 mHz, 600 mHz with CT-600
- Resolution: 10 Hz @ 0.1 sec gate, Hz @ 1 sec gate
- Readout: 8 digit, 0.4" high LED, direct readout in mHz
- Accuracy: adjustable to 0.5 ppm
- Stability: 2.0 ppm over 10° to 40° C, temperature compensated
- Input: BNC, 1 megohm 20 pf direct, 50 ohm with CT-600
- Overload: 50VAC maximum all modes
- Sensitivity: less than 25 mv to 65 mHz, 50-150 mv to 600 mHz
- Power: 110 VAC 5 Watts or 12 VDC @ 400 ma
- Size: 6" x 4" x 2", high quality aluminum case, 2 lbs
- ICS: 13 units, all socketed

CT-50, 60 mHz counter kit	$89.95
CT-50WT, 60 mHz counter, wired and tested	159.95
CT-600, 600 mHz scaler option, add	29.95
CB-1, Color TV calibrator-stabilizer	$14.35
DP-1, DC probe, general purpose probe	12.35
HP-1, High impedance probe, non-loadir	15.35

CAR CLOCK

The UN-KIT, only 5 solder connections

Here's a super looking, rugged and accurate auto clock which is a snap to build and install. Clock movement is completely assembled—you only solder 3 wires and 2 switches, takes about 15 minutes! Display is bright green with automatic brightness control photocell—assures you of a highly readable display, day or night. Comes in a satin finish anodized aluminum case which can be attached 5 different ways using 2 sided tape. Choice of silver, black or gold case (specify).

DC-3 kit, 12 hour format	$22.95
DC-3 wired and tested	$29.95
110V AC adapter	$5.95

Under dash car clock

12/24 hour clock in a beautiful plastic case features: 6 jumbo RED LEDS, high accuracy (1 min/mo.), easy 3 wire hookup, display blanks with ignition, and super instructions. Optional dimmer automatically adjusts display to ambient light level.

DC-11 clock with mtg. bracket	$27.95
DM-1 dimmer adapter	2.50

PRESCALER

Extend the range of your counter to 600 mHz. Works with any counter. Includes 2 transistor pre-amp to give super sens, typically 20 mv at 150 mHz. Specify ÷ 10 or ÷ 100 ratio.

PS-1B, 600 mHz prescaler	$59.95
PS-1BK, 600 mHz prescaler kit	49.95

OP-AMP SPECIAL

741 mini dip	12/$2.00
B1-FET, mini dip, 741 type	10/$2.00

VIDEO TERMINAL

A completely self-contained, stand alone video terminal card. Requires only an ASCII keyboard and TV set to become a complete terminal unit. Two units available, common features are: single 5V supply, XTAL controlled sync and baud rates (to 9600), complete computer and keyboard control of cursor. Parity error control and display. Accepts and generates serial ASCII plus parallel keyboard input. The 3216 is 32 char. by 16 lines, 2 pages with memory dump feature. The 6416 is 64 char. by 16 lines, with scrolling, upper and lower case (optional) and has RS-232 and 20ma loop interfaces on board. Kits include sockets and complete documentation.

RE 3216, terminal card	$149.95
RE 6416, terminal card	189.95
Lower Case option, 6416 only	13.95
Power Supply Kit	14.95
Video/RF Modulator, VD-1	6.95
Assembled, tested units, add	60.00

CALENDAR ALARM CLOCK

The clock that's got it all. 6-.5" LEDs, 12/24 hour, snooze, 24 hour alarm, 4 year calendar, battery backup, and lots more. The super 7001 chip is used. Size: 5x4x2 inches.

Complete kit, less case (not available) DC-9	$34.95

30 Watt 2 mtr PWR AMP

Simple Class C power amp features 8 times power gain. 1 W in for 8 out, 2 in for 15 out, 4 W in for 30 out. Max output of 35 W, incredible value, complete with all parts, less case and T-R relay.

PA-1, 30 W pwr amp kit	$22.95
TR-1, RF sensed T-R relay kit	6.95

FM MINI MIKE KIT

A super high performance FM wireless mike kit! Transmits a stable signal up to 300 yards with exceptional audio quality by means of its built in electret mike. Kit includes case, mike, on-off switch, antenna, battery and super instructions. This is the finest unit available.

FM-3 kit	$12.95
FM-3 wired and tested	16.95

CLOCK KITS

our Best Seller your Best Deal

Try your hand at building the finest looking clock on the market. Its satin finish anodized aluminum case looks great anywhere, while six .4" LED digits provide a highly readable display. This is a complete kit, no extras needed, and it only takes 1-2 hours to assemble. Your choice of case colors: silver, gold, bronze, black, blue (specify).

Clock kit, 12/24 hour, DC-5	$22.95
Clock with 10 min. ID timer, 12/24 hour, DC-10	27.95
Alarm clock, 12 hour only, DC-8	24.95
12V DC car clock, DC-7	27.95

For wired and tested clocks add $10.00 to kit price.

Hard to find PARTS

LINEAR ICs	
301	$ .35
324	1.50
380	1.25
380-8	.75
555	.45
556	.85
566	1.15
567	1.25
1458	.50
3900	.50
CMOS ICs	
4011	.20
4013	.35
4046	1.85
4049	.40
4518	1.25
5369	.75
TRANSISTORS	
2N3904 type	10/1.00
2N3906 type	10/1.00
NPN 30W Pwr	3/1.00
PNP 30W Pwr	3/1.00
2N3055	.60
UJT 2N2646 type	3/2.00
FET MPF102 type	3/2.00
UHF 2N5179 type	3/2.00
MRF-238 RF	1 .95
SOCKETS	
8 pin	10/2.00
14 pin	10/2.00
16 pin	10/2.00
24 pin	4/2.00
28 pin	4/2.00
40 pin	3/2.00

REGULATORS	
78MG	$1.25
723	.50
309K	.85
7805	.85
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7905	1.25
7812	.85
7912	1.25
7815	.85
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7447	.65
7475	.50
7490	.50
74196TI	1.35
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Ramsey's famous MINI-KITS

FM WIRELESS MIKE KIT

Transmits up to 300' to any FM broadcast radio, uses any type of mike. Runs on 3 to 9V. Type FM-2 has added sensitive mike preamp stage.

FM-1 kit $2.95 FM-2 kit $4.95

COLOR ORGAN/MUSIC LIGHTS

See music come alive! 3 different lights flicker with music. One light for lows, one for the mid-range and one for the highs. Each channel individually adjustable, and drives up to 300W. Great for parties, band music, nite clubs and more.

Complete kit, ML-1 $7.95

LED BLINKY KIT

A great attention getter which alternately flashes 2 jumbo LEDs. Use for name badges, buttons, warning panel lights, anything! Runs on 3 to 15 volts.

Complete kit, BL-1 $2.95

VIDEO MODULATOR KIT

Converts any TV to video monitor. Super stable, tunable over ch. 4-6. Runs on 5-15V, accepts std. video signal. Best unit on the market!

Complete kit, VD-1 $6.95

TONE DECODER

A complete tone decoder on a single PC board. Features: 400-5000 Hz adjustable range via 20 turn pot, voltage regulation, 567 IC. Useful for touch-tone decoding, tone burst detection, FSK, etc. Can also be used as a stable tone encoder. Runs on 5 to 12 volts.

Complete kit, TD-1 $5.95

WHISPER LIGHT KIT

An interesting kit, small mike picks up sounds and converts them to light. The louder the sound, the brighter the light. Completely self-contained, includes mike, runs on 110VAC, controls up to 300 watts.

Complete kit, WL-1 $6.95

SUPER SLEUTH

A super sensitive amplifier which will pick up a pin drop at 15 feet! Great for monitoring baby's room or as general purpose amplifier. Full 2 W rms output, runs on 6 to 15 volts, uses 8-45 ohm speaker.

Complete kit, BN-9 $5.95

POWER SUPPLY KIT

Complete triple regulated power supply provides variable 6 to 18 volts at 200 ma and +5V at 1 Amp. Excellent load regulation, good filtering and small size. Less transformers, requires 6.3V @ 1 A and 24 VCT.

Complete kit, PS-3LT $6.95

SIREN KIT

Produces upward and downward wail characteristic of a police siren. 5 W peak audio output, runs on 3-15 volts, uses 3-45 ohm speaker.

Complete kit, SM-3 $2.95

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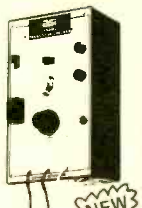
CIRCLE 42 ON FREE INFORMATION CARD

CIRCLE 36 ON FREE INFORMATION CARD

CIRCLE 9 ON FREE INFORMATION CARD

Transistor Checker



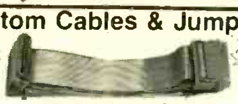
— Completely Assembled —
— Battery Operated —

The ASI Transistor Checker is capable of checking a wide range of transistor types, either "in circuit" or out of circuit. To operate, simply plug the transistor to be checked into the front panel socket, or connect it with the alligator clip test leads provided. The unit safely and automatically identifies low, medium and high-power PNP and NPN transistors. Size: 3¾" x 6¼" x 2"
"C" cell battery not included.

NEW

Trans-Check $29.95 ea.

Custom Cables & Jumpers

NEW  NEW

DB 25 Series Cables

Part No.	Cable Length	Connectors	Price
DB25P-4-P	4 Ft.	2-DP25P	$15.95 ea.
DB25P-4-S	4 Ft.	1-DP25P/1-25S	$16.95 ea.
DB25S-4-S	4 ft.	2-DP25S	$17.95 ea.

Dip Jumpers

DJ14-1	1 ft.	1-14 Pin	$1.59 ea.
DJ16-1	1 ft.	1-16 Pin	1.79 ea.
DJ24-1	1 ft.	1-24 Pin	2.79 ea.
DJ14-1-14	1 ft.	2-14 Pin	2.79 ea.
DJ16-1-16	1 ft.	2-16 Pin	3.19 ea.
DJ24-1-24	1 ft.	2-24 Pin	4.95 ea.

For Custom Cables & Jumpers. See JAMECO 1979 Catalog for Pricing

CONNECTORS
25 Pin-D Subminiature

DB25P (as pictured)	PLUG (Meets RS232)	$2.95
DB25S	SOCKET (Meets RS232)	$3.50
DB51226-1	Cable Cover for DB25P or DB25S	$1.75

PRINTED CIRCUIT EDGE-CARD

.156 Spacing-Tin-Double Read-Out — Bifuracted Contacts — Fits .054 to .070 P.C. Cards

15/30	PINS (Solder Eyelet)		$1.95
18/36	PINS (Solder Eyelet)		$2.49
22/44	PINS (Solder Eyelet)		$2.95
50/100 (.100 Spacing)	PINS (Wire Wrap)		$6.95
50/100 (.125 Spacing)	PINS (Wire Wrap)	R681-1	$6.95

4-Digit Clock Kit

* Bright .357" ht. red display
* Sequential flashing colon
* 12 or 24 hour operation
* Extruded aluminum case (black)
* Pressure switches for hours, minutes & hold functions
* Includes all components, case and wall transformer
* Size: 3¼ x 1¾ x 1¼

JE730 **$14.95**

Jumbo 6-Digit Clock Kit

* Four .630"ht. and two .300"ht. common anode displays
* Uses MM5314 clock chip
* Switches for hours, minutes and hold functions
* Hours easily viewable to 30 feet
* Simulated walnut case
* 115VAC operation
* 12 or 24 hour operation
* Includes all components, case and wall transformer
* Size: 6¾ x 3⅛ x 1¾

JE747 **$29.95**

* Bright .300 ht. comm. cathode display
* Uses MM5314 clock chip
* Switches for hours, minutes and hold modes
* Hrs. easily viewable to 20 ft.
* Simulated walnut case
* 115 VAC operation
* 12 or 24 hr. operation
* Incl. all components, case & wall transformer
* Size: 6¾" x 3-1/8" x 1¾"

JE701
6-Digit Clock Kit $19.95

REMOTE CONTROL TRANSMITTER & RECEIVER

* CAN BE USED AS REMOTE CONTROL FOR TV
* USE IT FOR YOUR OWN GARAGE DOOR OPENER
* TRANSMITS BETWEEN 38KHz AND 41.5KHz
* THOUSANDS OF USES FOR REMOTE CONTROL APPLICATIONS
* TRANSMITTER USES A 1.5V BATTERY
* SCHEMATIC INCLUDED

$19.95

Digital Stopwatch Kit

* Use Intersil 7205 Chip
* Plated thru double-sided P.C. Board
* LED display (red)
* Times to 59 min. 59.59 sec. with auto reset
* Quartz crystal controlled
* Three stopwatches in one: single event, split (cummulative) & taylor (sequential timing)
* Uses 3 penlite batteries
* Size: 4.5" x 2.15" x .90"

JE900 **$39.95**

MICROPROCESSOR COMPONENTS

8080A/8080A SUPPORT DEVICES

8080A	CPU	$ 9.95
8212	8-Bit Input/Output	3.25
8214	Priority Interrupt Control	5.95
8216	Bi-Directional Bus Driver	3.49
8224	Clock Generator/Driver	3.95
8226	Bus Driver	3.49
8228	System Controller/Bus Driver	5.95
8238	System Controller	5.95
8251	Prog. Comm. I/O (USART)	7.95
8253	Prog. Interval Timer	14.95
8255	Prog. Periph. I/O (PPI)	9.95
8257	Prog. DMA Control	19.95
8259	Prog. Interrupt Control	19.95

6800/6800 SUPPORT DEVICES

MC6800	MPU	$14.95
MC6802CP	MPU with Clock and Ram	24.95
MC6810API	128X8 Static Ram	5.95
MC6821	Periph. Inter. Adapt (MC6820)	7.49
MC6828	Priority Interrupt Controller	12.95
MC6830L8	1024X8 Bit ROM (MC68A30-8)	14.95
MC6850	Asynchronous Comm. Adapter	7.95
MC6852	Synchronous Serial Data Adapt.	9.95
MC6860	0-600 bps Digital MODEM	12.95
MC6862	2400 bps Modulator	14.95
MC6880A	Quad 3-State Bus. Trans. (MC8T26)	2.25

MICROPROCESSOR CHIPS—MISCELLANEOUS

Z80(780C)	CPU	$19.95
Z80A(780-1)	CPU	24.95
CDP1802	CPU	19.95
2650	MPU	19.95
8035	8-Bit MPU w/clock, RAM, I/O lines	19.95
P8085	CPU	19.95
TMS9900JL	16-Bit MPU w/hardware, multiply & divide	49.95

SHIFT REGISTERS

MM500H	Dual 25 Bit Dynamic	$ .50
MM503H	Dual 50 Bit Dynamic	.50
MM504H	Dual 16 Bit Static	.50
MM506H	Dual 100 Bit Static	.50
MM510H	Dual 64 Bit Accumulator	.50
MM5016H	500/512 Bit Dynamic	.89
2504T	1024 Dynamic	3.95
2518	Hex 32 Bit Static	4.95
2522	Dual 132 Bit Static	2.95
2524	512 Static	.99
2525	1024 Dynamic	2.95
2527	Dual 256 Bit Static	2.95
2528	Dual 250 Static	4.00
2529	Dual 240 Bit Static	4.00
2532	Quad 80 Bit Static	2.95
2533	1024 Static	2.95
3341	Fifo	6.95
74LS670	4X4 Register File (TriState)	2.49

UART'S

A-Y-5-1013	30K BAUD	5.95

MICROPROCESSOR MANUALS

M-Z80	User Manual	$7.50
M-CDP1802	User Manual	7.50
M-2650	User Manual	5.00

ROM'S

2513(2140)	Character Generator(upper case)	$9.95
2513(3021)	Character Generator(lower case)	9.95
2516	Character Generator	10.95
MM5230N	2048-Bit Read Only Memory	1.95

RAM'S

1101	256X1	Static	$1.49
1103	1024X1	Dynamic	.99
2101(8101)	256X4	Static	3.95
2102	1024X1	Static	1.75
21L02	1024X1	Static	1.95
2111(8111)	256X4	Static	3.95
2112	256X4	Static MOS	4.95
2114	1024X4	Static 450ns	9.95
2114L	1024X4	Static 450ns low power	10.95
2114-3	1024X4	Static 300ns	10.95
2114L-3	1024X4	Static 300ns low power	11.95
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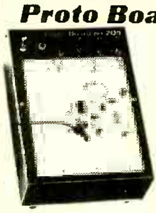
7489	16X4	Static	1.75
74S200	256X1	Static Tristate	4.95
93421	256X1	Static	2.95
UPD414 (MK4027)	4K	Dynamic 16 pin	4.95
UPD416 (MK4116)	16K	Dynamic 16 pin	9.95
TMS4044-45NL	4K	Static	14.95
TMS4045	1024X4	Static	14.95
2117	16,384X1	Dynamic 350ns (house marked)	9.95
MM5262	2KX1	Dynamic	4/1.00

PROM'S

1702A	2048	FAMOS	$5.95
2716INTEL	16K*	EPROM	59.95
TMS2516 (2716)	16K*	EPROM	49.95
		*Requires single +5V power supply	
TMS2532	4KX8	EPROM	89.95
2708	8K	EPROM	10.95
2716 T.I.	16K**	EPROM	29.95
		**Requires 3 voltages, −5V, +5V, +12V	
5203	2048	FAMOS	14.95
6301-1(7611)	1024	Tristate Bipolar	3.49
6330-1(7602)	256	Open C Bipolar	2.95
82S23	32X8	Open Collector	3.95
82S115	4096	Bipolar	19.95
82S123	32X8	Tristate	3.95
74186	512	TTL Open Collector	9.95
74188	256	TTL Open Collector	3.95
74S287	1024	Static	2.95

CSC CONTINENTAL SPECIALTIES

Proto Board 203



A total ready-to-use power breadboard prototest device with a built in regulated, short-proof power supply. Just plug in and start building! 2 extra floating 5-way binding posts for external signals. Self contained with power switch indicator lamp and power fuse 24-14 pin DIP capacity. Attractive two tone quality case All metal construction. 9¾"L x 6½"W x 2¾"H 5 lbs.

PB 203 **$75.00**

Model Number	L x W x H (Inches)	Price
PB-6	6.0 x 4.5 x 1.4	$15.95
PB-100	6.0 x 4.5 x 1.4	$19.95
PB-101	6.0 x 4.5 x 1.4	$22.95

Proto Board 203A

All the features of the PB 203 plus additional power supply flexibility. Provides 1%-Regulated 5VDC supply (same specifications as PB 203). Regulated separate +15VDC and −15 VDC 0.5A supplies, each with internally and independently adjustable output voltage. Ripple and noise of + and −15V supplies 10mV at 0.25A.

PB 203A **$124.95**

Model Number	L x W x H (Inches)	Price
PB-102	7.0 x 4.5 x 1.4	$26.95
PB-103	9.0 x 6.0 x 1.4	$44.95
PB-104	9.8 x 8.0 x 1.4	$54.95

THE SINCLAIR PDM35

Options: AC adapter for 117 V 60 Hz power. De-luxe padded carrying wallet

DC Volts (4 ranges)
Range 1mV to 1000V.
Accuracy of reading 1.0%± 1 count.
Note: 10MΩ input impedance.
AC Volts (40 Hz-5 kHz)
Range 1V to 500 V.
Accuracy of reading 1.0%± 2 counts.
DC Current (6 ranges)
Range 1 nA to 200 mA.
Accuracy of reading 1.0%± 1 count.
Note. Max. resolution 0.1 nA
Resistance (5 ranges)
Range: 1Ω to 20 MΩ.
Accuracy of reading: 1.5%± 1 count.
Also provides 5 junction-test ranges.
Dimensions: 6 in x 3 in x 1½ in.
Weight: 6½ oz.
Power Supply: 9 V battery or Sinclair AC adapter (Battery not incl.)
Sockets: Standard 4mm for resilient plugs.

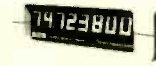
PDM35: Digital Multimeter . . . **$59.95**
(completely assembled)
PDM-AC: 117V AC Adapter . . . **6.95**
PDM-DP:
Deluxe padded carrying case. . . **6.95**

CSC 100 MHz 8-Digit Counter

CONTINENTAL SPECIALTIES CORPORATION

* 20 Hz-100 MHz Range
* 6" LED Display
* Crystal controlled timebase
* Fully Automatic
* Portable — completely self contained
* Size — 1.75" x 7.38" x 5.63"
* Four power souces, i.e. batteries, 110 or 220V with charger 12V with auto lighter adapter and external 7.2-10V power supply

MAX-100 **$134.95**



ACCESSORIES FOR MAX 100:
Mobile Charger Eliminator
use power from car battery — Model 100 — CLA $3.95
Charger/Eliminator
use 110 V AC — Model 100 — CAI $9.95

REGULATED POWER SUPPLY

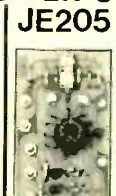
NEW

JE200 5V-1 AMP POWER SUPPLY

* Uses LM309K
* Heat sink provided
* PC Board construction
* Provides a solid 1 amp @ 5 volts
* Can supply up to ±5V, ±9V and ±12V with JE205 Adapter
* Includes components, hardware & instructions
* Size: 3½"x5"x2"H

JE200 $14.95

JE205 ADAPTER BOARD
— Adapts to JE200 — ±5V, ±9V and ±12V



* DC/DC converter w/ +5V input
* Toriodal hi-speed switching XMFR
* Short circ. protection
* PC Brd. construction
* Piggy-back to JE200 board
* Size: 3½"x2"x 9/16"h

JE205 $12.95

$10.00 Minimum Order — U.S. Funds Only
California Residents — Add 6% Sales Tax

Spec Sheets — 25¢
1979 Catalog Available—Send 41¢ stamp

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The Incredible "Pennywhistle 103"

$139.95 Kit Only

The Pennywhistle 103 is capable of recording data to and from audio tape without critical speed requirements for the recorder and it is able to communicate directly with another modem and terminal for telephone "hamming" and communications. In addition, it is free of critical adjustments and is built with non-precision, readily available parts.

Data Transmission Method	Frequency-Shift Keying, full-duplex (half-duplex selectable).
Maximum Data Rate	300 Baud.
Data Format	Asynchronous Serial (return to mark level required between each character).
Receive Channel Frequencies	2025 Hz for space; 2225 Hz for mark.
Transmit Channel Frequencies	Switch selectable: Low (normal) = 1070 space, 1270 mark; High = 025 space, 2225 mark.
Receive Sensitivity	−46 dbm accoustically coupled.
Transmit Level	−15 dbm nominal. Adjustable from −6 dbm to −20 dbm
Receive Frequency Tolerance	Frequency reference automatically adjusts to allow for operation between 1800 Hz and 2400 Hz.
Digital Data Interface	EIA RS-232C or 20 mA current loop (receiver is optoisolated and non-polar)
Power Requirements	120 VAC, single phase, 10 Watts.
Physical	All components mount on a single 5" by 9" printed circuit board. All components included.

Requires a VOM, Audio Oscillator, Frequency Counter and/or Oscilloscope to align.

TRS-80 16K Conversion Kit

Expand your 4K TRS-80 System to 16K. Kit comes complete with:

* 8 each UPD416-1 (16K Dynamic Rams) 250NS
* Documentation for conversion

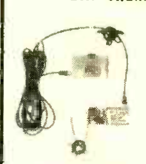
TRS-16K $75.00

COMPUTER CASSETTES

* 6 EACH 15 MINUTE HIGH QUALITY C-15 CASSETTES
* PLASTIC CASE INCLUDED 12 CASSETTE CAPACITY
* ADDITIONAL CASSETTES AVAILABLE #C-15-$2.95 ea

CAS-6 $14.95
(Case and 6 Cassettes)

SUP 'R' MOD II
UHF Channel 33 TV Interface Unit Kit



Wide Band B/W or Color System
* Converts TV to Video Display for home computers, CCTV camera, Apple II, works with Cromeco Dazzler, SOL-20, TRS-80, Challenger, etc.

MOD II is pretuned to Channel 33 (UHF).
* Includes coaxial cable and antenna transformer.

MOD II $29.95 Kit

Function Generator Kit

* Provides 3 basic waveforms: sine, triangle & square wave
* Frequency range from 1 Hz to 100K Hz
* Output amplitude from 0-volts to over 6 volts (peak to peak)
* Uses a 12V supply or a ±6V split supply
* Incl. chip, P.C. board, components and instructions.

JE2206B **$19.95**

IDEAL FOR TRS 80 — CASSETTE CONTROLLER

"Plug/Jack interface to any computer system requiring remote control of cassette functions"

The CC100 controls cassette motor functions, monitors tape location with its internal speaker and requires no power. Eliminates the plugging and unplugging of cables during computer loading operation from cassette.

#CC-100 **$29.50**

63-Key Unencoded Keyboard

This is a 63-key, terminal keyboard newly manufactured by a large computer manufacturer. It is unencoded with SPST keys, unattached to any kind of PC board. A very solid molded plastic 13 x 4" base suits most application. IN STOCK **$29.95/each**

Hexadecimal Unencoded Keypad

19-key pad includes 1-10 keys, ABCDEF and 2 optional keys and a shift key. **$10.95/each**

CIRCLE 6 ON FREE INFORMATION CARD

TYPE	25-UP	10-24	1-9
2SA 473	.45	.55	.60
2SA 483	2.00	2.20	2.50
2SA 484	1.50	1.75	1.95
2SA 485	1.40	1.60	1.80
2SA 489	1.10	1.25	1.40
2SA 490	.70	.80	.90
2SA 493	.45	.53	.59
2SA 495	.30	.35	.40
2SA 496	.50	.64	.70
2SA 497	1.00	1.20	1.30
2SA 505	.50	.64	.70
2SA 509	.30	.35	.40
2SA 525	.50	.64	.70
2SA 530	1.50	1.70	1.90
2SA 537A	1.50	1.70	1.90
2SA 539	.40	.45	.50
2SA 545	.45	.53	.59
2SA 561	.30	.35	.40
2SA 562	.30	.35	.40
2SA 564A	.20	.27	.30
2SA 565	.70	.80	.90
2SA 566	2.50	2.70	3.00
2SA 606	1.00	1.20	1.30
2SA 607	1.10	1.25	1.40
2SA 624	.70	.80	.90
2SA 627	3.10	3.30	3.60
2SA 628	.30	.35	.40
2SA 634	.40	.45	.50
2SA 640	.30	.35	.40
2SA 642	.30	.35	.40
2SA 643	.30	.40	.45
2SA 653	1.90	2.10	2.40
2SA 659	.35	.40	.45
2SA 661	.50	.64	.70
2SA 663	3.65	3.80	4.20
2SA 666	.35	.40	.45
2SA 671	.80	.90	1.00
2SA 672	.30	.35	.40
2SA 673	.35	.40	.45
2SA 678	.35	.40	.45
2SA 679	4.20	4.40	4.90
2SA 680	4.20	4.40	4.90
2SA 682	.80	.90	1.00
2SA 683	.30	.35	.40
2SA 684	.35	.40	.45
2SA 695	.40	.53	.59
2SA 697	.40	.53	.59
2SA 699A	.50	.64	.70
2SA 705	.40	.53	.59
2SA 706	.85	1.00	1.10
2SA 715	.60	.70	.80
2SA 719	.30	.35	.40
2SA 720	.30	.35	.40
2SA 721	.30	.35	.40
2SA 725	.30	.35	.40
2SA 726	.30	.35	.40
2SA 733	.20	.27	.30
2SA 738	.40	.53	.59
2SA 740	1.50	1.70	1.90
2SA 743A	.85	1.00	1.10
2SA 744	4.20	4.40	4.90
2SA 745R	3.80	4.00	4.40
2SA 747	4.20	4.40	4.90
2SA 748	.70	.80	.90
2SA 750	.35	.40	.45
2SA 755	.80	.90	1.00
2SA 756	2.30	2.40	2.65
2SA 758	3.40	3.55	3.90
2SA 764	3.80	4.00	4.40
2SA 765	3.10	3.30	3.60
2SA 774	.40	.45	.50
2SA 777	.50	.64	.70
2SA 794A	.60	.70	.80
2SA 798	.50	.55	.60
2SA 814	.70	.80	.90
2SA 815	.60	.70	.80
2SA 816	.50	.64	.70
2SA 818	.70	.80	.90
2SA 837R	2.50	2.70	2.90
2SA 839T	1.30	1.45	1.60
2SA 908	8.60	8.80	9.80
2SA 913	.70	.80	.90
2SB 22	.30	.35	.40
2SB 54	.20	.27	.30
2SB 55	.40	.53	.59
2SB 75	.35	.40	.45
2SB 77	.35	.40	.45
2SB 173	.30	.35	.40
2SB 175	.20	.27	.30
2SB 176	.30	.35	.40
2SB 178	.35	.40	.45
2SB 186	.20	.27	.30
2SB 187	.20	.27	.30
2SB 202	1.10	1.20	1.30
2SB 220	.90	1.10	1.20
2SB 303	.30	.35	.40
2SB 324	.30	.35	.40
2SB 337	.70	.80	.90

TYPE	25-UP	10-24	1-9
2SB 346	.30	.35	.40
2SB 367	1.10	1.25	1.40
2SB 368B	1.80	2.00	2.25
2SB 379	.70	.80	.90
2SB 381	.30	.35	.40
2SB 400	.30	.35	.40
2SB 405	.30	.35	.40
2SB 407	.80	.90	1.00
2SB 415	.30	.35	.40
2SB 434	.80	.90	1.00
2SB 435	.90	1.10	1.20
2SB 440	.40	.53	.59
2SB 449	1.30	1.45	1.60
2SB 461	.90	1.10	1.20
2SB 463	.90	1.10	1.20
2SB 471	1.10	1.25	1.40
2SB 472	2.10	2.50	2.80
2SB 473	.80	.90	1.00
2SB 474	.70	.80	.90
2SB 481	.90	1.10	1.20
2SB 492	.60	.70	.80
2SB 507	.80	.90	1.00
2SB 509	1.10	1.20	1.30
2SB 511	.70	.80	.90
2SB 514	.70	.80	.90
2SB 523	.70	.80	.90
2SB 526C	.70	.80	.90
2SB 527	.90	1.10	1.20
2SB 528D	.70	.80	.90
2SB 529	.70	.80	.90
2SB 530	3.20	3.40	3.70
2SB 531	1.80	2.00	2.25
2SB 536	1.00	1.20	1.30
2SB 537	1.00	1.20	1.30
2SB 539	3.20	3.40	3.70
2SB 541	3.20	3.40	3.70
2SB 554	5.00	6.00	6.60
2SB 556	3.20	3.40	3.70
2SB 557	2.10	2.50	2.80
2SB 561B	.35	.40	.45
2SB 564	.40	.53	.59
2SB 595	1.10	1.40	1.50
2SB 596	1.10	1.40	1.50
2SB 600	5.00	6.00	6.60
2SC 183	.40	.53	.59
2SC 184	.40	.53	.59
2SC 281	.30	.35	.40
2SC 283	.40	.53	.59
2SC 284	.80	.90	1.00
2SC 317	.40	.53	.59
2SC 352A	2.00	2.20	2.50
2SC 353A	1.40	1.60	1.80
2SC 367	.60	.70	.80
2SC 369	.30	.35	.40
2SC 370	.20	.27	.30
2SC 371	.30	.35	.40
2SC 372	.20	.27	.30
2SC 373	.20	.27	.30
2SC 374	.30	.35	.40
2SC 375	.30	.35	.40
2SC 377	.30	.35	.40
2SC 380	.20	.27	.30
2SC 381	.35	.40	.45
2SC 382	.35	.40	.45
2SC 383	.35	.40	.45
2SC 387A	.35	.40	.45
2SC 388A	.40	.53	.59
2SC 394	.20	.27	.30
2SC 403	.30	.35	.40
2SC 430	.50	.64	.70
2SC 454	.30	.35	.40
2SC 458	.20	.27	.30
2SC 460	.35	.40	.45
2SC 461	.35	.40	.45
2SC 478	.60	.70	.80
2SC 481	1.30	1.40	1.50
2SC 482	1.10	1.25	1.40
2SC 484	1.30	1.40	1.50
2SC 485	1.30	1.40	1.50
2SC 486	1.30	1.40	1.50
2SC 493	3.00	3.20	3.40
2SC 495	.45	.55	.60
2SC 496	.45	.55	.60
2SC 497	1.10	1.25	1.40
2SC 509	.35	.40	.45
2SC 510	1.30	1.40	1.50
2SC 515A	.80	.90	1.00
2SC 517	2.50	2.70	3.00
2SC 535	.30	.35	.40
2SC 536	.30	.35	.40
2SC 537	.30	.35	.40
2SC 627	1.30	1.45	1.60
2SC 631	.35	.40	.45
2SC 632A	.35	.40	.45
2SC 634A	.35	.40	.45
2SC 680	1.90	2.10	2.40
2SC 681A	3.00	3.25	3.50
2SC 684	.80	.90	1.00

TYPE	25-UP	10-24	1-9
2SC 693F	.20	.27	.30
2SC 696	1.00	1.20	1.30
2SC 708	1.30	1.45	1.60
2SC 710	.20	.27	.30
2SC 711	.20	.27	.30
2SC 712	.20	.27	.30
2SC 715	.30	.35	.40
2SC 717	.35	.40	.45
2SC 727	1.00	1.20	1.30
2SC 730	3.00	3.20	3.40
2SC 731	2.50	2.70	2.90
2SC 732	.20	.27	.30
2SC 733	.20	.27	.30
2SC 734	.20	.27	.30
2SC 735	.20	.27	.30
2SC 738	.20	.27	.30
2SC 756	1.50	1.80	2.00
2SC 756A	1.50	1.80	2.00
2SC 763	.35	.40	.45
2SC 772	.30	.35	.40
2SC 773	.35	.40	.45
2SC 774	1.00	1.20	1.30
2SC 775	1.40	1.60	1.80
2SC 776	2.00	2.20	2.50
2SC 777	3.00	3.25	3.50
2SC 778	2.90	3.20	3.40
2SC 781	1.90	2.10	2.40
2SC 783	2.10	2.50	2.80
2SC 784	.30	.35	.40
2SC 785	.35	.40	.45
2SC 789	.80	.90	1.00
2SC 790	.80	.90	1.00
2SC 793	2.00	2.20	2.50
2SC 799	2.00	2.20	2.50
2SC 828	.20	.27	.30
2SC 829	.20	.27	.30
2SC 830H	2.50	2.70	3.00
2SC 838	.35	.40	.45
2SC 839	.30	.35	.40
2SC 853	.70	.80	.90
2SC 867	3.20	3.40	3.70
2SC 867A	3.20	3.40	3.70
2SC 870	.35	.40	.45
2SC 871	.35	.40	.45
2SC 895	4.20	4.40	4.90
2SC 897	2.00	2.20	2.50
2SC 898	2.50	2.70	3.00
2SC 900	.20	.27	.30
2SC 923	.20	.27	.30
2SC 929	.20	.27	.30
2SC 930	.20	.27	.30
2SC 941	.20	.27	.30
2SC 943	.35	.40	.45
2SC 945	.20	.27	.30
2SC 959	1.00	1.20	1.30
2SC 971	.70	.80	.90
2SC 982	.70	.80	.90
2SC 983	.50	.64	.70
2SC 1000	.35	.40	.45
2SC 1012	1.20	1.40	1.50
2SC 1013	.50	.64	.70
2SC 1014	.50	.64	.70
2SC 1017	.80	.90	1.00
2SC 1018	.60	.70	.80
2SC 1030	1.80	2.10	2.40
2SC 1047	.35	.40	.45
2SC 1051	3.40	3.55	3.90
2SC 1060	.70	.80	.90
2SC 1061	.70	.80	.90
2SC 1076	30.00	35.00	39.00
2SC 1079	3.40	3.55	3.90
2SC 1080	3.40	3.55	3.90
2SC 1096	.45	.55	.60
2SC 1098	.50	.64	.70
2SC 1111	2.10	2.50	2.80
2SC 1114	4.20	4.40	4.90
2SC 1115	2.50	2.70	3.00
2SC 1116	3.20	3.40	3.70
2SC 1116A	3.40	3.55	3.90
2SC 1124	.80	.90	1.00
2SC 1127	.80	.90	1.00
2SC 1161	1.30	1.45	1.60
2SC 1162	.70	.80	.90
2SC 1166	.20	.27	.30
2SC 1167	3.80	4.00	4.40
2SC 1170B	3.80	4.00	4.40
2SC 1172B	3.20	3.60	3.95
2SC 1173	.50	.55	.60
2SC 1175	.35	.40	.45
2SC 1177	11.00	12.60	14.00
2SC 1189	1.00	1.10	1.20
2SC 1209	.30	.35	.40
2SC 1211D	.30	.35	.40
2SC 1212A	.80	.90	1.00
2SC 1213	.30	.35	.40
2SC 1215	.35	.40	.45
2SC 1222	.20	.27	.30
2SC 1226	.50	.55	.60

TYPE	25-UP	10-24	1-9
2SC 1226A	.50	.55	.60
2SC 1237	1.80	2.00	2.25
2SC 1239	2.20	2.70	2.90
2SC 1279	.50	.55	.60
2SC 1306	1.30	1.45	1.60
2SC 1307	1.90	2.10	2.40
2SC 1310	.20	.27	.30
2SC 1312	.20	.27	.30
2SC 1313G	.20	.27	.30
2SC 1316	4.20	4.40	4.90
2SC 1317	.20	.27	.30
2SC 1318	.35	.40	.45
2SC 1325A	6.50	6.90	7.60
2SC 1327	.20	.27	.30
2SC 1330	.50	.55	.60
2SC 1335	.50	.55	.60
2SC 1342	.45	.53	.59
2SC 1344	.45	.53	.59
2SC 1358	4.20	4.40	4.90
2SC 1359	.30	.35	.40
2SC 1360	.50	.55	.60
2SC 1362	.35	.40	.45
2SC 1364	.35	.40	.45
2SC 1377	3.20	3.40	3.70
2SC 1383	.30	.35	.40
2SC 1384	.35	.40	.45
2SC 1396	.45	.53	.59
2SC 1398	.70	.80	.90
2SC 1400	.35	.40	.45
2SC 1402	3.00	3.20	3.40
2SC 1403	3.20	3.40	3.70
2SC 1407	.50	.55	.60
2SC 1419	.60	.70	.80
2SC 1444	1.60	1.80	2.00
2SC 1445	2.50	2.70	2.90
2SC 1447	.60	.70	.80
2SC 1448	.70	.80	.90
2SC 1449	.60	.70	.80
2SC 1451	1.00	1.10	1.20
2SC 1454	3.20	3.40	3.70
2SC 1475	.80	.90	1.00
2SC 1478	.50	.55	.60
2SC 1509	.50	.55	.60
2SC 1567	.60	.70	.80
2SC 1567A	.60	.70	.80
2SC 1584	6.00	6.30	7.00
2SC 1586	6.50	6.90	7.60
2SC 1624	.60	.70	.80
2SC 1626	.60	.70	.80
2SC 1628	.60	.70	.80
2SC 1647	.70	.80	.90
2SC 1667	3.00	3.20	3.40
2SC 1669	.90	1.00	1.10
2SC 1674	.30	.35	.40
2SC 1675	.20	.27	.30
2SC 1678	1.10	1.25	1.40
2SC 1679	3.00	3.20	3.40
2SC 1681	.30	.35	.40
2SC 1682	.30	.35	.40
2SC 1684	.30	.35	.40
2SC 1687	.40	.45	.50
2SC 1688	.35	.40	.45
2SC 1708	.30	.35	.40
2SC 1728	.70	.80	.90
2SC 1730	.45	.53	.59
2SC 1756	.50	.55	.60
2SC 1760	.70	.80	.90
2SC 1816	1.50	1.75	1.95
2SC 1856	.45	.53	.59
2SC 1885	.45	.53	.59
2SC 1908	.30	.35	.40
2SC 1909	1.80	2.00	2.25
2SC 1945	4.50	5.00	5.60
2SC 1957	.60	.70	.80
2SC 1969	3.60	4.00	4.40
2SC 1973	.70	.80	.90
2SC 1975	1.30	1.70	1.90
2SC 1978	5.40	6.00	6.60
2SC 2028	.50	.64	.70
2SC 2029	1.50	1.80	2.00
2SC 2074	.80	.90	1.00
2SC 2076	.50	.64	.70
2SC 2091	.90	1.10	1.20
2SC 2092	1.80	2.00	2.25
2SC 2098	3.20	3.40	3.70
2SC 2166	1.40	1.60	1.80
2SD 72	.50	.64	.70
2SD 77	.35	.40	.45
2SD 90	1.30	1.45	1.60
2SD 91	1.30	1.45	1.60
2SD 92	1.30	1.45	1.60
2SD 93	1.60	1.80	2.00
2SD 118	2.90	3.20	3.40
2SD 130	1.10	1.25	1.40
2SD 187	.35	.40	.45
2SD 201	2.30	2.40	2.65
2SD 202	3.40	3.55	3.90
2SD 218	2.50	2.70	3.00

TYPE	25-UP	10-24	1-9
2SD 234	.60	.70	.80
2SD 235	.60	.70	.80
2SD 261	.35	.40	.45
2SD 287	2.50	2.70	2.90
2SD 300	4.50	5.00	5.60
2SD 313	.60	.70	.80
2SD 315	.60	.70	.80
2SD 325	.60	.70	.80
2SD 330	.60	.70	.80
2SD 350	3.80	4.00	4.40
2SD 380	5.20	5.40	5.95
2SD 381	.85	1.00	1.10
2SD 424	3.80	4.00	4.40
2SD 425	2.90	3.20	3.40
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3SK 45	1.30	1.45	1.60
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STK 439	7.90	8.00	8.80
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TA 7061AP	.90	1.10	1.20
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TA 7204P	2.00	2.20	2.50
TA 7205P	1.60	1.80	2.00
TA 7222P	3.40	3.55	3.90
TA 7310P	1.30	1.45	1.60
TBA 810SH	1.90	2.10	2.40
TC 5080P	5.00	5.20	5.80
TC 5081P	3.00	3.20	3.40
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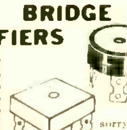

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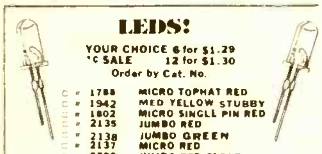

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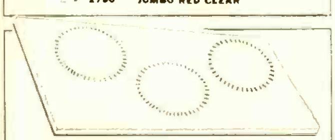

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25	25	.17	Axial	.18
25	50	.24	P.C.	.25
50	15	.17	Axial	.18
50	25	.19	Axial	.20
50	100	.21	Axial	.22
100	15	.23	Axial	.24
100	25	.25	P.C.	.26
100	50	.35	Axial	.36
100	100	.39	Axial	.40
150	15	.23	Axial	.24
200	15	.24	P.C.	.25
220	25	.32	P.C.	.33
250	16	.29	Axial	.30
250	25	.32	Axial	.33
250	50	.45	Axial	.46
300	15	.31	Axial	.32
300	25	.33	P.C.	.34
500	15	.33	P.C.	.34
500	25	.36	P.C.	.37
500	50	.39	Axial	.40
1000	15	.55	P.C.	.56

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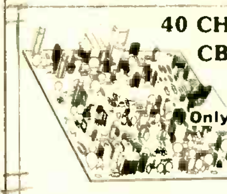

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