SATellite TV
How to receive broadcasts

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Easy-to-build telephone accessory

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I-FI TURNTABLES
They do more than spin records

DIGITAL SLOT MACHINE
Easy to build, fun to play

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TRS-80 BREADBOARD
Application circuits and programs

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When digital circuitry isn't behaving as logically as it should, you need answers—fast. A quick, unambiguous look at what's happening. To show you at a glance the state of any point or port in the circuit.

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CSC logic probes capture pulses as narrow as 10 nanoseconds, to over 50 MHz.

Prices from $260.00 to $777.00*

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A new invention by America's space agency will help all Americans save energy and make some companies very wealthy.

Exxon has it. So does about a dozen other manufacturers. And if our hunches are correct, a new space-age product invented by NASA may not only save Americans millions of dollars but make fortunes for the companies that sell it.

The new NASA invention is known as a refrigerator, for example, is a major energy user. With this new device, your refrigerator will run quieter, there will be considerably less heat generated from the motor, and it will run more efficiently saving up to 30% in energy.

The invention requires no installation. Just plug it into your outlet and plug your refrigerator into the device.

OVER PRICED UNIT

But there's a catch. Most manufacturers sell their units for as much as $200. Using it with your refrigerator, it will take many years before it will pay dividends on a powerful motor, however, the device will pay for itself much quicker.

Manufacturers who have announced their units are selling them like hot cakes. Although you may have heard a great deal of publicity about the product, you may not have seen any advertising because most manufacturers are currently sold out.

Watch for all the great success for all those associated with the product. The power-saving device invented by NASA is a big hit. It will grow in popularity and save energy and make many companies very successful.

A SMALL COMPANY

There is one small company, however, that is credited with improving the device and developing it for the consumer market. Called ERI (Electronic Relays, Inc.) the company has developed several models to service specific products such as a refrigerator, a washing machine, dishwasher, swimming pool and a typewriter.

This small company actually improved the NASA invention by adding its own refinements. ERI had a great deal of experience in solid state relays which use TRIACs and integrated circuits—two important elements in the NASA invention. A TRIAC is a bidirectional thyristor which controls AC from a single control input. TRIACs also produce a great deal of heat.

ERI's experience taught them how to control the TRIAC and its heat dissipation and thus they were able to reduce the device's cost through more efficient handling of the heat problem. They were already one of the nation's largest purchasers of TRIACs—thus their costs were already low.

NATIONAL PUBLICITY

They called their product a Power Factor Controller and sent a sample to a national magazine for their review. In several tests, the device out-performed even the claims made by the manufacturer and the magazine ran glowing articles on its findings.

The manufacturer felt that the product might at first be misleading. Although it does save up to 30% on energy and in many cases up to 60%, ERI felt most consumers would expect a 30% reduction in their total electric bill— which of course the product will not do. Consumers will only get up to a 30% savings on the particular appliance used with the unit.

STILL PESSIMISTIC

The manufacturer also felt that the product was primarily for the industrial market—restaurants with large banks of refrigerators. The consumer must wait a few years before the device would pay for itself. And finally, the manufacturer did not feel that the consumer would respond in great numbers to the article which ran in the July, 1978 edition of Popular Science magazine.

Well, the consumer did respond. So much so that the small manufacturer, with absolutely no marketing staff, was buried with mail. The president of ERI called JS&A to help him out.

TEST ONE YOURSELF

We called it the Power Chopper and agreed to offer it to the consumer market for $29.95—a major price breakthrough.

Even if Exxon lowers their prices considerably, they'll never come close to the low cost of the Power Chopper. ERI's expertise with the TRIAC and JS&A's direct-to-consumer marketing, make the new NASA invention a practical power-saving accessory for every home.

The sophisticated electronics of the Power Chopper consists of a TRIAC, two integrated circuits and several solid state devices.

We urge you to test the refrigerator module. Order one from JS&A on a 30-day no-obligation trial. In the meanwhile, while you are waiting for your unit, feel the heat generated from the bottom of your refrigerator. Listen to the sound level of your compressor.
**Super Special**

**Hickok 385**
500 MHz Counter
Reg 419

**NOW 199.95**

**Limited Quantities**

**Model LB-620**
30 MHz Dual Trace Scope with Delay Line

List Price $1100
$879.95

- High Sensitivity
- Wide Bandwidth
- Single Shot Trigger, P-D-A CRT
- 5mv sensitivity facilitates accurate signal viewing from low level sources
- Built in delay line makes it easy to view the leading edge of a pulse
- Single shot trigger (CH 1, CH 2) captures transient phenomenon—no guesswork, no "double-takes"

**New**

**8022A**

**Now $129.**

- Extensive overload and tamper protection
- Redundant construction
- 96-unit panel permits full in-circuit resistance and voltage testing
- 100 MHz input impedance doesn't heat crystal
- 200 hour battery life — low battery indicator
- Large LCD readout — 3500 counts
- 1 year calibration cycle
- One year total operation

**Basic Specifications**

- 28 ranges, 3 functions plus New Capacitance Function for up to 10,000 pF, 10 pF accuracy Measurements
- Extensive overload and Transient protection
- Rugged Construction — 2 year Warranty
- 50 kV Peak, DC c/w Circuit Protection and Surge Testing
- 10 Meg AC/DC input impedance Doesn't Limit Circuit
- 500 MHz, 10 Battery Life — Low Battery Indicator
- Large LCD readout — 3500 Counts
- 0.1% Basic dc accuracy
- One year operation
- Complete with battery and test leads

**The New Hickok 8022A continues the standard of excellence set by the Hickoktester models. With its high performance AC/DC input impedance, 500 MHz sweep rate, 10 Meg AC/DC input impedance, 10 Meg DC input impedance, and 100 MHz input impedance, the 8022A is the ideal choice for maintenance and troubleshooting.**

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**New Low Distortion Function Generator**

**Model 3010**
- Generates sine, square and triangle waveforms
- Variable amplitude and fixed TTL square-wave output
- 0.1 Hz to 1 MHz in ten ranges
- Push button range and function selection
- Typical sine wave distortion under 0.5% from 0.1 Hz to 100 kHz
- Variable DC offset for engineering applications
- VCQ external input for sweep frequency tests

**New Sweep/Function Generator**

**Model 3020**
- Four instruments in one package — basic generator, function generator, pulse generator, tone burst generator
- Covers 0.02 Hz to 2 MHz
- 10 HID tuning range
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- Tone sweep alternates plus variable control
- Internal linear and log sweeps
- Tone burst output with front panel or externally programmable

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ON THE COVER

The radio-controlled R2-D2™ robot toy manufactured by Kenner Products contains two PC boards, 3 motors, a 3-cell battery pack and even a speaker, but it has nowhere near the capability of a true android. To find out what a household android would require and how you can go about designing your own, turn to page 37.

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IDENTIFYING UNMARKED IC’s can be a real headache unless you know how to go about it. The full story starts on page 45.

THIS INEXPENSIVE SATELLITE ANTENNA makes backyard reception of satellite TV broadcast a reality. If you're interested in building an inexpensive earth station, turn to page 55.


Subscription Service: All subscription orders, address changes, correspondence and Postmaster Notices of undelivered copies (Form 3579) to Radio-Electronics Subscription Service, Box 2520, Boulder, CO 80322.

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CIRCLE 15 ON FREE INFORMATION CARD
Earth-station bonanza: The direct satellite-to-home market is expected to open up wide as a result of the latest FCC action—virtual "deregulation" of receive-only earth stations. This followed by two months the Commission's decision to "routinely" grant such applications (Radio-Electronics, November 1979). Under the new ruling, an earth station may now be built without any license and without the necessity for frequency coordination. This opens the way for the use of dishes smaller than 4.5 meters, which generally has been the minimum size the FCC would approve. It also means cheaper and faster installations.

Sidney Topol, chairman and president of Scientific-Atlanta, hailed the decision as opening the way to thousands of home receiving stations. The FCC proposed that operators who want the anti-interference protection of frequency coordination should be able to use a "self-licensing" procedure by simply notifying the Commission of their intention to build the station following frequency coordination—but amateurs aren't expected to follow that procedure. This doesn't mean that privately owned programs are now free to all. The Commission noted that copyright statutes and the Crime Control Act are adequate to take care of this problem, along with scrambling. The last-named is now being explored by companies which provide programming for pay cable.

Victory for tapists: A tapist, in my lexicon, is someone who tapes TV programs off the air ("taper" sounds too much like some kind of South American animal). Anyway, tapists won an important victory in Los Angeles District Court when Judge Warren Ferguson ruled that the home videotaping of copyrighted television programs for personal use is completely legal. In the suit brought by MCA and Walt Disney Studios against Sony and others, the judge ruled flatly: "Non-commercial home-use recording of material broadcast over public airwaves does not constitute copyright infringement." He specifically said his ruling didn't apply to pay TV, cable TV, tape-swapping or home duplication of copyright tapes because these weren't included in the suit.

High-resolution home TV: Have you often wondered why somebody hasn't developed a compatible television broadcast system with double the number of lines of today's TV to make possible high-resolution television for those who want it? Well, so have I. And we can stop wondering right now. Because such a system is under development. By the Japanese, of course—and anything they do must be taken seriously. It's too early to say much about it, but watch this space. With the development of giant-screen projection, and eventually electroluminescent TV displays, this is bound to be one of the hottest topics of the 1980's— not only in Japan, but in North America and Europe. Remember where you read this first.

Videodisc progress: The optical videodisc is gaining new adherents in Japan. Sony and Philips have agreed to cross-license videodisc and videotape developments, giving Sony access to Philips' patents on the optical disc system. Sony has already built, and is demonstrating, an optical system compatible with the Philips/MCA technique. Sharp of Japan has taken out a license to build a Philips-type disc player. And at the Japan Electronics Show, Sanyo and Toshiba also displayed optical disc systems. But all of this doesn't necessarily mean the optical technique will sweep the videodisc field. Toshiba is a licensee of the RCA capacitance disc system and has demonstrated an RCA-compatible machine. Sanyo is a licensee of the Telefunken-Deca-TED mechanical system. Sony has also signed a cross-licensing pact with Matsushita and JVC covering videodisc developments. Matsushita has developed the Visco-Pac mechanical system and JVC developed a capacitance system. What this means is that the Japanese are keeping all their options open as they await a government ruling on videodisc standards. There are some who feel that the optical system will get the go-ahead as an institutional-industrial-educational and advanced consumer system, and a simpler technique will be designated for the mass market.

Heath joins Zenith: Zenith, one of America's "Big Two" television set manufacturers, is entering the small computer and consumer kit field through its recent purchase of the Heath Company. As soon as the merger was consummated, Zenith established a Data Systems Division, charged with developing Zenith-brand microcomputer products and systems in the small computer field for homes and businesses. The Zenith line will be marketed through Zenith dealers, retail computer stores and through Heath Electronic Centers and the Heath catalog. Of course, the entire Heath line will be continued and augmented under its new ownership.

Zenith has already been in the computer component field through manufacture of color monitors for Texas Instruments' new small computer. Other consumer electronics makers are egging computers, too. RCA's Solid-State Division has been manufacturing small computers for two years. GTE Sylvania will market the Mattel Intellivision video game, which is convertible to a computer. Magnavox's Odyssey line, now equipped with alphanumeric keyboard, is beginning to look suspiciously like a series of products that can easily be converted to a computer.

FCC on videoplayers: The FCC has modified its policy on interference so as not to discourage the growing home video field. The Commission has proposed to make it easier for manufacturers to comply with interference rules for videotape recorders and videodisc players. It proposes to eliminate the necessity for FCC testing of such products, and to permit a fairly large increase in RF radiation from them. This, says Commission staffers, is a calculated decision. One member put it this way: "We now feel we have the responsibility to protect the neighbors of people using these devices, but not reception within the same residence."

This is the same rationale that led to the FCC's adoption of a rule permitting the use of stand-alone RF modulators as Intermediaries between home computers and TV sets (Radio-Electronics, December 1979).
Facts from Fluke on low-
When you're looking for genuine value in a low-cost DMM you have a lot more to consider than price. You need information about ruggedness, reliability and ease of operation. Accuracy is important. And so are special measurement capabilities. But above all, you must consider the source, and that company's reputation for service and support.

Fact is, as electronics become more a part of our daily lives, dozens of new manufacturers are rushing to market their "new" DMM's. In theory, this is healthy; but in practice, confusion is the result. To help you deal with this flood of new products, here are some facts you should know about low-cost DMM's.

The economics of endurance. Even the least expensive DMM isn't disposable. Accidents happen, and test instruments should be built to take the abuses of life as we live it.

Look for a DMM with a low parts count for reliability, and rugged internal construction protected by a high-impact shell. Make sure the unit meets severe military tests for shock and vibration.

Another feature to check out is protection against overloading, whether from unexpected inputs, transients, or human error.

Just for the record, all Fluke low-cost DMM's meet or exceed military specs, and feature extensive overload protection.

The importance of being honest. Just because a multimeter is digital doesn't mean it's automatically more accurate than a VOM — even though the LCD might give you that impression. The benchmark for accuracy in DMM's is basic dc accuracy. The specs will list it as a percentage of the reading for various dc voltage ranges.

Of course accuracy is more critical in some applications than others, and increasing precision and resolution in a DMM usually means increasing price. In the Fluke line, you can choose a model with a basic accuracy of 0.05% (the 8022A), others rated at 0.1%, or the new 8050A bench/portable at 0.03%.

Special measurements: getting more from your DMM.

Actually, for all the variations in size, shape and semantics, most DMM's perform basic five-needle measurements: ac and dc voltage and current, and resistance. Prices vary according to the number of ranges and functions a DMM delivers.

The Fluke line includes DMM's with from 24 to 39 ranges, 3½ and 4½ digit resolution, and some unique functions you won't find in any other DMM. Additional measurement capabilities like temperature, dB, conductance and circuit level detection.

If your work involves temperature measurements, the new 8024A delivers direct temperature readings via any K-type thermocouple. This is especially useful in testing component heat rise and checking refrigeration systems.

Another talented instrument is our new 8050A bench/portable. The microprocessor-based 8050A features a self-calculating dB mode in which dBm readings are displayed automatically referenced to one of 16 selectable impedance ranges — a real timesaver when servicing audio equipment.

And of course no discussion of DMM's is complete without considering conductance — a Fluke exclusive featured on five of our low-cost DMM's — which allows you to make accurate resistance measurements to 100,000 Megohms. You can't do that with any ordinary multimeter, but it's a must for checking leakage in capacitors and measuring transistor gain.

A handful of efficiency. When every minute matters, your schedule is tight and so is your workspace, you need a portable DMM that's fast and easy to operate. We designed our handheld DMM's with color-coded in-line pushbuttons for true one-hand operation; no need to hang onto the meter with one hand while twisting a rotary dial with the other.

But there's more to convenience than fingertip control. The 8024A, for example, is also designed to function as an instant continuity tester, with a selectable audio tone to indicate shorts or opens. It also has a peak hold feature to capture transients.

A word about warranties. Last but not least, look closely at the company that manufactures a low-cost DMM. Their service is just as important as their products. Look for no-nonsense warranties, a large family of accessories, an established network of service centers and technical experts you can rely on.

That's how you'll recognize a knowledgeable supplier of low-cost DMM's, a company with experience, resources and a commitment to leadership in the industry. Incidentally, you'll find it all at Fluke.

Look for more facts from Fluke in future issues of this publication. Or call toll free 800-426-0361, use the coupon below, or contact your Fluke stocking distributor, sales office or representative.

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**For literature circle no. 34**

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Microcomputers are here! Get in on the ground floor with NRI's new "at home" training in computer technology.

Only NRI Gives You "Hands-on" Experience as You Build Your Own Designed-for-learning Microcomputer
The microprocessor, that amazing little chip which shrinks electronic circuitry to microscopic size, has changed the world of the computer with dramatic speed. Now, high-performance computers are here in compact sizes—priced to make them practical for thousands of medium and small businesses, even homeowners and hobbyists.

Microcomputers are already being put to work on jobs like inventory control, payrolls, cost analysis, billing, and more. In homes, they're able to handle budgets and tax records, control environmental systems, index recipes, even play sophisticated games. And hobbyists across the country are expanding the state of the art while developing their own programs.

**Become a Part of This Incredible World ... Learn at Home in Your Spare Time**

NRI can give you the training and background you need for this exciting new science. Microcomputers require a new discipline, a broader viewpoint... the ability to think in both hardware and software terms. And NRI's new course in computer technology is geared to bridge the gap.

You get a firm foundation of digital theory while you get practical, "hands-on" experience working with the NRI Discovery Lab, assembling test instruments you keep, and even building your own fully-functional microcomputer.

Best of all, you do it at your own convenience. You learn at home with clearly written, "bite-size" lessons that carry you through the course in logical progression. There's no need to go to night school or quit your job... you progress at the pace that's most comfortable to you, backed by your personal NRI instructor and Individual counseling whenever you want it.

**Assemble an Advanced Microcomputer with Exclusive Designed-for-Learning Features**

Only NRI trains you with a microcomputer that's specifically designed to teach you important principles as you build it. This state-of-the-art unit performs every function of comparable commercial units, has capabilities well beyond many. But each step of construction provides specific training, reinforces theory to make it come alive. And once you've finished, your microcomputer is ready to go to work for you. Or you can even sell it commercially.

You also assemble professional test instruments for use in your training. You get your own CMOS digital frequency counter and transistorized voltmeter to keep and use in diagnosing problems and servicing computers. Together with up-to-the-minute lessons and NRI's 60-plus years of home study experience, you get the most in training and value.

**Other Courses in Today's Electronics**

Even the servicing of home entertainment equipment has taken quantum jumps forward. NRI keeps you right up with the latest, with training in stereo, video tape and disc players, and the latest TVs. You even build your own 25" diagonal color TV, the only one complete with built-in digital clock, varactor tuning, and computer control that lets you program an entire evening's entertainment. In our complete communications course, you learn to service two-way radio, microwave transmitters, radar, AM and FM transmitters, CB radio, paging equipment, and more. And you build your own 2-meter transceiver or 40-channel CB while you learn.

**Free 100-Page Catalog No Salesman Will Call**

Send the postage-paid card today for your personal copy of the NRI electronics course catalog. It shows all the equipment, training kits, and complete lesson plans for these and many other courses. There's no obligation of any kind and no salesman will ever bother you. Find out how you can learn new skills, keep up with technology, advance your future with training for new opportunities. Get in on the ground floor now! If card has been removed, write to:

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3939 Wisconsin Ave.
Washington, D.C. 20016
A New Decade

The decade of the 70's has come to a close, and the decade of the 80's has begun. The new electronics decade, however, is already under way and is going full blast. To get a feel for the latter technology and what the 80's will hold in store for us, let's glance at some of the happenings and some of the terms and acronyms that are presently being used in the semiconductor industry—the foundation upon which tomorrow's electronics industry is built.

Do you remember when C-MOS (complementary-MOS) was the greatest thing to happen since the invention of the light bulb? Now there's also n-MOS (N-channel MOS). This logic family has several different names, depending on who is doing the manufacturing. They include HMOS, X-MOS and S-MOS. The HMOS (high-performance n-MOS) family also has a sister (brother?) called H-MOS II. On top of this, Advanced Micro Devices has a scaled-down MOS process called Polyplanar. How about a pIC-MOS which is a double-poly silicon process? Other logic families around include ISL (Injection Schottky Logic), STL (Schottky Transistor Logic). Isoplanar-S, and even BEST (Base-Emitter Self-Align- ed Technology). Manufacturers even mix technologies within the same IC. Matsushita has an IC that combines p-channel MOS with IFL and ion-implanted NPN transistors. One last one; we've all heard about MOSFET's, but how about a MESFET (Metal Semiconductor Field Effect Transistor).

Where is all this technology leading us? Not long ago, the jump from 4K to 16K RAM's opened many new doors. Today, semiconductor manufacturers have introduced 64K RAM's. Bubble memories were introduced in the 70's with a capacity of 256K. Two bubble memory devices were introduced in 1978, each with a capacity of 1 megabit. Now manufacturers are talking of 8-megabit capacities per device within the next few years.

Microprocessors have also come a long way. From the original 4004, through the 8008, 8080 and Z-80, we now have the Z-8000. It is a 16-bit processor that has many 32-bit attributes. In other words, it behaves like a 32-bit processor in many ways. There are also the 68000 and NS16000, both 16-bit processors. Many, many processors have been introduced, and if I were to list them, they would fill several more paragraphs. One introduction however, cannot go without mention, the analog microprocessor. Intel's 2920 is a digital microprocessor that includes D/A and A/D converters on the input and output ports. It's a digital processor that connects to analog signals.

Remember SSI (Small Scale Integration) and MSI (Medium Scale Integration)? We're now working with LSI (Large Scale Integration) but the push is on for VLSI (Very Large Scale Integration). Oh well. I remember working with RTL (Resistor Transistor Logic) and DTL (Diode Transistor Logic). I wonder what we'll be using in 1990?
The Protectors

The two products shown below are the latest in Space-Age Electronic Home Security. Do you know which one is right for you?

The GE Zonar Burglar Alarm is a Superior False-Safe unit that has an invisible ultrasonic beam to deter intruders.

The Micro FM Wireless Mike has a range of over 300 ft and transmits through any standard FM radio.

The two new products shown in this ad are the latest in space-age electronics. The Zonar Burglar Alarm comes with similar burglar alarms selling for $200 or more. The Micro FM Wireless Mike, the world's smallest wireless microphone, represents new technology in the field of FM Radio Electronics.

We bought both of these products from the manufacturers and tested them under every possible condition. The following are the results of our experiments with both the Zonar Burglar Alarm and the Micro FM Wireless Mike. Please read on. The results may surprise you.

THE ZONAR BURGLAR ALARM

The new GE Zonar Burglar Alarm sounds a loud (85dB) alarm — so loud that it can cause pain — and scare away intruders that cross the invisible ultrasonic beam.

The Zonar Burglar Alarm requires no installation and is portable, so you can place it anywhere in your home. Operating the Zonar is as easy as turning on your television. To arm the unit, you simply press the On Instant or On Delay button. You now have 35 seconds to leave your home. When you return, you enter and have 10 seconds to press in your secret code numbers. This will disarm your unit. The personalized code numbers for alarm shall mean that only you or your family knows the code to disarm the alarm.

The Zonar Burglar Alarm looks like a handsome piece of furniture and its small unobtrusive design helps to make it look less noticeable. It measures only 7" x 4" x 3" and weighs less than two pounds. To help protect your home or office, it comes with warning decals for windows or doors that state, “WARNING Protected by Electronic Surveillance Equipment,” to help deter potential burglars.

The GE Zonar Burglar Alarm is battery operated, so even if a burglar cuts off your power, the unit will still be operational to alert you and your neighbors.

The GE Zonar Burglar Alarm comes with complete instructions and a One-Year limited warranty backed by General Electric. Should your unit ever malfunction, you may drop it off at any authorized General Electric Dealer or you may use GE's convenient service-by-mail center.

To order your unit for a 30-day test, simply send your check for $29.95 plus $2.50 postage and handling to Chandler's, One Chandler Plaza, Chantilly, Virginia 22021 (Virginia residents please add 4% sales tax). Credit Card Buyers may call our 24-hour Toll-Free number below.

THE MICRO FM WIRELESS MIKE

The Micro FM Wireless Mike is a miniature microphone that picks up your voice and transmits it through any standard FM radio.

The new Micro FM Wireless Mike measures only 1 1/4" x 3/4" and weighs less than one ounce. We found that the superior electronic components put into the microphone surpass anything else on the market. It has a transmitting range of over 300 feet (the length of a football field) and its exceptional fidelity gives you clear reception with practically no interference. Unlike citizen band radios, which operate in the 27 to 29 MEGAHertz range, the Micro FM Wireless Mike uses the 88 to 108 MEGAHertz range, giving you the freedom to operate from your car radio, portable radio or home stereo.

BUT WAIT, THERE'S MUCH MORE. The Micro FM Wireless Mike is capable of more than just being a remote mike. It can be used as an intercom in both your home and office. For example, if you are in the garage and your wife or children are in the upstairs bedroom, you can turn on the mike and use it just like an intercom. Secondly, it is small and can be clipped to your jacket while in meetings or during a speech in your conference room or office. The Micro FM Wireless Mike is FCC approved for use in homes, apartments, offices or factories.

Finally, it's inexpensive — only $29.95 complete with 27" flexible antenna, carrying case, operating instructions and a fresh 1.3 volt mercury battery (which can be replaced at any hearing aid or radio-electronics store).

Your Micro Mike comes with a 30 day limited warranty backed by two substantial companies. Should a malfunction ever occur, there's a complete service-by-mail center as close as your postman.

The Micro FM Wireless Mike can be ordered by calling our 24-hour toll free number below or by sending your check for $29.95 plus $5.00 for two. Please add $1.25 each for postage and handling and Virginia residents add 4% sales tax.

OUR OPINION

We are convinced that both of these new products are superior in value and quality.

The Micro FM Wireless Mike and the GE Zonar Burglar Alarm are backed by two substantial American companies. MLI Industries and General Electric both have years of experience in manufacturing and design leadership. Chandler's is one of America's innovative companies specializing in bringing the American public new and unique products — additional assurance that your prudent investment is well secured.

With any Chandler's product, you may return it within 30 days for a full, courteous and prompt refund, with positively no questions asked, and we even refund our postage and handling charge. There's no risk when you can own the best. Order one or both of our remarkable new products, at no obligation today.
Second satellite seminar scheduled for Miami

Following the highly successful satellite seminar held at Oklahoma City last August, a second one will be held in Miami, February 5, 6, and 7. The three-day program will include more than two dozen technology lecture sessions by three authorities on satellite technology, as well as special sessions on marketing and selling low-cost satellite terminals.

The cost of the three-day seminar is $150. Pre-registration is mandatory. Because a large number had to be turned away at Oklahoma City, where 508 attended, facilities for a thousand or more are being obtained at Miami. Full information is available from Satellite Television Technology, P.O. Box G, Arcadia, OK (phone 405-396-2574).

Olympic ski communications to get power from the sun

The 1980 Winter Olympics command post (Lake Placid, NY) and the top of 4,867-foot Whiteface Mountain, on which the ski events take place, will be linked by a communications system powered in part by 20 photovoltaic solar panels. Each of these panels consists of 36 three-inch single-crystal silicon cells in a weatherproof assembly. Power output of each panel averages 1.2 amperes at 16.2 volts (approximately 20 watts of peak power).

There will be two primary links and one standby system for communication between the peak of Whiteface Mountain and the base camp below. The first, a wired system, consists of 12 semi-portable telephones between the peak and base of the mountain. The second system, which acts as an intercom, uses a dozen fixed-position telephones. The standby system works with a General Electric UHF-radio.

All the systems can be powered by the group of 20 large panels. Eight panels of an 18-panel array on the roof of White Mountain Ski Lodge supply 2.4 amperes at 48 volts for the first race communications system; the remaining ten can provide 6 amperes at 10 volts for the second, electrically independent intercom setup.

A two-panel array powers the emergency standby system and charges a bank of storage cells. Should the regular electric power fail completely, it will be able to supply energy for all the communications systems, as well as the fighting required for the games, for as long as two hours.

New evaporated recording tape increases density ten times

A recording tape in which the magnetic recording layer is evaporated directly onto the base film surface has a density ten times that of conventional tape. It was invented by University of Wisconsin physicist Sau Lan Wu, aided by Georg N. Sobering, the University of Wisconsin—Madison reports. The team spent the last two years at Hamburg, working with the new electron accelerator (which is known by its German acronym PETRA), to observe events following collisions between high-energy electrons and oppositely charged positrons.

When high-energy electrons and positrons collide, they convert all their energy and mass into an energy bundle called a virtual photon. From that energy bundle a quark and an antiquark are produced. These move apart in opposite directions. This causes the quark and antiquark to form a stream of particles in a narrow cone, called a jet.

One jet is formed from each of the original quark and antiquark that are produced from the virtual photon. If the energies of the colliding electrons and positrons are high enough (in this case 15 billion volts each) then one of the quark jets can radiate a gluon, which then turns into a jet of particles.

Using a method devised by Drs. Wu and Gobenring, the research team developed a computer program to analyze the data from the electron-positron annihilations, and the third jet—evidence for the gluon—was discovered. "If the 3-jet events we detected are not from the gluon," Dr. Wu told the conference in Geneva, Switzerland, last June, at which the information was first presented, "then something very
Sabtronics NEW Hand-held Digital Multimeters . . .

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Accurate performance you can rely on—time after time. That's what you expect from a quality DMM. But don't expect to pay as much for it anymore. Because now Sabtronics brings you top quality DMMs with more features and better accuracy than other comparable units on the market today. And they cost surprisingly less!

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What you get is a precision crafted unit that features single-chip LSI logic, laser trimmed resistor network and a stable hand-slip reference element for better long term accuracy. Basic DCV accuracy is 0.1%. The Model 2035A gives you 31 measurement ranges over 6 functions and the Model 2037A an additional two temperature ranges.

First in features. First in price.

Both models feature touch-and-hold capability with the optional probe—its so convenient, you'll wonder why the expensive models haven't got it yet! And two-terminal input for all measurements—this eliminates lead switching and makes your job easier. The Model 2037A even has a built-in temperature measuring circuit with a -50° C to +150° C range (-58°F to +302°F) and is supplied complete with the sensor probe. Of course, auto zero, auto polarity and overload protection are standard. And you get 200 hour operation from a single 9V transistor battery. A low battery indicator warns you of the last 20% of battery life. The large, crisp LCD readouts allow easy viewing even in bright sunlight.

Assembling either kit is simple with our easy-to-follow, step-by-step instructions. And the built-in calibration references allow you to calibrate the unit any time, any place.

We've even eliminated difficult inter-connect wires. All parts mount on the PCB board. The only wires you solder are the two battery-snap leads.

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- **LOW OHMS**: 0Ω - 20MΩ, 6 ranges
- **TEMPERATURE**: -50° C to +150° C (-58°F to +302°F), 2 ranges

**WEIGHT**: 11 oz (excl. battery)

**OVERLOAD PROTECTION**: 1000V DC or ACovpeak all voltage ranges, 250V DC or ACovpeak all Ohms ranges, 2A/250V fuse all current ranges.

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JANUARY 1980

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exciting is just around the corner.""

Why is the gluon so important to physicists? Scientists since Einstein have proposed the existence of four forces, electromagnetic, gravitational, strong, and weak, each of which has elementary carriers of force. The photon is the carrier of force of electromagnetism and until now it was the only one known.

The existence of the gluon, the carrier for the strong force, is encouraging to physicists who are seeking the carriers of the gravitational and weak forces. It is the hope of many physicists to eventually combine all four forces into one grand unified theory of matter.

Marriage of sound and print in new audio-visual system

What the manufacturer, Microsonics Corp., calls a "totally new dimension in publishing" has just been introduced. It consists of a miniature handheld player, called a "Microphonograph," and a 24-inch transparent record that can be applied directly to a page of a book or to a card designed for the purpose. The record plays for a minute and a half.

HOW THE MICROPHONOGRAPH IS USED. The device adds sound to the information obtainable from a printed book.

The user simply places the Microphonograph on the page, locates the record and presses the "play" button. Instantly he has his own multimedia system, combining pictures, print and sound.

The system would seem especially valuable in the language field, giving even a home student practically the services of a native-speaking teacher. In other subjects the added sound can make a dry text come alive, with the author's voice commenting on the texts (in historical or biographical works, often with the voice of the subject). Special formats for combining sight and sound in training courses are already being produced by several firms.

In the card format, one side can display photos, maps or diagrams that will complement information on the record, and the back can carry additional information or instructions. The system can even be adapted to existing printed material, making it one of the least expensive of audio-visual systems.

The system-Microphonograph and records-is priced from $20 up, depending on the choice of hardware and quality and quantity of software. Updating or extending is easy, simply by adding new microrecords and cards.

Lights three times as good are forecast for year 2000

A research study just conducted by Westinghouse Electric scientists concludes that—while electric costs will triple by the year 2000—improvements in lighting will mean that the lighting part of the average user's bill will rise only slightly.

High-intensity mercury, vapor, metal halide and high-pressure sodium vapor discharge lamps—which are now in use in industry—will make great energy savings in residential lighting. Up to 150-175 lumens per watt is attainable with such lamps. The Westinghouse scientists predict. (Standard bulbs in use today have an efficiency of only 15-20 lumens per watt—a 100-watt bulb is rated at 1710 lumens.)

The average homeowner, the study found, pays $57 per year, or 27 percent of his total electric bill, for lighting. By the year 2000, this should decrease to about 8 percent. But—the new light bulbs will cost more, maybe $5 to $15 each. The cost of lighting will have to be calculated on the price of the bulb together with the amount of light it will give in its useful lifetime.

The fluorescent lamp—already at least four times as efficient as the tungsten bulb—will take over in the home, through color improvement and new design. Already screw-in types are being made to use in existing incandescent fittings.

Further new developments are predicted: Lighting will be used for home security; proximity sensors installed around the perimeter of a residence and activated by an intruder will turn on the inside lighting. New products will improve perception, reduce eye strain and satisfy specific health requirements. Special lighting will be introduced for older people. A major area of research will be devoted to the psychological, behavioral and physiological effects of lighting on people.

Students do original research in summer training session

A near-unique type of industrial "student training" program is being cosponsored by GTE Laboratories and the National Science Foundation. Some 40 students, representing 10 colleges and universities, are participating in research projects at GTE facilities.

ALFREDO ARCHILLA, of the University of Puerto Rico, working with GTE scientist William Hertz on his "smart telephone" project.

Unlike many "student training" programs, this one provides the student with genuine research and real work. If they succeed in their tasks, they have the realization that they have added to the world's knowledge, technology or convenience.

For example, Alfredo Archilla of the University of Puerto Rico at Mayaguez, is working on a "smart telephone" that will not only accept voice commands but will talk back. "Right now," says Mr. Archilla, "you can tell a telephone to perform a task in your home (such as turning the oven on or off) from a remote location by touch tone. When you ask it if it has finished the job, it also answers in tone. We want it to answer in words, and my job is to develop such a program."

Subscription TV stations now permitted to proliferate

The FCC voted, in a meeting late in September, to rescind the rule that permitted only one pay-TV station in a community.

The opposition to subscription television by broadcasters and movie theaters that was so marked when pay-TV was first proposed has decreased to only token opposition, FCC sources reported. It is possible that the extensive development of cable television has reduced the relative importance of over-the-air subscription systems.

There are at present only six pay-TV stations on the air. The largest, KBSG, Corona, CA, which serves the Los Angeles region, has 210,000 subscribers. The others are KTVY in Phoenix, AZ; KWHY, Los Angeles, CA; WOTV, Boston, MA; WWHT, Newark, NJ, and WXON, Detroit, MI. R-E
Sabtronics new counter gives you 600 MHz capability for only $89.95

This highly accurate frequency counter can be yours at the unbelievably low price of $89.95. The Sabtronics 8610A is your best buy today in a lab-quality instrument.

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Count on satisfaction: Keep our kit for 10 days' free trial examination. If you're not completely satisfied for any reason whatsoever, simply return it unassembled for a prompt and courteous refund of your purchase price.

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BRIEF SPECIFICATIONS
- Frequency Range: 10 Hz to 600 MHz guaranteed (5 Hz to 750 MHz typical). Sensitivity: ≤ 10 mV RMS, 10 Hz to 100 MHz, prescaler mode; 50 mV RMS, 100 MHz to 450 MHz; 70 mV RMS, 450 MHz to 600 MHz. Impedance: 1 MΩ, 10 MHz & 100 MHz range; 500, 500 MHz. Temperature Stability: 0.1 ppm/°C. Gate Time: Switch-selectable, 0.1 sec., 1 sec., 10 sec. Ageing Rate: ≤ ± 5 ppm/yr. Accuracy: 1 ppm + 1 digit. Input Protection: 150 V RMS, 5 Hz to 10 kHz; 90 V RMS, 10 kHz to 2 MHz; 30 V RMS, 2 MHz to 100 MHz; 10 V RMS, 100 MHz to 750 MHz. Power Requirement: Battery-operated, 4.5 to 6.5 VDC @ 300 mA. External power supply, 7.5 to 9 VDC @ 300 mA. Size: 8”W x 6.5”D x 3”H (203 x 165 x 76 mm). Weight: Without batteries, 1.2 lbs. (0.54 kg).

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If you have put off learning more electronics for any of these reasons, act now!

☐ I don't have the time.

☐ High school was hard for me and electronics sounds like it may be hard to learn.

☐ I can't afford any more education.

☐ I have a family now.

☐ I'm here. You're there. I've never learned that way before. I'm not sure it will work for me.

Read the opposite page and see how you can get started today!
Be honest with yourself. Are the reasons really excuses? You already know enough about electronics to be interested in reading this magazine. So why not learn more? If you need encouragement, read on and see how excuses can be turned into results.

You don't have the time. Be realistic. All you have in life is a period of time. Use it. Try to know more tomorrow than you do today. That's the proven way to success. CIE studies require just about 12 hours of your time a week, two hours a day. You probably do have the time.

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Senior Technical Director

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MAIL TODAY!
HEART RATE

I am a physician, currently in my fourth year of surgical residency. In addition, I hold a Masters Degree in Electrical Engineering. Because of my background, I am naturally fascinated by articles in your magazine relating to medical applications of electronics. Such an article was Mark C. Worley's "Heart Rate Monitor" (July 1979 issue). I must, however, take exception with several points in the author's description of the device's operation.

The "heart beat waveform" depicted in the article correctly shows a typical electrocardiogram tracing. This is a recording of the electrical activity measured between a pair of electrodes in contact with the skin of the body. It corresponds to the discharge and recovery of the electric charge across the membranes of heart muscle cells, which initiates contraction of the muscle.

The device, that is described in the article is commonly referred to as an optical plethysmograph (from the Greek plethysmos, an enlargement). It measures the minute expansion and contraction of the finger in response to the blood pressure pulsations within its arteries. The enclosed diagram illustrates the relationship of the heart electrical activity (ECG, or electrocardiogram) and the blood pressure (BP). The R-wave, or more correctly the QRS complex, is the activity that initiates the contraction of the main pumping chambers. The T-wave is the activity that accompanies electrical recovery of the charge across the cell membranes.

The pressure tracing is characterized by a sharp rise to peak (systolic) pressure, and a more gradual fall off to the (diastolic) pressure before the next contraction. The "notch" in the curve on its downslope is caused by the one way valve at the outlet of the heart snapping shut as the pressure falls. The delay, d, is a function of the response time of the muscle to the electrical stimulation, and the propagation delay of the pressure pulse down the artery.

From this discussion, it can be seen that prevention of multiple triggering is indeed necessary. However, Mr. Worley's statement "triggering on... R- and T-waves" is misleading.

Another inaccuracy contained in the article is the reference to the 300 ms (misprinted as 300 µs) period of trigger lockout as a Schmitt trigger. A Schmitt trigger is a circuit that has hysteresis, i.e., a different threshold for positive-going and negative-going input changes.

Finally, it must be kept in mind that the heart rate may rise over 200 beats-per-minute under stress or after heavy exercise, and that in a young, well trained athlete the resting heart rate may be as low as

---

"I prefer RCA SK's because they have the abilities:

Ready Availability
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and High Reliability.

All these add up to Good Profitability."

These are the words of Stanley J. Lysy of Service Plus, Westfield, Massachusetts.
ETCHANT DISPOSAL

James Temple's "How to Make Your Own PC Boards" (July 1979 issue) was interesting and I am looking forward to future articles.


Disposal of expended etchants via a scavenger service is probably the only method that is both completely safe and legal in all communities, but scavenger services are not likely to be interested in handling individual hobbyists' quantities. Perhaps an organized group, such as an electronics club, could find a way to pool their waste chemicals.

Spent ferric chloride etchant can be made safer by neutralizing the acid with sodium carbonate. Sodium carbonate is sold in grocery stores as "sal soda" or "washing soda." Immediately after the etchant is expended, pour it into a plastic container large enough to allow for foaming. Rinse the tray with fresh water and pour that into the container. Slowly add the sodium carbonate neutralizer, while stirring with a wooden or plastic utensil, until foaming ceases.

Disposal of waste chemicals in public sewers is forbidden in many communities, and for valid reasons. In the case of PC etchants, copper dissolves from the boards may upset the role of bacteria required for sewage breakdown and may destroy plants and fish if it ends up in natural waters. Small amounts of etchant would become extremely diluted by the large volume of water in a public sewer and probably would do no harm. On the other hand, hobbyists in rural areas who rely upon a single-dwelling sewage system (septic tank) may have cause for concern if they process a large number of boards.

Direct burial is an inexpensive and frequently used (but not necessarily legal) method of disposal. A disposal sump can be made by filling a hole several feet deep with coarse gravel. Neutralized etchant is poured into the gravel and washed down with fresh water to further dilute and disperse the chemicals.

L. SCOTT HOEVER
Federal Way, WA

An Electronic Service Technician speaks out for RCA SK's

To paraphrase Mr. Lysy, one of the ten winners in RCA's recent SK slogan contest, RCA SK's are indeed readily available. As for interchangeability, over 950 SK types replace over 153,000 domestic and foreign types. Our new SK numbering system which incorporates the other leading numbering system used by ECG* REN and TM makes it easier than ever for you to identify the right SK replacement. And of course, SK reliability means fewer costly call-backs for you.

As Mr. Lysy points out, all these "Abilities" add up to the most important "Ability" of all... Profitability.

See your RCA SK distributor for all your solid state replacement needs and ask for your copy of the new authoritative RCA SK Replacement Guide, SPG 202X, or send your request with check or money order for $1.50 to RCA Distributor and Special Products, P.O. Box 597, Woodbury, N.J. 08096.

RCA SK Replacement Solid State
Panasonic Model RF-2900
Portable Multiband Radio

ONE OF THE MOST ATTRACTIVE MULTIBAND portable radios on the market is the model RF-2900 from Panasonic Corporation. While definitely not of communications quality, it does perform well for its intended applications.

Housed in an attractive black military-type case with chrome accents, the radio has a bright digital fluorescent display that provides an accuracy of 1 kHz through 30 MHz, and 100 kHz on FM.

The circuit is a double-conversion type for good selectivity. The frequency ranges are: 325 Hz-1605 kHz and 3.2 Hz-30 MHz (AM/CW/SSB) and 88 Hz-108 MHz (FM). Power is supplied by a 120 VAC source or by internal batteries (six D-cell batteries, which are not included). A dual-speed main tuning dial handles fine adjustment on all ranges. During battery operation, the dial lights and frequency display can be switched off to conserve power. An integral telescoping whip antenna enhances the receiver's portability, and external antennas are included.

CIRCLE 101 ON FREE INFORMATION CARD

An S-meter acts as a tuning aid and often doubles as a battery tester. An adjustable BFO (beat-frequency oscillator) control permits the manual selection of CW (continuous-wave) pitch or LSB/USB reception.

Front-panel jacks are provided for an external speaker (or headphones), a tape recorder output and an audio input to the receiver amplifier. In addition, a detachable sun shade for the frequency display and a carrying strap are included.

Testing the unit, we found the FM reception to be entirely adequate. The audio was clean, and the automatic frequency control was very effective for drift cancellation. The digital frequency display proved to be quite accurate in locating stations.

On the AM broadcast band the unit's selectivity was good. Images were undetectable through most of the tuning range; display accuracy was within 2 kHz, and the audio quality was found very good.

When the unit was used in the shortwave mode, high sensitivity brought in weak signals using only the whip antenna. A front-panel trimmer allows close frequency calibration. A wideband/narrowband selectivity switch provides sharp adjacent-channel rejection in any mode. The receiver displayed good mechanical stability.

It must be remembered that the model RF-2900 portable radio is not intended for communications use where performance is needed, but it does perform well in its intended applications.
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DUAL TRACE
DELAYED SWEEP
OSCILLOSCOPE

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CIRCLE 75 ON FREE INFORMATION CARD

JANUARY 1979
Sometimes It Pays
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Radio Shack System
Seven Stereo

GOOD THINGS COME IN SMALL PACKAGES! THIS
familiar saying could well apply to the Radio Shack
(500 One Tandy Center, Fort Worth, TX 76110) System Seven stereo. Although we all have a	endency to take manufacturer's specifications with a grain of salt, it appears that in this case, the manufacturer's good press is well deserved.

Radio Shack System
Seven Stereo

EQUIPMENT REPORTS
continued from page 24

2400 is not designed as a communications
receiver. It is primarily a portable radio with
shortwave coverage. Serious single-sideband
(SSB) or continuous-wave (CW) reception is
difficult because of constant oscillator drift.
Spurious signals were present throughout the
shortwave tuning range. Dial backlash is quite
noticeable on the higher frequency ranges.
Frequency tuning is rapid, making fine adjust-
ment difficult. Noise-limiter circuitry is not
included, making the receiver vulnerable to an
electrically noisy environment.

In spite of the receiver's problems with
shortwave reception, it performs well for the
AM/FM listener who wants good sound, port-
ability, an accurate frequency readout and
access to shortwave broadcasts.
The model RF-2900 multimode portable
radio sells for $299.95 and is manufactured by
Panasonic Corporation. One Panasonic Way,
Secaucus, NJ 07094.

CIRCLE 102 ON FREE INFORMATION CARD

System Seven's matching Minimum-7 speaker
sets (No. 40-2030) are reminiscent of the popu-
lar Maximum-5 bookshelf speakers of more than
decade ago and perhaps even better. The
speakers produce an astounding bass and
smooth, silky highs. Measuring only 75/8 X 41/8
X 41/4 inches, the cabinets are made of heavy
metal casting, each encasing a 4-inch high-
compliance woofer and a 1-inch dome tweeter.
Careful placement is one secret means of
achieving maximum performance from these
miniature dynamos.
The receiver (model STA-7) is handsomely
designed. It is enclosed in a low-profile (161/4
X 37/8 X 12-inch) black satin-finish metal

CIRCLE 102 ON FREE INFORMATION CARD

cabinet. The blackout dial and tuning meter
are attractively edge-lighted when the receiver
is switched on.
The amplifier specifications are excellent:
15 Hz-30 kHz ±2.2 dB; under 0.5% THD from
20-20,000 Hz into 8 ohms and a full 10-watt
output.
The amplifier can accommodate several
front-panel switch-selectable inputs. The rear
apron houses an array of jacks in order to allow
wide amplifier flexibility. The rear apron switch
provides 6.5-db bass enhancement for the
matching speakers.
The AM/FM tuner stages are equally im-
pressive: FM sensitivity (IF) is typically 2.2
µV; limiting sensitivity (-3 dB) is 3.2 µV;
S/N ratio (1 mV) is 60 dB. Total harmonic
distortion (stereo) is 0.6%; stereo separation
(at 1 kHz) is 34 dB; image rejection is 50 dB;
1F rejection is 80 dB, and selectivity is 45 dB.
A built-in ferrite loop is provided for AM
reception, and line-cord coupling can be used
for metropolitan FMlistening. External anten-
na terminals are provided on the rear apron for
both AM and FM reception.

Power requirement is either 120 VAC or
240 VAC.

Our test

Initial hookup and installation were easy; we
followed the suggestions outlined in the litera-
ture that accompanies the system. Our advice:
DO READ the instructions. Speaker place-
ment is critical for optimum performance. You
need speaker hookup wire; and use color-coded
wire: red for correct and efficient power transfer.
The tuning dial markings are well-spaced and
easy to read, and the flywheel tuning knob
has a professional feel. FM stability is excel-
I:ent, with warm-up drift undetectable. The
bass and treble controls have definite stops,
giving the impression of incremental steps;
similarly, the balance control has a center-position
detent stop. We liked these features.
Although the quality of sound from the Sys-
tem Seven would merit using the most expen-
sive stereo headphones, we selected a set of
Realistic's new model PRO-20 headphones
($24.95) to see how well they would perform
with the receiver. The results were quite sail-
continued on page 32
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factory: these low-cost phones are a good choice in matching economy stereo headsets for noncritical requirements.

Clearly, the System Seven is a product for other manufacturers to reckon with: it should become a standard of comparison among low-cost, high-performance component music systems. The Radio Shack System Seven sells for $219.95.

**B & K Model E-200D RF Signal Generator**

**CIRCLE 103 ON FREE INFORMATION CARD**

A reasonably priced, metered-output signal generator is a difficult item to find. B & K's model E-200D RF Signal Generator helps fill that void.

The E-200D is a handsome, husky compact generator featuring straightforward operation. Functions are very clearly marked, and familiarization comes quickly. The accompanying owner's manual is well written, and very flexible in its subject matter. The usual circuit descriptions and control identifications are provided, but several other test subjects are included. A handy dB-to-microvolt conversion table is provided and is very helpful for sensitivity measurements. Alignment procedures for AM radios, FM receivers, and TV sets are given step-by-step.

The E-200D measures 12 1/4 x 7 1/4 x 8 inches, and weighs 14 pounds. It is securely enclosed in a steel cabinet, AC powered through a 3-wire grounded cord.

Fundamental frequency generation ranges from 100 kHz through 54 MHz, with calibrated harmonics usable through 216 MHz (TV Channel 13). Frequency accuracy is advertised as being ±1.5% of highest frequency on any band, usable to 0.1% with internal calibrator. The calibrator is heterodyned against the signal generator frequency, producing an audio beat note that can be heard from an internal speaker.

RF signal voltage output (maximum) varies from 3 volts (lowest frequencies) to 0.3 volt (highest frequencies). Using the calibrated attenuator and level control, the output level may be selectively adjusted from -106 dB (5mV) to +2 dB (21.6 mV) ± 0.2 dB. Accuracy throughout the entire fundamental frequency range is specified as being within 2 dB.

Modulation is provided by an internal 400 Hz ±20% oscillator. Level is set at 1/2 W RMS for 50% modulation. External and internal sources of modulation are both continuously adjustable and metered.

Both a block diagram and circuit schematic are included for servicing the generator, and to make internal calibration easier. The subject of calibration needs to be mentioned. While it is possible to bring the E-200D into specified accuracy, the unit that we evaluated was considerably off in its dial reading. On several lower-frequency segments, (between 100 kHz and 9 MHz) the adjustable backlash could not be offset far enough to coincide with the actual output frequency. Nonlinearity in the dial ranges aggravates the problem. Although we made no attempt to align the unit, our feeling is that it could probably be brought within specifications.

To assist with calibration accuracy, two internal reference oscillators are included. The 1 MHz crystal oscillator is very accurate and stable. It is usable up to about 33 MHz. The 100-kHz oscillator is an L-C unit and had strayed considerably off frequency. Adjustment of the 100-kHz oscillator is easily accomplished by aligning the slug of the oscillator coil, readily accessible through a small hole in the shielded RF section.

Shielding and mechanical stability are two vital areas in any signal generator design. We were pleased at the RF isolation provided by the extensive copper-plated steel shielding. The cabinet cover is also interlocked to discourage stray radiation.

One of the most serious drawbacks in using inexpensive hobby-type RF signal generators comes with low signal levels. When it is important that very low output signals (in the microvolt region) must be used to measure minimum sensitivities of radio receivers, stray radiation will wreck havoc! These leakage paths may occur between cabinet/panel cracks, or with poor cable shielding, poor continued on page 34

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EQUIPMENT REPORTS
continued from page 32

ground strapping, AC line radiation, or even loose panel hardware. The E-200D seems to have much lower stray radiation than most other low-cost competitive signal generators. That condition must be attributed in large part to the heavy shielding around the internal oscillator section.

While the shielding made the unit relatively RF tight, mechanical instability is still apparent, especially at higher frequencies. A gentle tap on the cabinet will cause severe detuning on the upper ranges. Above 5 MHz, the frequency dial tuning becomes increasingly rubbery, making exact adjustment virtually impossible on close tolerance alignment. Thermal drift, however, is minimal with this solid-state instrument.

Considerable frequency pulling occurs from the attenuator control. With the dial set at some useful frequency, rotating the fine attenuator control results in extensive frequency change. Even though the attenuator pot is isolated by a buffer stage, interaction with the oscillator is still quite prevalent. Some loading effect on frequency is also noted when the output of the generator is connected to its injection point in the circuit to be checked.

Metering in any unit is desirable. Obviously, absolute accuracy cannot be expected except in generators costing considerably more than the E-200D, but used as a relative reference, it can be very useful. For most applications, and non-demanding test bench use, the E-200D is loaded with useful features. The E-200D RF signal generator sells for $100. Available from B & K-Precision, Dynason Corp., 6460 W. Cortland St., Chicago, IL 60635. R-E
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Do not be fooled by the low prices, these brand new lab quality frequency counters have important advantages over instruments costing much more. The models 7010 and 8010 are not old counters repackaged but 100% new designs using the latest LSI state-of-the-art circuitry. With only 4 IC's, our new 7010 offers a host of features including 10 Hz to 600 MHz operation, 9 digit display, 3 gate times and more. This outperforms units using 10-15 IC's at several times the size and power consumption. The older designs using many more parts increase the possibility of failure and complexity of troubleshooting. Look closely at our impressive specifications and note you can buy these lab quality counters for similar or less money than hobby quality units with TV xtal time bases and plastic cases!

Both the new 7010 and 8010 have new amplifier circuits with amazingly flat frequency response and improved dynamic range. Sensitivity is excellent and charted below for all frequencies covered by the Instruments.

Both counters use a modern, no warm up, 10 MHz TCXO [temperature compensated xtal oscillator] time base with external clock capability - no economical 3.579545 MHz TV xtal.

Quality metal cases with machine screws and heavy gauge black anodized aluminum provide RF shielding, light weight and are rugged and attractive - not economical plastic.

For improved resolution there are 3 gate times on the 7010 and 8 gate times on the 8010 with rapid display update. For example, the 10 second gate time on either model will update the continuous display every 10.2 seconds. Some competitive counters offering a 10 second gate time may require 20 seconds between display updates.

The 7010 and 8010 carry a 100% parts and labor guarantee for a full year. No "limited" guarantee here! Fast service when you need it too, 90% of all serviced instruments are on the way back to the user within two business days.

We have earned a reputation for state-of-the-art designs, quality products, fast service and honest advertising. All of our products are manufactured and shipped from our modern 13,000 square foot facility in Ft. Lauderdale, Florida.

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MODEL 7010 600 MHz

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CERTIFIED ABS TRACEABLE CALIBRATION EXTERNAL CLOCK INPUT
COMPACT SIZE—7010

DISPLAY HOLD FUNCTION
9 RED LED DIGITS @ "HIGH"
1 Hz RESOLUTION
0.1 PPM 10 MHz TCXO TIME BASE

LAB/PORTABLE AC ADAPTER INCLUDED
1 MEGOHM & 50 OHM INPUTS
STATE-OF-THE-ART LSI DESIGNS
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SENSITIVITY
50 OHM INPUT
250-400 MHz
450 MHz-1000 MHz
20 kHz-50 MHz

GATE TIMES
12 kHz
1 kHz
10 kHz
100 kHz

RESOLUTION
20-400 MHz

TCXO TIME BASE
20-400 MHz

EXT. CLOCK INPUT
YES
YES
YES
YES
YES

CLOCK BATT PACK
YES
YES
YES
YES
YES

MODEL 8010 1 GHz

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100% PARTS & LABOR YEAR GUARANTEE
CERTIFIED ABS TRACEABLE CALIBRATION EXTERNAL CLOCK INPUT
COMPACT SIZE—8010

DISPLAY HOLD FUNCTION
9 RED LED DIGITS @ "HIGH"
1 Hz RESOLUTION
0.1 PPM 10 MHz TCXO TIME BASE

LAB/PORTABLE AC ADAPTER INCLUDED
1 MEGOHM & 50 OHM INPUTS
STATE-OF-THE-ART LSI DESIGNS
COMPREHENSIVE USER MANUAL PROVIDED

SENSITIVITY
50 OHM INPUT
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450 MHz-1000 MHz
20 kHz-50 MHz

GATE TIMES
12 kHz
1 kHz
10 kHz
100 kHz

RESOLUTION
20-400 MHz

TCXO TIME BASE
20-400 MHz

EXT. CLOCK INPUT
YES
YES
YES
YES
YES

CLOCK BATT PACK
YES
YES
YES
YES
YES

ACCESSORIES

MODEL 7010
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Design Your Own Android

No doubt many of you have dreamed of the day when you will have an android at your beck and call. Well, that day is not yet here but you can get an early start by designing your own android. Here are the basics.

MARTIN BRADLEY WEINSTEIN

There are at least half a dozen individuals in America who have designed and built their own working robots, and at least two companies now offer robot plans and kits as commercial products.

The day when almost anyone can go to his hobby workshop and emerge with a home-built robot is more than near; it's arrived.

But that isn't the kind of project to go into with a headlong plunge. There are many important decisions to be made at the outset. And a complex, interwoven electronic/mechanical/human engineering task to be accomplished.

What is offered here is not a set of plans, nor the final word in design; it is a thought-out attempt at organizing and recording one man's decisions on how to approach that design task. You will have to make your own judgments as to whether or not these decisions apply to the robot or android you build.

The first step: defining terms

To avoid confusion—yet not necessarily to define these terms for anyone but ourselves—let's sort out what we mean by terms like robot, android, and so on.

A robot is a mechanism, fixed or mobile, possessing the ability to manipulate objects external to itself under the constant control of a programming routine previously supplied by an external intelligence.

An android is a mobile mechanism possessing the ability to manipulate objects external to itself under the constant control of its own resident intelligence, operating within guidelines initially established and occasionally updated by a human being, a computer, or some other external intelligence.

A cyborg (or "cybernetic organism") is an android capable of heuristic (learning by experience) updating of its own resident intelligence.

A mandroid is an android or cyborg in the shape, size, and likeness of a human being. Mandroids might be used, for example, to pilot aircraft or ground vehicles, initially designed for human operation, through dangerous or humanly unsurvivable conditions.

Philosophical aspects

Frankly, my decision to build an android was an emotional impulse. I knew that the necessary technology existed, and I knew I could build one. So I decided to do it before I decided just what my creature should do.

When I announced my intention to several friends and colleagues—who have been enthusiastic and supportive—I found that the almost universal response to my announcement "I've decided to build a robot" was the understandable question "What will it do?" This article is, in part, my attempt to answer that question.

With a bow to Dr. Isaac Asimov (whose science fiction classic I, Robot introduced the "Laws of Robotics"), here are the criteria for our tentative first steps at android design that comprise our own "laws of robotics."

First, our creations should not be destructive to any part of their environment, including living cohabitants, walls and furniture, the breathableness of the air, radiation levels, or anything else.

Second, our creations should not be destructive to themselves. We need to include adequate hardware and software protection to assure self-preservation, except where that violates our first "law."

Third, we must design in an instinct for survival, meaning here self-continuance of operation, except where that would violate the first two laws. The most immediate manifestation of the survival trait, for example, would be a mechanism to assure that low batteries would be recharged before failure. (Throughout our text, the term "mechanism" will be used to identify any means—hardware, software, human cooperation, whatever—by which an end or design goal, may be achieved.)

Obstacles in the human environment

If our robots and androids are to "live" with us, they must be capable of maneu-
vering through our individual environments. To better appreciate the difficulties that entails, join us in a little mental scenario for a last experimental demonstration.

Imagine that you have a remote-controlled motorized toy, and that you want to drive it on a tour of your house. As you do so, make a list of the goals you are setting for yourself, and be sure to list the specific obstacles that make your task more difficult.

Figure 1 shows a typical (for the sake of this discussion, anyway) upstairs floorplan for a Colonial home. Even with no furniture to contend with, we can quickly identify a number of obstacles: stairs, narrow hallways, doors, and closets.

Figure 2 takes us into a sparsely furnished room, where furniture, cords, and so on begin to take a significant role.

While the detail of your imaginary excursion might vary from ours, you will notice that the goals and obstacles listed in Table 1 offer a good, fairly general, starting point for our design.

That gives us some of our first requirements for our robot or android: obstacle recognition, collision avoidance, and obstacle manipulation.

One example of that might be recognizing a closed door and not colliding with it, but opening it, then proceeding.

Stairways

A vehicle with wheels of the same order of size magnitude as a step cannot negotiate the step in a controlled manner.

![Diagram of a furnished room with obstacles](image)

**TABLE 1**

<table>
<thead>
<tr>
<th>GOALS</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Steer away from walls</td>
</tr>
<tr>
<td>- Steer around and between furniture</td>
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<tr>
<td>- Avoid wires and cords</td>
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<tr>
<td>- Follow long, straight clear paths</td>
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<tr>
<td>- Continue forward, avoid reverse</td>
</tr>
</tbody>
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<table>
<thead>
<tr>
<th>OBSTACLES</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Closed doors</td>
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<tr>
<td>- Stairs</td>
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<tr>
<td>- Carpets and high-drag surfaces</td>
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<tr>
<td>- Transitions between floorings</td>
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<tr>
<td>- Hanging items extending from walls</td>
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<tr>
<td>- Shelves</td>
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<tr>
<td>- People and pets</td>
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<tr>
<td>- Clutter on floors</td>
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<tr>
<td>- Wires and cords</td>
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<tr>
<td>- Closets and cabinets</td>
</tr>
<tr>
<td>- Narrow hallways</td>
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<tr>
<td>- Fireplaces</td>
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</tbody>
</table>

Physical aspects

You've probably heard that a woman's high heel exerts more force per unit area than an elephant or a jumbo jet. While you probably haven't been considering having an elephant or a jumbo jet walking around your house, you don't have too many fears of a woman in high heels doing the floor in.

No, we're not suggesting an android in high heels. What we are suggesting is that placing reasonable limits on the size, shape, and weight of your machine before it's built can save you and your property needless grief afterwards.

First, decide what temperatures your machine should be prepared to endure, then choose your materials carefully to meet or somewhat exceed those conditions.

A house android, for example, that will never leave the comfort of a heated/air conditioned "room temperature" home, can be built out of the handiest, cheapest materials that will handle the mechanical
and electronic design goals. But if you, for example, take an NMOS or PMOS
android outside when it’s snowing, you
can count on him “forgetting himself”
as his electronics will stop functioning.
Battery performance is likely to suffer, too,
as is mechanical and lubricant perfor-
mance.
A more generalized machine will be
designed for, say, $-10^\circ F$ to $10^\circ F$,
depending on your geographic location.
CMOS electronics work well to $-40^\circ F$
and in quite a bit more heat than we can withstand.
Those same temperature ranges are readily available for
relays, discrete components, motors,
lubricants, plastics, adhesives, and most of
the other materials we'll need.

**Size and weight**
The size and weight of your machine
depend very much on the size and weight
of your assembly; this design loop requires
that you force yourself to make some ini-
tial assumptions.

For reasons we’ll discuss later, practical
power and motor design options re-
duce to electric rechargeable batteries
and electric motors. The biggest current
required for the battery is nearly
a function of the motor drive. The current required is
a function of the power required from the
motors, which is a function of the
product of load and speed.

Obviously, the same amount of power
is required to move a machine half as
heavy twice as fast as is needed to move a
machine twice as heavy half as fast.

So first we must decide on the total
load we would ever want to carry and the
minimum speed we would settle for; or
we could consider the top speed we wish
to attain and settle on the minimum load
we want to carry at that speed.

We will present the math later, right
now, a few examples are in order.

A machine with a design weight, un-
loading 1000 pounds, designed to travel
at a top speed of 20 miles per hour, or to
carry a 300 pound load at 5 mph, requires
3/4 horse power or 4500 Watts. That
means 375 amps of stall current from a
12-volt battery.

A reasonable battery configuration,
permitting several hours of operation be-

**SOURCES**
The following is a list of places to go
for more information about robots,
analysts, and some of the hardware dis-
cussed in the article.

Tab Books (Blue Ridge Summit, PA
17214) offers two books of interest.
Build Your Own Working Robot by
David L. Hausaman (Tab No. 841,
$5.95) details the construction of a small
of a wheelchair driving vehicle.
The Complete Handbook of Robotics by
Edward L. Sefford, Jr. (Tab No. 1071,
$7.95) includes excellent discussions of
batteries, motors, sensors and more.

Hayden Books (50 Estes Street, Ro-
chele Park, NJ 07662) offers How to
Build a Computer Controlled Robot by
Tom Foolbourn (No. 5681-8, $7.95),
which details the hardware and soft-
ware design of Tod’s small robot.
“Mika.” Hayden also offers the accom-
panying KIM 6502 software on cas-
sette.

The International Institute for Robo-
tics (PO Box 615, Pelahatchie, MS
39145) publishes a newsletter and offers
a home study course, which in-
cludes a microcomputer and parts for
a small machine. The basic course
requires $890. Subscriptions to the newsletter
are $8 annually. Contact Director T.
Dale. Cowdser for Information.

The United Robots Society (PO
Box 26484, Albuquerque, NM
87125) acts as a clearinghouse for
robotics information and irregularly
publishes a very worthwhile newsletter.
Membership is $14 a year. Contact
Director Glenn Norris for information.

Gallacher Research (PO Box 10767,
Staunton-Salem, N.C. 27318), or GRI,
are the people who introduced the
“Driver” robot arm.
They have a three-ring binder (with
Robotica in big letters on the front and
spine) full of sketches and specifi-
cations of manipulator systems. That
binder, available for $10, serves as
the company catalog of kits and
components for manipulator assem-
bles and manufactured parts. Contact John
K. Gallacher, Jr.

Lour Cne (1852 Largo Court,
Schaumburg, IL 60194) offers a manual
for $15 which details construction of a
small wheeled vehicle, sans intelligence.
A kit version is available for $237.5

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between recharges, involves four 17-pound batteries. But once we add in the weight of motors, mechanics, housings, etc., we can see that we've exceeded our 100-pound weight criterion.

So what must give way? Probably the top unloaded speed and the load carrying requirements. If we cut the top speed to 10 mph and the top loaded weight to 200 pounds (100 pound machine + 100 pound load), we eliminate two batteries, saving 34 pounds—plus trimming weight from the motors, supports, on-board charger, and more. We also lighten up the current requirements for the control electronics.

So by sacrificing the capability of giving us a ride around the block, we see we can build quite a lot of more important capability into a 50-150 pound machine.

But before continuing with our discussion of the physical attributes of our machine, let's go back to a definition of what we want it to do.

The manipulative imperative

There is a toy on the market, a "Radio-Controlled R2-D2." It's cute, and you really can remote control its motion and direction. Indeed, a number of hobby computer enthusiasts have taken to using their computers to push the buttons. But that toy, on whatever grand a scale, fails to meet our definition for robot or android because it cannot "manipulate objects external to itself."

That requirement also means that our machine must be designed to reach those "objects external to itself" with some sort of mechanical arm. In theory, this mechanical arm requires only three degrees of freedom, along the X, Y, and Z perpendicular axes. In practice, however, our rule that the machine must not destroy things in its environment demands the ability to reach around obstacles; that means we must have five or six degrees of freedom.

We get the number of those "degrees of freedom" by counting each "axis of movement"—more simply, each joint. For example, in a human being, the wrist represents one such axis (rotational), the elbow two (both rotational and hinge), the shoulder two. If you add in the hand-wrist hinge action, and all the degrees of freedom in the fingers, you can begin to appreciate the complexity of following an anthropomorphic design.

Another available degree of freedom is telescopic, as is found in the large industrial robots.

A great deal of work has gone into the design of manipulator arms. Those used in industry are out of our scope because of size and cost. But there are others.

Most notable of those is the "Grivet," once (but no longer) offered by Gallaher Research Incorporated for something around four hundred dollars. It used six DC motors and a wealth of machined parts. But it wasn't very sturdy, nor nim-

ble, nor strong. Gallaher is still in business, though, offering optimistic plans, kits, and parts for a number of other manipulators with varying sizes and degrees of freedom. Their catalog, which includes some plans, comes in a handsome 3-ring binder that reads "Robotics 1979" for $10 (send to GRI at PO Box 10767, Salem Station, Winston-Salem, North Carolina 27108).

Arm design problems

Some sort of position information will need to be sent back to the controlling intelligence, as well as control information for the "fingertips." That requires additional components—at the minimum, a potentiometer for each motor and pressure sensors for the fingertips.

As the weight of the arm rises, so does the necessity of providing counterbalancing weights at each axis, as well as the requirement for structural sturdiness.

Yet, for all of its required strength, the arm has to be able to "give" if it is to survive the shock of a substantial load, suddenly applied. Even the task of catching a football can destroy a too-rigid arm. Shock-absorbers must be built in.

Then there's the problem of knowing where the arm is, both in relationship to the body of the machine and in relationship to the object that's to be manipulated.

One special task we can anticipate requiring the arm to accomplish involves inserting the on-board battery charger plug into an available wall socket. While the on-board memory can recall the relative position of the plug as a head start, and while the on-board intelligence may have mapped the particular room the machine is in, giving the locations of available outlets, there still remains the problem of lining the plug up exactly with the socket and inserting it—without pushing it through the wall or applying 110 Volts to the shell of the machine.

For that task, there is no substitute for vision.

Next month we will continue this absorbing story with discussions of how an android sees, how it gets about and how it overcomes such obstacles as stairways and tight corners.

FRED BLECHMAN, KG6UGT
and DAVID MCDONALD

"ONE-ARMED BANDITS" ARE THE MAINstay of gambling centers wherever games of chance are allowed. Go to any hotel lobby in Las Vegas or Reno, for example, and people are pulling the slot machine handles all night. The typical mechanical devices, with three or more rotating drums that randomly stop, are being replaced with microprocessor based video units that feature color graphics and highly sophisticated scoring.

This unit is not that involved. It is an all-electronic design using TTL digital logic, with a set of four LED's programmed to flash on and off when all three characters are the same, indicating a jackpot.

When the power is first applied to the unit, all three displays (usually) light up with the letter "C" (for Cherry), and four discrete LED's flash on and off. (If the LED's don't flash, it's because the three displays did not start up the same—usually they do, but sometimes they don't.) Now press the roll pushbutton. The digits will "roll", looking something like a blinking 8, until you release the pushbutton. Now the left-most digit stops, followed shortly thereafter by the center digit, then the last digit. Each digit will display either a "C" for Cherry, an "L" for Lemon, an "O" for Orange or an "A" for Apple. If all three displays stop with the same letter, the LED's flash.
DIGITAL SLOT MACHINE

Games of chance and mechanical gambling devices were with us for years, then came electric and now electronic games. Here is a simple electronic version of the one-armed-bandit that you can build.

The odds of getting all three displays with any of the four same letters are 1 in 16. For any two displays to have the same letter in selected locations, the odds are also 1 in 16. The odds of getting the same selected letter in all three displays is one chance in 64.

How it works

This explanation will assume you have some knowledge of digital circuitry. Figure 1 is a block diagram of the Digital Slot Machine and Fig. 2 shows the schematic. Each display has its own logic section that is clocked by a separate oscillator. The WIN logic section monitors the state of each display, and when all three are the same, it commands the LED’s to flash on and off at a rate determined by the WIN oscillator.

Let’s describe how display 1 is operated, since the same technique is used for display 2 and display 3 (with small differences described later).

Clocking

Inverters ICl3-a and ICl3-b, together with resistors R22 and R23 and paralleled capacitors C1, C2 and C3, form the oscillator 1 circuit. The output of this oscillator is applied to one input (pin 10) of NAND Schmitt trigger ICl2-a.

When pushbutton switch S1 is depressed, capacitor C4 immediately charges through blocking diode D1, and a positive voltage appears on pin 9 of the Schmitt trigger ICl2-a. Now whenever the output of oscillator 1 (ICl3-a & ICl3-b) is HI, pin 8 of ICl2-a, which is normally HI, snaps LO and clocks flip-flop ICl5-b at its pin-5 input. The Q and Q outputs of ICl3-b, pins 8 and 9, change state each time a LO clock pulse comes from ICl2-a.

When S1 is released, C4 discharges through resistor R24 until the input to ICl2-a at pin 9 falls below threshold to a LO, so the output of ICl2-a is held HI and no further clocking occurs, even though oscillator 1 is still running.

The snap-action Schmitt trigger is used here rather than a normal NAND gate so the slow decay time of C4/R24 doesn’t cause erratic operation and false triggering.

Display Logic

When power switch S2 is closed, flip-flops ICl3-a and ICl3-b usually come up to voltage with a logic LO on the Q output of ICl3-a, and a logic HI on the Q output of ICl3-b. Figure 3 shows the logic states at the inputs and outputs of each
logic element. This results in a display of the letter "C". All display segments have a series resistor to prevent burnout, since these are LED displays. Display segments E and F are always lighted since they are wired to ground through their resistors R5 and R6. A logic LO at the output of inverter IC1-a allows segment A to light, and the LO at the output of inverter IC1-b lights segment D. The logic HI at the output of NAND gate IC2-b keeps segments B and C off, while the HI at the output of IC2-d keeps segment G off.

When the pushbutton switch is depressed and the first LO clocking pulse arrives at the input of flip-flop IC5-b, its output changes state: Q goes LO and Q goes HI. As the Q output of IC5-b goes LO, this also clocks flip-flop IC5-a, driving its output HI and the Q output LO. If you follow the changes through the display logic network, you'll find only one segment is effected: segment A goes off, so the "C" becomes an "L".

When the next LO arrives from the oscillator, flip-flop IC5-b outputs change state again. Output Q goes HI, and output Q goes LO. However—and this is important—flip-flop IC5-a does not change state, since it needs a logic LO at its clock input, and it just received a HI! Thus, flip-flop IC5-a is counting in binary, only changing state with every second cycle of the oscillator. This is the way binary counters operate.

The display changes from "C" to "L" to "O" to "A" and then repeats as long as S1 is pressed. When S1 is released the delay time of C4/R24 allows the display to keep changing for a short time, finally stopping at one of the four letters.

The logic networks for the other two
of S1, by C4 and R24 with a relatively short time constant. For display 2, however, C7 is five times the value of C4, and for display 3 the combination of C9 and C10 is four times greater than C7. Even though bleeder resistor R32 is a lower value than R24 or R27, the results are that display 1 stops almost immediately after S1 is released, followed shortly by display 2, and then display 3 a little bit later. This creates suspense and virtually guarantees a random combination.

**WIN Logic**

When each display is identical, the output states of each pair of flip-flops (IC5-a and -b, IC6-a and -b, IC7-a and -b) are also identical. The schematic shows each of the flip-flop outputs are designated A1, A1, B1, B1, etc. If all three displays are not identical, the logic network comprised of IC8-a, IC8-b, IC10-a, IC10-b, IC9-a, IC9-b, IC9-c. IC9-d and IC10-c holds output pin 6 of Schmitt trigger IC12-d LO. However, whenever any of the 4 possible combinations of identical outputs appears at each flip-flop set, the output of IC12-d goes HI.

Looking at AND gate IC8-c, we see three inputs. One input (pin 11) is from IC12-d, pin 6 as just described. Another input (pin 9) is from pin 6 of inverter IC11-a. Inverters IC11-e and -d, together with R30, R31, and C11, form an oscillator running at a very slow speed—about 4 Hz.

This is the "WIN" oscillator. The third input to IC8-c at pin 10, is from inverter IC11-a. Obviously, whenever pushbutton switch S1 is pressed, a HI appears at input pin 1 to IC11-a, through blocking diode D3. However, when S1 is released, the HI at pin 1 of IC11-a is maintained by the decaying voltage across the parallel combination of C9 and C10, with bleeder resistor R32 controlling the decay time. When this voltage falls below threshold, Schmitt trigger IC12-e no longer enables oscillator 3 pulses, so the display "freezes." Also, the input to IC11-a is now LO, so its output goes HI. This tells AND gate IC8-c that the last display has stopped, and thus prevents the four WIN LED's from flashing spuriously anytime the displays happen to be identical.
Now we can see that three conditions must exist for pin 8 of AND gate IC8-c to output a HI: (1) the three displays must be the same (IC12-d’s output HI); (2) the WIN oscillator must be providing a HI at pin 2; and (3) S1 must be open and the last display stopped.

When these three conditions exist, the output of AND gate IC8-c is HI and the input to inverter IC11-b is HI. The output of IC11-b goes LO and the cathodes of all four LED’s see a path to ground and light. As the WIN oscillator output goes LO, AND gate IC8-c output goes LO, the output of IC11-b goes HI and the LED’s go off. This sequence continues at a rate of about 4 times per second (WIN oscillator frequency) until either S1 is pressed again, or power is turned off.

Construction

The Parts List shows that this design uses a lot of parts, including 13 integrated circuits. While you could certainly wire this on a perforated board, it is far easier and less troublesome to use a printed circuit board. Figures 4 and 5 show the top and bottom of a two-sided PC board design. If you make this board yourself, be certain that the top and bottom traces are aligned very closely. Since you probably won’t have the equipment to plate through the holes after you drill them, be sure to solder each component on both the top and bottom of the board wherever traces would feed through. This might mean using Molex pins instead of sockets for the IC’s since the pins can be soldered to both the top and bottom of the board, while regular IC sockets can only be soldered to the bottom of the board.

The actual construction is very simple if you use the PC layout shown, with only a few precautions. Insert all parts into the top of the board in the positions shown in Fig. 6. Use sockets for all IC’s—just in case you insert the IC’s backwards (see Fig. 7 for orientation), or if an IC ever needs to be replaced for any reason. Be sure all capacitors are inserted into the board with the proper polarity; the same is true for the diodes and LED’s. For the diode, the banded end is your guide; for the LED, look for a flat spot or notch in the base. Be particularly careful to note that the top edge of the displays have 4 notches along that side. Be very careful to put the right valued resistor in each location.

Testing

Use either 4 “D” cells, a 6-volt lantern battery or a 5-volt regulated supply for power. DO NOT reverse polarity or you’ll probably zap the IC’s! It would be wise, actually, to add a diode (1N4001 or equivalent) in series with the power supply lead (see Fig. 8), especially if you’re using batteries. With the diode, the 6 volts from the lantern battery is dropped closer to the ideal 5 volts for TTL circuits. (If the display is dim or erratic, jumper or remove the diode you added.)

Turn on S2. The displays should all light. If all three are the same, the four LED’s should flash. Troubles can usually be traced to (1) poor soldering (2) parts in backwards, for those requiring proper orientation, (3) component values in wrong locations. Actually, the least likely problem is defective parts. so check (1) to (3) above before blaming the parts.

Press S1 and watch the action!

Modifications and Packaging

The entire unit could be packaged in a large box, but my model is sandwiched between sheets of clear Plexiglas with screws and spacers, with the switches and power jack mounted on the upper panel.

You might want to increase the stopping time of the displays, to add to the suspense. This is most easily done by adding capacitance to each display’s slowdown circuit—C4, C5 or C9/C10. While the Digital Slot Machine won’t allow you to go home with a pocket full of silver dollars, at least you’ll still have the shirt on your back!
Some time or other, every electronics buff gets hooked on at least one super deal for unmarked components. Though I generally shy away from such “bargains” as too time-consuming, I fell into this one by making an all-too-common mistake.

It began when a neighbor introduced me to a new surplus outlet operated by a local manufacturer. On my first visit I looked at many circuit boards, filled with IC’s, and marveled at the low prices. Memorizing a few numbers and codes, I resolved to see if any data sheets in my collection revealed information on those boards.

Success! Some numbers seemed familiar—911, 914, 912 seemed to belong to a resistor-transistor logic family (RTL) introduced some years ago by Fairchild. Symbols that I remembered from the packages told me that Fairchild, Motorola, and Transistor had manufactured those circuits. Although I had no specific data sheets, my collection revealed that RTL had been made in dual-inline packages (DIP’s) like those I’d seen.

I resolved to buy some boards on my next visit, and parted with a few dollars for several. Hedging my bet, I chose those containing discrete components as well as integrated circuits. That way, if the IC’s were valueless, I could at least salvage a reasonable number of resistors and capacitors. Tucking my prize behind the seat, I drove home, elated.

Kirtland H. Olson, P.E. & Ann L. Zevnik

After several days of poring over data sheets, and back issues of Radio-Electronics, my collection of diagrams, pin-connections, and type numbers filled several sheets of notes; but discrepancies began to arise. Some numbers had four digits that didn’t appear in any logic family; other numbers suggested linear circuits.

Such was my introduction to date coding: The numbers that guided my purchase turned out to be manufacturing dates. Crushed, I put the boards aside for several months. From time to time I contemplated attempts at identification.

Now almost a year after my original purchase, I wanted some IC gates and decided to try to identify some of those unmarked units experimentally. Although I ultimately succeeded, frustrating failures dogged my path. However, each failure taught me valuable lessons from which I derived a scheme for identifying unmarked digital IC’s.

Hooking up the power supply

I started by trying to identify IC elements that would clearly indicate a logic family. Still believing that the DIP’s contained RTL, I expected to use a 3.6-volt power supply; but I still needed to know which pins to try. Several pin-pairs commonly serve as power and ground—7 and 14 often serve TTL DIP’s—but RTL uses 4 and 11.

For most digital logic families, you can connect any pin to a positive supply or ground without damage. However, some power gates would not survive that, if you...
happened to connect a collector directly to the supply while the transistor was turned on, and RTL NOR gates might also be damaged. I put 500- to 1000-ohm protective resistors in series with test probes to each side of the supply. Of course, I couldn't put such resistors in series with the power supply, but I was using a diode string (see Fig. 1) that could deliver only 50 mA anyway.

Using printed circuit traces as clues, I saw that pin 4 of all packages connected to a common point. What I took to be pin 11 also returned to a common bus. As leads didn't always go directly, I patiently traced back to the common point on the board. Using RTL specs as a guide, I applied about 4 volts to one DIP after removing it from the board.

Missed again! First, the voltage across the IC was only millivolts and I suspected that the supply was backward. Reversing the leads raised the voltages to more reasonable levels. Past experience told me that I should find gate outputs at definite logic levels, and that inputs would not be so precise.

I began to measure voltages at each pin. The strange results puzzled me; few pins showed anything sensible. I shut down the supply and turned to my notes to check my work.

Idly picking up a board, I checked the pinout again. As I counted the pins, I realized that it was pin 10, not 11, that was common to many IC's. On turning the board over, I spotted an electrolytic bypass cap, clearly marked with + and −. Now I knew the power pins and the correct polarity.

**Identifying the gates**

Quickly soldering the power leads to the proper pins, I began to repeat my measurements. As the numbers filled my chart, the gate structure began to reveal itself. On those IC's, some strange voltages appeared. I recorded them without understanding, hoping to find an explanation later. Clearly, however, those voltages didn't look like RTL. Many terminals were near 1.5 volts, suggesting internal pull-up resistors for a current-sinking form of logic.

With the chart filled in, I checked the components near the place I'd removed the IC from the circuit board. Small capacitors connected the terminals with oddball voltages to others. A cursory check revealed that the circuit boards contained many such caps, connected between pins on the various DIP's.

Two pins showed values essentially equal to the supply voltage, and I took those to be outputs. Since gates are the most common functions, I also assumed that the DIP contained one or more gates of an unknown kind. Deducing that I would most likely find a NAND gate, I put the meter on the output terminal and began to ground each unidentified pin in turn.

I soon discovered four pins that made the assumed output pin go low, when any one was grounded. Moving the meter probe, I found that the pin with the strange voltage behaved logically opposite to the output — but varied between 0.4 and 0.8 volts, rather than between zero and supply. Moving on, I tried the other high-voltage pin and found a similar gate structure.

At that point, I wondered how I would identify the proper supply voltage. Capacitor ratings of 15 and 35 volts certainly set an upper limit. Most logic families use five volts, but how could I be certain? Luckily, I found one card with a Zener diode on it, clearly connected to supply the IC's.

**CHECKLIST FOR TESTING SURPLUS DIGITAL IC'S**

1. **Use circuit clues to identify power pins, polarity, and voltage, if possible.**
2. **Sketch the circuit connections to an IC before removing it from the board.** Record pins that are grounded, tied to plus, tied together, or left open. That procedure reduces the number of combinations you need to try. Also record the presence of pin-to-pin resistors or capacitors; they often give valuable clues.
3. **Measure the supply voltage at each IC plus immediately after bringing up the test circuit.**
4. **Use a voltmeter and grounding probe to group gate inputs together.** The open-circuit voltage at one input to a gate drops mv when you ground another input to the same gate.
5. **Test one IC at a time until you can identify it.**
6. **Use a power supply that can only deliver a few mA when shorted.**
7. **Use a socket mounted to a breadboard.** Known pins on drilled breadboards, or the upside-down socket type, will accept soldered pins.
8. **If you don't know the voltage, start at 3.6 to 4 volts.** This way you won't kill RTL but will operate DTL/TTL.
9. **Make a simple clock pulse so you know you get one clock pulse per actuation.**
10. **Use 470 ohms to 1k ohms in series with probes to connect Inputs to pins or ground.**
11. **Once you identify one function, test another mystery IC that has identical markings to see if it is the same function, then test another with some (not all) markings different.** Establish which marks relate to function.
- Outputs tend to take either the highest or lowest voltages, second only to the power and ground connections.
- Clock inputs may appear to be grounds when left floating.
- Normal gate inputs for current sinking logic are 2 to 3 diode drops above ground — that is, 1.2 to 1.8 volts when floating.
- Voltages differing from the standard logic levels usually indicate nodes, expanders, or special inputs for external components.
good moves. Choosing boards with discrete components gave me clues (like the Zener voltage) that would otherwise have been missing. Using a current-limited supply meant that my mistakes in connecting power were not fatal to the IC and provided both information and a second chance to use it. Buying IC's on boards meant I could use it. Buying IC's on boards gave me circuit clues not available in "by the bagful" specials.

Getting the first IC off the board had been a chore. Lifted pads and bent leads gave mute evidence of trouble to come. Unfortunately, the pads lifted easily from those boards (some kind of paper epoxy, not glass). The manufacturer had bent the IC leads over on the circuit side of the PC board, making removal difficult.

Then I had an inspiration! Realizing that there was no real reason to save the useless board, I decided to cut the traces next to the pads and deliberately lift the pads individually with my soldering iron.

Using a small hobby grinder, I cut each trace as close to the pad as possible. (If you don't have a grinder, use a razor blade or sharp knife to cut the circuit.) Heating the pad until it lifted, I slid the pad off the bent IC pin. With longnose pliers, I straightened each lead and the DIP's fell off the board into my waiting hand.

Sorting the IC's

Near the date code, the IC's I bought bore cryptic markings consisting of four letters and one number. For example, the first IC I tried was labelled AAAL1. Finding another DIP marked AAAL4 with a different date code, I removed it from the board and proceeded to test the circuit, assuming it would be the same. Within minutes, my assumption was proven correct.

![Diagram of IC with 2-input and 4-input AND gates feeding a 2-input NOR gate](image_url)

Although many manufacturers offer devices to ease IC removal, most of those tools are designed to try and preserve the circuit board, if you recognize that the surplus board is worthless, except to carry home your IC's, it is easier to remove DIP's from cards.

The trick is to do the job in steps:
1. Cut the circuit traces, so each pad can be removed separately.
2. Heat the pad with your soldering iron until you can slide it over the bent IC pin.
3. Straighten the IC pins, one by one, so the DIP drops off the board.
4. After removing all pads, straighten each pin with long-nosed pliers.

![Diagram of IC before removal, traces and pads intact](image_url)

![Diagram of IC after removal](image_url)

Removing IC's FROM SURPLUS CIRCUIT BOARDS

![Diagram of IC with soldering iron and straightened pin](image_url)

FIG. 2—DEVICE had 2-input and 4-input AND gates feeding a 2-input NOR gate.

Excited by success, I sought a new challenge. A DIP marked AAAL1 seemed less formidable than one marked AAAL4—suppose that meant "full adder"? Removing the AAAL1 IC, I still marveled at how easily I could remove the circuit trace from the package, rather than trying to wrest the package from the board.

By now I knew that the circuit contained many valuable clues. Accordingly, I made notes to show where the small capacitors connected, which pins were grounded; which connected together, and which had no connection. This time I quickly verified that one of the pins connected to the capacitor was an output, and there were two of them.

Figure 2 shows the diagram as I derived it. Because pin 11 presents a NOR function, I needed more time to determine its operation. I found it easiest to define those functions for positive logic, since the gate inputs normally assume the high state. Thus, pin 11 of AAAL1 normally stays low if all inputs are open. Grounding 3 or 5, or both, raises 11 only if 13, 14, 1, or 2 is also grounded. Later, I learned a way to tell which pins were in the same gate input, but at this point, logic alone sufficed.

Since a Vin the identifying number sequence occurred when I encountered a NOR function, I resolved to see if AAAL5 numbered device would be only AND gates. Again using circuit board clues, I made my sketch (see Fig 3). The outputs were high and did not respond rapidly to grounding single input pins. Clearly those were not simple AND gates.

Using the meter and the grounding probe, I discovered that some inputs affected others. If the DVM read 1.483

![Diagram of IC with grounded input and output](image_url)

...on one input, grounding any one of several other inputs reduced the reading to between 0.9 and 1.1 volts. I had found a way to deduce which inputs entered the same gate! External pin measurements reveal close internal connections. Knowing which inputs comprise the same gates provides the key to unscrambling complicated IC's.
Rapidly checking each pin against the others, I found four input pairs. Deducing that those pairs further combined inside the gate, I strapped them together and to ground in various combinations until a sensible pattern emerged. In a short while I derived the diagram shown in Fig. 4. That DIP contains two pairs of two-input AND gates followed by the OR INVERT sections. As I'll show you later, you can connect each of those to make an exclusive OR.

My assumption that "Y" signified NOR was clearly down the drain. Testing several units of each type, I could verify that the alphanumeric code uniquely identified the device, but still could not deduce the meanings. On to other IC's

Confident that I could attack more complex functions, I tried an AAAL5.

CHECKLIST FOR BUYING SURPLUS DIGITAL IC's

1. Avoid multilayer boards. They make it hard to get the IC's off without special equipment. (You can tell multilayer boards by holding them up to a light, if you see circuit traces that aren't on either side of the board, it's a multilayer type.)

2. Pick singlesided PC boards whenever possible.

3. Next choose doublesided boards.

4. Choose boards with physical defects (bad solder or cracks) over those with burn marks or other obvious warnings. You are more likely to get good, new materials.

5. Get boards with discrete components—especially Zeners or filter caps—to give you clues to IC voltages and pinout. That way, if the IC's turn out badly, at least you'll salvage some components.

6. Pick boards that have repetitive patterns and many IC's of one kind. They will help you find clock lines, power pins, and essential control lines.

7. Prefer boards with straight IC pins.

8. Pick boards that have the smallest pads around IC pins, making it easier to lift them with a soldering iron. Big solid blocks of circuit are hard to lift.

9. Avoid glass epoxy boards. They hold their pads better, so you must work harder to get the IC's off.

10. Remember that numbers like 911 or 7222 are likely to be date codes unless you see the complete manufacturer's number.

Tables of inputs & outputs

By reducing the number of terminals to be tested, I generated simple tables relating the logical inputs and outputs before clocking to the logic outputs after a clock cycle. Having then a guide to operation, I could alter the state of pins 2, 3, 5, and 6 in various combinations and derive a logic representation of the flip-flop.

Using the functional diagrams I developed, I built a seven-stage feedback shift register that generates 125 of all 127 possible sequences of 7 bits. In essence it makes digital noise. I used an AAAL5 as an exclusive OR (Fig. 7) to feed back signals from the last two stages of the shift register to the first.

As you can see from Fig. 7, the AND gates form the functions A'B' and BA' before being OR'ed and inverted. Thus they provide an output only if one flip-flop is high and not when both are high. That generates the exclusive OR function.

Now, I realize that your unmarked or house-numbered IC's will be coded differently from the ones I bought. But with simple equipment and careful measurements, you can identify digital IC's precisely enough to use them for many projects. Buying carefully will help you to gain many hints for the solution of your particular puzzle.

Use the three checklists on buying and testing surplus digital IC's to help yourself to bargain components.
Have you ever wished that you could converse via telephone with two separate parties at the same time? If so, it is possible that you can do it using this inexpensive and easy-to-build telephone adapter.

**JULES H. GILDER**

Would you like to be able to talk to your Aunt Bessie in Florida and your sister Etta in New York at the same time? You could ask the telephone operator who (for a special fee) could probably arrange such a round-robin conversation, commonly referred to as a conference call. Or, if you may be lucky enough to live in an area where the telephone company offers its subscribers a special conference-call service for an additional monthly fee.

If neither of these solutions appears practical, then just rummage through your junk box for a handful of parts, or buy everything you need from your nearest electronic parts dealer to make a conference-calling device for less than $5. All you need is two 1-µF nonpolar capacitors and a double-pole-single-throw (DPST) switch. If you want your project to look nice and make it simple to hook up, you can also buy a 3 X 2 X 1-inch plastic box and a telephone jack and plug.

One more important thing: To use this device, you must have two separate phone lines (i.e., two different phone numbers). Also, since this project is directly connected to the phone line, you should check with your local telephone company to see if it has any objection to your using this device.

**About the circuit**

Talk about simple circuits... there aren't many simpler than this one. All the circuit consists of is two capacitors and a switch: even a novice electronics hobbyist should have no problem assembling this handy telephone accessory.

![Conference Caller Diagram]

**Parts List**

- **C1** — 1-µF 100 VDC, nonpolar capacitor
- **C2** — 1-µF 100 VDC, nonpolar capacitor
- **SW** — DPST switch

Basiclly, the circuit couples two telephone lines together without interfering with the operation of either line. It does this by letting the audio signals pass from one line to the other and preventing the DC control signal of the telephone network from passing through.

One way to accomplish this is to use a specially wound isolation transformer that has windings of equal impedance. A simpler and less costly method is to simply place a 1-µF capacitor in series with the connections between the two telephones as shown in Fig. 1. The switch merely makes it possible for you to decide when to connect the second line in and when to cut it off.

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*continued on page 71*
By HUGO GERNBSBACK

A half-century ago, the first radio for the public's use and enjoyment was marketed.
Differing vastly from today's radios in construction and function, it opened the field of radio for private interest and amusement rather than commercial communications use.

The year 1955 marked the 50th anniversary of the first home radio sold to the public anywhere in the world.

It was not radio as we know it today because in 1905 there was no commercial broadcasting. But wireless had been going strong for several years and amateur radio too had just begun. Marconi and other pioneers were transmitting intelligence by the dot-and-dash method; indeed wireless in those days was rapidly forging ahead.

The public at large knew little or nothing about wireless before 1905 except what they read in the papers and in magazines. For owning a wireless home set, it had not as yet been born.

Previous to 1905, in 1903-04, the writer had been working on a small portable transmitter and receiving outfit which he felt could be sold to the public. It took several years to perfect it and make it foolproof so it would work under practically all conditions. It had to be low in cost so everyone could buy the outfit.

This ambition was realized some time in 1905. After making a number of models the writer began to market the first home or private radio set ever sold to the public.

As there were few wireless stations in the country, it became necessary to sell a transmitter, too, so amateurs could set up a transmitter and receiver at home. Then while one person was transmitting signals, the other could receive them. Or the transmitter could be set up in one room and the receiver would ring a bell in the other room without any intervening wires whatsoever.

The outfit that accomplished all this was known as the TELIMCO Wireless Telegraph Outfit. TELIMCO is a contraction of the first letters of the writer's old pioneer firm, The Electro Importing Company (E. I. Co.), which became famous between 1904 and 1915 as the first radio mail-order house in the world. Only comparatively few sets were sold in 1905. But in 1906 the little outfit went into quantity production and was sold through many large outlets, including such famous stores as Macy's, Gimbel's and F. A. O. Schwarz, the country's largest toy establishment.

Incidentally, it was first advertised in the magazine Scientific American in the issue of Jan. 13, 1906. This was the first home radio set advertisement to appear in print anywhere.

The writer well remembers the incredible looks of many of the store owners when they were first approached to buy "wireless sets." It was necessary to make a demonstration in each case before anyone would stock them.

The complete set, both receiver and transmitter, at first was marketed for $7.50. This was raised later on to $10, at which price most of them were sold.

The photograph shows an exact replica of the original outfit, built by the writer, to commemorate the 50th anniversary of the first home radio set. The transmitter, with the three dry cells and key, was composed of a 1-inch spark coil. The "1-inch" here means that the coil threw a 1-inch spark through free air, between wire points.

Above—Advertisement for the first radio set offered the public. It appeared in Scientific American, Jan. 13, 1906. Right—Picture diagram of layout, drawn by Hugo Gernsback in the 1900's: A, G, antenna, ground; S, spark coil; B, batteries; K, key; AS, relay adjusting spring; SD, coherer; Connections: 9, 8, to relay electromagnets; 7, 11, coherer; 13, 16, decoherer; 14, 15, relay contacts.
Mounted on the spark coil, on two metal standards, were two brass oscillator balls between which a small blue spark jumped the \( \frac{3}{16} \)-inch gap. The spark coil had a fast vibrator so that every time you depressed the key a spark would jump between the two balls. Depressing the key for a short period would give a dot, a longer period would give a dash.

The receiver was a 75-ohm "pony" relay which had to be so sensitive that if you blew your breath slightly against the armature its contacts would close. There was also a single dry cell and the all-important coherer. It was simply constructed of two large, double binding posts through the bottom holes of which passed two silver-plated brass rods. A glass tube, placed between the two binding posts, was slipped over the two brass rods. These silver-plated \( \frac{3}{16} \)-inch metal rods fitted the glass so that there was extremely little or no play. The two rods were separated about \( \frac{3}{16} \) inch forming a gap. This gap was filled with the "soul of the set"—the coherer filings, composed of 90% coarse iron and 10% coarse silver filings. By shaking the mixture well it was ready to be used. The filings had always to be loose, never packed tight.

The coherer—a common house bell—was mounted so that the clapper of the bell would strike against the glass tube of the coherer at the exact spot where the filings were. If the diagram is studied, it will be seen that every time the relay closed its contacts, the bell will ring through the single cell.

Now, if you depress the key at the transmitter, the two aerials (aerial and counterpoise) will emit radio waves. Curiously enough, the waves which the writer used 60 years ago were of the very short variety (above 30 megacycles) to which modern radio has come back. The two aerial wires of the transmitter measured less than \( \frac{1}{4} \) feet.

Inasmuch as the coherer is directly in the receiver aerial circuit, the filings offer a very high resistance. But under the onslaught of the radio waves they instantly become an excellent conductor—as if they were a solid conductor. The relay, in the same circuit, now goes into action, attracting the armature which closes its contacts. This sets off the coherer bell which rings and shakes up the coherer filings. These now fly apart—they decohere—and the coherer becomes nonoperative until the next wave train comes along.

Thus every time you press the transmitter key, the bell at the receiver rings. It rings as long as you hold the key down. A long ring is a dash, a short one a dot.

You can pick up the receiver and walk to the next room, yet the bell sounds without any visible connection. Even through thick walls, signals still come in.

One of the things that bedeviled us in the early days was sparking at the relay contacts. This would set up electromagnetic waves and often the outfit gave no clear signals; sometimes the bell would ring for seconds after the signal. This was overcome by putting a 1-k ohm resistance across the relay points.

The range of the TELIMCO Wireless Telegraph Outfit was between 300 to 500 feet when used without ground connections. By using an elevated aerial 50 to 100 feet in length and by grounding one side of both transmitter and receiver to a water or gas pipe, the range was easily increased to one mile. Indeed, hundreds of people who bought the outfit at the time reported excellent reception even over greater distances, but those, of course, were exceptions. Note that this set used no tuning whatever.

A curious thing about this little outfit today is its strange effect on radio people who never heard of the ancient spark coil and coherer sets. Young radiomen, who have never seen one of these outfits, are usually very much perturbed and astonished when the writer demonstrates it. The reason of course is that people have difficulty realizing that with a little three-dry-cell transmitter it is possible to ring a bell through intervening walls while the novice holding the receiver.

Radiomen today think of devices which operate relays as being relatively large and find it hard to believe that such a small portable transmitter and receiver could do the work.

It is conceivable that some time in the future these same instrumentalties may still find a use in modern radio and electronics which may not be apparent today.

The TELIMCO outfit here described has recently been acquired by the Henry Ford Museum of Dearborn, Mich. It was donated by the writer. It will be permanently exhibited in the radio section of the museum.

END

HOME RADIO

Replicas of the original transmitter and receiver, soon being sent to the Ford Museum at Dearborn. Left—the receiver: A, antenna system; B, dry cell; C, coherer; D, decoherer; E, adjustable coherer rods; F, 75-ohm relay. Right—the transmitter: A, antenna and counterpoise; B, dry-cell power supply; C, \( \frac{3}{16} \)-inch spark coil; D, spark-gap oscillator; E, transmitter key.
Part 3—Build this breadboarding device that serves as an interface between the TRS-80 microcomputer and circuits you are designing. Here are some experiments that show how the device can be used.

JON TITUS, CHRIS TITUS, and DAVID LARSEN

The Four NOR Gates Are From SN7402

**FIG. 15—SCHEMATIC DIAGRAM of the NOR gate circuit used for testing the breadboard.**

**FIG. 16—A SIMPLE traffic-light simulator. See text for program.**
execute an OUT 6,255 command. Now, with the following LED configuration:

<table>
<thead>
<tr>
<th>Bit</th>
<th>LED</th>
</tr>
</thead>
<tbody>
<tr>
<td>D0</td>
<td>Red</td>
</tr>
<tr>
<td>D1</td>
<td>Yellow ELM Street</td>
</tr>
<tr>
<td>D2</td>
<td>Green</td>
</tr>
<tr>
<td>D3</td>
<td>Red</td>
</tr>
<tr>
<td>D4</td>
<td>Yellow MAIN Street</td>
</tr>
<tr>
<td>D5</td>
<td>Green</td>
</tr>
</tbody>
</table>

determine what patterns of logic ones and logic zeros are needed to control each of the individual LED’s.

Since the latches can drive the LED’s directly, the following bit patterns were assigned to each of the LED positions:

- **ELM** Red: 254
- **ELM** Yellow: 232
- **ELM** Green: 251
- **MAIN** Red: 247
- **MAIN** Yellow: 239
- **MAIN** Green: 223

Once you have compared these individual patterns with the ones you have determined, test them using your computer and your interface. You should be able to use statements such as OUT 6,251 to test each LED.

When all of the LED’s have been tested, write a short program that will flash the yellow lamp on Main Street, while flashing the red lamp on Elm Street. Both of the lamps may flash at the same time, or they may alternate. Use a 2-second flash period, that is, 2 seconds on, 2 seconds off, and so on. The following program may be used to flash the lights at the same time:

```
10 OUT 6,255  ; Red on Elm, Yellow on Main
20 FOR T=0 TO 300:NEXT T
30 OUT 6,238  ; Red on Elm, Green on Main
40 FOR T=0 TO 300:NEXT T
50 GOTO 10
```

Determine what patterns of logic ones and logic zeros are needed to control each of the individual LED’s.

While this program worked quite well, there are a number of simplifications that can be made to make the program more compact and more efficient. Can you suggest some changes that could be made?

In the second traffic light controller program, an array has been set up for the traffic light lamp patterns, and also for the periods for which they are to be activated. Now, a generalized control program can be used, rather than the long sequencing program used previously. Some statements have also been added so that you may enter the periods needed for Elm and Main green times (in seconds):
be cycles through a 30-second (or less) green period. Since it will irritate drivers on Main Street when a single car actuates the Elm Street green period for 30 seconds, the program must also count the cars sensed on Main Street, when the Elm Street green period has started. When a certain number of cars, say five, are sensed on Main Street, then a new green period on Main Street will be started. Of course, each "switch" in the light patterns must go through the normal green-yellow-red sequence. Try and develop this program to control the traffic light. With some variations in timing, we used the program that follows. Shortened time periods were used to speed the testing of the program:

```
10 A=0
15 REM RED ON ELM, GREEN ON MAIN
20 OUT 6,222
30 FOR I=0 TO 10
40 FOR T=0 TO 300:NEXT T
50 NEXT I
60 A=A+1
65 REM E KEY PRESSED AFTER 10 SECONDS
70 IF A$="e" THEN 80 ELSE 60
75 REM RED ON ELM, YELLOW ON MAIN
80 OUT 6,238
90 FOR I=0 TO 2
100 FOR T=0 TO 300:NEXT T
110 NEXT I
115 REM GREEN ON ELM, RED ON MAIN
120 OUT 6,243
130 FOR I=0 TO 10
140 FOR T=0 TO 150
150 BS=INKEY$'s
160 IF BS$="M" THEN 190
170 NEXT T:NEXT I
180 GOTO 210
190 A=A+1
200 IF A=5 THEN 210 ELSE 170
205 REM YELLOW ON ELM, RED ON MAIN
210 OUT 6,245
220 FOR I=0 TO 2
230 FOR T=0 TO 300:NEXT T
240 NEXT I
250 GOTO 10
```

**Controlling an analog voltage:**

There are many situations in which a variable analog voltage is required. Controlling such a voltage by using the TRS-80 computer and some simple software provides a great deal of flexibility that cannot be obtained in other ways. Probably the easiest way to have a small computer generate an analog voltage is through the use of a digital-to-analog converter (D/A). These devices are available in many configurations, but they can be briefly explained by stating that they can produce a voltage within a normal range, say zero to +10 volts.

The actual voltage produced is proportional to the binary value provided to the converter by the computer. Thus, for an eight-bit D/A converter, a binary value of zero would cause the converter to output zero volts, while an input of 255 (11111111) would cause the converter to generate the full 10-volt output. A binary value between these limits would cause the converter to generate a proportional voltage, for example, 10000000, or 128, would generate a +5.0-volt output. For additional information on D/A converters and other interesting converter devices, we refer you to: Microcomputer-Analyzer Converter Software & Hardware Interfacing, Howard W. Sams and Co., Inc., 1978.

In this experiment, a Signetics NE5018 eight-bit D/A converter IC has been used. Other similar eight-bit converters may also be used, providing similar results, but the NE5018 has some nice features that make it easy to use in computer systems. These features include a built-in eight-bit output port latch, an on-chip reference and an on-chip buffer amplifier. The NE5018 is wired as shown in Fig. 17. An SN7402 NOR gate chip has also been used to generate the required latch enable (LE) signal that will control the flow of eight bits of information to the latch, and thus to the D/A converter.

Actually, the D/A converter does not generate a continuously varying voltage, since only 256 different voltages may be produced, one per eight-bit value. This means that in a converter with a zero to 10-volt range, the individual voltages will be approximately 39 millivolts from the one on either "side" of it. With the interface shown in Fig. 17 connected to your interface board, try and write short programs that will 1) generate a positive-going voltage ramp over and over again, 2) do the same thing for a negative-going voltage ramp, and 3) generate a slowly increasing and then slowly decreasing voltage output to generate a triangular output. These programs are listed below:

1) **Program for a Positive Ramp**

```
10 FOR I=0 TO 255
20 OUT 6,1
30 NEXT I
40 GOTO 10
```

2) **Program for a Negative Ramp**

```
10 FOR I=255 TO 0 STEP -1
20 OUT 6,1
30 NEXT I
40 GOTO 10
```

3) **Program for a Triangular Voltage Output**

```
10 FOR I=0 TO 255
20 OUT 6,1
30 NEXT I
40 GOTO 10
```

There are many applications in which D/A converters are useful, and in fact, some computer systems have a number of D/A converters interfaced to them. Some possible applications include the control of X-Y plotters so that graphic displays of information may be produced, the control of servo motors for positioning solar detectors/collectors, the sweeping of frequency generators to generate computer music, the control of filters to filter out various types of electrical noise, and even the generation of known voltages that may be compared against unknown voltages to determine their value.

There are many, many other digital devices that may be interfaced to your TRS-80 computer through the interface boards: UART's and USART's for serial communications, 20 mA RS-232C loops for teletypewriter and terminal control, advanced programmable controller chips, analog-to-digital converter chips for measurements, and even other microcomputers. In fact, we have interfaced our TRS-80 computer to an MMD-1 computer (Dyna-Micro, Radio-Electronics. May, June & July 1976), so that programs may be listed on a teletypewriter.
Home Reception Using Backyard Satellite TV Receivers

Part 4—In this installment of a series, we will go into more technical details on receiver characteristics and specifications and will show how some satellite receivers have been built at comparatively low cost.

ROBERT B. COOPER, JR.

IN PARTS ONE, TWO, AND THREE OF THIS multiple-part series (appearing in the August, September, and October 1979, issues of Radio-Electronics) we learned how the geo-stationary satellite system is designed, what it is intended to do and what a private individual, living someplace south of the 80th north parallel, north of Venezuela, and east-west between Bermuda and Hawaii can anticipate being able to receive with a private, backyard satellite television terminal. Satellite television is the next "generation" of television service in America and throughout wide areas of the world. Because of the mechanics of the service, it is virtually immune to interference and signal degradation, is not adversely affected by weather, and holds the potential to provide every home in North America with several hundred direct-access television channels.

Receiving system

Having determined that the basic system consists of an antenna, a low-noise amplifier (LNA) and a receiver-decoder, let's look at what it is that goes into each of these three major component modules to make up the operating system.

The antenna system has been adequately covered in previous portions of this series. Basically, in order to achieve the kind of gain necessary (38 to 45 dB) a parabolic reflector is the best antenna choice. This parabolic reflector has a single focal point where all of the energy intercepted by the reflective antenna surface is re-directed and focused. There are several acceptable members of the antenna family known as parabolics that can be pressed into this service: prime focus parabolics, Cassegrain parabolics and spherical parabolics are included. For as long as the (limited) supply holds out, surplus (as in no longer used in commercial or military service) parabolic (or "dish") antennas larger than 6 feet in diameter provide very economical "reflectors surfaces" for most portions of North America. The exception to this is in New England where anything smaller than a twelve-foot reflector surface would be a mistake. Beyond that, one of the least expensive antenna surfaces for this service has been developed by a fellow in Arizona named Oliver Swan. Using aluminum window screening as a reflector surface and stock square aluminum or steel tubing as reflector frame material, Swan has developed a spherical antenna system that can be constructed in virtually any size from 10 feet by 10 feet to 20 feet by 20 feet for as low as approximately $500 for the ten-foot by ten-foot version. It is inevitable that some commercial firm will soon begin marketing antenna "kits" in this area, perhaps copying the Swan developed spherical antenna and that from this will spring a whole new family of "backyard decorative pieces."

Because we are dealing with a low-power transmitter source (the typical satellite has a 3-watt peak power transmitter) and a fairly high loss between the "bird" and your receiving location (196 to 200 dB is typical at 4 GHz), not very much signal power arrives at your antenna. Fortunately, the signal received is very constant (variations of ± 0.7 dB over a full year are typical limits) and this allows us to design the system for peak performance and forget it rather than be concerned with wide-range AGC systems to cope with large signal fluctuations.

To make the most of the weak signal, we have to place a very high gain, and extremely low noise (figure) signal amplifier (or booster in TV terms) right at the antenna. Since the reflector surface on the parabolic is merely a focusing tool, the actual "pickup antenna" is really separate and distinct from the reflector. This receiving antenna, directed backwards away from the satellite and towards the focused energy coming from the reflector surface, is called a "focal point" or feed-point antenna.

The most efficient feed antenna is one that looks at the reflector surface in such a way that the "pattern" on the feed antenna is down 10 dB at the out-
FIG. 1—MOST COMMERCIAL FEED-ANTENNA LOW NOISE AMPLIFIERS consist of a feed antenna (often a horn as shown for a prime-focus feed) which is equipped with a waveguide flange that bonds it directly to the input flange on the LNA (Low Noise Amplifier). The LNA has an input (ferrite) isolator both for frequency selectivity and as an impedance matching device for the first stage of the amplifier itself. The extremely low-noise amplifiers developed their superior operating characteristics because of extreme care taken in matching the first stage to the input source impedance and because hand selecting the expensive GaAs-FET (Gallium Arsenide Field Effect Transistor) transistors. GaAs-FET devices are chosen for the first two stages. Once the noise figure is "established" by these two stages, less costly bipolar transistors are used in 3-4 additional stages for "bulk" gain. The output, to the low-loss downline coaxial cable, is through another ferrite isolator device or through a "loss pad" inserted to force an impedance match.

side edges of the reflector's surface area. A horn-feed antenna, properly designed, handles this function. Look closely at Fig. 1. Note that the horn-feed antenna is flanged or bolted directly to the low-noise amplifier itself; the energy from the horn feed-point antenna couples through the waveguide flange into the input circuit on the low-noise amplifier, a section that has a piece of ferrite (red) in it as an isolator.

Low-noise amplifiers

This commercial style low-noise amplifier is the state-of-the-art high-dollar approach to the low-noise amplification aspect of the system. There are less expensive ways to go as we shall see in subsequent portions of this series. The purpose of the ferrite isolator is primarily to ensure that the input circuit to the first active (transistor) amplifier stage sees a constant impedance or load. This is done to ensure that the transistor used in the first stage, a GaAs-FET (GaAlAs) field-effect transistor), is noise-figure matched at the 4 GHz operating frequency. Most of the high-dollar GaAs-FET's available for this service have two separate peak operating points: maximum gain does not coincide with best (i.e. lowest) noise-figure performance. In this case, gain is backed off in the first couple of stages as a trade off for lowest noise figure since noise generated in the early preamplifier stages is impossible to eliminate later on in the system.

Most of the commercial LNA units employ a pair of ultra-low-noise GaAs-FET's in the first two stages, and then follow that up with between three and five less expensive (typically bipolar as opposed to GaAs-FET) amplifier stages. Once the noise figure for the LNA is established by the first couple of stages, less expensive (and higher noise figure) bipolar stages can make up the remainder of the LNA system gain required.

Noise figure is measured in both dB and by the Kelvin noise temperature scale. Most of the commercial data sheets will specify Kelvin temperature only and most commercial installations are using amplifiers with 120-degree Kelvin (or 1.5 dB noise figure) specs.

State-of-the-art has been cracking on quickly in this field; in late 1976 the price for a 120-degree Kelvin LNA was in the $3,500 region. By late 1978 you could find the same amplifier for around $1,100. Today the price is down in the $1,000 region and many expect it to drop down to under $500 by this time next year. That still may be high for your pocketbook and there are other options.

As previously discussed in this series, you can get a raw signal input to the receiver by one of two techniques: use a big antenna and an LNA with not such hot specs, or use a smaller antenna and a hot-spec LNA. If you set out to build your own antenna system, rather than buying commercially, you might be better off in this fast-changing technology time to invest in a little more steel and mesh and build a larger antenna going in, especially if you plan on having to purchase your LNA.

As recently as early in the past summer anyone who wanted to build his own LNA was pretty much stuck with working with 300-degree Kelvin type bipolar transistors. The belief was that any home constructor attempting to work with the touchy and hard-to-make-work GaAs-FET amplifiers was probably asking for a quick way to lose a $100 bill, that being the going price for the GaAs-FET transistors these days from Hewlett-Packard (HFET 2201). However, during the recently completed Satellite Private Terminal Seminar this past August 14-16 in Oklahoma City, several home terminal builders demonstrated two- and three-stage GaAs-FET amplifiers they had constructed for between $225 and $350 that gave an excellent account of themselves against commercial amplifiers costing three to four times as much. This major achievement has changed the name of the private or backyard terminal game for the home constructor.

Well now: if a chap in Arizona can build a 10-foot by 10-foot spherical reflector and feed for $500 or less, and you can build your own GaAs-FET low-noise amplifier on the kitchen table for $350 or less, that sets to get the home-constructed terminal down to an affordable price does it not? What about the receiver?

Receivers

In 1976 the first satellite video receivers around came into the cable television field via the Intelsat or international satellite marketplace. They cost upwards of $10,000 and were literally hand wired and hand aligned.

By early 1978 the price for essentially the same receiver was down to about half that; perhaps $5,000. But there had been only minor changes in the original design. The price reductions were largely due to slightly more volume production, and of course competition.

Needless to say many people were working on bringing the cost down: way down. Most however were involved in the cable TV, broadcast TV and other commercial market areas where nobody really expected receiver prices to drop much below say $3,000 for many years to come. Outside of these broadcast related industries other engineers with a totally different set of markets in mind were quietly doing their own developmental work. Their goal was a $3,000 complete terminal; including the antenna and the LNA.

By mid-1979 some inter-receiver marrying had taken place. Commercial receivers are available in two formats: some tune only one channel and to change channels you have to either change crystals or go through some sequence of screwdriver adjustments, or both. Not exactly what the home viewer accustomed to detent tuning has in mind. The other commercial receiver format is called "frequency agile" and that means you push buttons or twist a knob and the full set of 12 (or 24) satellite channels flips by in front of you. By late 1979 most of the commercial receivers in the single channel format were down under $250 list price while the tunable versions were just a tad above $3,000.
Let's stop for a minute and study Fig. 2. To appreciate what is involved in a satellite television receiver, we ought to understand what it has to do.

In a commercial installation the LNA (which mounts at the antenna, usually married to the feed-horn or focal-point antenna) has to develop sufficient RF signal voltage gain, at 4 GHz, to (1) drive the microwave signal, through the interconnecting coaxial cable and into the receiver, and (2) provide sufficient signal gain to establish the noise figure of the LNA as the noise figure for the entire receiving system.

The typical satellite TV receiver has a relatively high noise figure; 10-12 dB is not uncommon. To attempt to use such a high “front-end” noise figure to receive the weak satellite signals would be a mistake. To lower the noise figure to a more usable level (such as under 2 dB) requires not only a low-noise LNA but sufficient gain in the LNA stages to overcome the noise contribution by the 10-12 dB noise figure of the receiver. As a rough rule of thumb you need between 2.5 and 3 times as much voltage gain (in dB) as the noise figure (also in dB) to establish the new, lower noise figure of the LNA as the noise figure of the system as a whole.

Back now to Fig. 2. To keep unwanted energy out of the receiver (and there is plenty of unwanted or off-frequency energy, floating around microwaves these days) the typical commercial receiver has a pre-selector (either totally passive or active plus passive) at the input. This is followed by a “high frequency mixer” that combines the incoming (3.7 to 4.2 GHz) signals with a local oscillator signal source generated within the receiver to produce a new lower frequency (IF) output. Gain is then applied at the high-frequency IF and then the signal goes through yet a second mixer that further down-converts the high IF to yet another lower IF. This lower IF is often 70 MHz although there are some variations to this rule in commercial receivers. When we finally reach the lower IF, we have gone through a pair of down conversions each employing a high-quality mixer and a high-quality local oscillator. If this is a frequency-agile (i.e., tunable) receiver, the first mixer is driven by a tunable local oscillator source while the second mixer is driven by a fixed local oscillator source. Just for dollar reference, we are looking at using $75 to $100 mixers in these applications and the local oscillators are priced in about the same range. If this suggests that microwave components or modules are not cheap, you read the message correctly.

Once at the low IF we are ready to go to work on the modulation itself. Gain at a relatively low IF such as 70 MHz is inexpensive these days and 40-50 dB of gain in this range is typical. When the twicedown-converted signal is built up to a sufficient voltage level, it is ready to be demodulated. Remember that the video is frequency modulated onto the carrier, and the audio coming along with the video is further frequency modulated as a sub-carrier. This says that we use discriminators to demodulate the video and the audio in our detection system.

By removing the video signal out of the IF signal with a detector, we end up with a 70 MHz electronic waveform that is perfectly suitable for the TV receiver. This waveform swings between -42 to +42 V. The waveform is then processed through an IF amplifier that boosts the signal to 70 dB above noise before it goes through the composite video filter which eliminates the video carrier (the oscilloscope trace of the video filter is marked “IF”). The video signal then goes through the video detector and discriminator circuit to produce a square waveform that is sent to the video amplifier for further processing. This squares the waveform to produce a +42 V swing at its output. The video is then applied to the deflection plates of the CRT to form a video image on the screen.
with what is called baseband; that means pure video in this case. Only because the audio is carried along as 6.2- or 6.8-MHz add-on or subcarrier, when we demodulate to baseband video we also have a subcarrier in the baseband output. By using a low-pass filter and a high-pass filter for the subcarrier, we can then separate the video into one chain for further processing and the audio into another.

The video is preemphasized at the uplink transmitter site as a means of increasing the system performance and at the receiver we need to deemphasize to establish the original baseband video characteristics. The deemphasis network is strictly an L-C network and is not complicated. Next in line for the video is a video clamp circuit that may mystify you if you are accustomed to normal video.

Video at the uplink site is "frequency-dithered" or dispersed at a 30-Hz rate as a means of reducing potential interference between strictly terrestrial 4 GHz video circuits (such as the telephone companies employ) and the satellite service. The easiest way to clean up the dispersal waveform is to shove the video through a clamping circuit. If you clamp something like this hard enough, the 30-Hz waveform simply goes away. Finally a bit of passive video filtering and you are in business with baseband video (typically 540-600 kHz bandpass).

Over on the audio side, after passing the 6.2 or 6.8 MHz subcarrier through a frequency filter that eliminates the video baseband information, the signal is fed into yet another discriminator (detector) that recovers the audio. From here it goes through yet another deemphasis network (this one for the audio) and finally an audio amplifier. Most commercial receivers release the audio across a 600-ohm balanced output line.

If you are engaged in the television receiver servicing industry, you may be asking yourself why this should cost between $250 and $300. If you are new to receivers in general, you probably have the opposite reaction. As we shall see in the next part of this series of articles, several experimental or private terminal builders have asked themselves the same thing. One terminal builder, Taylor Howard of California, has managed to assemble the LNA (a bipolar unit in his case) and the receiver for around $1,000. If he did this back in 1976-77 when parts were considerably more expensive and we estimate you can do it today for under $700.

Assuming you don't want (or need) to start off with a bag full of new parts, and can assemble some equipment from other services into a satellite TV receiver, just how simple can it really be? Well, a man in South Carolina by the name of Robert Coleman has put together a 10-foot dish, a two-stage GaAs LNA and a complete receiver for around $500! His "secret," if you can call it that, is that he is a sharp attendee of Hamfests and other outlets where surplus electronic equipment is brought out for sale at often just a few pennies on the original dollar value. The Coleman approach is a good one, but it requires being able to trace down surplus parts, modules and components that may not be a good supply because of limited production runs many years (or decades) ago. Still, if this approach does interest you and you are not afraid to go into the surplus market to look for parts, there is help available for you in this specialized area.

Suppose you wanted to try a cross between building a complete terminal receiver from scratch and assembling one from surplus equipment? Well that is an approach many people have followed, largely patterned after the work done by English satellite TV experimenter/pioneer Steve Birkill (amateur G8AKQ). The Birkill receiver is similar to that shown in Fig. 3. The LNA is a bipolar system of three to five stages using Hewlett-Packard HXTR (6102 and 6101) transistors. For those who want to investigate this particular approach, Hewlett-Packard Application Note No. 967 tells how to build a stage of this amplifier at 4 GHz (a multiple stage-device is simply several separate stages cascaded together). The Birkill Receiver places the LNA stages at the face of the antenna, follows that with a double-balanced mixer (also located at or near the feed) and the mixer is driven by both the input 1 GHz range signals plus a "free-running" oscillator operating at around 3,200 MHz. There are several ways to derive the local oscillator injection signal: one of the easiest is to use a completely self-contained oscillator. One of the 8360-family of oscillators manufactured by Avantek Inc., P.O. Box 3736, Santa Clara, CA 95051 will do the job nicely. This TO-8 packaged device has four pins on it: one for the positive operating voltage, another for a ground, a third for the RF output, in the gigahertz range and a fourth for a tuning voltage that allows you to run the oscillator through a 500-MHz span. Most homebrew (from
FIG. 3—MOST HOMEBREW TERMINALS place a lower grade LNA stage plus first mixer, local oscillator source and an IF stage or two at the feed antenna, coming down to the baseband demodulator through lower-cost 50-ohm cable at the high-IF (500-1,000 MHz) region. In this version, essentially patterned after English experimenter Steve Birkill, a Mullard ELC1043/05 (European) TV tuner is slightly modified as combination oscillator and mixer to translate high IF range down to 35-MHz region low IF. Birkill processes his 35-MHz IF to video through a Signetics 561 phase-locked-loop demodulator, a system that offers advantages for weak input level signals. Full block diagram is not shown at this time.

FIG. 4—VARIOUS METHODS OF DISPLAYING BASEBAND (i.e., demodulated) video and audio. Typical receiver produces 1VP-P video and some usable level of audio (often at 600-ohms balanced although that is design decision of builder). Baseband signals will directly drive TV channel RF modulator, a high-quality video monitor (with audio display system built-in or separate), a consumer VTR (for recording or as loop thru to use RF modulator), or low-cost [private] microwave system.
Realistic Model
STA-2200 Receiver

LEN FELDMAN
CONTRIBUTING HI-FI EDITOR

REALISTIC AUDIO PRODUCTS ARE SOLD exclusively by the thousands of Radio Shack stores located throughout the United States and through their mail-order catalogues. The company has its own engineering staff located in Fort Worth, Texas, to design the products which are then manufactured for them overseas. Their most sophisticated stereo receiver to date is the model STA-2200 shown in Fig. 1.

The gold-colored front panel has no conventional dial scale or pointer. Instead, a large, highly visible digital display indicates the frequencies selected. The display reads out in 200-kHz increments for FM and in 10-kHz increments for AM and is associated with a true frequency-synthesis tuning scheme. The display also serves as a real-time digital clock, indicating the time of day (including “AM” or “PM” notations) when non-radio program sources are being heard, or even in the AM and FM mode when a clock pushbutton located behind a cleverly arranged sliding door panel is depressed. Program functions, such as phone and auxiliary, are also designated by alphabetic notations in the display area, in reception of stereo FM signals.

Sliding up the aforementioned panel (located at the left of the display) reveals additional buttons for setting the hour and the minute of the digital clock display, for dimming the intensity of the display, for turning off output-power and signal-strength LED displays and for activating the “station-memory” feature. When the MEMORY-SET button is pushed, you have five seconds in which to enter the tune-to-frequency of six AM or six FM stations (a total of twelve) by depressing one of six buttons located beneath the digital readout area. Just to the left of the sliding panel are tape monitor and dubbing lower switches for operation of two connected tape decks for dubbing from one to the other.

The upper right of the panel is equipped with several tuning option buttons. Pressing the auto-tuning or down buttons makes the tuner scan in the desired direction until the next usable signal is reached. A second pair of buttons (equipped with arrows, like the first pair) can be used for manual tuning. (The tuner continues to move up or down in frequency as long as the button is held down.) Just below these, a SCAN button, when depressed, makes the tuner scan to each of the memorized station frequencies in sequence, stopping for five seconds at each station for auditioning. If you want to stop the scan sequence, press the HOLD button during the 5-second interval. A power on/off button is also located at this end of the panel.

The center of the lower section of the front panel contains two banks of LED’s (10 LED’s per bank), which serve as power-output meters. These LED’s are calibrated in watts, referred to 8-ohm loads. Calibration is either 100 watts or 10 watts per channel maximum, depending upon the setting of a pushbutton. Additional pushbuttons in that cluster include a mute button for FM, A and B speaker selector buttons, a tone control defeat button, mono/stereo switch, an MPX high-blend filter switch, and a loudness switch.

Concentric volume and balance controls are located at the lower right corner of the panel, as is the usual headphone connection jack. To the left of the power LED display are bass and treble tone controls, and between them are a pair of pushbutton switches that determine the frequency at which the tone controls begin to boost or cut (150 Hz or 300 Hz for the bass, 3 kHz or 6 kHz for the treble). A program selector switch is located at the extreme left of the panel and, in addition to its expected settings (phone, AM, FM and aux), also has a setting for Dolby FM. The receiver is equipped with a complete Dolby FM decoder circuit.

The rear panel of the STA-2200 is shown in Fig. 2. A line fuseholder and switched and unswitched AC receptacles are at the left. Nearby are spring-loaded color-coded speaker terminals for the two pairs of speakers. There are also RCA-type phono jacks, for use when your speakers are equipped with permanent cables terminating in matching phono plugs. Preamp-out/main-amp-in jacks are interconnected by a pair of removable wire jumpers.

Two sets of tape-out/tape-in jacks are augmented by European type DIN multi-contact connectors. Other inputs (auxiliary and magnetic phono) are at the lower right of the panel, for removal from any AC hum fields, and a chassis ground terminal is located near the phono input jacks. Antenna screw terminals for AM, 75-ohm and 300-ohm FM antenna connections are provided along with a portable AM loopstick ferrite bar antenna.

Construction and circuit highlights

An internal view of the STA-2200 chassis is shown in Fig. 3. The FM front-end uses a dual-gate MOS FET and is tuned by variable-capacitance diodes, controlled by a microprocessor. The FM IF section uses 3 IC’s and three
FM performance measurements

Table 1 summarizes performance measurements made for the FM section of the receiver:

- Frequency response in mono and stereo FM was extremely flat, with very little evidence of roll-off often encountered at around 15 kHz (the upper limit of FM transmission) in many tuners and receivers. Signal-to-noise and distortion in mono and stereo FM were not as good as are usually encountered with conventionally-tuned FM tuner sections, however. Figure 4 illustrates the frequency response of the FM section, as well as the stereo FM separation characteristics of the monaural detector without the use of the blend filter (lower trace) and with the MPX blend filter activated (center trace). Figure 5 is a composite spectrum analyzer sweep photo used to illustrate the nature of the cross-talk fed into the unmodulated channel from the modulated one when a 5-kHz signal is used to modulate one channel. The desired 5-kHz output from the modulated channel is the null peak at the left of the display. (The display is linear from 0 Hz to 30 kHz with 5 kHz per horizontal division.) Contained within this peak is the second peak, at lower amplitude, which represents the 5-kHz component observed at the output of the unmodulated channel, while to the right of this are distortion components as well as the expected 15- and 30-kHz subcarrier components.

The action of the Dolby FM decoder circuitry is best illustrated by Fig. 6. Each sweep (logarithmic, from 20 Hz to 20 kHz) was made at a different level of modulation and, as expected, the upper sweep is virtually flat while correspondingly lower level sweeps show the Dolby high-frequency attenuation required to restore flat response at those lower levels to signal strength. A very inverse boosted during transmission. The FM generator was set for 25 microseconds per emphasis in making these plots.

Frequency response in AM was remarkably good compared with the AM sections of many stereo receivers that we have tested in the past. As can be seen from the response plot of Fig. 7, the frequency range of 6-15 Hz and 4 kHz which, though hardly "hi-fi" compares very favorably with the usual 2.5- to 3-kHz roll-off normally found on AM tuners built into high-fidelity receivers.

Amplifier and preamplifier section measurements

Table 2 is a summary of measurements made for the power amplifier and preamplifier sections of the ST-2200 Receiver. The unit seems quite conservatively rated in terms of power output, as well as rated distortion, delivering a clean 72 watts per channel at mid-frequencies and just under 70 watts per channel at the 20 Hz and 20 kHz frequency extremes for its rated harmonic distortion of 0.02%. Since no ratings were provided for 4-ohm loads, we did not measure maximum output for this load condition. We did, however, operate the amplifier for long periods into 4-ohm speaker systems without encountering
any thermal or shut-down problems.

While our signal-to-noise measurements for both phono and high-level inputs are made in accordance with the new IIEF Amplifier Measurement Standards (and cannot therefore be compared with Radio Shack's published specifications), the 77-dB S/N measurement in the phono and the 81-dB measurement for the high-level inputs (both A-weighted and referred to 1-watt output) compare very favorably with measurements obtained for other receivers in this, or even higher-priced categories. Phono overload capability exceeded Radio Shack's claimed figure of 200 mV by a wide margin and there is absolutely no danger of overdriving the first stages of the phono equalizer section of the receiver.

Range of the variable-turnover bass and treble controls is illustrated in the spectrum analyzer sweep photo of Fig. 8. Sensitivity of the analyzer was 10 dB of amplitude between horizontal lines and sweep is logarithmic from 20 Hz to 20 kHz.

### Summary

Our overall product analysis of the Realistic STA-2200 will be found in Table 3. On the whole, the receiver embodies a great many innovative design features, most of them concerned with ease of use and convenience of accurate tuning. In our bench and listening tests, the receiver ran very cool under all listening conditions, including extended periods when it was operated near its clipping point.

The purist audiophile may not think much of the fancy tuning schemes, the digital and LED displays and the time clock, but we suspect that the music enthusiast who wants ease of use and welcomes a "conversation piece" such as the built-in digital clock will find the STA-2200 appealing. The less-than-spectacular signal-to-noise performance of the FM section, will probably not prove to be a limiting factor in FM listening. Few stations we know of actually transmit a signal-to-noise or dynamic range ratio much above 60 dB. For all of these reasons, and because of its clever design and pleasing layout, we have assigned a VERY GOOD R.E.A.L. rating to the Realistic STA-2200.

### Table 2

<table>
<thead>
<tr>
<th>AMPLIFIER PERFORMANCE MEASUREMENTS</th>
<th>R-E</th>
<th>Measurement</th>
<th>Evaluation</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>POWER OUTPUT CAPABILITY</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RMS power/Channel, 8-ohms, 1 kHz (watts)</td>
<td>120</td>
<td>Excellent</td>
<td></td>
</tr>
<tr>
<td>RMS power/Channel, 8-ohms, 20 kHz (watts)</td>
<td>69.0</td>
<td>Very good</td>
<td></td>
</tr>
<tr>
<td>RMS power/Channel, 4-ohms, 1 kHz (watts)</td>
<td>N/A</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>RMS power/Channel, 4-ohms, 20 kHz (watts)</td>
<td>N/A</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>Frequency limits for rated output (kHz-0Hz)</td>
<td>10-30</td>
<td>Excellent</td>
<td></td>
</tr>
<tr>
<td>Dynamic headroom (dB)</td>
<td>1.2</td>
<td>Non-rated</td>
<td></td>
</tr>
<tr>
<td><strong>DISTORTION MEASUREMENTS</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Harmonic distortion at rated output, 1 kHz (%)</td>
<td>0.014</td>
<td>Very good</td>
<td></td>
</tr>
<tr>
<td>Intermodulation distortion, rated output (%)</td>
<td>0.035</td>
<td>Very good</td>
<td></td>
</tr>
<tr>
<td>Harmonic distortion at 1-watt output, 1kHz (%)</td>
<td>0.017</td>
<td>Very good</td>
<td></td>
</tr>
<tr>
<td>Intermodulation distortion at 1-watt output (%)</td>
<td>0.018</td>
<td>Good</td>
<td></td>
</tr>
<tr>
<td><strong>DAMPING FACTOR AT 8 OHMS, 50 Hz</strong></td>
<td>67</td>
<td>Very good</td>
<td></td>
</tr>
<tr>
<td><strong>PHONO INTEGRATED CIRCUITS</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Frequency response (Hz)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hum/noise A-weighted, referenced to 1-watt or 0.5-volt output, for 5 mV input (dB)</td>
<td>77</td>
<td>Good</td>
<td>Excellent</td>
</tr>
<tr>
<td>High level input sensitivity. phono 1/phono 2, referenced to 1-watt or 0.5-volt output, 0.5-volt input (dB)</td>
<td>81</td>
<td>Very good</td>
<td>Excellent</td>
</tr>
<tr>
<td>Residual noise A-weighted minimum volume, referenced to 1-watt output (dB)</td>
<td>82</td>
<td>Very good</td>
<td></td>
</tr>
<tr>
<td><strong>TONAL COMPENSATION MEASUREMENTS</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Action of bass and treble controls</td>
<td>See Fig. 9</td>
<td>Excellent</td>
<td></td>
</tr>
<tr>
<td>Action of secondary tone controls</td>
<td>N/A</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>Action of high and low cut filters</td>
<td>N/A</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td><strong>COMPONENT MATCHING MEASUREMENTS</strong></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Input sensitivity, phono 1/phono 2, referenced to 1-watt or 0.5-volt output (mV)</td>
<td>0.5/10</td>
<td>Good</td>
<td></td>
</tr>
<tr>
<td>Input sensitivity, high level referenced to 1-watt or 0.5-volt (mV)</td>
<td>18</td>
<td>Very good</td>
<td></td>
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<tr>
<td>Output level, tape outputs, at rated output (mV)</td>
<td>160</td>
<td>Very good</td>
<td></td>
</tr>
<tr>
<td>Output level, headphone jack, at rated output (mV or mW)</td>
<td>307mV/8 ohms</td>
<td>Excellent</td>
<td></td>
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### Table 3

<table>
<thead>
<tr>
<th>OVERALL PRODUCT ANALYSIS</th>
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<tr>
<td><strong>Retail price</strong></td>
<td>$599.95</td>
<td>Medium</td>
<td>Very good</td>
</tr>
<tr>
<td>Price category</td>
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<td></td>
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<tr>
<td>Price/performance ratio</td>
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<tr>
<td>Styling and appearance</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Sound quality</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mechanical performance</td>
<td></td>
<td></td>
<td></td>
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</tbody>
</table>
| Comments: Last year, Radio Shack's most expensive model sold for the same price as the STA-2200. This year, their top model has given up power in favor of a more sophisticated FM and AM tuning system, known as frequency synthesis. This tuning method guarantees center-of-channel tuning that is fully as accurate as the tuning of the broadcast station. The digital display, the 12-station memory (6 for FM, 6 for AM), the use of the display as a time clock plus its adequate specifications of program source, stereo FM signal reception, and the idea all add to the cost of the unit, so that, in effect, Radio Shack has traded power for convenience features and ease of tuning. The STA-2200 is a joy to use, a high-quality "LEO," and LED signal-strength indicators are far more accurate and easier to interpret than are mechanical tuning and power output meters.

Some small sacrifices result from the frequency synthesis approach. The maximum signal-to-noise ratio in mono FM is less than 70 dB. Variable tuning simply does not yield the same signal-to-noise performance as variable capacitor tuning. The Realistic STA-2200 delivers clean, natural sound in phono and tape reproduction. Tone controls are well designed and the variable turntable feature is welcome one. A sub-sonic filter would have been welcome addition, however. A word of commendation is in order for the excellent AM section which had surprisingly good frequency response.
Better Pick-up Arm Performance

The design of the phonograph pickup arm plays an important part in the overall performance of a high-fidelity system. Len gives details on the Thorens approach to pickup arm design.

Len Feldman
Contributing Hi-Fi Editor

A recent trip to Switzerland included a visit to the well-known Thorens Company, a few miles outside of Zurich. There, several audio experts and I were treated to a seminar that explored many of the myths associated with turntable design and performance. Admittedly, any manufacturer is going to make a strong point for his own design approaches to a product, but much of what we learned was backed up by solid theory. In any record playing system, we deal with two major elements: the turntable with its drive system, and the pickup arm and cartridge combination. In this article, we will discuss some of the design considerations involved in insuring optimum pickup arm/cartridge interface. In a future article we will discuss design approaches for the turntable and its drive system.

In recent years we have seen significant improvements in both turntable designs (to reduce rumble, improve speed precision and to minimize speed variations known as wow-and-flutter) and cartridge designs (to improve frequency response, lower tracking distortion and reduce mass). While design improvements of turntable and cartridges can be considered independently of each other, design improvements in pickup arms cannot be analyzed without considering the total playback system.

Tracking characteristics of an arm at very low frequencies (below 20 Hz) are influenced primarily by arm resonance and record warp. Arm resonance is the vibration of the arm/cartridge assembly that results while the stylus tracks the record. Record warp can affect arm tracking by altering instantaneous stylus pressure, as shown in Fig. 1. As the stylus rides up the record warp, the inertia of the arm mass causes the downward stylus force to increase. Conversely, when the pickup rides down the warp, the inertia of the pickup arm mass causes the downward stylus force to decrease. This varying stylus force, especially when the stylus rides down the warp, often results in mistracking and increased distortion as the stylus loses intimate contact with the record groove. Reducing the effective pickup arm mass would lower the inertial forces affecting stylus force as warped records are tracked and would, therefore, improve tracking and provide for lower distortion when playing warped records.

Messrs. Happ and Karlow, in a paper titled "Record Warps and System Playback Performance", analyzed the velocity spectrum of record warp using a representative sampling of records. The results of their work are shown in Fig. 2. From this graph we see that the velocity of record warp is greatest between 0.5 Hz and 7 Hz. To minimize pickup arm mistracking caused by record warp, the arm-resonance frequency should be between 10 Hz and 12 Hz, or above the frequencies that cause maximum record warp velocities. However, arm resonance must be below the 20-Hz lower limit of audio modulation on the record.

The chief factors that influence the resonant frequency of an arm/cartridge combination are the weight of the cartridge, the effective mass of the pickup arm, and the compliance of the cantilever arm of the pickup cartridge. The way these factors affect arm resonant frequency is illustrated in Fig. 3. The curves
show how arm resonant frequency changes with respect to the effective mass of the pickup arm and with the compliance of the cartridge used. Note that the resonant frequency varies inversely with effective mass and with compliance. Increasing either of these two parameters decreases the resonant frequency of the arm.

For example, if we have an arm with an effective mass of 15 grams and add a lightweight cartridge that weighs only 3 grams it has a compliance of $30 \times 10^{-6}$ cm/dyne. As shown in Fig. 4, the effective mass of this arm/cartridge combination would be 18 grams (15 grams for the arm plus 3 grams: the weight of the cartridge). The resonant frequency of this arm/cartridge combination would be 7.5 Hz. This frequency borders on the range of greatest velocity caused by record warp (as previously shown in Fig. 2).

Three grams is a rather light weight for a cartridge, so suppose we increase its weight to 7 grams. Total effective mass of the combination would now be 22 grams (see Fig. 5), and the new resonant frequency of the arm/cartridge combination would be 6.3 Hz, or very close to the maximum velocity of record warps.

Most popular phono pickup cartridges do weigh between 3 and 7 grams and ideally, if we are dealing with cartridges whose compliance ranges between $15$ and $30 \times 10^{-6}$ cm/dyne (also typical) the effective mass of a pickup arm that would keep resonant frequencies in the range 7.5 Hz for the Isotrack arm, resonance falls to 7.6 Hz to 12 Hz is between 6 and 10 grams (not including the weight of the cartridge).

To keep the effective mass of a pickup arm within this specified range, only certain factors in the arm design may be altered, while others must remain constant. The various dimensions and masses involved are illustrated in Fig. 6. For example, the length of the pickup arm tube from stylus tip to pivot center (L1) is fixed by the record diameter and the overall dimensions of the turntable system. The mass of the pickup cartridge, one of the factors determining the value of M1 in Fig. 5, is determined by the cartridge manufacturer and, as we have stated, generally ranges from 3 to 7 grams. The remaining factors that lend themselves to redesign are the mass of the headshell assembly (part of M1), the mass of the pickup arm tube (M3), the mass of the counterweight tube (M4) and its length (L2), and the mass of the counterweight itself, (M2).

The degree to which the mass of the counterweight may be altered and, to some extent, the degree to which the length of the counterweight tube may be altered, is limited by the weight range of popular pickup cartriges. The counterweight, after all, serves the primary function of balancing out the weight of the cartridge, shell and forward part of the pickup arm. The only elements of the structure, then, that may be dealt with in attempting to lower effective mass are that portion of M1 represented by the headshell and the mass of the pickup arm itself (M3).

For example, the headshell. The headshell can be reduced by using a light material and eliminating the screw collar that normally secures the headshell to the pickup arm tube. That approach, however, makes it difficult to interchange pickup cartridges.

An alternate solution (and one that Thorens eventually adopted) is to move the screw collar closer to the pivot point of the arm. By doing so, the mass is moved closer to the pivot point. In effect, because the formula for effective mass includes the term $M3 (LT/2)$, and since $L1$ is now shorter, there is a significant decrease in overall effective mass. Since the mass of the pickup arm has been decreased, the mass of the balancing counterweight can also be decreased, further reducing the effective pickup arm mass (see Fig. 7).

The pickup cartridge must, of course, be rigidly connected to the pivot assembly. The material of the arm must be rigid but also light in weight. According to

$$M_{eff} = M1L1^2 + M2L2^2 + M3(L1/2)^2 + M4(L2/2)^2$$

FIG. 3—RESONANT FREQUENCY of arm and cartridge are affected by effective mass of pickup arm and cartridge combination. Effective mass of pickup arm (M1) and counterweight (M3) is seen in Fig. 5. Effective mass of pickup arm (M1) and counterweight (M3) is seen in Fig. 5.

FIG. 5—HOW INCREASING CARTRIDGE weight affects arm mass and frequency.

FIG. 7—EFFECTIVE MASS of pickup arm is lowered in new Thorens design by moving the screw collar closer to the pivot point.

Thorens' new pickup arms ("Isotrack" arms), have been designed with all of the foregoing in mind. A thin-wall, straight anodized aluminum tube is used and the screw collar is located close to the pivot point. Instead of removing the head-shell to interchange cartridges, the user purchases as many forward tube portions as he or she wishes, mounting each cartridge in a separate unitized forward tube structure.

The arm's effective mass turns out to be approximately 7.5 grams (exclusive of the cartridge used). Figure 8 compares the range of arm resonance that might be expected from a typical arm with an effective mass of 15 grams when used with cartridges weighing between 3 and 7 grams and having compliances of between $15$ and $30 \times 10^{-6}$ cm/dyne with the resonance range that will result if those same cartridges are used in the Thorens Isotrack arm. For the typical higher-mass arm, resonant frequencies range from 6.3 Hz to 9.5 Hz after adding in the weight of the cartridge to the effective arm mass. For the Isotrack arm, resonance falls
between 7.6 Hz and 12 Hz, thanks to its lower effective mass.

In addition to its lower mass, the Thorens Isotrack arm has a low 25-milligram (maximum) pivot friction in both the vertical and horizontal planes. Aaa-skating is applied through a magnet arrangement that has the advantage over the familiar spring or weight arrangement that tends to introduce additional and variable friction components as the arm traverses the record.

According to Thorens, there is one additional advantage to be gained through the use of a low-mass arm. That is, lower susceptibility to vibration and shock from outside sources.

There is one other important consideration that should be discussed in any analysis of pickup arm design. That is the configuration of the bearing assembly and the length of the arm itself. Because so many of the records we play are warped, the bearing pivot point should ideally lie in the same plane as the playing surface. With such positioning, the longitudinal displacements caused by record warp are kept to a minimum, and the resulting wow-and-flutter components are lower. We are not discussing the wow-and-flutter that is inherent in the turntable drive system itself (that will be discussed next month). Rather, we are discussing that wow-and-flutter component that is generated entirely by vertical motion of the cartridge stylus as it is lifted and lowered by a warped record. Figure 9 illustrates this effect as it occurs with a pickup arm of normal length. The closer the pivot point is to the level of the record surface, the lower the wow and flutter produced by warped records.Extremely high levels of wow-and-flutter occur with short-arm designs that have a relatively high bearing-pivot point. Some of the so-called tangentially tracking arms that are available today have short arms, simply because tracking-angle error (the main reason for attempting a tangential-tracking arm in the first place) is eliminated in such designs. (The arm and cartridge cantilever assembly are always tangent to the groove being played).

After investigating this approach, Thorens concluded that while tangential arms are certainly feasible, the additional drive requirements for such arms make them too complicated to be practical.

In any case, referring once more to the wow-and-flutter problem inherent in short-arm designs (including the tangentially tracking ones currently available), consider the short, 4-cm arm constructed as shown in Fig. 10. The wow-and-flutter added by a warped record to that inherent in the turntable drive system itself works out to be:

<table>
<thead>
<tr>
<th>TOTAL WARP</th>
<th>EXCERUSION</th>
<th>ADDED WOW-AND-FLUTTER</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 mm</td>
<td>0.12%</td>
<td>0.24%</td>
</tr>
<tr>
<td>2 mm</td>
<td>0.24%</td>
<td>0.48%</td>
</tr>
<tr>
<td>3 mm</td>
<td>0.36%</td>
<td>0.72%</td>
</tr>
</tbody>
</table>

If we assume that a high-quality turntable exhibits its own basic wow and flutter component of around 0.05%, then with a 1-millimeter record warp the total wow-and-flutter will rise to 0.17%. A quick survey of your own records will show that you have very few that have less than 1 millimeter of warpage!

It is clear that the design of a complete turntable system involves many diverse factors, not the least of which is the fact that most phonograph records are less-than-perfect. To design a record playing system on the premise that records that will be played on it are perfectly flat, have completely concentric holes, and will be played in an environment that is totally free of outside vibration or noise is to ignore the real-world situation. In the next installment, we will talk about rumble, wow-and-flutter, mounting suspensions, and other factors relating to the turntable platter itself and its drive system. We will also try to show why one manufacturer's turntable, that has a -70 dB rumble figure, may, in fact, produce more rumble than another turntable that has a -50 dB rumble figure.

TV RECEIVERS continued from page 59

high quality reception from the Russian stationary series of satellite transponders although he is working with signals 7-9 dB weaker than we have available here from North American domestic satellites, and he has acceptable (if not high quality) pictures from the much weaker Intelsat satellites (they run from 12 to 15 dB weaker than our domestic satellites). The balance of his receiver approach is pretty standard since once you have baseband video and audio there is only one way to process it for conversion back to RF as an AM format signal.

To some people, being at baseband with the signal may seem like ending up at the wrong place. To view baseband directly, you feed the video and audio signals into a video "monitor" and a speaker. Not everyone has a video monitor of course and some means of getting the baseband signal back to a standard NTSC television channel (with the video portion amplitude modulated) is required.

A word about viewing the signal(s) at pure baseband; i.e., into and through a video monitor. This is the ultimate (high class) viewing technique since the baseband signals are of very high quality (48- to 54-IR signal to noise) and purity. However, this generally limits you to viewing the signals on a single monitor since video monitors tend to be expensive.

In Fig. 4 we have several methods suggested to get the baseband back to an RF channel. Clearly the baseband video and audio must be used to modulate a TV channel modulator device. Numerous circuits for these devices have appeared in Radio-Electronics through the years. One of the easiest ways to modulate back to RF is to use a LM1889 IC which is a complete TV channel 3 or 4) RF carrier generator/modulator intended for TV games and home VTR's. If you already have a home VTR, you can simply loop the baseband video and audio to the home VTR's "camera" and "audio" inputs. This turns the VTR into a modulator for you and you can then watch the satellite TV signals on multiple TV receivers, connected to the VTR modulator through 75-ohm coaxial cable (as in a miniature TV distribution system).

American Heart Association

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JANUARY 1980

65
SOUND-ACTIVATED LAMP DIMMER

MY NEW IDEA CONCERNS THE USE OF MOTOROLA’S MOC3011 OPTO-ISOLATED TRIAC DRIVER. THE TRIAC DRIVER CONSISTS OF A LED AND AN OPTICALLY COUPLED UNIJunction TRIPPLE switch (better known as a DIAC). THIS DEVICE PERMITS LOW-VOLTAGE CONTROL SIGNALS TO CONTROL HIGH-VOLTAGE, HIGH-POWER LOADS. IT ESSENTIALLY ALLOWS THE USER TO CREATE A SOLID-STATE RELAY FOR A FRACTION OF THE COST.

I WANTED TO MAKE A SIMPLE AND INEXPENSIVE DEVICE CAPABLE OF SOUND MODULATING THE INTENSITY OF A LIGHT SOURCE USING A MICROPHONE BUILT INTO THE CASE. THE DEVICE THAT I DESIGNED EMPLOYS A CONVENTIONAL LIGHT DIMMER CIRCUIT IN ADDITION TO THE SOUND ACTIVATION CIRCUIT. THE LIGHT DIMMER MAY BE USED EITHER INDEPENDENTLY OR IN CONJUNCTION WITH THE SOUND CIRCUIT. WHEN USED SEPARATELY, THE AUDIO SENSITIVITY CONTROL IS SET TO MINIMUM AND THE LIGHT DIMMER IS USED IN THE CONVENTIONAL MANNER. WHEN THE LIGHT DIMMER IS ACTIVATED BY SOUND THE 100K POT SETS THE MINIMUM INTENSITY THAT WILL REMAIN IN THE ABSENCE OF SOUND AND RETURN TO AFTTER IT HAS BEEN TRIGGERED TO FULL INTENSITY BY THE SOUND SECTION. THIS FUNCTION IS MADE POSSIBLE BY THE MOC3011. THE SIGNAL THAT CONTROLS THE TRIAC IN THE LIGHT DIMMER IS SO LOW THAT IT DOES NOT HARM THE UNIJUNCTION SWITCH IN THE MOC3011. FURTHERMORE, WHEN THE UNIJUNCTION SWITCH IN THE MOC3011 TRIAC DRIVER IS TRIGGERED BY THE LED, IT CAUSES THE TRIAC TO CONDUCT FULLY AND OVERTIDE THE PRESET LIGHT DIMMER SETTING.

THE CONSTRUCTION OF THE CONTROL UNIT IS SIMPLE AND STRAIGHTFORWARD. IF CIRCUIT ASSEMBLY IS DONE USING POINT-TO-POINT WIRING RATHER THAN A CIRCUIT BOARD, USE EXTREME CAUTION WHEN WIRING THAT PORTION OF THE CIRCUIT WHICH IS CONNECTED TO THE 120-VOLT POWER LINE. BE SURE THAT DURING THE WIRING OF THE TRIAC DRIVER (MOC3011), NO CONNECTION OF ANY KIND IS MADE TO PIN 5. SET THE MICROPHONE ELEMENT INTO A HOLE DRILLED ON THE TOP OF THE CASE AND SECURE IT WITH A SILICON RUBBER COMPOUND. THE AUDIO GAIN AND LIGHT DIMMER CONTROLS WERE PLACED NEAR THE MICROPHONE ELEMENT TO ALLOW ADEQUATE SEPARATION BETWEEN THE LOW-VOLTAGE SECTION AND THE 120-VOLT POWER CONTROL SECTION. A CHASSIS-MOUNTED POWER SOCKET WAS USED AS A CONVENIENT WAY TO MAKE THE DEVICE FLEXIBLE IN USE. IF A HIGH-POWER LOAD IS ANTICIPATED, BE SURE THAT ADEQUATE HEAT SINKING IS PROVIDED FOR THE TRIAC.

In addition to using this unit to produce scary effects for Halloween and cause your Christmas tree lights to dance with the Christmas music, you can also use this device to produce unique DISCO lighting effects with just about any lamp in the house. Several units placed around the room create a wild effect and there is no required connection to a sound source.

David L. Holmes

NEW IDEAS

This column is devoted to new ideas, circuits, device applications, construction techniques, helpful hints, etc.

All published entries, upon publication, will earn $25 plus a Circuit Board Holder, Standard Base and Tray Base Mount from Panavise Products, Inc. (See photo below.) Selections will be made at the sole discretion of the editorial staff of Radio-Electronics.

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An easy-to-build circuit that monitors sound level and lets you know when it rises above or falls below a predetermined point, plus a nifty new solder station.

EARL "DOC" SAVAGE, K4SDS, HOBBY EDITOR

THERE ARE TIMES WHEN ONE WISHES TO know when and if a sound level exceeds a certain point. It may be machinery that requires adjustment when its noise reaches a given level. It may be children (yours or the ones you babysit) who need to be reminded automatically when they get too noisy. Among other possibilities are your school or summer camp lunchroom or, even, your neighbor's stereo.

Of course, you could get an audio level meter, but have you priced one of those lately? And, besides, you have to watch the meter. Well, if all you want to know is when the level reaches a certain point, this simple project is what you have been looking for. As an added bonus, it can be set up to tell you if the noise falls below the setting—that is, if things get too quiet!

The heart of the loudness detector is a common 555 IC wired as a Schmitt trigger. As shown in Fig. 1, the output changes state—from high to low—whenever the input crosses a certain voltage. That threshold voltage is established by the setting of pot R4.

The prototype circuit uses a LED in the output. As wired, it turns ON to indicate a higher voltage (noise). Obviously, if the LED and its associated resistor R5 were wired between pin 3 and ground, it would turn OFF to indicate that same condition.

The 555 control (input pins 2 and 6) voltage originates from a small audio amplifier. The amplifier output is fed to R2 which develops an AC voltage proportional to the sound level at the microphone. That voltage is rectified by D1 and filtered by C1 and R3. The gain of the audio amplifier is controlled by potentiometer R1.

The amplitude of the voltage out of the filter is dependent upon the sound level. The greater the sound level, the greater the voltage.

When that voltage exceeds the threshold set by R4, the 555 output changes state and the LED turns ON. There you have it—a loudness detector! But a few details remain.

The audio amplifier can be whatever you happen to have on hand as long as it will output 150 mV or so. You may want to build a simple transistor or IC amplifier or you can use a commercial module. My loudness detector was first tried by running the output of a "shirt-pocket" radio across R2.

The LED can be replaced by a relay with a DC voltage rating appropriate to the supply voltage you apply to pin 8. The hook-up is shown in Fig. 2. Do not omit the diode. The back EMF from the relay is likely to ruin the 555. By using a relay, you can cause a bell to ring, a bright light to turn on or, even, the offending ma-

The difference between the two voltages varies with the setting of R4.

Certainly there are other uses to which you can put the basic 555 circuit. Variable voltage from any source will cause the light or other alarm to activate. All you have to do is to apply that voltage to pins 2 and 6 of the 555. Be sure, however, that the voltage on pins 2 and 6 does not exceed the applied voltage on pin 8 or the 555 will be damaged. In cases where this is a possibility, you should use a voltage divider or a Zener diode to prevent it.

Please hold

I would like to pause to give a bit of gentle (?) advice to some advertisers of parts and equipment. It is very nice of you fellows to provide your telephone numbers, especially if you have a toll-free line.

You must know, however, that it is quite disconcerting to be placed on "hold" before the caller has a chance to say a word. It is more than disconcerting if the number is not toll-free and the caller is left paying to listen to a dead line.

Accordingly, I trust that all you good guys will review your procedures. If your establishment suffers from this malady, a correction will benefit both your customers and you. After all, other folks sell the same items.

A suggestion: if you can't handle it right then, don't answer it. We'll be glad to call back in a few minutes.

continued on page 70
On the bench, in your hand or on-the-go, LX303 is your number one value in a compact DVM. Even though it is low priced, the LX303 provides the level of performance you'd expect to find in more expensive instruments. A full 3½ digit display (3,999 full-scale reading) provides range-to-range overlap for best accuracy and typical precision of better than 1%. The 100 mV DCV range gives you low level measurement capability usually found on instruments costing nearly twice the price. The maximum resolution of 0.1 ohms lets you accurately check ballast resistors, windings, coils, etc. The low-power output (0.35 V max, full-scale voltage) makes in-circuit resistance measurements sure and easy.

Fast, easy, one-hand operation. Automatic polarity, automatic zero, automatic over-range indication and a sharp (3 per second) reading rate speed up and simplify operation. R.F. shielding assures you of jitter free readings on the big, ½ inch high, easy reading, wide angle, LCD display. Panel switches are human engineered for easy one hand operation.

Years of hassle-free reliability. The 300 hour battery life means you'll only need to install a new battery once every 6 months or so (at 2 hours/day, 5 days/week). A convenient battery check capability is built in. The LX303's excellent overload characteristics also assure long reliable operation. All DCV ranges will take 1000 volts without damage except the 100 mV range which will handle 500 volts. All AC V ranges will withstand 600 volts. The ohms ranges are fully protected too — up to 1200 volts AC or DC without damage — up to 240 volts short term.

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RESISTANCE (5 RANGES, LOW POWER): 200Ω to 2MΩ full scale: RESOLUTION: 0.1Ω. ACCURACY: ±0.5% rog ±0.5% f.s.d. 2.5kΩ at 5kHz OVERLOAD PROTECTION: 120VDC or rms full range, 24VDC rms for 30 sec. DC CURRENT (5 RANGES): 20 nA to 200 mA full scale. ACCURACY: ±0.5% rog ±0.5% f.s.d. OVERLOAD PROTECTION: 800mA on 10 mA
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Solder station
PanaVise (2850 29th St., Long Beach,
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effective solder station. It consists of a
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and a holder for your iron. Also provided
are two sponge tip cleaners. The holders
can be used separately or fastened togeth­
er (bolts provided) as a single unit for
either right or left hand use. (See Fig. 3)
The station can be mounted on your
workbench, on the wall, or you can put it
on a movable base. One or both holders,
separately or as a unit, also may be
mounted on PanaVise's holders for
boards/parts (and you already know how
great I think they are).

HOBBY CORNER
continued from page 68

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great I think they are).

If you aren't using a solder station, con­
sider the convenience of having an iron,
solder, and wire right where you need
them. You may not be as careless as I, but
it is good to have a place to put your iron
so it isn't lying around waiting to burn
your hand! The model 371 solder station
sells for about $5.

E-A-T
ELECTRONICS

"Next time you check resistance ranges
around here, leave me out of it!"
INTERIOR VIEW of the Conference Caller. The two non-polarized isolating capacitors are wired directly to the switch.

Construction and installation

Construction is simple and wiring is not at all critical. The components can be mounted directly to the switch. When you connect the conference caller to your telephone lines make sure only the green wires go to the green terminals, and the red wires to the red terminals. 

C1 and C2 must be nonpolar (not electrolytic) capacitors rated at more than 100 volts. If you want to expand your conference caller to use three or more telephones, simply add two more capacitors and a switch for each additional line (see the dashed box in Fig. 1).

To test this device, have a friend call one of the numbers connected to it. Next, call someone else, using the other phone. Now, close the switch and all three of you should be able to talk together.

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A phonograph record that tells all about shortwave listening, plus a tri-band monitor antenna.

HERB FRIEDMAN, COMMUNICATIONS EDITOR

THE CHINESE PHILOSOPHER CONFUCIUS once said: "A picture is worth a thousand words." Had he lived in our time he might have added: ... but one good LP recording is worth all the words and all the pictures.

For more than a quarter century I have been reading about one of my favorite hobbies, shortwave listening—or SWL'ing as it is more commonly known—and in all that time I have yet to find a book on the subject that was not deadly dull. One of the problems with modern books is that a publisher usually contracts for a specific length. The writer has to fill so many pages; and an exciting subject, such as SWL'ing, can easily get buried in excess verbiage, sure to put one to sleep by the twentieth page. (It takes five pages just to thank all those who helped the author.)

If you'd like to get the real flavor of SWL'ing, or if there's some youngster who you think would enjoy getting into it, the pathway to this little known but widely practiced hobby is through a 12-inch LP record that goes by the rather insipid title of Long Live Shortwave! (exclamation mark and all). Put together and narrated by Mitch Murray, one of Great Britain's leading songwriters, who is also an avid SWL (Short-Wave Listener), the record is an obvious labor of love. (See Fig. 1.) Side A tells us about SWL'ing: what it is, its frequencies in use during different time periods, antenna tips—just about everything a new SWL would want to know. For example, there are actual samples of the sounds of RTTY, SSTV and satellite signals. There isn't a wasted word on the whole side, which runs about 22 minutes. One subject flows into the next, and the youngsters—and a few old-timers—we played the record for were left sitting on the edges of their seats waiting to hear what Mitch would cover next.

A small booklet, actually a piece of paper about 8 x 13 inches that is folded in thirds, contains the artwork that Mitch refers to. Some of the pictures are antenna designs; others are charts, such as the SINPO code and frequency conversion. (SINPO is a method of reporting reception quality—Editor.)

On that one side of an LP, Mitch Mur-
requires really precise tuning for lowest SWR. Nontuneable models positively require a broad groundplane underneath, such as the roof of a car or RV, or the center of a trunk.

Tri-band monitor antenna.
Our final item this time falls into the "Why didn't I think of it?" category. It's the magnetic mounted mobile low/high VHF and UHF monitor antenna. Hustler model MOM, covering the 30-50, 150-174, and 450-512 MHz bands. Basically, it consists of a magnetic mount with an antenna approximately 34 inches long. The whip antenna has a loading coil in the approximate center that "tunes" the whip to the low (30-50) VHF band. On the high VHF band the coil functions as an "isotizer," or trap, so signals are received by the lower part of the antenna that functions as a 3/4-wave whip at the high VHF frequencies. On the UHF band the lower part of the antenna appears to function as a 1/4-wave whip. (The sizes are only approximate. The antenna is for receiving only; not for transmitting.)

The supplied 17-foot coax cable has Motorola-type plugs on both ends since it plugs into a matching connector on the magnetic base.

Why a plug-in connector? That is where the "Why didn't I think of it?" comes in. The magnetic base has two slots cut in the rear. A small metal bracket supplied with the antenna is attached to the edge of the trunk lip behind the rear window. The bracket is similar to those used for "standard" trunk-lip antennas except for two small hooks that protrude upward. If you intend to barrel down the highway at speeds that might tear a magnetic mount loose (and contrary to what anyone says it does happen), you simply engage the slots in the mount with the hooks when you install the antenna and it will stay put under any driving condition. Between the hooks and the magnet that antenna doesn't come loose.

To remove the antenna you simply unplug the coax at the mount and lift the antenna off the hooks. A weatherproof cap is provided for the coax plug in case you want to leave it out for possible instant use.

One other bit about the Hustler MOM: It makes a great "indoor" VHF/UHF antenna if your monitoradio has a metal cabinet. Simply place it on top of the cabinet; the magnet locks it in place.

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WERSI

CIRCLE 21 ON FREE INFORMATION CARD
The "Christmas tree" pattern reveals itself once again.

JACK DARR, SERVICE EDITOR

The exception to this rule is in sets with the popular Syncroguide oscillator circuit. By carefully setting this up exactly right, you could find a combination of adjustments to the two coils that would let it Christmas tree.

With later model sets we haven't seen the Christmas tree pattern for a long time. The other day, I saw one! Real dandy too. Some unmistakable pattern but a double; there were two trees, top to bottom, complete in every detail. (Fig. 2) This was in a Sylvania E06-02 chassis. Original complaint was loss of height. Replacing the vertical driver/amplifier IC cleared this up, and the set went home. Back in a few days, with complaint of "lines in the picture and makes funny noise at turn-on". On the bench, it played very well for quite a while.

Finally, it began to show horizontal pulling at a 2-3 second rate, then went into the new Christmas tree pattern. From force of habit, I scope the B+ line feeding the horizontal oscillator. The scope showed pulses here. DC Voltage readings were low, and the B+ boost line, +170 V, was also low and showed pulses. A bad filter was suspected. Turned out to be a 100 μF 250 V capacitor on the +170 V boost line. This is a flyback-derived voltage and could be expected to be low with the odd drive waveform from the oscillator. However, it was the culprit; the open filter was allowing high pulse voltages to develop on the +170 V line, and this was managing to get into the B+ line feeding the horizontal oscillator, in amplitude great enough to cause the incorrect feedback and Christmas tree pattern. However, the old concept seems to be valid still; the major cause was a bad filter capacitor, and the proof of the pudding was the presence of pulses in the B+ lines. Replacing this capacitor cleared up the problem.

So if you start seeing Christmas trees in the middle of the summer, up scope and look first on your B+ lines feeding the horizontal oscillator. As far as I know, it is not possible for a normally-operating horizontal oscillator of the modern type to be misadjusted in such a way that it will Christmas tree. In the Syncroguides, the two coils made it fairly easy to find a setting that would cause this. Some used to call this "squeeging". A fascinating word, and I've never yet been able to find out where it came from or what it means! Sounds like one that was invented to describe something, and in that way, I guess it's OK!

HORIZONTAL PROBLEM

I have a problem with a model 1872 XAM color set. It came in with sound and no raster. I changed the output, the high-voltage rectifier and the damper. The picture came back, but now it runs horizontally. Adjusting the hold control finally produced three pictures side by side, vertically locked. I've checked everything I can think of. Any ideas? I used a solid-state high-voltage rectifier. Could this be causing it? —J.G., Brooklyn, NY.

This is a horizontal-frequency problem, and I doubt that the high-voltage rectifier would affect it at all. Try this to see if it works: Shunt out the horizontal AFC and see if you can adjust the horizontal-hold control, etc., to get ONE straight-sided flicking picture.

If you can't, then there's a part off-tolerance somewhere in the frequency-determining section of the oscillator, either the coil or the capacitors across it. Check C261, C262 and the resistance of the coil, both sides of the tap. Be sure to use exact replacements for these parts; they are critical.

VERTICAL SHRINK, POOR SYNC

Here's one that fooled me for a while. The picture on this GE KC chassis shrank up from the bottom, and had very poor vertical sync. After checking a few things with no luck, I finally pulled the deflection yoke and found that the little thermistor in series with the bottom half
of the yoke was bad. Apparently this also caused the sync problem. Please pass this along.

Sure will, and thanks to Bob Stevens, TV Rebuild Service, for this tip.

MAGNAVOX HEAD NEEDED
I need a play-record head for a Magnavox model 2TR2005 reel-to-reel tape recorder. The factory says it's not available any more. Do you have any information on this?—L.T., Wartburg, TN.

The Nortronics Company (8101 Tenth Ave., North, Minneapolis, MN 55427) does list this Magnavox part number. They list their type 1002 as a replacement for the Magnavox 761J9043 head. I hope this helps.

BRIGHTNESS PROBLEM
Don Black, service manager for Sony of Canada Ltd., sends along this note about the raster shading problem in the Sony model KV-1910 mentioned in the January 1979 issue. He says that it is apt to be caused by filter capacitor C707, (4.7 µF, 250V) on board T. This is a filter in the collector supply circuit to the R-G-B output transistors. Thanks to Mr. Black for his help.

BAD FLYBACK
I'm a teacher's aid in a vocational school radio-TV repair class. We have a problem with an RCA model KCS-153B. The high voltage is very low there is severe blooming and not enough width. I found that the high-voltage winding of the flyback read 50,000 ohms. (The diagram shows this should read 5900 ohms.) The transformer shows continuity, but also shows "short." Do you think this flyback is bad?—L.L., LaGrange, KY.

Yes, it has probably overheated and shorted a few turns in the high-voltage winding. This will cause all of the symptoms you describe.

SCOPE POSITIONING PROBLEM
Your crystal ball hit it right on the nose in a horizontal positioning problem in my Sylvania model 400 scope. The voltages on the 7C5's were the same, but on the horizontal internal/external switch, one voltage was OK and the other way up. The 0.1-µF coupling capacitor, C37, was shorted! I replaced C37 with a new capacitor and bingo! Thanks.—Roger Williams, New Orleans, LA.

HIGH-VOLTAGE PROBLEM
This Admiral model 3K10 is showing several odd symptoms. The cathode current in the 26L65 is way up, and the high voltage is way down. The boost voltage is just about right at 875 volts. Any ideas you might have would be welcome.—J.C., Berlin, NY.

I have one idea: If your boost voltage is normal, this tells you that the horizontal-output stage, deflection yoke and flyback continued on page 76
are OK. Since you have a high-voltage problem, try a new high-voltage tripler; that would be a more likely cause.

(Feedback: Yes, it was indeed a very "bad tripler"!)

SHORT TUBE LIFE

This Penncrest model CB233 TV has a 16" tube that lasts only about 5 days to a week! I've monitored all the voltages on it, but can't see anything wrong. I have another model of this make with the same problem--v.s., Burlington, Wl.

There is one thing shown on the schematic diagram that might be causing this problem. A dropping diode is used in the heater string; result--reduced power. If this diode is leaky or shorted, it places the full sine wave AC on it and overloads the tubes. Check the diode for leakage, or replace it. Incidentally, a sine wave AC voltmeter will not measure the heater voltage correctly because this voltage is a half-wave pulsating AC. Take note that Sams shows only 10 volts across the 16" tube.

HINT ON MAD MODULES

RCA is now enclosing a note in its shipments of MAD modules that reads:

"When using Module Stock No. 139665 as a replacement for Modules MAD40A-H1, I1, IP or IR, it may be necessary to solder the potmeter socket leads to the external terminals of the module." This might be helpful.

LUCK OR GENIUS?

Your crystal ball must have been really working in the April 1976 issue! A neighbor to the east of me had the intermittent horizontal oscillator problem; the neighbor to the west had the Zenith high-voltage regulator trouble! Now do you do it?--L.H., Rochester, NY.

There are two distinct schools of thought on this: one group favors genius; the other seems to lean more toward pure luck. As far as I can see, the second group has a slight edge—something like 97.3%. However, if it works take it!

SHUTDOWN TROUBLE

Thanks to your help, "we" finally found what was causing this model 19TS-949 Quasar to shut down after about 15–30 seconds! You said that it would shut down on both low and high voltages. I found that the 25-ohm, 20-watt resistor, R185, was cracked right under the metal clamp that holds it in place. The center wire wasn't broken, but the resistance was close. I replaced it and all system was OK. I figure that the loose wire in the cracked insulator heated more at turn-on and was upsetting the anode voltage on the SCR, causing it to trip. --L.F., Fulton, MO.

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NEW PRODUCTS
continued from page 77

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Since all tuner subs that we know of are modified TV Tuners, we decided to market an excellent performing yet very low cost sub for the technician who has to get all he can for his money— a "Poor Boy's Sub" for only $19.95.

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DeSoldering Wick, 35-Wpc; comes in spools containing a 5-foot, 5-inch length and costs $.49 each for O.E.M. Quantities of 5000. Each spool is

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More information on stereo products is available. Use the Free Information Card inside the back cover.

CAR STEREO EQUIPMENT LINE, 20 models (model SB2100 shown) ranging from under-dash 8-track and cassette units to 6-track/cassette AM/FM stereo radio combinations, several with digital displays. Many units feature loudness, muting, high-filler and AM/FM controls. LED indicators; audio-reverse cassette; and automatic key-off reject. Suggested retail price for the model SB2100: $219.95.—Sparkomatic Corp., Milford, PA 18337.

EXTENDED-RESPONSE PHONO CARTRIDGE, model EDR9, has an aluminum cantilever with a nude-mounted diamond stylus. The stylus has a 0.3 by 3.0-mil radius. Other specifications: frequency response, 10 Hz-50 kHz, 20-35 kHz; tracking force range, 3.5-9.7 grams; frequency response, 10 Hz-50 kHz; tracking force range, 40-100 grams; the cartridge weighs 5.2 grams.

AM/FM STEREO RECEIVER, Spatial Control receiver, provides 100 watts-per-channel, contains four amplifiers and features a total side control. Side control is used in conjunction with the

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Spatial Control System, a direct-reproduction system with a sensitivity rating of 86 dB at 1 watt, a maximum power-handling capability of 50 watts; it measures 28.5 by 17 inches; it provides a low bass response; it has a sensitivity rating of 86 dB at 1 watt, and a maximum power-handling capability of 50 watts; it measures 22.2 by 12 W X 10.4 inches D. All speaker enclosures are finished in natural veneer with a brown grille cloth and come in pairs. Suggested retail prices: XP20, $197; XP40, $115; XP60, $180; XP80, $210.—Rank Hi-Fi Inc., 20 Bushes Lane, Elmsford, N.Y. 10523.

CIRCLE 133 ON FREE INFORMATION CARD

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digital displays. Many units feature loudness, muting, high-filler and AM/FM controls. LED indicators; audio-reverse cassette; and automatic key-off reject. Suggested retail price for the model SB2100: $219.95.—Sparkomatic Corp., Milford, PA 18337.

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- **Features:**
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  - LCD display.
  - Time and temperature.

### DIGI-CLOCK

- **Price:** $19.95

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<tr>
<th>IC</th>
<th>Description</th>
<th>Price</th>
</tr>
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<tbody>
<tr>
<td>74LCX245</td>
<td>Inverter</td>
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</tr>
<tr>
<td>CD4049BE</td>
<td>D-Type Flip-Flop</td>
<td>$0.17</td>
</tr>
<tr>
<td>74HC138</td>
<td>Decoder</td>
<td>$0.23</td>
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### Resistors

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<tr>
<td>10KΩ</td>
<td>$0.05</td>
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</table>

### Capacitors

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<tr>
<td>1µF</td>
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<tr>
<td>10µF</td>
<td>$0.06</td>
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<tr>
<td>100µF</td>
<td>$0.05</td>
</tr>
</tbody>
</table>

### Temperature

- **Programmable:**
  - Digital temperature display.

###惠普

- **Engine:**
  - Programmable features.

### DIGI-KEY Corporation

- **Contact:**
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AY3-8910

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- Frequency response: 10Hz - 100KHz
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- S/N ratio better than 90dB
- Input sensitivity: 4V max.
- Power supply: ±40V @ 5 amp

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SPECIFICATIONS
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AC Current: ±5mA, ±10mA, ±20mA, ±50mA, ±100mA, ±200mA, ±500mA
Resistance: 10Ω up to 10kΩ, 100kΩ (max. capacity) 1kΩ up to 10MΩ

Load Current: 30mA 3mA 300mA 30A
Load Voltage: 3V 3V
Decibels: -15 to ±55dB
Batt Check: 0.0 to 1.9V (1001 ohm)
LED Check: (Available)
Temperature: 0° to +100°C and 0° to +40°C
Accuracy:
DC Voltage: ±2.5% (±5%)
DC Current: ±2.5% (±5%)
Batt Check: ±2.5% (±5%)
AC Voltage/Powers on 1V range ±5% (±5%)
AC Voltage/Powers on 5V range ±3.5% (±5%)
AC Current: ±5% (±5%)
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Dimensions: 145 x 97 x 22mm thick
Weight: 240g

NEW MARK III
9 STEP 4 Colors
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This new level indicator kit consists of 18-color LED lamps which indicate the sound level output of your amplifier from -40dB to +6dB.
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MARK IV KIT $31.50

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It works in 12V DC as well Kit includes 1 PC-SANYO STK-043 stereo power amp, IC LM 1458 as pre-amp, all other electronic parts, PCB board, all control pads and special heat sink for hybrid. Power transformer not included. It produces ultra-high output up to 60 watts (+6dB per channel) yet gives out less than 0.1% total harmonic distortion between 100Hz and 10kHz.

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BATTERY POWERED FLUORESCENT LANTERN
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FEATURES
- Circuitry designed for operation by high efficient, high power silicon transistor which enable illumination maintenance in a standard level, even the battery supply drops to a certain low voltage.
- 9" 6W cool/warm white fluorescent mini tube.
- 8 g hot/white LED indicator with wide angle illumination. Power supply is 6V-20V D.C.

STEREO AMPLIFIER
60 W + 60 W

|STEREO AMPLIFIER

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All parts are assembled on a single PCB Board. Battery: Voltage 6 9V D.C. SPECIAL PRICE $1.95 ea.

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