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FEATURE ARTICLES

CHEMICALS FOR ELECTRONICS
Degreasers, cleaners and polishers
25 Lon Cantor

BUILD A TIMBRE GATE
Envelope generator for new sounds
29 Croig Anderton

BATTLE OF THE GIANT BRAINS
Electronics conquers all
39 Frank Y. Dill

PICK & CHOOSE AMONG STEREO HEADPHONES
What do they have to offer?
44 John Steele

THE IN-OUT ANNUNCIATOR
Gets them coming and going
48 John S. Simonton, Jr.

BUILD THE CHARGE NOW
Recharge most any battery
53 A. A. Mangieri

VR12 VOLTAGE REGULATOR
Solid state dependability for your car
65 C. R. Ball, Jr.

COMMUNICATIONS

THE PRODUCT GALLERY
Heathkit 1B 101 Counter
Lafayette RK 890 Recorder
Tompkins Mobilink
76

STEREO SCENE
The best of everything
82 J. Gordon Holt

OPPORTUNITY AWARENESS
Your wages vs average
85 David L. Heisemon

SOLID STATE
Digital counting grows up
86 Lou Garner

DEPARTMENTS

DIRECT & CURRENT
7 Oliver P. Ferrell

INTERFACE
8

NEW LITERATURE
14

READER SERVICE PAGES
15, 95

ELECTRONICS LIBRARY
16

NEW PRODUCTS
22
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April, 1971
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CIRCLE NO. 5 ON READER SERVICE PAGE
If you haven’t noticed, the audiophiles have a new vocabulary. All their serious discussions now involve words and phrases such as: ambiance, encoder, L-R, total compatibility, etc. It all has to do with either getting something for nothing or making an attempt to compress four channels of music information into the same track width or groove depth that last year was occupied by two channels—in other words, surround quadraphonic stereo.

This editorial is not a progress report on four-channel sound—simply because events in this field are moving so rapidly that, in the relatively short time between the writing and publication of an editorial, there is almost certain to be the birth of another new idea or innovation—and more new words. Also, I find it difficult to stifle a nagging sensation that all is not right with four channel. Has the hi-fi industry turned its engineers loose to run amuck and stimulate business through new product developments, or is there a "call" for four channels? Does good listening really require total immersion of the listener or are the first four-channel demonstrations minimizing musical values for electronic showmanship?

It’s fascinating from an engineering point of view to see and hear what a relatively simple decoder—such as that used in the Electro-Voice system—reveals to be hidden away on present disc or tape stereo recordings. But simultaneously, it’s musically unnerving to be bombarded with sound from all directions.

There’s a good chance that properly used (whatever that might be) four-channel reproduction has some very desirable advantages for the serious, or even the background music, listener. However, at the moment, it is difficult to believe that four channel is of great interest to anyone other than the devotee of modern pop and rock music. Certainly my teenagers—more than I—would find four channel to their liking—although that affinity might well be due to the fact that four channel sounds louder and gets the listener more "involved."

The outboard gadgets, the doubling up of amplifiers and speakers, recall the introduction of the stereo disc in 1958. Hopefully, the hi-fi industry recalls the confusion created then after the first flush of success. I think that four channel is on the threshold of something big. Whether it’s in the techniques of recording or playback remains to be seen; but, gentlemen, don’t make us go around again.
orders into the GPO in time to receive the full complement of manuals.

THOSE HARD-TO-FIND PARTS

Your Direct & Current editorial (February issue, p 7) emphasizes a very annoying problem. However, I believe the blame lies more with the manufacturers than the distributors. Here are some of the reasons the local store may not have the “latest and greatest”:

1. New devices are announced months before they can be made available. This is a deliberate sales policy to feel out the market.
2. Manufacturing the device runs into trouble and after products have been announced they cannot be manufactured.
3. There are frequent minor mechanical or electrical parameter changes and/or the numbering may be changed.
4. Many manufacturers bring out devices first under their “house” numbers and after they become popular the same device is assigned a new, but standard, EIA number.
5. Conversion lists from house numbers to standard EIA numbers are hard to come by.

For many uses, there may be devices that are equally suitable and many manufacturers offer “replacement” devices. However, sometimes replacements do not work and the original number would have been preferred in the article—in other words, how does the magazine reader without access to a full list of standard numbers replace a replacement? I agree that it would be good business to

Reader response to the “Electronics Self-Study Program” article far exceeded our best estimates. The Government Printing Office apparently received over 1000 orders for the electronics training manuals mentioned in the story and soon found that stocks of certain manuals had been depleted. Our apologies to those readers who didn’t get their

W. STROH III
Short Hills, N.J.

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April, 1971

CIRCLE NO. 18 ON READER SERVICE PAGE
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The Turner Company

CIRCLE NO. 25 ON READER SERVICE PAGE

INTERFACE (Continued from page 8)

make such devices available to experimenters. But the good will you mention does not pay salaries. I think the semiconductor industry deserves credit for holding down single unit costs to usually two times the thousand lot price—the factor that is more than likely to be more than 10 or 20 times greater for most other components.

T. LAMB
Mansfield, Ohio

THE LONER

One of the biggest obstacles for the hobby-list-experimenter is that by situation he is basically an outsider or loner. His progress is hampered by lack of contact with other hobbyists and he often does not own or even have access to “essential” test equipment.

Unlike the radio amateur, the hobbyist is hard put to find other hobbyists even in his own town. And, these problems are compounded if the hobbyist does not live in or around a large city or some electronically-conscious area.

I think we need a middleman—such as POPULAR ELECTRONICS—to maintain a file of information about individual hobbyists—arranged by geographic locale. If this were put to work, the hobbyist could send in some personal data, list his equipment, activities, desires, address, phone number, availability, etc. If each listing were accompanied by a nominal filing fee, the cost of distributing this information to people of like interest could be amortized.

R. A. BRUSH
Salt Lake City, Utah

SMALL ORDER DEPARTMENTS

We are presently opening a mail order division for integrated circuits and all other semiconductor sales. We will cater especially to the experimenter. Our prices should be in line with distributor prices; for example, the SN7400N will be sold for $1.90 and the MC7424P for $1.10 each, plus shipping.

E. L. ROBINSON
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A new, quick-service “Small Order” department has just been announced by Simpson Electric Company, Chicago. By isolating small orders (50 pieces or less) we have found that both large and small orders can be expedited. Simpson Electric manufactures a complete line of test equipment including the world-famous 260 family of VOM's.

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CIRCLE NO. 26 ON READER SERVICE PAGE
Hold it and you'll know why more pros have chosen Ungar's new #6760. Kit assembly or professional servicing...it's the most advanced gun available for soldering today's sophisticated circuitry. First, it's less than five ounces light—for pinpoint accuracy without hand fatigue...advanced circuitry replaces the usual heavy transformer.

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...the new Heathkit® 25" ultra-rectangular TV color picture is that perfect.

"Picture postcard perfect"...an apt description for the quality of color reproduction in the new Heathkit GR-371MX 25" ultra-rectangular solid-state color TV. And the reasons are as clear as the expanded 315 sq. in. view:

New Heath MTX-5 ultra-rectangular matrix picture tube. Developed in conjunction with leading domestic tube manufacturers to produce a sharper picture, purer colors, more natural flesh tones. Specially formulated etched face plate cuts out unwanted glare, increases contrast without sacrificing brightness. Matrix screen around phosphor dots eliminates reflected light, allows use of higher transmission glass for greater light output. New square-corner rectangular design opens up the largest picture in the industry...25" diagonal measurement, a full 315 sq. in. of viewing enjoyment. New shape allows complete transmitted image to be seen for the first time. Pictures don't wrap around sides of tube as before. And 25,000 volt high voltage assembly assures optimum picture quality.

Unique solid-state design: 45 transistors, 55 diodes, 2 silicon controlled rectifiers; 4 advanced ICs containing another 46 transistors and 21 diodes; and just 2 tubes (picture and high voltage rectifier) combine to deliver performance and reliability unobtainable in conventional tube sets.

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CIRCLE NO. 15 ON READER SERVICE PAGE

April, 1971
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Parent Pending

Blonder-Tongue Labs., Inc., recently made available their No. 70-72 "Home Products Catalog." The catalog contains specifications and photos for mast-mounted preamplifiers, broadband amplifiers, amplified signal dividers, UHF converters, antenna rotors, antennas, and miscellaneous home TV system accessories.

Circle No. 75 on Reader Service Page 15 or 95


Circle No. 76 on Reader Service Page 15 or 95

A six-page catalog (No. C171) available from Bell P/A Products Corp. gives detailed specifications and descriptions of the company's broad line of commercial sound components and special-purpose sound systems. The catalog covers amplifiers, tuners, boosters, mixers, turntables and record changers, carrying cases and cabinetry. Complete specifications and photographs of the Bell P/A Mod Series, the Carillon Series, the Transistor Power Amplifier Series, and the SLA Series of automatic limiting amplifiers.

Circle No. 77 on Reader Service Page 15 or 95

More than 25,000 American, European, and Japanese semiconductors are cross-referenced to HEP equivalents in Motorola's new replacement guide/catalog No. HEP HMA-07. Listings for thousands of manufacturers' regular and "house" numbers are also included. The semiconductor cross-reference guide features the company's full-line HEP product catalog which gives minimum and maximum ratings and electrical characteristics for 285 HEP devices. The devices are listed by type number with a packaging index, dimension drawing, and selection guide information.

Circle No. 78 on Reader Service Page 15 or 95
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from the proper source for the asking. Since no one would envy Mr. Moore the task he undertook, he must be congratulated on the reduction of so much data to such a palatable format. This is a reference work and hopefully will find its way into many technical libraries and possibly the hands of a few SWL's who tune between the broadcast bands.

Published by Howard W. Sams & Co., Inc., 4300 West 62 St., Indianapolis, IN 46268. Hard cover. 198 pages. $7.95

AMATEUR RADIO TECHNIQUES
by J. P. Hawker, G3VA

The British, and in particular The Radio Society of Great Britain, are favored by the presence of J. P. Hawker, G3VA, on the editorial scene. Pat (what else is there to call him) has the talent for wading through a jungle of schematics and finding the crucial circuits. Once he has located them, Pat employs what must be one of the world's most underrated photographic memories to point out what is different, new, unusual, or worthwhile. It is a constant amazement to those of us who look forward to reading his monthly "Technical Topics" column in Radio Communication how one man can know so much about so many aspects of electronics.

This book is a nicely put together collection of several hundred "Topics" columns arranged in categories such as: components, receivers, audio, power supplies, antennas, etc.

(Continued on page 94)
The new KLH Thirty-Two is the best speaker you can buy for the money.

Bravado has never been our bag. But after carefully comparing the new model Thirty-Two with our competitor's best-selling loudspeaker, we're going to break our rule.

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For more information on the Model Thirty-Two, write to KLH Research and Development Corporation, 30 Cross St., Cambridge, Mass. 02139. Or visit your KLH dealer.
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The answer: it’s not that simple. The government’s licensing exam is tough. In fact, an average of two out of every three men who take the FCC exam fail.

There is one way, however, of being pretty certain that you will pass the FCC exam. And that is to take one of the FCC home study courses offered by Cleveland Institute of Electronics.

CIE courses are so effective that better than 9 out of 10 CIE graduates who take the exam pass it. That’s why we can back our courses with this ironclad Warranty: Upon completing one of our FCC courses, you must be able to pass the FCC exam and get your license—or you’ll get your money back!

They got their licenses and went on to better jobs

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Ed Dulaney, Scottshuff, Nebraska, for example, passed his 1st Class FCC License exam soon after completing his CIE training...and today is the proud owner of his own mobile radio sales and service business. “Now I manufacture my own two-way equipment,” he writes, “with dealers who sell it in seven different states, and have seven full-time employees on my payroll.”

Daniel J. Smithwick started his CIE training while in the service, and passed his 2nd Class exam soon after his discharge. Four months later, he reports, “I was promoted to manager of Bell Telephone at La Moure, N.D. This was a very fast promotion and a great deal of the credit goes to CIE.”

Eugene Frost, Columbus, Ohio, was stuck in low-paying TV repair work before enrolling with CIE and earning his FCC License. Today, he’s an inspector of major electronics systems for North American Aviation. “I’m working 8 hours a week less,” says Mr. Frost, “and earning $228 a month more.”

Send for FREE book

If you’d like to succeed like these men, send for our FREE 24-page book “How To Get A Commercial FCC License.” It tells you all about the FCC License...requirements for getting one...types of licenses available...how the exams are organized and what kinds of questions are asked...where and when the exams are held, and more.

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April, 1971

CIRCLE NO. 6 ON READER SERVICE PAGE
Additional information on products described in this section is available from the manufacturers. Each new product is identified by a corresponding number on the Reader Service Page. To obtain additional information on any of them, circle the number on the Reader Service Page, fill in your name and address, and mail it in accordance with the instructions.

**ESTERLINE ANGUS DIGITAL MULTIMETER**—Priced just under $200, the new Esterline Angus multimeter has eight ac voltage and current ranges, eight dc voltage and current ranges and five ohm ranges. It measures in 10-mV and 10-μA steps on the lowest voltage and current ranges. Accuracy on linear readings is 1% with a 10% over-range on all scales. Three-digit display has automatic positioning of decimal point.

Circle No. 79 on Reader Service Page 15 or 95

**LBJ BOOKSHELF SPEAKERS**—Originally developed for recording studios where high quality but small size (1.5 cu. ft.) were necessary, the L100 Century speaker system is now available from James B. Lansing Sound, Inc. Though small in size each unit still contains 3 speakers: a long-exursion 12” woofer, a 4” midrange for 2500 to 7500 Hz, and a direct radiator for the top notes. Tonal balance can be controlled from the front of the unit. Note the three-dimensional grille material, which is reportedly better than cloth.

Circle No. 80 on Reader Service Page 15 or 95

**LAFAYETTE DUAL-BAND RECEIVER**—Monitoring the police and fire frequencies is made easier by Lafayette Radio Electronics Corp.’s new Model PF200, covering 30 to 50 and 144 to 174 MHz. It uses 19 transistors, 9 diodes, 1 IC and 3 ceramic i-f filters for ±325 kHz, 60 dB selectivity and 1 microvolt sensitivity. There are two crystal positions on each band as well as squelch, built-in speaker, tape recording output jack and external speaker jack.

Circle No. 81 on Reader Service Page 15 or 95

**SCOTT 125-WATT AM/STEREO FM RECEIVER**—The exclusive Perfectune automatic tuning circuit—which provides a visual indication when FM tuning is optimum—is one of the features of the H. H. Scott Model 636 receiver. Another is the use of field effect transistors in the front end (to get the most stations with the least distortion) and in the tone control for maximum range. All the controls and input and output jacks are there too—at a price of $249.95, including the case.

Circle No. 82 on Reader Service Page 15 or 95

**CROWN PREAMPLIFIER**—You can do just about anything in the way of mixing and controlling with Crown's new IC-150 preamplifier. A 7-position stepped program selector accommodates 2 phono, 2 tape recorders, 1 tuner, and 2 auxiliaries; plus controls for balance, panorama,
AR FM TUNER—In the last 2 or 3 years, ACOUSTIC RESEARCH has been building up a line of electronic components to go with their speakers and turntables. (A receiver and an amplifier are already on the market.) Now they are introducing a stereo multiplex FM tuner. It is all solid state and has a FET front end with 4-section variable capacitor, multisection phase-linear i-f filter and integrated circuit i-f amplifiers. Guaranteed distortion is less than 0.5% IM or THD—a good feature for off-the-air recording.

SONY CASSETTE/RECEIVER SYSTEM—As if we needed proof that the cassette is here to stay, SUPERSCOPE, INC. has introduced a new line of Sony systems which include a stereo cassette recorder, an AM/stereo FM receiver, and two speakers. Top of the line is the CF-620 (at $299.95) which features a tape select switch to optimize performance for both standard and chromium dioxide cassettes, straight-line volume and tone controls, and FET tuner. Other models (CF-610 and CF-500) vary in packaging and sophistication of controls at somewhat lower prices.

B&K COLOR GENERATOR—The professional TV repairman and the do-it-yourself-at-home guy can choose between two new IC digital color generators available from B&K-DYNA SCAN. DELUXE MODEL 1246 (pictured) has crystal-controlled picture carrier oscillators for channels 3 and 4, a 4.5-MHz unmodulated carrier, and red, blue, and green color killers. It provides 9 patterns including center dot. More modest Model 1243 has 6 patterns and is tunable to channels 3, 4 or 5 but factory set to channel 3.

COURIER CB TRANSCEIVER/FM MONITOR—There's a new combination for CB'ers who would like to monitor the VHF/FM band from 150 to 175 MHz. COURIER COMMUNICATIONS' Chief 23 is a 23-channel mobile transceiver combined with a 3-channel monitor for police, fire, weather, and industrial frequencies. All 23 crystals are supplied for the CB channels and all the necessary controls are included. In addition, an auxiliary speaker-phone jack and built-in PA system with volume control.

SONAR BATTERY ADAPTER—Combining a battery charger and audio booster, SONAR'S Model CH2913 Mobile Adapter provides mobile capability for any 2300 series FM transmitter receiver. The nickel-cadmium battery charger and 5-watt amplifier are all solid-state for low power consumption and can be used in any vehicle having a 12-volt dc, negative-ground, system. There is a fast charging rate (12-14 hours) and an indefinite trickle.

April, 1971
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Just send in your warranty card on any of these RCA test instruments purchased between February 25 and May 8. With each instrument purchased, you get free a leather tool holder and another gift of your own choosing from the 37 handsome offerings described in the RCA gift catalog. The catalog will be sent to you without charge when your warranty card is received. This offer is good in the U.S.A. only. See your RCA distributor for more information and an advance look at the catalog gifts. Do it now, because the offer expires on May 8.

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CIRCLE NO. 22 ON READER SERVICE PAGE
It is surprising that so few electronic experimenters make use of the many chemical aids available to them from innumerable jobbers and distributors. Store shelves hold a wide variety of chemicals and cleaners in either convenient aerosol cans or bottles. Many of these chemical tools should be as important to the experimenter as a good screwdriver or a pair of pliers. Chemicals can be used for everything from heat sinks to troubleshooting, although this particular article will concentrate on control and contact cleaners, chemicals for the audiophile, and tuner or band-switch spray cleaners.

Types of Cleaners. Sooner or later every electronics hobbyist encounters problems with "noisy" contacts, raspy potentiometers, erratic switching and/or sticking relays. If you know what is behind the advertising claims and verbiage, you can pick the right cleaner off the shelf to solve each problem.

In the very early days of radio and electronics, carbon tetrachloride was the most universally used cleaner. Many experimenters think carbon tet is still the basis for most cleaning chemicals—but in 9 cases out of 10, this is not so. Carbon tet is both an inefficient and dangerous cleaner. Fumes from carbon tet are approximately 200 times as toxic as those of most modern electronic cleansing compounds.

Today, cleaners are usually blends of Freon solvents. Freon is Dupont's registered trademark for chlorofluorcarbon derivatives of methane and ethane. There are two types of Freon generally used in aerosol contact and control cleaners: Freon 12—a propellant that provides only slight cleaning power, but supplies the necessary pressure to spray the cleansing formula out of the can. Freon 11, on the other hand, is similar, but in itself is an excellent cleaning agent.

Freon is nonflammable, relatively nontoxic
and stable in use. Freon 11 is a selective solvent meaning that it dissolves oils and greases, yet will not affect most metal contacts, common plastics, or carbon-type potentiometers. In cleansing action Freon 11 ranks above hydrocarbons and just below chlorinated solvents.

Besides dissolving oils and greases, Freon 11 also provides a "washing" action, especially if sprayed on the target area under high pressure. The high density and low surface tension of Freon 11 enables this solvent to thoroughly wet the surface of most materials thereby washing away dirt and "gunk."

The Allied Chemical name for a solvent roughly equivalent to Freon 11 is Genesolv-D. In fact, Genesolv-D has the same mouthful of a name as Freon—trichlorotrifluoroethane. The Dow Chemical Company sells two similar types of chemicals used by some manufacturers in the electronics industry—Chlorex then NU and Dow Cleene EC.

The above basic chemicals are blended by the various manufacturers of electronic cleansing chemicals to produce commercial products. None of these manufacturers is willing to reveal the formulation of its cleaners, so it is impossible to know—by true chemical definition—exactly what you're buying. Nevertheless, any cleaner incorporating any of the above mentioned chemicals is good. The problem in electronics is to avoid the cheaper products which use kerosene, benzine, or de-natured alcohol as solvents. You can usually detect any of these products by the smell. They are also flammable and should be so identified on the can or bottle. These products may also be cheaper, but you pay for this cost saving through detuned circuits and deformation of soft plastic parts. For every experimental application you are better off to pay a little more money for a better and safer cleaner.

**To Lubricate or Not to Lubricate.** Aside from the cleansing action, some electronic aerosol chemicals also include lubricants. Lubricants not only reduce the friction of moving contacts, they may also minimize arcing and provide a protective coating to inhibit further corrosion.

Lubrication, however, is not an undisguised and unixed blessing. A heavy residue of a lubricant can detune a critical circuit and for this reason, most electronics technicians prefer non-lubricating cleaners for work around critical tuned circuits.

Until the late 1960's, hydrocarbon lubricants were seen in most cleaning solutions incorporating a lubricant. Since hydrocarbon lubricants are organic, they are not particularly long lasting or known for their chemical stability. In addition, the hydrocarbon lubricant is itself flammable.

Today, some of the newer electronic chemical cleaners use silicone lubricants. Organic lubricants are hydrocarbon polymers, but silicone lubricants are derived from silicon-

This is exactly what you want a cleaner in an aerosol can NOT to do—be flammable. Though spectacular, a test like this is relatively safe in a wide open area.
oxygen linkages which should give this sort of lubricant better high temperature capabilities. Silicone lubricants generally last longer and are inert. Whereas hydrocarbon lubricants sometimes break down under application of high voltage or heat, leaving a carbon residue, synthetic silicone lubricants seem to withstand greater variation of voltage and temperature without noticeable ill effects.

Polishing. Recently a new dimension has been added to switching contact sprays: polishing. In addition to cleansing and lubrication, these new products attempt chemically to assist the polishing of switching contacts through the normal wiping action of the switch itself. However, cleaners containing polishing compounds must be used with care. Many switch contacts in electronic equipment use a precious metal plated on a base metal. It is quite possible for the polishing agent—if it is abrasive—gradually to scrape away the thin precious metal plating—along with the dirt. Once the base metal is exposed, it tends to corrode rapidly, ruining the contact.

Various manufacturers are currently emphasizing the incorporation of polishing compounds in their cleaners. One manufacturer calls polishing, “the continuous cleaning method,” while another emphasizes the non-abrasive polishing agent in his cleaner. Regardless of the advertising claims, all cleaners that clean, lubricate and polish have particular applications. The basic ground rule calls for a moderately thick permanent lubricant that is less likely to “run” into adjacent circuitry. These cleaner/polishers must be applied with considerable care—just on the contacts—and in the case of TV tuners or band switching components in receivers or transmitters—never near capacitive, sensitive devices.

Making Your Own Tests. A few “recommendations” prepared by the Editors of Popular Electronics appear in conjunction with this article. However, if you encounter an unknown chemical cleaner, here’s a quicky test you can use to get an idea of just what you have bought:

1. Spray the cleaner onto a clean piece of
white paper. Smell it carefully to see if you can detect the odor of alcohol, kerosene, or camphor. If any of these odors are detected, use this cleaner ONLY on equipment that you can sacrifice.

2. Feel the paper you have just sprayed with your fingertips. If the product is advertised as including a lubricant, you should be able to feel it. Rub the paper between your thumb and forefinger to see if there is any decrease in lubricating action. Simultaneously, if the product is supposed to contain a polishing agent, you should be able to feel an initial grittiness. This grittiness should disappear after a few rubs. If the grittiness persists, this product should be rejected or used with care.

3. If in doubt as to the action of the unknown cleaner on plastic, lightly spray it on several types of scrap plastic. A good cleaner will have no effect on plastic—neither dissolving it or making it turn cloudy.

4. As illustrated in the photograph on page 26, carefully spray the unknown cleaner directly at a lighted match. There should not be a “flame thrower” effect and if the product supports combustion it should be rejected. However, certain reputable products will decompose in a flame and produce toxic gasses. Do this experiment last—and do it carefully.

**Chemicals for Audio Equipment Maintenance.** Chemicals can be very useful in

![Image](image_url)

For effective spraying many aerosols have hollow extension tubes that plug into the release button.

<table>
<thead>
<tr>
<th>WHAT TO USE WHERE</th>
<th>Suggested Products</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Work to Be Performed</strong></td>
<td><strong>Chemtronics</strong></td>
</tr>
<tr>
<td>Cleaning (washing) around rf circuits</td>
<td>Tun-O-Wash</td>
</tr>
<tr>
<td>Cleaning bandswitches</td>
<td>Miller-Stephenson Freon T-F Degreaser</td>
</tr>
<tr>
<td>Cleaning noisy potentiometers</td>
<td>&quot;No Noise&quot; Super Spray Bath</td>
</tr>
<tr>
<td>Cleaning relay contacts</td>
<td>Rawn Power Degreaser</td>
</tr>
<tr>
<td>Cleaning tape heads</td>
<td>Tech Spray Blue Stuff</td>
</tr>
<tr>
<td>Cleaning PC Boards</td>
<td>Chemtronics Contact Kleen</td>
</tr>
<tr>
<td>Cleaning relay contacts</td>
<td>Miller-Stephenson Contact Re-Nu</td>
</tr>
<tr>
<td>Cleaning relay contacts</td>
<td>Workman Lubrite</td>
</tr>
<tr>
<td>Cleaning relay contacts</td>
<td>Chemtronics Super Trol Aid</td>
</tr>
<tr>
<td>Cleaning relay contacts</td>
<td>GC Spra Kleen &quot;No Noise&quot; Spray Lube</td>
</tr>
<tr>
<td>Cleaning relay contacts</td>
<td>Ampex Tape Head Cleaner</td>
</tr>
<tr>
<td>Cleaning relay contacts</td>
<td>Chemtronics Tape Head Cleaner</td>
</tr>
<tr>
<td>Cleaning relay contacts</td>
<td>GC Audio/Video Magnetic Head Cleaner</td>
</tr>
<tr>
<td>Cleaning relay contacts</td>
<td>Miller-Stephenson Magnetic Head Cleaner</td>
</tr>
<tr>
<td>Cleaning relay contacts</td>
<td>Tech Spray Tape Head Spray</td>
</tr>
<tr>
<td>Cleaning relay contacts</td>
<td>Miller-Stephenson Flux Remover</td>
</tr>
<tr>
<td>Cleaning relay contacts</td>
<td>Print-Kote Solvent</td>
</tr>
<tr>
<td>Cleaning relay contacts</td>
<td>Tech Spray Rosin</td>
</tr>
<tr>
<td>Cleaning relay contacts</td>
<td>Flux Remover</td>
</tr>
</tbody>
</table>

**POPULAR ELECTRONICS**

(Continued on page 91)
What is the quality that distinguishes the sound of one musical instrument from another? The answer, of course, is timbre; and timbre is determined primarily by the geometry of the sound wave generated by the instrument—be it mechanical, electronic, or human.

Electronic synthesizers have added new dimensions to the creation of music because they can generate sounds of many different timbres—some closely resembling known instruments, others previously unknown. They do this by producing amplitude envelopes of various shapes and sizes. The “Timbre Gate” described here is an envelope generator that creates any number of different timbre qualities and will be a valuable addition to your sound setup at a fraction of the cost of commercially available generators.

As shown in Fig. 1, the amplitude envelope of a musical note consists of an imaginary line drawn from $T = 0$ across the peaks of each successive cycle of the note. The amplitude envelope shows rise time (time required for the envelope to go from initial zero to maximum), on time (envelope remains at maximum), and fall time (envelope goes from maximum to zero). These three parameters—rise, on, and fall times—geometrically describe the shape of the amplitude envelope and, hence, the timbre of the sound.

**Theory of Circuit Design.** The schematic diagram of a strictly manual version—which can be used where economy is important and complexity is unimportant—is given in Fig. 2. Field effect transistor $Q1$ operates as a voltage-controlled amplifier where the gain of the stage is a function of the magnitude of the bias voltage. Applying a negative bias to the gate of $Q1$ allows the stage to conduct until at about $-4$ volts bias, $Q1$ ceases to conduct current from source to drain. This cutoff action is the key to envelope generation.

With momentary-action switch $S1$ in its normal position (shown), negative bias current flows through $R1$ and is stored in $C1$. 

In addition to his writing, Craig Anderton is electronic musician for the group "Anomali."
The charge on $C1$ maintains $Q1$ at cutoff. Depressing $S1$ to its alternate position allows the charge on $C1$ to be dumped to ground through $R2$. The resistance setting of $R2$ determines the amount of time required for $C1$ to lose its negative charge and thus controls the rise time of the envelope. With $R2$ set at maximum resistance rise times of a few seconds are obtained.

For the duration of the time $S1$ is in its depressed position, there will be no negative bias on $Q1$ and the stage will operate at full gain. Consequently, the length of time $S1$ remains in this position determines the duration of the on time of the envelope being generated.

Releasing $S1$ allows $C1$ to again charge up to the -4 volt level required to cut off $Q1$ and reduce stage gain to zero. The larger the resistance setting of $R1$ through which the charging current for $C1$ flows, the longer will be the full time of the envelope. Consequently, simply by depressing and releasing $S1$, a complete envelope can be generated. Of course, as has just been demonstrated, the geometry of the envelope must be constructed by setting $R1$ and $R2$ and holding depressed $S1$ for a discrete interval of time.

When pitch and level controls must be operated, having to operate a switch to generate the envelope as well can become a bother. To alleviate this problem, the trigger process section shown in Fig. 3 which allows a single short-duration pulse to initiate the envelope action was designed. The trigger processor is used in conjunction with the basic generator circuit. Connected to the generator via a relay, $K1$, which replaces $S1$, the processor provides both automatic and manual modes of operation. Here, AUTO/MANUAL switch $S2$ is used to select the desired mode of operation.

In the MANUAL mode momentary-action pushbutton switch $S3$ is briefly depressed to initiate envelope generation. The pulse delivered by closing this switch charges $C5$ which, in turn, applies a bias voltage to $Q2$. With the bias applied, $Q2$ cuts off and de-energizes $K1$, allowing the upper contact circuit to be completed and initiating the rise and on time characteristics of the envelope. The charge on $C5$ now slowly discharges through ox time control $B9$ until sufficient bias is removed from $Q1$ to allow $K1$ to again energize and initiate the fall time characteristic, thus completing the cycle.

Setting $S2$ to the AUTO position allows pulses to be developed at the $B1$ terminal of unijunction transistor $Q3$ to provide the trigger. The speed of the pulse generator, with the component values specified, is adjustable over a wide range.

A second optional attachment that can be used with the envelope generator system is shown schematically in the box on page 33. This circuit consists of a dual-gate IC and operates as a fuzz box used with guitars.

**Construction.** Straightforward design makes assembling the envelope generator, trigger processor, and clipper a relatively uncomplicated operation. As shown in the photos, the circuits were assembled on perforated phenolic boards. But if you are enterprising, you might want to design printed circuit boards for your project.

Since the prototype shown in the photos employed all three subassemblies, one board was used for mounting both the generator and trigger processor, while the clipper was assembled on a separate board. If you plan to use perf board, mount the components and make connections—from the under side of the
Fig. 2. Fall and rise times of the envelope are controlled by R1 and R2, respectively; on time is determined by the time S1 is in alternate position.

**PARTS LIST**

- **C1**—10-mF, 10-volt electrolytic capacitor
- **C2**—25-mF, 20-volt electrolytic capacitor
- **C3**—0.1-mF ceramic disk capacitor
- **C5**—20-mF, 20-volt electrolytic capacitor
- **D1**—1N749 zener diode (see text)
- **D2**—1N914 or similar silicon diode
- **K1**—1.5-volt spdt relay with 1000-ohm, 3.5-mA coil (Calextr D1-962 or similar)
- **Q1**—2N5459 field effect transistor
- **Q2**—Bipolar transistor (Motorola MPS2926)
- **Q3**—Unijunction transistor (General Electric)
- **R1, R2**—50,000-ohm linear-taper potentiometer
- **R3**—1-megohm logarithmic-taper potentiometer
- **R4**—10,000-ohm
- **R5**—100-ohm
- **R7, R8**—100,000-ohm
- **R10**—470-ohm
- **R11**—1500-ohm
- **R12**—100-ohm
- **R13**—470-ohm
- **R14**—3300-ohm
- **R16, R17**—200,000-ohm
- **S1**—Spdt switch (see text)
- **S2**—Spdt switch
- **S3**—Spst normally-open momentary-action pushbutton switch
- **S4**—Spst switch (part of R15)
- **Misc**—Perforated phenolic board with flea clips; 17" x 4" x 3" aluminum chassis; cover for chassis (see text); control knobs; machine hardware; hookup wire; solder; etc.

**Fig. 3.** When adding this automatic circuit, match lettered contacts on K1 to same lettered points in manual circuit and eliminate S1. Use S3 to initiate envelope.
Single piece of perforated board was used in prototype to accommodate all parts (except jacks and controls) in basic circuit and auto/manual add-on.

board—via flea clips. And be as neat as you possibly can when laying out the components.

Certain precautions must be exercised when soldering transistors and diodes into the circuit. Use a low-wattage soldering iron with a clean tip and a heat sink. Remember that excessive heat can damage solid-state components rather easily. So, use the heat sink on all transistor and diode leads and apply the iron tip long enough only for the solder to flow over the connection.

The prototype project was built into a 17" x 4" x 3" aluminum chassis, fitted with a white Plexiglas® front panel on which were mounted all controls and input, output, and monitor jacks. This size chassis is more than adequate to accommodate all of the components. If you wish, you can considerably reduce the size of the chassis required.

**Setup and Use.** Connect a suitable power supply to the circuit. If a dual-polarity 24-volt dc power supply cannot be obtained, a single-polarity 24-volt supply will provide most of the voltages needed, and a 9-volt transistor battery can be used to supply the negative voltage required for biasing Q1.

Connect the output of the envelope generator to an instrument or hi-fi amplifier. Then feed into J1 a signal from an electric guitar or audio generator. Set the AUTO/MANUAL switch to the MANUAL position and the RISE, ON, and FALL time controls to zero. With the LEVEL control set for midposition,
In its simplest form, the envelope generator consists of the circuit shown in Fig. 2. Incorporating the circuit in Fig. 3 merely adds an automatic/manual feature. For additional signal processing, the clipping amplifier shown here can greatly increase the versatility of the system. The clipping amplifier is similar to the fuzztone circuits often used with electric guitars and can, in fact, be used separate from the envelope generator by having a 9-volt battery at the point indicated instead of the 24-volt supply.

The clipping amplifier consists of an inexpensive dual two-input gate RTL integrated circuit, IC1, in which each of the gates is biased into linear operation. The gates are then cascaded. The output from the second gate is clipped by D3 and D4.

Two controls are provided in the clipping amplifier. Potentiometer R22 allows you to adjust the percent of clipping you desire, while potentiometer R23 lets you adjust the output signal level from the subassembly.

When the clipping amplifier is connected at the output of the envelope generating system, the percent (%) control can be adjusted so that clipping occurs only after a certain amplitude has been exceeded. Hence, the signal would start clean, but past a certain level would start to sound "fuzzy." If, however, the clipping amplifier were connected at the input of the envelope generator, the signal from the input source should be clipped regardless of amplitude. Then it would be given an envelope.

When assembling the clipping amplifier, use the same techniques employed with the two circuits that make up the envelope generator. Be particularly careful when installing IC1 to make the proper orientation of the indexing tab. Also, use caution when soldering the IC leads in place.

Operation of system is greatly simplified when rise, on, and fall controls (R2, R9, and R1) are grouped together as shown.
Solder shields of audio cables to the housings of potentiometers R22 and R23. Also note that capacitor C8 mounts on the bottom of clipper amp circuit board.

there should be no sound coming out of the system. If Q1 is not being overloaded and you hear sound, not enough bias is available to cut off Q1; use a higher voltage zener diode for D1 in this case.

Depress and hold down S3; you should hear whatever signal is connected to the input of the system. In Fig. 4 are shown the effects the various controls have on the shape of the envelope being generated. Bear in mind that the on and rise times overlap.

Try various adjustments until you become familiar with each control. Plug into J2 an oscilloscope or VTVM if you have either of these items, and you can monitor the effect each control has on the envelope. Set S2 to AUTO and the RATE control fully clockwise. You should now hear a pulsing sound. (Note: if the on or fall time is longer than the period of the pulse generator, the signal will remain on indefinitely.)

External pulse jack J5 is another handy built-in feature of the envelope generator. It allows you to use a footswitch to initiate the envelope generating cycle while your hands are busy playing your musical instrument. This feature is typically used with a guitar setup as shown in the block diagram in Fig. 5. The straight sound of the guitar feeds to one input of a two-input mixer, while

For operating convenience, all jacks (except those used for power) are best located in a group. Power jacks J6 and J7 can be located on side of box.
the output of the envelope generator connects to the second mixer input. When the envelope generator is triggered, a slowly rising wave of fuzz can be initiated—or, for that matter, a burst of fuzz can be initiated by presetting a fall time with zero rise and on times.

The system can also be set in the automatic cycling mode, with rise and fall times adjusted so that the end of a fall coincides with the beginning of a rise. Under these conditions, the sound generated is like a super tremolo with adjustable amplitude slope.

Sometimes the slowest pulse generator range will appear not to be working at the low end. To remedy this, turn the space control fully clockwise for a few seconds. Then return the control to the low end again.

The values of certain key components in the envelope generator can be changed to tailor the system to your needs. To double the maximum rise and fall times, R2 and R1 can be increased in value to 1 megohm. Increasing C5 to 50-µF will yield on times of up to 20 seconds. Lastly, if the low end of the pulse generator is too slow for your particular application, reduce C7 to 100 µF.

Several controls interact in the envelope generator. So, if at first the system does not seem to be operating correctly, make sure that the problem is not a misadjusted control or switch or an incorrectly installed diode, transistor, or electrolytic capacitor.

Space limits the description of what can be done with the envelope generator when a little imagination and a lot of experimenting are applied. So far, the system has been used successfully with guitar, organ and bass—as well as both commercial and homemade music synthesizers. Even an audio oscillator can become a musical instrument with the aid of the envelope generator.

Remember that an electronic musical instrument is really no different from the more conventional musical instruments with which you are familiar. The more practice you put in, the better will be your technique. The number of controls on the envelope generator means that it may take you several hours just to figure out how everything works. But at the end of that time, you will feel the effort well worth while.
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BATTLE of the GIANT BRAINS

or Electronics Conquers All

A STARTLING REVELATION OF THE EARLY DAYS OF DIGITAL COMPUTERS

CONSIDER for a moment the hardware that goes to make up a digital computer. Could any way of implementing digital functions be better or more natural than the use of electronic components? Our first reaction is to say "no"—conditioned as we are by a quarter of a century of electronic computers and an $8 billion (annually) computer manufacturing industry. It happens, however, that this has not always been the case. In the late 1930's, the question of how to design a digital computer was very much up in the air.

For more than a century after its theoretical invention, the digital computer was an idea in search of realization through suitable technology. Electronics, while it was used in some limited precision analog devices, was

Frank Y. Dill is a freelance writer specializing in computers and electronics. Above are copies of old engravings of Charles Babbage and his plans for the Difference Engine.

April, 1971
generally overlooked for digital applications. Designers were still thinking of representing discrete quantities in terms of rotating wheels, punched cards, and relays. These devices had shown great promise as far as reliability was concerned and had proven workable in small-scale digital machines. Thus, when the first large-scale digital computers were being designed over 40 years ago, they used non-electronic devices.

Unchallenged success of these non-electronic “giant brains” would have set important design precedents. Fortunately, however, before this could happen construction of an electronic digital computer was begun. Actually, a three-way contest developed between two electromechanical designs and one electronic. The electronic project was at a disadvantage due to the lead start enjoyed by its rivals. However, the fate of electronics in computers rested on the success of this project. If this machine were to fail to operate at all or to be not competitive in reliability and overall cost, the future of electronics would be greatly damaged.

**Where It All Began.** Before witnessing this three-way design race, let’s see where the idea of digital computation began. In September 1834, an Englishman named Charles Babbage, hoping to free mathematicians from the drudgery of calculating tables and to rid the tables of the mathematicians’ errors, made the first drawings for what he called an “Analytical Engine.” These plans contain many of the basic modern computing principles: punched card input, multiple registers to store intermediate results, automatic sequencing of control, sequencing based on both calculated results and original instructions, and direct mechanical printout of results.

Babbage’s device was an extension of the then two-century-old adding and multiplying machines in that it included multiple step calculations whose sequence was controlled by the machine itself. The older machines used a wheel with teeth to advance an adjacent wheel for an arithmetic carry. Similar wheels were to be used in the Analytical Engine to store one thousand numbers of fifty decimal digits each. Calculations and control were to be accomplished by a combination of metalcams, rods, shafts, and levers capable of coupling and decoupling as the program demanded.

Unfortunately, the Analytical Engine was never built. Its construction—like that of twentieth century digital computers—required considerable financial support. The most likely sponsor, the British Government, had already spent £17,000 on an uncompleted, 10-year project of Babbage’s called the “Difference Engine.” This project had encountered unexpected delays since the mathematician’s art, lacking modern alloys and mechanical drawing conventions, was unable to fashion Babbage’s ideas into metal. So, when Babbage asked the government whether he should continue work on the older project or begin the more powerful and complex Analytical Engine, they, in typical bureaucratic fashion, deliberated for nine years and then said, “neither.”

The IBM Automatic Sequence Controlled Calculator, also called the Harvard Mark I, was the first electromechanical, general-purpose digital computer. Neat in appearance, it used counter wheels and relays, had relatively small size, required little maintenance, but computations were slow. (Photo courtesy IBM)
Unable to obtain financial support, Charles Babbage spent the remainder of his life (until 1871) trying to improve the mechanical technology of the period. The general purpose digital computer remained unbuilt for more than a century after Babbage conceived his plans. However, it was a fruitful period for electromechanical technology and the advances obtained led to the design in the twentieth century of the first large-scale computer.

Babbage Is Vindicated. In 1937, Howard H. Aiken, of Harvard University, aware of the school's need for computational facilities, wrote a paper describing the connection between Babbage's ideas and machines then being produced by International Business Machines. It turned out that IBM was willing to build such a machine, believing that many of their existing mechanisms could be used with little or no modification.

The project was begun in 1939 at Endicott, N.Y., and was officially called the IBM Automatic Sequence Controlled Calculator. Computer jargon was not tolerant of such long names, of course, so it is now usually referred to as the IBM A.S.C.C. or the Harvard Mark I, depending on the speaker's industrial or academic background.

In this first electromechanical project (as in Babbage's machine), variable numbers were stored on ten-position metal wheels. They were rotated by a shaft connected to a 4-hp motor and were engaged by a magnetically controlled clutch. Unlike the Analytical Engine, numbers were not transferred mechanically, but electrically through a bus. Relays controlled access to the bus and provided for arithmetic carries and borrows. Mechanical wheels and relays were used to implement the mathematical functions.

**The Second Project.** Proceeding concurrently with the IBM-Harvard effort was a computer design originated by George R. Stibitz of Bell Telephone Laboratories. Not surprisingly, this design relied heavily on existing telephone and teletype devices. The fundamental computing device was the ordinary telephone relay, which was so reliable that it could be expected to operate continually for years without failure. An added advantage was that standard telephone practice already included design and maintenance procedures necessary to keep the computer in order.

A series of six computer models was eventually built by Bell Labs. The success of each provided incentive and design experience which contributed to the next. The Model I, called the Complex Computer, was put into operation in January 1940. It contained 450 relays and was used to perform the arithmetic of complex numbers for the Labs. In the Models II, III, and IV, which followed, 440, 1400, and 1425 relays were used, respectively. Finally in 1944, Bell Labs had gained enough experience to attempt to build a 9000-relay general-purpose computer—the Model V.

Electromechanical technology was used in
both of the projects just described. The main difference was that the IBM-Harvard computer used some purely mechanical devices for number storage and for implementing the arithmetic operations. The need for a mechanical drive system however placed severe spatial restrictions on the design. The Bell Labs machines, using only relays, eliminated these space problems, but speed was not greatly improved. This problem was a fundamental one, involving the inertial mass of the moving parts. Even the short time required to close the relay contacts was an important factor.

Solving the Speed Problem. Events leading to a solution of the speed problem were taking place at the same time. Soon after the start of World War II, the Army's Ballistic Research Laboratory needed more capacity for handling ballistic tables. It had been using a differential analyzer (an analog computer) designed by the Moore School of Electrical Engineering, University of Pennsylvania. Since the Moore School had a larger analyzer, the BRL contracted to use it and the combination developed into what was probably the largest scientific computing group in the world.

Unfortunately, the results were still unsatisfactory. More than a hundred desk calculators were needed to supplement the analog computers. The Army needed, as soon as possible, a better way of producing firing tables, each of which involved 250,000 to 500,000 mathematical operations.

In the spring of 1943, Dr. John W. Mauchly, a professor at the U. of Pennsylvania, circulated a report which offered a solution to the Army's computing problem. In 1941, he had visited Iowa State College to study the Atanasoff-Berry computer. This 300-tube electronic computer was being built to solve algebraic equations. It was never finished but it reinforced Mauchly's belief that electronic high-speed computing devices were feasible. His report advocated building such a machine. An appendix to the report by J. Prosper Eckert, Jr., gave explicit suggestions for implementing Mauchly's ideas in electronic hardware.

The Army's need at that time justified taking a chance on the project and $61,700 was allocated in 1943 for six months of research and development on Project PX, Mauchly's electronic digital computer. The project later became known as ENIAC, an acronym which originally stood for Electronic Numerical Integrator and Computer, though the last word has since been incorrectly reported as Calculator.

During those six developmental months, the most challenging electronic problems ever encountered in a single design were tackled. Since the reliability of a computer is all-important and since the reliability of the whole is no better than that of its individual parts, component reliability was the first major technical consideration.

The most likely component to fail was the vacuum tube. While a single tube had a life expectancy of many thousands of hours, a total of 18,000 tubes were to be used. This meant that the probability of a single tube failure at any particular time was rather high. Prior to this, the largest electronic system was a radar set with 400 tubes, and the problem was important even then.

The solution was to use proven standard tubes and to operate them well below their normal ratings. Filaments were run at 5.7 volts instead of 6.3 and they were rarely

<table>
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<th>COMPARISON OF EARLY COMPUTERS</th>
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The temperature got over 115°F. Values turned off to increase their life. Plate and screen powers were limited to 25% of rated values.

It is easy to see how the heat generated by all those tubes provided another problem. There were 70,000 resistors and 10,000 capacitors in the system which could be damaged by excessive heat. Of the 150 kW of power consumed by the ENIAC, 80 kW was dissipated by the tubes and another 20 kW was used to drive cooling fans. In addition, each panel of the machine was protected by a thermostat which would shut off that panel if the temperature got over 115°F.

Another problem encountered in the design of the computer was synchronization. Control pulses of two to five microseconds were repeated in cycles. Still other pulses were generated by the computing process. Although the idea of gating is now fundamental to computer design, one of the first applications of a "gating tube" was in the ENIAC computer.

For storage, the ENIAC used the Eccles-Jordan trigger circuit commonly called a flip-flop. The arrangement of the flip-flops to represent decimal digits was rather unusual in terms of modern design. Ten flip-flops were used to represent a single digit.

This resulted in a very expensive main memory. Eckert estimated that the average cost of storage was $15.00 per decimal digit. By comparison if the largest main memory of a modern computer like the IBM System 370 Model 165 used such a memory, the 3 million bits would cost in excess of one hundred million dollars.

The Race Quickens. When the ENIAC project was just a year old, the complete electromechanical Mark I was unveiled in a public dedication ceremony on August 7, 1944. Its impressive 51-foot, neatly encased exterior was in sharp contrast to the jumble of wire and panels that were to comprise the ENIAC. Actually the Mark I had been tested prior to the start of ENIAC and it had undergone a complete debugging while operating in secret. The age of digital computers had arrived and the Mark I operated around the clock with a down-time record that was impressive by modern standards.

Thus the Mark I posed a real threat to electronic computers. The total need for computers had been greatly underestimated. In fact, a prediction had been made that the entire computing requirements of the U. S. could be satisfied by six computers. So the Army might have been justified in cancelling the ENIAC in favor of a Mark I type of machine, especially if unexpected delays or expenses were encountered. Such loss of sponsorship had happened to Babbage a century before.

An even more direct challenge to ENIAC came from the Bell Labs Model V. The same Army group that had contracted for ENIAC, hedging on its gamble, had also ordered one of the two Model V's being built. However, the hedge was not needed since ENIAC was completed and shown to the public in February 1946, after 30 months and $486,804.22 in the making.

(Continued on page 99)
PICK & CHOOSE AMONG STEREO HEADPHONES

GETTING TO HEAR WHAT THEY HAVE TO OFFER

BY JOHN STEELE
STEREO HEADPHONES are near the top of the audiophile's "most wanted" list. In an informal, statistically irrelevant poll, I have tried to turn up some reasons for the popularity of headphones. Headphones have been climbing on the audio sales charts year after year since their introduction in the early 1960's. Use of headphones has expanded from the original narrow base as a tape recording accessory for pro's and advanced audiophiles, to take their place among the glamour kings of the audio salons. User comments ran as follows:

"The music is so there you can reach out and touch it. Headphones keep everything else away—room noise and conversation from people you thought would be quiet when you invited them in to hear your record."

"My roommate hates Berg and Weber, but with headphones, I never worry and we are staying good friends."

"Having those cats blowing their horns right in my ears turns me on. I can make the sound loud enough to blow my ears off without stirring up my parents."

Each of the above comments tells the story of the widespread acceptance of headphones among audiophiles. Of course, there are some
BUYERS' GUIDE TO STEREO HEADPHONES

The list below is a sampling of stereo head-phones available for a listening check at the time this article was prepared. Most manufacturers offer a variety of models ranging from the economical to those guaranteed to stretch your budget. All of the head-phones have the ability to generate sound at very low distortion levels and up to sound pressure levels far beyond that any listener can tolerate. Frequency balance differs notably from manufacturer to manufacturer and the listener interested in securing top quality reproduction should always try two or three different head-phones before finalizing a purchase. A trial run is also desirable to find out how comfortable the head-phones are to the listener—since this is an individual matter.

Use the tone controls on your amplifier as a means of achieving optimum frequency balance. Start any trial with the tone controls in the flat position, but correct the controls to suit your hearing. Don’t forget that many head-phones must be tightly coupled to your ear since air leakage around the rim of the ear-set will attenuate the bass. This does not mean that the head-phones must exert pressure against the listener’s head, but that the earphone pads must be settled snugly.

All of the head-phones listed (except the Sennheiser HD-414) are low impedance and must be used at the amplifier’s speaker terminals or plugged into the head-phone jacks as a part of the package of most amplifiers and receivers. High impedance head-phones may be driven from a preamplifier or from a tape recorder with a high impedance head-phone jack. High impedance head-phones are considered those at 600 ohms and up. Low impedance head-phones used in high impedance circuits will produce some sound with a slight loss in bass response, but this is not considered a satisfactory arrangement. Most of the head-phones listed are dynamic which in effect means that each ear-piece is a miniature loud-speaker. The exceptions are the Koss ESP series and the Stanton 770 which are electrostatics.

AKG-60 (Div. of North American Phillips Co.). Good balanced sound with extended clean high end. Seven foot cord. Less than $40. The AKG-120 is similar and less expensive.

Beyer DT-48 (Gotham Audio). Used mostly by professionals. Notable presence and high end. Ten foot cord. Less than $100.


Clark 100A (David Clark Co.). Smooth response with good balance and strong bass. Ten foot cord. High impedance models available. About $50.


Koss Pro-4AA (Koss Electronics). Excellent low bass response with extended highs—possibly one of the best available. Ten foot cord. About $60.

Koss ESP-9 (Koss Electronics). Electrostatic head-phones with separate energizer that must be connected to amplifier speaker terminals. Extremely wide, flat frequency response with superior sound reproduction. Ten foot cord. About $150.


A negative aspect of using head-phones and on some people head-phones may be physically bothersome or downright uncomfortable. However, the comfort index has also shot upward in the past few years and there are many head-phones that now sit lightly—almost imperceptibly—on the user’s head and put only a small measure of pressure on each ear. Don’t be fooled by the bulky shape of some head-phones. Frequently the bulky head-phones—probably because of weight distribution—are more comfortable over a long period of time than some of the smaller minute—almost stethoscopic—head-phones.
The Road to Success. Keeping room and environmental noise out of the music you want to hear is more than reducing an annoyance. Headphones may well be a positive contribution to improved fidelity because room noise can, in effect, diminish the frequency response of a good audio system by masking the highs or lows, or both. Room noise can also be so intense at a particular frequency that it may punch a hole in the response of an otherwise good system—or even create a sort of intermodulation distortion.

Naturally, no one is going to buy just headphones and forget about his speaker system. We will always use speakers. Headphones have simply added a wonderful, convenient additional way to listen to recorded music.

If you want to give your friends a quick impressive dose of headphone listening, play for them Stereo Review's "Binaural Demonstration Record,"* which, in effect, takes each of your ears back to the scene of the original recording. This particular record, designed specifically to be listened to with headphones, provides the truest reproduction of the original acoustic environment since the recording microphones were literally "installed" in the ears of a life-sized dummy head. The sounds reaching the microphones have been reflected and refracted by the head, just as real sounds are at a real head: all of the directionality and spacing cues are those of actual listening.

The New Experience: Pro and Con. If you are one of the few that hasn't listened to one of your favorite recordings through a top-quality pair of headphones (driven by a first-rate audio system) you will be stunned by the immediacy and super-fidelity of all instrumental sounds. This experience is not likely to be a first-contact thrill that gradually fades away with further listening. Headphones have an addictive quality; you rapidly become acclimated to the freedom from noise, plus the concentration and closeness of the music.

The best headphones rival the performance characteristics of the best stereo speakers. You can obtain headphones where the frequency response is excellent without peakiness or hills and dales from the bottom of the bass range to the top treble notes. In fact, the bass range can sometimes be smoother than that heard via speaker systems because the headphones are free of room reflections and resonances. These resonant effects often cause large and uncontrollable unevenness in bass response. Since the amplifier power that must be handled by the headphones is very small, distortion can be extraordinarily low and the heavy damping used to produce a smooth response with excellent transient handling qualities in the middle and high audio frequencies.

There is one area in headphones performance that may not be to your liking. This is the abnormality evident in certain American stereo discs manufactured in the mid-1960's. The acoustics of the recording space—as reproduced by the headphones—may seem strange. Instruments heard right-of-center through speakers will, through headphones, be far, far out on the right; and those left-of-

*Available from Ziff-Davis Service Division, 595 Broadway, New York, NY 10012. Price $5.98.

April, 1971
The In-Out Annunciator
GETS THEM COMING AND GOING

BY JOHN S. SIMONTON, JR.

THE ELECTRIC "EYE" has been a faithful, reliable workhorse in all sorts of burglar alarms and counting systems since before the word "electronics" was coined. Even today, it is extensively used in these applications. But too often it is used in circuits that are far from up-to-date.

The "In-Out Annunciator" described here is, in fact, an electric eye system — using a highly sophisticated circuit. Designed for the special case where it is not enough to know simply that someone or something has interrupted the beam of light, the Annunciator tells you whether the person was entering or leaving the passageway covered.

Uses of the Annunciator include monitoring one-way-only garage doors, operating automatic doorbells or chimes that do not sound when a visitor is leaving, guarding high-security areas, and discriminating sizes of objects. It also makes an interesting, attention-getting Science Fair project.

Two inexpensive resistor-transistor logic IC's are at the heart of the Annunciator, containing enough electronics to provide the amplification needed for good sensitivity in high ambient light areas and the logic necessary to distinguish between objects passing in either of two directions.

**Theory of Circuit Design.** Before going into a detailed examination of the operation of the Annunciator's circuit, it is useful to point out that gate pairs G1/G3 and G2/G4 in IC1, as shown in Fig. 1, are wired with regenerative feedback through resistors R1 and R2, respectively. This feedback arrangement adds hysteresis to the response of the circuit so that slight changes in ambient light level will not be misinterpreted by the circuit and generate "false" counts. Capacitors C3 through C6, by rolling off the high-frequency

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John S. Simonton, Jr. is a graduate electrical engineer who now spends most of his time developing unusual projects.
response of IC1, reduce the sensitivity of the circuit to transients. Also, G3 and G4 are
cross-coupled to form a set-reset latch.

The steady-state outputs of the NOR gates
with both LDR1 and LDR2 fully illuminated
are: G1 and G2, high; G3 and G4, low; G5
and G6, high; and G7 and G8, low.

Now, suppose the light source is interrupted
on first LDR1 and then on LDR2. By darken-
ing LDR1, its internal resistance increases
and causes a high input to be presented to G1.
In turn, the output of G1 goes to low. Since
both inputs to G3 are now low, the output
of this gate goes to high and is then inverted
by G5. The output of G3 is also applied to one
of the inputs of G4 to guarantee that this
gate’s output will remain low.

Gate G7 now has one of its inputs at low
and the input from G2 at high; so, its output
it still low. When LDR2 is darkened, the output
of G2 goes to low, applying a second input
to G7 and causing the output of G7 to
go to high. As a result, Q1 conducts and ener-
gizes K1. The state of G4 does not change
because the output of this gate is held low by
the high output of G3.

As the light again illuminates LDR1, the
state of the circuit does not change by virtue
of feedback from G7 which holds the output
of G1 at low. When the light illuminates full-
ly LDR2, the output of G2 goes to high and,
consequently, the output of G7 goes to low,
unlocking the loop formed by G1, G3, and G5.

Objects passing between the light source
and the system so that LDR2 is darkened first,
followed by the darkening of LDR1, generate
a similar chain of events to energize K2.

Construction. Since integrated circuits
are used in the Annunciator, printed circuit
board construction is the only realistic ap-
proach to assembly. You can etch and drill
your own circuit board by carefully following
the actual size etching guide provided in Fig.
2, or you can purchase a ready-to-use board
from the source given in the Parts List.

Begin assembly by mounting the compo-
ments on the board (see Fig. 2). Be careful to
orient properly polarized components, and
use heat from a 35-watt soldering iron sparingly.
Also, as you solder, take pains to avoid
solder bridges between closely spaced foil con-
ductors—particularly around the 1C solder
pads.

Mount K1 and K2 on the circuit board with
4-40 machine hardware. Then use insulated
jumper wires to connect the relay coils to the
appropriate solder points on the foil pattern
of the circuit board.

When mounting trimmer pots R5 and R6,
bend their leads to position the adjustment
slot directly over the 1/4"-diameter holes in the
circuit board. This allows the system to be ad-
justed through access holes in the plastic

cabinet once final assembly is complete.

A standard 6 1/4" x 3 3/4" x 2" Bakelite
case makes for an exceptionally compact
project. However, steps must be taken to keep

All components except power transformer, on/off switch, and LDR’s mount on printed
circuit board. Spacers and 4-40 machine hardware fasten circuit board to case top.
Fig. 1. Two quad two-input gate digital IC’s supply all functions for proper bidirectional operation of Annunciator system. Relays control counters and/or signaling devices.

**PARTS LIST**

C1, C2—100-µF, 15-volt electrolytic capacitor
C3-C6—0.1-µF, disc capacitor
1C1, 1C2—Integrated circuit (Motorola MC724P)
K1, K2—12-volt, 1640-ohm relay (Sigma No. 65F14-12Dc or similar)
LDR1, LDR2—Light-dependent resistor (Clairex No. CL703L or similar)
Q1, Q2—2N2712 transistor
components and assemblies from interfering with each other. The following general assembly sequence should be followed as closely as possible.

Begin mechanical assembly by drilling the mounting holes for transformer T1. Locate the transformer so that it is in contact with one of the long sides of the case. (Note that the same machine hardware used to fasten T1 in place is also used to anchor the terminal strips which serve as tie points for the leads of the LDR’s.)

Position the light shields (5-dram pill containers) at opposite ends of the transformer, and use a pencil or scoring tool to mark their outlines on the Bakelite case. Then remove and set aside the shields. Locate the centers of the light shield outlines and slowly and carefully drill first a $\frac{3}{16}$" hole, following it up with a $\frac{1}{4}$" bit to enlarge the holes. At this point, you can use a multiple-drilling tech-

---

**Fig. 2.** At top is given actual size etching and drilling guide for fabricating the printed circuit board. In the component location and orientation guide (above) note particularly orientations of IC’s.

April, 1971
unique, a nibbling tool, or a chassis punch to enlarge the holes or cutouts so that they are slightly larger in diameter than the shields.

The mounting holes for power switch S1 and the circuit board, and the access holes for the slots of R5 and R6 trimmer pots can now be accurately located and drilled. Position the circuit board as close as possible to the front of the case to obviate any possibility of the lugs on S1 from contacting T1.

When all front-panel holes are drilled, paint and label the panel as desired. Allow sufficient time for the paint to dry; then drill a hole for and mount the line cord—via its strain relief—and the terminal block on the rear of the case.

Drill two #60 holes, about 30° apart and as close as possible to the bottom of each pill container. Then use flat black paint to coat the interior surfaces of both containers. When the paint dries, use a pin to clear the #60 holes of paint. Insert the leads of the LDR’s through the holes, dab a drop of epoxy cement on the undersides of the LDR’s, and press the LDR’s to the bottoms of the containers.

Slip the light shield assemblies into their respective cutouts, taking care not to tear off the LDR leads. Run a thin bead of epoxy cement around the lip of each shield; then seat the shields squarely in their cutouts and allow the cement to set at least overnight.

Intereconnect all components and assemblies as shown. Then mount the circuit board inside the case with 4-40 machine hardware and 3/4"-long spacers.

Fig. 3. When wiring dual chimes into system, use only normally open and common contacts on relays.

**Setup and Use.** Rotate R5 and R6 fully clockwise (viewed from the component side of the board). Point the LDR’s at a relatively bright light source, plug the power cord into a convenient ac outlet, and close S1. Use a piece of opaque cardboard to completely cover LDR1; neither relay should be energized. With LDR1 still covered, place another piece (Continued on page 92)
Build the Charge Now

RECHARGES ANY NICKEL-CADMIUM OR
ALKALINE AA, C, OR D CELL

NAME your battery charging problem! The “Charge Now” solves them all—with some added extras. With a Charge Now in your workshop or lab, you have all the advantages of an expensive commercial unit—at much less cost.

Here are some of the uses to which you can put the Charge Now. It provides de currents in values from less than 1 mA to 1 A in ten ranges for recharging nickel-cadmium cells. It recharges any alkaline AA, C, or D cell in fourteen hours using voltage-limited, tapered charging to automatically prevent overcharging. With a well-filtered de output available at a pair of binding posts, the charger serves as a fully adjustable constant-current source for testing semiconductors and many other components and circuits. And with a zener diode across the output, a well-regulated, low-voltage source is available for other testing.

Construction. The schematic of the battery charger is shown in Fig. 1. Wiring and layout are not critical. In the prototype shown in the photos, a piece of perf board 3½” × 4” was used to support most of the components. Layout is shown in Fig. 2. Optional transistor sockets were used in the prototype. Note that the metal cases of R27, R28, and R29 provide negative return to terminal ZZ.

Another piece of perf board 2” × 2” was mounted directly on the meter terminals to hold all of the components directly associated with the meter circuit. Terminals on the board should be identified for making connections.

A. A. Mangieri, when not developing projects or writing articles, is an amateur radio operator.

April, 1971
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April, 1971
Fig. 1. The letters in circles are terminals on the main perf board. The position identifiers for S3 and S4 should be duplicated at these front-panel controls.
When assembling the power supply within the chassis, make sure that filter capacitor C1 is completely insulated from the metal chassis by a plastic sleeve. The rectifier (RECT1) is mounted on four heat sinks, one attached to each leg, so that sufficient heat is conducted away during use with 1 ampere drain. The heat sinks were made of four copper L brackets mounted on perf board with the bottom of the L up. The leads of the rectifier were then soldered to their respective heat sinks. Also on this perf board was the fuse holder.

The large heat sink for Q2 can be mounted on the rear wall of the chassis using four insulated shoulder washers for support. It is then possible to omit the usual mica washer, but use silicone grease between the transistor and the heat sink. The transistor was fitted into a socket on the other side of the heat sink and a three-lug terminal strip was mounted on one of the heat sink nuts for connections to the transistor. Include some vent holes if the rear wall of the chassis is solid metal.

**Cell Holders.** Before building the chassis, determine what type of cell holders you prefer. Obviously, conventional holders for AA, C, and D cells may be used. In this case, simply mount the cell holders to an outboard wooden frame and connect them to the charger through short lengths of insulated wire. To duplicate the prototype, a special cell holder must be made as follows.

Obtain a 1 1/2" deep × 2 3/4" × 3 3/4" plastic utility box with plastic cover. Cut two holes in the rear of the box as shown in Fig. 3.

Two-inch steel corner braces must be made...
and filed smooth; also make a thin brass or stainless steel cover for the arm that protrudes into the case. Make sure that both braces slide smoothly up and down in their slots. Swage a conventional solder eyebolt to the rear of each slide as shown. Cut two slots in the plastic cover so that the eyebolts can slide up and down to the maximum travel of the steel braces. Then secure a pair of solder lugs to the bottom of the cover directly under each slot. Use small spacers to attach the cover to the rear of the box so that, when assembled, the two braces can slide up and down unhindered. Mount a spring to each soldering lug and attach the other end to the eyebolt. The electrical connection is made through a short length of insulated wire.

The interior of the case is fitted with wood V blocks faced with black vinyl tape. These blocks are cemented in place after test aligning a cell. Use double-sided tape to attach the blocks while aligning them. Then use cement or epoxy for final mounting.

With an AA cell in place on the V blocks and with the steel braces partially up in their slots (the rear spring providing tension), locate the lower minus contact button and use 6-32 x 3/4 hardware and a spacer to mount it. With a cell in place, the brace should automatically clamp the cell between the brace and lower minus contact.

Because of different cell diameters, two sets of minus contacts should be provided for each side of the cell holder. Electrical connections to these contacts are made through a soldering lug at each minus contact. Identify the cell holders as B1 and B2 and identify the PLUS and MINUS sides of the holder.
The face of meter M1 must be retouched to add two more scales. The original 0-1 scale will be used for the 1000-mA range. Using some form of press type, add the numbers 50, 100, 150, 200, and 250 over the original indications for 2, 4, 6, 8, and 1.0 respectively. This is the 250-mA scale. Similarly, add 10, 20, 30, 40, and 50 for the 50-mA scale. When making these additions, take care not to damage the meter movement or the needle.

The front panel of the charger is shown in the photographs. Note the cutout for the plastic cell holder, which is supported by four mounting screws. Switch S3 is marked for VLTC (voltage-limited tapered charge) on three positions and CC (constant current) on two positions. The CC positions are further identified by a line going to the R31 (FINE) and S4 (COARSE) controls. This aids in setting up the correct switches.

Note the placement of the other switches and controls on the panel and inside the chassis. Since lead length and placement are not critical, it is not necessary to duplicate the prototype exactly; but the arrangement has been found to be convenient.

**Adjustment.** Before making any adjustments, connect a 5- to 10-watt, 20-ohm resistor between the plus of the power supply and the remainder of the circuit to test the VLTC ranges and check the CC mode for positions 1 through 9 of S4. For position 10 of S4, use a 10- to 15-ohm resistor.

Set R29 for a resistance of about 300 ohms.

---

**THEORY OF CIRCUIT DESIGN**

The schematic shown here is a simplification of the Charge Now circuit. Section A illustrates the constant-current (CC) mode. The load is on the collector circuit of the Q1-Q2 Darlington pair. The emitter circuit includes S4 which selects the various current range shunts. The constant-current adjustment circuit (R31, R3, and R29) is a voltage divider on the base of Q3. Resistor R1 in the collector circuit of Q3 also supplies base drive for the Darlington pair. If the emitter current of Q2 rises, Q3 receives more base drive and reduces the drive to Q1 correcting for the change (and vice versa). With high loop gain through Q1, Q2, and Q3, the current through the load is regulated very closely.

In the voltage-limited tapered-current (VLTC) mode, two series-connected shunt voltage clamps are switched into the circuit of Q2. (See section B.) The CC adjust circuit and S4 are replaced by a current shunt made up of R11, R12, or R13, which are selected by S3E. Diodes D1 and D2 and transistor Q4 are matched so that, with the cell out of the holder, the open-circuit voltage is 1.7 to 1.5 volts. With a discharged cell (about 1 volt) connected between J1 and J2, the voltage clamp does not conduct and current is supplied to the cell. As the cell voltage builds up, the voltage clamp begins to shunt current around the cell, thereby providing the voltage-limited tapered charging.

Resistor R3, which is used in the constant-current mode and shorted out in the VLTC mode, insures base drive to Q3 under all conditions when non-shorting switch S3 is used.
The V-blocks are used to center the cells in the holder so that good contact is made between the two electrical connectors. After final positioning, cover the wood blocks with black plastic tape.

and R27, R28, and R30 for maximum resistance. Place S3 in the CC mode, S4 in the first LO position, and S2 on 1000.

Connect a multi-range milliammeter between J1 and J2 and turn on the power. As S4 is advanced from position 1 to position 9, observe an increasing output current from less than 1 mA to several hundred mA with variable control through R31 in each position. Set the output current to 200 mA, place S2 on 250 and adjust R30 until the meter on the front panel indicates 200 mA.

With R31 set for low current, place S4 on H1. Adjust R28 until the meter indicates 400 mA. Shut down the power and replace the external 20-ohm resistor with a 10-ohm resistor. Turn on the power, and slowly advance R31 and R29 until the meter indicates one ampere with R31 fully clockwise. Repeat these steps until R31 controls the current from 400 to 1000 mA. Then set S4 to position 9 and adjust R27 until R31 covers the range up to 500 mA. Check that all lower ranges have a slight overlap.

Check that the meter on the charger tracks the external milliammeter on the three major ranges of S4. Potentiometer R30 is used to make any necessary scale adjustments. It may be advantageous to set R30 so that the high range (1000 mA) is correct, and then trim the shunts of the lower ranges (R23-R25) for reasonably close meter indications.

In the VLTC mode, diodes are paired off with Q4 and Q5 and resistors R11 through R13 are sized to set the charge rates indicated in the Table. Use a 20-ohm resistor in the plus lead of the power supply and re-
Arrangement of the resistors associated with S4 shows an easy method of mounting.

move the outboard meter from J1 and J2. Allow a 5-to-10-minute warmup for the diodes and transistors.

Accuracy is more important in setting the voltage limit than in measuring the charge rate. Check the accuracy of the low-voltage dc range (5 volts) of the external VOM you are going to use.

Place S3 on position 5 (VLTC-D) and, if necessary change the value of R13 until M1 indicates 200 mA. Then measure the voltage across the B1 and B2 holders. It should be about 1.7 volts. The diodes in each circuit may be interchanged to get a better match. If the voltage is less than 1.7, increase the charge rate using R13. If the matched volt-

Each terminal of the rectifier is soldered to a copper plate that acts as a heat sink during heavy power consumption. Each segment is individually mounted. Capacitor C1 is insulated from chassis by a plastic wrap.
Although the author used sockets for the transistors, they are optional. To avoid wiring errors, clearly identify each terminal and component. To create a neat appearance, leads going to a common area are bundled together to form a wiring harness.

### Current and Voltage Limits

**VLTC Mode**

<table>
<thead>
<tr>
<th>Mallory Type</th>
<th>Rated Capacity (mA-hr)</th>
<th>Charging Rate (mA)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SA-15AA</td>
<td>300</td>
<td>30-37.5</td>
</tr>
<tr>
<td>SA-14C</td>
<td>1000</td>
<td>100-115</td>
</tr>
<tr>
<td>SA-13D</td>
<td>2000</td>
<td>200-230</td>
</tr>
</tbody>
</table>

Charge open-circuit voltage limits (volts): 1.7-1.75.

Voltages are above 1.75, set the charge rate slightly under 200 mA or select other diodes. Just make sure that the voltages on the B1 and B2 holders are matched.

Set S3 to position 4 (VLTC-C) and adjust the value of R12 to obtain 100 mA on M1. The voltage on the holders should remain the same. If not, interchange or change the values of R8 and R9. To increase the voltage, it is preferable to raise the charge rate rather than use higher resistances.

Follow the same procedure with S3 in position 3 (VLTC-AA). In this case, it will probably be necessary to set the charge rate toward the high limit of the Table.

**Application.** To charge a single nickel-cadmium cell, set S3 to position 1 (CC-B1) and place the cell in the B1 holder. For two identical cells, place S3 in position 2 (CC B1+B2). Recharge nickel-cadmium cells at the rate and for the time marked on the cell or as specified by the manufacturer. Both S4 and R31 can be adjusted for the correct values, with the current indicated on M1. If the charging information is not specified, but the milliampere-hour rating is known, divide this rating by 10 and charge at that rate for 14 hours.

(Continued on page 97)

Power transistor Q2 is mounted directly to its heat sink, and the heat sink is insulated from the metal chassis. Vent holes allow cooling air to circulate within the closed container.
MECHANICAL contacts in electrical circuits are known for their tendency to are, wear, chatter, and gradually change spacing with use. Sooner or later, every car owner becomes cognizant of the two most important electrical contacts in his automobile—the “points” in the distributor and the voltage regulator in the generator/alternator circuit.

While some minor resetting of the contacts in the voltage regulator is always possible, there is a tendency among automobile mechanics to discard the regulator and replace it with a brand-new unit.

The voltage regulator performs more tasks than its name would imply. Mechanical relays in this device monitor the battery charging voltage and current and effectively control the operation of the generator/alternator so the battery is kept properly charged. Although mechanical regulators have been considerably improved in recent years, there is an obvious question in the minds of many electronics hobbyists and experimenters as to why in this day of integrated circuits it is necessary to put up with a temperamental mechanical product?

This all-silicon IC and solid-state regulator provides a solution to all problems created by the mechanical regulator. This device has been use-tested for nearly two years and is considered completely safe, can cause no external damage to the automotive electrical system, and at very most requires one additional wire to be added to the average American car. If the suggestions are followed as to the size and insulation requirements of the hookup wire, your installation should be as safe as that of the original automotive equipment manufacturers. The device is temperature compensated and can be con-structed for under $18.

Charging Systems. The only major
change in automotive battery charging systems in the last 15 years has been the switch from the dc generator to the ac alternator system.

The old-style generator uses mechanical commutation to generate the necessary dc to charge the battery and as a result requires the use of a relay to disconnect the armature when the automobile ignition is turned off. The generator also requires over-current protection in order to prevent its own self-destruction in a high charge condition.

The ac alternator incorporates heavy-duty silicon diodes to act as rectifiers and to block current flow back through the alternator when it is in a no-charge condition. The alternator is inherently a self-limiting device in current and requires no over-current outboard protection.

Four common types of charging circuits are shown in Fig. 1. The four are obvious combinations of generator with lamp or ammeter and alternator with lamp or ammeter. The VR12 Voltage Regulator, whose basic schematic is shown in Fig. 2, can be used in any of the four arrangements.

**Construction.** Before constructing the regulator, use Fig. 1 to determine which configuration fits your needs and refer to Fig. 3 for the proper connections for the VR12.

The main part of the regulator uses the foil pattern and component layout shown in Fig. 4. Use an epoxy glass board for the PC. In installing the components, be sure that the IC is properly oriented. If power transistor Q8 is used (for lamp circuits), it must be thermally connected to a length of metal which is bolted to the chassis wall as shown in the photographs. Transistor Q5 is thermally mounted to the rear wall of the chassis. Solder leads of adequate length to the board terminal points. Excess solder flux should be removed and the board inspected for correct component installation and clean solder joints. Spray the board with a moisture-resistant, non-conductive spray.

For generator systems, the resistor pattern shown in Fig. 5 must be made (following the pattern exactly) on a 2-oz copper-clad board to provide current-sensing resistor $R14$. The resistance is 0.02 ohms and it can regulate 30 amperes.

---

**Fig. 1.** The four common types of charging circuits are shown here. The two at the top are for an alternator system, while the two at the bottom are for a generator system. The two at the left are for meter circuits, while the two at the right are for those vehicles using a pilot lamp as charge indicator.
**PARTS LIST**

C1—82 pF disc capacitor
D1—1N1183 diode
IC1—Integrated circuit (GE PA230)
Q1, Q4, Q6, Q9—2N3638 transistor
Q2, Q7—Transistor (Motorola MPS6566)
Q3—Transistor (Motorola MM4005)
Q5—2N3055 transistor (Motorola MJE3055)
Q8—2N4921 transistor
R1—2200-ohm, 5% resistor
R2—15-ohm thermistor (Fenwal JD1214 or similar)
R3, R5—560-ohm, 10% resistor
R4—100-ohm, PC potentiometer
R6—330-ohm, 10% resistor
R7, R8, R12—1000-ohm, 10% resistor
R9—620-ohm, 10% resistor
R11—330-ohm, 10% resistor
R13—470-ohm, 10% resistor
R14—0.02-ohm resistor (see text)
Misc.—Heat sink for D1 (Delco 7270725), case, oil-proof flame-retardant wire, 6-terminal barrier block, moisture-proofing spray, mounting hardware.

**Note**—The following are available from BECO Solid State Systems, P.O. Box 686, Salem, VA 24153: etched and drilled glass-epoxy PC board (820-036) at $2.25; R14 circuit board at $1.15; extruded aluminum case at $2.60; treated heat sink for D1 at $1.10. All prices plus postage. Residents of Virginia, 4% sales tax. A complete kit of parts for any of the four configurations is available, as are assembled and tested units. Write for prices.

---

Fig. 2. Basic circuit for the regulator showing both the lamp option (on the right), and the generator modification (at the bottom). Resistor R14 is created from foil pattern.
Fig. 3. This shows the four possible charging systems when using the VR12. Select the one that fits your requirements and wire the vehicle accordingly.

The printed circuit board is mounted in a heavy-duty closed metal chassis. (The one shown in the photographs was made of extruded aluminum.) Shock mounts are not required. Mount the six-terminal barrier strip on the chassis and connect the leads to the appropriate terminals. Make sure that each terminal on the outer side of the barrier strip is clearly identified.

An additional small heat sink will be required for diode DI for generator systems. All physical mountings must be made with lockwashers to prevent loosening due to vibration.

Adjustment. Before making any adjustments on the VR12 Regulator, the dc voltage at the present regulator must be measured and recorded. This must be done after the engine has been running for a while and the
battery is fully charged. Failure to measure this voltage may result in a mis-adjustment of the solid-state regulator and faulty charging of the battery.

Connect the VR12 to a power supply as shown in Fig. 6A. Set the dc power supply to deliver the exact voltage which was measured in the preceding paragraph. Adjust R4 on the regulator until the voltmeter indicates this voltage. Increasing the power supply output slightly should cause the voltmeter to drop to zero.

If a lamp indicator is to be used, set up the circuit shown in Fig. 6B, with the output of the power supply set for 13 volts. Adjust R10 on the regulator until the test lamp goes out. Decreasing the power supply output slowly should cause the lamp to come on. This ad-
The basic circuit, the combination of R1, Q1 (acting as a zener diode), and thermistor R2 provides a reference voltage for the non-inverting input of the differential operational amplifier IC1. The thermistor provides temperature compensation.

The voltage sensing network consisting of R3, R4, and R5 comes into operation when the ignition is on. The wiper of R4 provides an adjustable sensing point for the inverting input of IC1.

If the alternator (generator) output voltage increases, the input to IC1 from R4 increases. This causes Q5 to go toward cutoff, reducing the field current to the generator and causing the output voltage to decrease. The voltage at point A is stabilized at the value preset by R4.

In the indicator lamp circuit, as long as the wiper of R10 is at a sufficient level to fire Q6 (corresponding to a correctly charging system) transistor Q7 is held on and Q8 is cut off. If the input voltage drops so that R10 does not supply enough voltage to Q6 (acting as a zener diode), Q8 turns on and the lamp is lit.

The generator modification consists of blocking diode D1, which prevents current flow back into the generator when the battery is not being charged. If the voltage across R14 exceeds the base-emitter drop of Q9, this transistor turns on and brings the voltage at point B close to that at point A and causing the regulator to reduce its output. This, in turn, forces the generator to decrease its output.

If the input voltage increases, the voltage across the VR12 decreases, which indicates a need for an increase in the output of the regulator. This increase in output is achieved by reducing the field current of the generator, which in turn reduces the output voltage. The VR12 may be mounted within any small, but substantially built chassis, capable of withstanding vehicle vibration. Use lockwashers on all mounting hardware.

Adjustment will have to be re-checked when the regulator is mounted in the vehicle to ensure that the lamp is on when the ignition is on (but the engine is not running) and goes off when the engine is charging the battery.

This indicating circuit is much more sensitive than the conventional system and the lamp may remain on for as much as a minute after the engine is started—depending on the (Continued on page 98)
MOBILE RADIO

Comparative Tests—Motorola has been given a license for experimental/developmental station KB2XW/L to compare radio communications on the 900-MHz band with the 450-MHz band. The tests will be made in the northern part of Chicago on 451.65 and 956.1 MHz, usually during daylight with various widths of narrow-band FM and approximately 100 watts of output power. Results may enable greater development of mobile radio in the 900-MHz band.

CITIZENS RADIO (CB)

Two CB Projects—In cooperation with the Community Council, a CB base station has been installed in the headquarters of the 24th Police Precinct, 100th St. and Amsterdam Ave., Manhattan, New York City. Manned by REACT members, the station will monitor channel 9 and hopefully will be a successful and useful experiment in convincing the police force of a major city that they could make greater use of CB. Volunteers are being sought for this program and CB'ers in the area should contact Patrolman Tom Kelly... Meanwhile, the Louisiana Sabine River Authority has requested the FCC for permission to use channel 9 for "distress calls" on the 60-mile long Toledo Bend Lake, extending from Leesville to Logansport, La. The Authority hopes to install 24-hour CB stations along the lake and to require manning similar CB stations at sites leased by the state.

TELEVISION

The Vertical Interval—There’s a lot more information being transmitted in conjunction with your TV picture than ever appears on the screen. To see for yourself, adjust the vertical hold on your receiver until the black blanking bar appears. Especially on network relay transmissions, you’ll see a line of white dots and bars that appear to be modulating the first few lines just above the top of the picture. Besides controlling various test patterns for both monochrome and color, these signals contain the white level reference, facsimile (called Homefax by RCA), time signals (sometimes courtesy of the National Bureau of Standards), and any number of other experimental things. Most TV viewers are unaware that the last 12 lines of each scanned field—each line having the capability of a 12,000-Hz channel—are technically available for special signals.

CITIZENS RADIO (CB)

More Uses for Channel 9—Designation of channel 9 for emergencies has not been without headaches and problems. The Pennsylvania League of Emergency Associations (PLEA) has petitioned the FCC for “looser” controls as to who should or should not use channel 9. PLEA asked the FCC to permit use of channel 9 in non-emergency cases to maintain control of their mobile units on the road. In addition, PLEA feels that “broadcasts” should be made periodically (not oftener than every half hour) to motorists to assure them that channel 9 is being monitored. PLEA says looser rules would ultimately provide greater road safety.
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A LOOK at the workbench of a serious electronics hobbyist and experimenter shows a variety of test equipment that only a few years ago was only to be found in the most advanced laboratories. Digital readout multimters, super-clean waveform generators, triggered-sweep oscilloscopes, etc. are readily available to any experimenter, technician, or engineer with a modest budget. Until a few months ago, the only area not covered was frequency measurement. Of course digital readout frequency counters have been around for years, but always at a price!

There are a multitude of obvious uses for a frequency counter. Audio frequencies can be determined by eye straining interpretation of Lissajous figures—assuming that the reference frequency is correct. If you test audio systems using some form of audio generator or pre-recorded tones; how do you know that the tape deck or the disc player is on frequency? In the case of audio generators, there is always the chance of significant error due to warm-up drift and dial accuracy even if the unit is one with switch-selected frequencies.

When it comes to r-f alignments, there is little chance that a manually tuned oscillator can ever be placed exactly on frequency. In digital circuits, especially in long countdown stages, a frequency counter is the easiest way to check for proper operation. There are also uses for frequency counters in ham radio equipment, designing filters, etc. In general, knowing the exact frequency invariably saves a lot of headaches.

HEATHKIT FREQUENCY COUNTER MODEL IB-101

Once again, the Benton Harbor Rangers have come to the rescue. This time it's the Heathkit IB-101 counter currently offered at a price just under $200. This is a solid-state, five Nixie® tube readout device that actually produces the equivalent of eight-digit accuracy. The frequency range is from 1 Hz to slightly over 15 MHz with an accuracy of plus or minus one count within the crystal-controlled time base stability. Sensitivity is well under 100-mV up to 1 MHz and substantially less than 250 mV from there on up to 15 MHz. The IB-101 has automatic triggering and an input impedance of 1 megohm shunted by less than 20 pF.

Assembly. The circuit for the IB-101 is assembled on a single fiberglass double-sided printed circuit board and total construction time—including mounting the Nixies and switches should be about 7 hours. However, one word of caution: that figure assumes that you have had some previous experience assembling a digital circuit kit and have a narrow-tipped, low-wattage soldering iron available. Heath provides 1/32" diameter solder with details on how to convert your heavy soldering iron tip to a more usable tip for working with pins of the digital IC's.

As usual, if you follow the well illustrated Heathkit manual, you should have no problems assembling the IB-101. Your reviewer has found that it saves a lot of troubleshooting time (if necessary) to go over a PC board with snuggly mounted components using a small magnifying lens. Look for cold solder connections and whisker solder bridges between adjacent foil sections.

Operation. Once assembled, the IB-101 is self-calibrating. There is no secret to the unit's operation and if you attempt to make a kilohertz reading while on the hertz scale, the "overflow" light comes on. Your reviewer would suspect that most advanced experimenters and technicians after using the IB-101 for a few weeks will find that they have it ready to be attached to a signal generator and used as a "tuning dial" rather than depend on the accuracy of the mechanical dial on the instrument itself. Psychologically, there's a nice glow of confidence in
HEATHKIT IB-101 Frequency Counter is built around 26 in-line integrated circuits, 8 transistors and 5 cold-cathode display tubes. The IC's plug into special strips of IC pin connectors. The component density is rather high and the builder must exercise great care not to form solder bridges on board. Glow tubes are hidden by light shield in upper left-hand corner.

Handle on IB-101 swings through a 180° arc and is used for carrying and instrument tilt on workbench. Handle action is controlled by spring-loaded square detent visible in photo above. Also in this shot is back of overrange light.

Discrete component wiring density is particularly bad under the two range lamps. There are about 20 different components within range of this photo. The input sensitivity potentiometer can barely be seen at bottom. Sensitivity and calibration can be established without resorting to laboratory test instruments.
knowing that you are on the right frequency.

This reviewer had only two minor objections to the operation of the IB-101. For some reason, there appears to be no provision for protecting the input circuit from a reasonably high dc voltage. This can happen if the IB-101 is used to measure a frequency from the plate of a vacuum tube oscillator or from a high voltage output transistor. A blocking capacitor between the board and input terminal of the IB-101 is an easy and ready cure to this problem. There is plenty of room to install this component. Also, in the hertz position, the IB-101 takes a couple of "bites" at the frequency and requires three or four seconds to settle down. This is a slight annoyance—especially to those familiar with instruments that read on a "one and only one" basis.

LAFAYETTE RK-890
CARTRIDGE RECORDER/PLAYER

The 8-track cartridge has a tenacious foothold in the field of stereo playback for automobiles. Having arrived on the scene before full-fidelity cassettes, cartridges are probably here to stay for a long time. However, pre-recorded cartridges are expensive and this reviewer sees a trend toward home-recording—either off the air or off of discs and tapes that the car owner has available. If this recording can be done on a decent piece of equipment at a respectable price, the monetary saving can be substantial. In our travels, we have noticed advertisements for a reasonably priced 8-track cartridge recorder/player tape deck that might prove of interest to readers with tape cartridge players in their cars.

The RK-890 is a household tape deck with all the essential features of a 1971 open reel or cassette tape deck—modified by the special requirements of the 8-track tape medium. It allows recorded material to be played in the home through your stereo system and, perhaps more important, it makes recordings on blank cartridges for playback while driving.

The RK-890 has separate AUX and MIC inputs with individual channel level controls, concentrically mounted—for recording. The two sources can be mixed and each channel has an illuminated recording level meter—which also functions on playback.

Operation. Most of the routine functions—one the gain level has been set—are push-button controlled. The pushbuttons are for: EJECT, RECORD (lock), STOP, PLAY, and FAST FORWARD (FF). There is no "pause" button and the stopping action of the RK-890 is not quite instantaneous, since although the motor power is shut off, the internal fly wheels keep the tape advancing for a couple of seconds. The FAST FORWARD (FF) operation is by no means as fast as you find on a cassette player or open reel deck. Using FF, you can move to any portion of a 32-minute cartridge within about 90 seconds.

The EJECT button clears all other controls and literally pops the cartridge out of the slot. Ideally, this sort of interlock arrangement should prevent a cartridge from remaining in the machine with the rubber drive wheel engaged when the power is shut off. However, this disengagement does not take place if the cartridge is in place and the line cord is pulled out. There is also an AUTO EJECT switch, which can be set to play (or record) in sequence 1, 2, 3, or 4 tracks of the cartridge, and to eject the cartridge after the selected number of tracks has been played. With this switch in the OFF position, the recorder plays through all four tracks (in stereo) and then repeats the procedure indefinitely until either the EJECT or STOP button is actuated.

A manual pushbutton in the lower lefthand corner advances the RK-890 by one track each time the button is pressed. The number of the stereo track in use is always illuminated above the cartridge loading slot. This is a useful function in attempting to provide instant access to any track at any part of the cartridge. Obviously, there is really no way of determining what part of the track is being played, except at the tape splice, which triggers the automatic advance to the next track.

Test Results. The Lafayette RK-890 has a very respectable record/playback frequency response. Using BASF tape, the response was measured to be within ±3.5 dB from 22 Hz to 12 kHz. Nominal playback output was but 0.7 volts. At 1000 Hz, stereo crosstalk was —27 dB. The signal-to-noise ratio was also very good and, in a 22-kHz bandwidth, was measured at 49 dB. On record, the RK-890 required a 90-mV input at the AUX input and 0.85 mV at the MIC input.

Flutter was measured at 0.33% and although slightly higher than that of the better grade of cassette or open reel tape machines was not obvious on most program material. Wow was measured at 0.03% and distortion was measured at 2% at 0 dB, 1.8% at —3 dB, and 2.4% at +3 dB.

A Few Final Words. If you have become addicted to cartridge-player stereo in your car, the Lafayette RK-890 will soon pay for itself. The surprisingly high cost of prerecorded tape cartridges makes this machine a worthwhile investment. The RK-890 can be used to make recordings on blank tape car-
Builder assembling the IB-101 must be very careful soldering the IC pin connector strips. If a fine-tip soldering iron is not available (such as the Ungar "Princess" shown here), Heath recommends shaping up a piece of large bare wire into a tip extension for an ordinary 25-watt soldering iron. Inspect the soldered connections with a magnifying glass to see if any cold joints or bridges might have been made.

HEATHKIT IB-101 (Cont'd)

The five-digit readout enables accurate readings to be made into the megahertz range. The right-hand digit is always within plus or minus 1 count. Decimal point in the lower right corner of the glow tube showing most significant digit is always "on." The range lamps indicate the frequency in either kHz or MHz.

CARTRIDGE RECORDER/PLAYER
(Lafayette RK-890)

This 8-track stereo record/playback deck makes a nice addition to household setups that make use of cartridges. The owner can record off-the-air, tapes and discs on blank cartridges for playback in his car. Operation of the RK-890 is simple and all of the important record and playback controls are seen here. On/Off pushbutton is under the operator's thumb. Microphone and aux inputs may be mixed at the operator's pleasure.
tricles for subsequent playback in your car. In other words, you could take material off the air, or tape your favorite disc or open reel tape. The RK-890 is non-critical as to recording level and any program material that does not consistently drive the recording level meters to full scale should be recorded with satisfactory quality.

Of course, higher flutter seems to be inherent in the endless loop tape cartridge, but this also appears to vary widely between different brands of blank tape cartridges—and possibly even within each brand.

As a clincher, you will find your home-recorded cartridges sound much better than commercially recorded cartridges. If you don't believe this is possible, ask someone who has similar equipment and has tried it.

**TOMPKINS “MOBILINK”**

In the beginning, CB was proclaimed the “everyman’s two-way radio system” and the air was filled with visions of instant short-range radio communications. Things didn’t turn out as expected and many plans to make more and better use of CB were dropped. Not so for one accessory that recently arrived on my desk. It is called a “Mobilink” and is manufactured by Tompkins Radio Products and distributed by Herbert Salch & Company. It is a simple gadget consisting of a separate miniature transmitter and receiver. The transmitter is wired to the CB transceiver speaker and broadcasts signals picked up via CB to a pocket receiver that may be carried by the user. The range possible between this “extra” transmitter and receiver varies from 100 to 900-1000 feet depending on location of the transmitter and the surrounding terrain.

The Mobilink package received by your reviewer consisted of a crystal-controlled transmitter set on 27.264 MHz with a power input of about 90 mW. The pocket receiver was the shape and size of an ordinary broadcast-band AM receiver. The receiver itself is obviously an AM i-f strip with a new crystal-controlled mixer/oscillator stage in the spot normally occupied by the ferrite antenna. There is no tuning adjustment, only an on/off switch and volume control, plus a short collapsible antenna. The transmitter is apparently USA-made and consists of four transistors, a crystal control circuit, and a type 131 pilot bulb strapped across the input for volume limiting. The Mobilink transmitter is inoperative until an audio signal is received. The installation literature accompanying our test prototype indicated that the transmitter had VOX control, although we did not see a wiring diagram and it was difficult to disassemble the transmitter for circuit analysis.

**Some Test Results.** The Mobilink package was used with several CB transceivers and very satisfactory re-transmission of CB was noted from our laboratory workbench out to a range of just under 200 feet. Of course, everything audible on the base station CB was fed down the pipe and out through the Mobilink. Obviously, for a satisfactory type of “Page Call” relay the squelch control must be adjusted to eliminate as much background interference as possible. For maximum receiving range the short antenna on the receiver had to be extended, although more than adequate reception within 50-75 feet of the laboratory was obtained with the antenna partially collapsed.

The instructions supplied by the manufacturer of the mobilink recommend that the user try to cut into the CB transceiver at the speaker terminals. We found this rather inadvisable and prefer to drive the Mobilink transmitter from the “EXT SPKR” phono jack on the back of the transceiver (an output that is available on at least three out of every five units).

**Comment.** Because of its low cost, it is difficult to fault the Mobilink, although the manufacturer could have given more thought to the physical design of the transmitter. An RCA phono input would be preferred. The antenna out the top of the Mobilink is rather insecurely mounted and subject to breakage at the insulated base where it enters the transmitter package.

It’s also worth mentioning that the manufacturer or distributor neglected many other uses for the Mobilink—including ham radio and SWL’ing. Tying the Mobilink transmitter to a communications receiver enables the operator or listener to be somewhere else in his own home or backyard while monitoring a specific channel or frequency. Undoubtedly, other uses could be dreamed up for this surprisingly handy little item.

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**FOR MORE INFORMATION**

Heathkit IB-101—Circle No. 91 on Reader Service Page 15 or 95.
Lafayette RK-890—Circle No. 92 on Reader Service Page 15 or 95.
Tompkins Mobilink—Circle No. 93 on Reader Service Page 15 or 95.
**LAFAYETTE RK-890 (Cont’d)**

Track advance pushbutton and *auto eject* rotary switch add to flexibility of the RK-890 cartridge tape deck. Switch may be set to play or record, in sequence, 1, 2, 3, or 4 tracks. Pushbutton advance is indicated by the illuminated numeral (1 is visible) on panel above cartridge. Frequency response (below) shows test results from Hirsch-Houck Laboratories. See text for details.

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**MOBILINK**

*(Tompkins Radio Products)*

Two components of Mobilink are seen in the upper left photo. Above, transmitter is shown upside down. Lamp for volume limiting is soldered to the input terminal strip. At left, the open receiver shows how the AM mixer/oscillator, tuning capacitor and ferrite antenna have been eliminated and replaced by a miniature PC board, containing the crystal-controlled mixer on 27.264 MHz.
GET TO LISTEN to a lot of stereo equipment that I could never hope to buy. Some of it I wouldn't care to have around the house even if I could, but things have changed since those halcyon days when a four-figure price tag was no guarantee of anything except a designer's delusion of grandeur. Today, top price usually means top quality.

This is not to say that a speaker costing $1234 is $34 better than a speaker costing $1200. In fact, in performance the more expensive speaker may not be as good, but in most cases, the price tag is a fairly good guarantee that that system will be substantially better than a $500 speaker. Or, at least, I would personally judge it to be better—and not on the basis of price alone.

For some people catalog-perusing is not the fun it is for most serious audiophiles; it has become an agonizing chore. When you get down to it, these people do not want to choose; they want to be told what is The Best, preferably by a bonded, licensed Expert. For the benefit of those unhappy souls, let me say that the words below are going to disappoint them. I'm going to talk about some equipment that could be The Best, but I'm not going to name the very best equipment simply because I can't. I don't think anyone can, and here's why.

Is There A Best? Going at things in a typically backward fashion, let's consider loudspeakers. The Altec A-7-500 system isn't in the top price category, but it is certainly capable of reproducing cleanly almost any sound at absolutely ear-shattering levels. It also has excellent blending between the woofer and tweeter. But, the A-7-500 has a distinct coloration that says "horn" all over it. It puts you, the listener, in a seat close to the orchestra. It has rolled-off response at both ends of the audio range although it's fine between 60 and 10,000 Hz. The A-7-500 beams the high frequencies and as a result seriously restricts the stereo listening area.

An entirely different type of loudspeaker—the KLH Nine full-range electrostatic—sells at a bit over $1000 for a stereo pair and offers the closest thing to a perfectly clear window on sound that money can buy. It has a stupendous transient response, but it is as inefficient as the Altec is efficient and will overload or blow its fuses before you can get anything like "row A" concert hall volume out of it. On the minus side of the ledger, the KLH Nine also beams its high frequencies and has a somewhat restricted low end that's effective down to about 60 Hz. It produces a slightly remote sound and is devilishly sensitive to listening room characteristics. Since it is an electrostatic speaker, it's heavily capacitive load throws most power amplifiers into hysteric. If money presents no barriers, you can use four Model Nine panels coupled two per channel. This carries the bottom end down to a healthy 35 Hz and slightly increases the maximum volume capability. All of the other problems will remain, but this sort of four-panel setup is one of my favorite systems.

Of course, given unlimited funds, I might pick the Infinity Servo-Static I, which sells for $2000 for the complete system. Said system includes two large electrostatic panels, a rather large cube-shaped bass "commode" and a combination of electronic crossover and bass range amplifier. It also takes two stereo preamplifiers to drive the SS-I, so the total may come to well over $2700. Although the SS-I has much of that window-on-the-sound characteristic of the KLH Model Nine (plus better treble distribution and better stereo imaging), it's low end goes just a shade deeper than the four panels of the Model Nine and it is a much closer-sounding system but without the marked coloration of the Altec A-7-500. To my ear it seems to have more detail than the KLH and the Altec; and the SS-I can deliver something approaching close seat concert hall volume.
into a typical listening room if you have enough amplifier power. Nevertheless, the SS-I has certain colorations that the Model Nine doesn’t have—including a slight lower mid-range hollowness and a subtle high-end hardness that sometimes becomes annoyingly sharp when abetted by the performance of the usual top-quality solid-state amplifier.

So nothing’s really perfect, but to my taste—I emphasize that this is strictly a personal view—the SS-I is the most nearly perfect system that I have heard to date. All of this assumes that you don’t demand discotheque listening levels and don’t have the patience or desire to experiment maybe for weeks or months with various room placements, although like the Model Nines, the SS-I panels are very critical as to room placement.

Have I actually heard all the contenders for top speaker rating? Of course not. I have never heard an L. W. Erath, or a BBC Monitor, or the new Canadian Dayton-Wright. I have heard the J. B. Lansing Paragon which I felt sounded raucous, bass-shy, and somewhat dull at the top end. And, for all of their magnificent spaciousness, the Bose 901 setup strikes me as being a bit flabby at the low end and too steely at the top. Analogous to electrostatic speakers, the 901’s have a reputation for being hard to place optimally in the listening room.

The Audio Research Dual 50 is an all-vacuum-tube power amplifier with impressive figures for output, distortion, frequency response, hum and noise.

The speakers designed and manufactured by Paul Klipsch have an enviable reputation among audiophiles striving to obtain the very best. His new Klipschorns may be excellent, but I will probably never know, since I was not overwhelmingly impressed with some earlier models and Mr. Klipsch apparently feels that my ears are not adequate to judge his speakers.

The Question of Amplifiers. The preamplifier is probably the easiest component to evaluate sonically and I can make that qualification because, when it comes to the matter of “features,” personal taste is going to rule the roost. Some audiophiles will never be happy unless they can control every aspect of the sound—from separation to distortion and for these few a preamplifier with basic controls will have little or no appeal—even if it is a perfect piece of equipment. Most preamplifiers have enough diddling adjustments to satisfy the audiophile, but performance is always something else again and this is one field in which high price is not a guarantee.

I believe it was Julian Hirsch who first said, in describing the perfect preamplifier, that it should be nothing more than a “straight wire with gain.” In other words a device that amplifies and does absolutely nothing more. You can check this yourself by setting the controls to have minimal effect on the program material, then switching the preamplifier in and out of the signal circuit—in other words, bypassing it—and noting the audible difference. Whether or not the preamplifier sounds “good” or “bad” is irrelevant, since if the preamplifier changes the sound in any way, it isn’t a perfect piece of equipment.

To my knowledge, the most expensive preamplifier currently available is the Audio Research Model SP-1 currently selling at about $750. Oddly enough, it does not pass the bypass test, but neither do any of the preamplifiers selling at somewhat lower prices. The frustrating thing is that some preamplifiers do extremely well in half of their circuitry—the phono preamplifier stage—and less well in the high level circuits—the tone controls and outputs.

The Model SP-1, and its less costly cousin the SP-2, have the most nearly perfect phono preamplification sections of any preamp I’ve heard, but fare less well through the latter stages. The Harman-Kardon Citation 11, selling at just under $300, has a superb high-level section and by comparison to the Audio Research units, a less than successful phono preamp. The SAE preamplifier (weighing in at about $500) has an excellent front end, but the high-level stages lack some of the transparency of the Citation. I haven’t heard the Infinity preamplifier, but users have told me that some of the early samples sounded hard and had a tendency to blow the opamp modules, but later samples now sound as good as anything available—if not better.

Power amplifiers are harder to assess because they don’t lend themselves to the “straight-wire-with-gain” bypass test. The best you can do and hope for when evaluating a power amplifier is to make laboratory measurements and then listen to them on a variety of speakers that have elicited the “best” sound from previous amplifiers that have been tested. If this all sounds like cir-
cular logic, it is. The technique does work most of the time and amplifiers that I have judged to be "best" are usually ones preferred by other finicky listeners. The most expensive stereo power amplifier is another Audio Research product—the Dual 100 (meaning 100 watts rms per channel) that sells for a mere $2000. There is a cheapskate model—the Dual 50B—that only costs $440 and like their matching preamplifiers, the two Dual models are not solid-state—they are all vacuum tubes! Over most of the audio range, the Dual 50B sounds a shade better to my ears than any solid-state amplifier and even the 100-watt model is a smidgen better, although I will not stick my neck out to claim that it is worth an additional $1600. When it comes to controlling the speaker's low end, neither of these power amplifiers can touch the performance of the better solid-state units.

The Crown Model DC-300 (at just under $700) produces a much deeper and tighter low end—probably due to its very high power and exceedingly high damping factor. In fact, the DC-300 may be overdamped for some speakers and even cause a thinning out at the bottom. The DC-300 is not quite as transparent in the upper range as the Citation 12 which has a comparatively modest price ($300—or $225 in kits).

An Easy One. When discussing an FM tuner, there's really no contest—the Marantz 10B was and still is the best that money could buy. Unfortunately, money may not be able to buy it, since it's been discontinued and used Model 10B tuners now cost more than they did when brand new. Of course, there is the question whether or not the 10B is worth the money since there's only one FM station in the country—WFMT in Chicago—that transmits a signal clean enough to justify the price of the 10B tuner. The only saving grace is the 10B won't exaggerate the distortion that the average FM station is transmitting.

My personal choice for a solid-state tuner that stands out as conspicuously as the 10B is the Heath AJ-15. Not only is the Heath nearly $800 cheaper, but the performances of the two are closely matched.

Players, Turntables, and Pickups. For the man who probably wants the best of the most, the Thorens TD-125 turntable is probably as good a choice as any. If you don't insist on three speeds and a vernier speed adjustment, the Acoustic Research Model XA offers equally good performance at a mere $87. The XA comes with its own tone arm—about which the less said, the better. I always advise replacing it and it's worth investigating the Rabco Model SL8E which has become available with an adapter kit for installation on the AR turntable. If you opt for the Thorens you will be pleased to note that the Rabco arm matches the styling of the Thorens turntable so closely that they look as though they were made for each other.

Of course, the Rabco has problems and you can hear the servo system's vibration coming through the speakers when the audio gain is cranked way up. Unfortunately, the pivots are rarely adjusted for optimum performance when you buy the arm. In addition, there is no damping to the arm at all and this can lead to acoustic feedback problems. The Decca International arm has a superb damping system and is as feedback-resistant as anything you can get, but it just can't be mounted on most modern turntables—simply because it requires over 4" of depth under the motor board.

Finally, we come to the beginning of the system—the phono cartridge or pickup. And, if you say, "Why, of course, the Shure V-15-II is the best pickup," I'll argue with you. I grant that it does track splendidly, but trackability isn't the only criterion for judging a phono cartridge. A cartridge should be able to make good discs sound as much as possible like master tapes, and this is the one thing that the Shure pickup does not do—thanks to a rather peculiar response dip through the "brilliance" range. Personally, I've only found two pickups that really approach that master-tape sound and it may be heresy to add that both of them are spherical-stylus models—not ellipticals. These pickups are the Decca 4RC and the Stanton 681A. The Decca sounds a bit better than a Stanton, but it hums with some turnedtable platters and has a fierce magnetic pull toward ferrous platters. Decca's quality control is certainly nothing to cheer about and the 4RC is best pre-tested before buying. The Stanton, on the other hand, has no problems—it just doesn't sound quite as good as a hand-selected Decca. But then, how can anyone say which pickup is best?

Lastly, in discussing tape recorders, I won't even try to name the contenders—because there is really no audiophile ceiling in tape equipment. Quality and price range all the way up to the big professional machines costing nearly $5000 and there is no line of demarkation between the professional and the audiophile tape deck. In truth, some obvious machines for home playback like the Revox A-77 perform with higher fidelity than the studio machines, but the studio machines are more consistent and dependable and infinitely more rugged.

Now that you've heard the ifs, buts, and ands, what is the best of everything? You tell me.
Wages—Yours vs Average

How can I find out whether or not my wages are in line with other electronic technicians working in my part of the country?

The statistics division of your state employment bureau compiles the most complete and impartial wage statistics for your part of the country. These annual reports break down the wage figures according to occupation, type of business or industry, and city or geographic area.

You can generally get a free copy of the report—or at least see one—by visiting your nearest state employment office. If that doesn’t work, write directly to your state’s division of labor statistics.

Also, your local library should have a recent copy of Employment and Earnings Statistics for States and Areas. This book, published by the U.S. Department of Labor’s Bureau of Labor Statistics, is a collection of all the wage reports submitted by the states.

Engineering College Drop-Out

I am in my third year of study at a 5-year engineering college. Although the VA is helping me, I am finding it more and more difficult to be a responsible family man and full-time engineering student at the same time. So I will be dropping out of college at the end of this term to get a full-time job. I have four years of experience as a Navy Electronics Technician and three full years of college behind me. How can I use this background to help me get a good job in electronics?

You may think your three years of college add to your value as an employee; and strictly speaking, you’re right. However, without some kind of diploma in your hand, you’ll most likely find yourself making some tough compromises at job interviews. You certainly won’t be able to get a graduate engineer’s position and salary, for instance, but you should be able to do better than a man who has no higher education at all. You’ll find yourself being classified somewhere in a murky gray area between a technician and an engineer. The question is “where?” Unless you can get some kind of diploma or know someone who can vouch for your abilities, you’ll probably have to start out more on a technician level.

A transcript of grades might help convince prospective employers you have the potential for becoming a good engineer or engineering technician. Unless your grades are exceptionally good, however, displaying them at a job interview may do more harm than good.

It’s a sad fact of life that a college dropout with an “A” or “B” average has a tough time commanding the same kind of respect granted a college graduate with a “C” average.

You may have guessed by now that my advice is to stay in college—at least on a part-time basis. If you don’t have the money or time for part-time college work, I suggest you transfer your credits to a two-year technical school and attend evening classes. You might be able to get a degree in Electrical Engineering Technology in less than a year.

The point is to get some formal credentials. You’ll still have to work hard for what you want, but formal credentials will give you a better foothold at the start.

Out-Of-Town Jobs

In our October 1970 column, we suggested that readers looking for jobs in distant localities, should contact the headquarters of Snelling and Snelling (a nationwide employment agency) in Paoli, Penn. Since they have 540 offices in 45 states, the agency tells us that they can serve you better if you contact your local office or the one in the nearest large city. (See the white pages of the telephone book.) A list of these offices may be obtained by writing to the Public Relations Dept. of Snelling and Snelling, Inc., 2 Industrial Blvd., Paoli, PA 19301, but resumes should be sent to local offices.

April, 1971
DIGITAL counting is growing up. For the last three years, this magazine has been featuring the latest in digital readout circuits, usually involving separate pulse counters, latches, decoders and readout devices for each decade. We have often wondered why some semiconductor manufacturer didn’t package the whole "works" in one IC. It would appear logical (no pun intended) since the counter/decoder/readout always go together anyway.

Now, Motorola (Box 20924, Phoenix, AZ 85036) has brought us part of the way home with the introduction of their MC4050 IC. The unit, shown schematically in Fig. 1, contains a single MSI chip that includes a decade counter, a four-bit latch, a seven-segment decoder, and display driver transistors able to handle 15 volts with up to 40 mA of collector current, which is more than enough for most seven-segment readouts. Provisions are also made for lamp blanking to suppress leading zeroes in a display, and for a lamp test to check that all seven segments of the readout are operating properly.

Present cost is around $10 per unit. The TTL logic used is good to 35 MHz, making it very attractive for the serious electronics experimenter or engineer.

All that remains now is to add another layer on the IC and include a solid-state seven-segment readout under a transparent cover. How about it Motorola?

Other Digitals. Hewlett-Packard has been manufacturing logic-readout devices for quite a while, primarily for very high quality instruments and government projects. Now they are mounting a major push into the display market with their 5082-7300 logic/readout package. At this stage, the 7300 costs $10 per digit and includes a decoder/driver on the same chip as the LED 7-segment readout. With any kind of large orders, H-P hopes to bring this price down to about $5 per decade within two years. That’s some-
thing to look forward to. A spokesman for Monsanto, another manufacturer of LED 7-segment readouts, calls $5 per decade a reachable target by the end of this year, even though their present readout (MAN-1) now sells at $11. Meanwhile, back on the East Coast, the president of Opcoa (Edison, N.J.) claims that his company's present $8 readout could conceivably drop to $2 each in large quantities.

On the other side of the coin, Burroughs, which manufactures the world-famous Nixie® tube has a contender of its own. The Panaplex, a multi-digit gas discharge readout with up to 14 decades in a single tube, now averages about $3 per digit including drive circuits.

No matter what happens now, it would appear that the day of the analog meter is just about over.

On a slightly different subject but still in the digital world—when we used to use RTL logic, we were accustomed to providing a supply of 3.6 volts at several hundred milliamperes. When we graduated to TTL, we found that 5 volts of power was needed but at slightly less current. It now comes as a pleasant surprise to learn that a new class of logic, called COS/MOS by RCA, operates from a 1.5-volt supply with microwatt power dissipation. Some of the new devices are the TA5987, which can be used as an ultra-low-power crystal oscillator, NAND/NOR gate, triple inverter, dual transmission gate, etc.; the TA5988, a 14-stage ripple carry binary counter-divider; and the TA5993, an oscillator plus 14-stage ripple carry binary counter-divider that also includes an input inverter. This kind of power reduction is almost like a quantum jump for an old fogie like me.

**Reader's Circuit.** While acknowledging that Vincent Wood's PLL SCA adapter ("Build an SCA Adapter for FM Reception," *Popular Electronics*, December 1970, p 53) does a fine job, reader Allen R. Jackson (2334B Riverside Dr., Beloit, WI 53511) was disappointed, nonetheless, in the unit's lack of interstation muting. Of course he hadn't seen the squelch circuit we presented in last month's column, but he designed one (see Fig. 2), which has merit of its own.

Allen employed a three-stage direct-coupled amplifier to control Q2's emitter bias, adding a zener diode to provide a reference voltage for comparison with PLL's (IC1) output. In operation, removal of the SCA subcarrier, as between stations or when cut off by the broadcaster, is sensed by the control circuit, which then effectively grounds Q2's emitter cutting off both this stage and the emitter follower output. When the subcarrier returns, Q2's emitter bias is restored and normal operation resumes.

Relatively few inexpensive components are required for the muting circuit. All three transistors are general purpose audio silicon devices. Except for the potentiometer, the resistors are conventional half-watt types, while D1 is a low-to-medium wattage (actual rating not critical) 9-volt zener diode (although another voltage rating may be required if other than a 12-volt power supply is used with the SCA adapter). The correct zener value is 1 volt less than the dc voltage measured at pin 7 of IC1. If preferred, the zener may be omitted and the 2500-ohm potentiometer replaced with a 25,000-ohm type; but, according to Allen, this modification will result in less decisive action.

Although neither parts placement nor the wiring arrangement are critical, good wiring practice should be followed when duplicating the circuit. If the SCA adapter is being assembled from "scratch," Wood's original circuit board design could be modified to include the muting feature. On the other hand, the circuit could be added to an existing instrument as an outboard accessory simply by assembling it on a small board and connecting it to the main SCA circuit board using short, direct leads. After installation, the potentiometer is adjusted for optimum performance.

**Manufacturer's Circuit.** With potential
applications in volume expanders, signal compressors, analog computers, recorders, radiotelephone transmitters, receivers, PA systems, background music distribution equipment and test instruments, the linear AGC amplifier circuit illustrated in Fig. 3 is one of several application circuits described in the 14-page specifications brochure for Motorola's type MC1594L/1494L four-quadrant multiplier IC. Squaring, multiplication, division, square root, modulation and phase detection circuits also are included in the comprehensive booklet. Copies of the complete specifications brochure are available through Motorola Semiconductor representatives and franchised distributors or on direct request from Motorola Semiconductor Products, Inc., Box 20912, Phoenix, AZ 85036.

A four-quadrant multiplier arrangement offers several advantages over more familiar AGC systems. First, the AGC is truly linear, for the output signal amplitude is directly proportional to the dc control voltage. Second, its AGC dynamic range is theoretically infinite, in that a zero dc control voltage will reduce the output to zero regardless of the input signal. Of course, in practice the circuit’s actual dynamic range is limited to some extent by the control ability of the input offset potentiometers. Third, unlike older circuits, changes in the AGC control voltage have no effect on its signal handling capability, nor do they alter its input impedance. Finally, the multiplier’s output voltage swing capability and output impedance both remain unchanged despite variations in the AGC dc voltage.

According to Motorola, the circuit shown in Fig. 3 is capable of handling input signals of up to 1 volt rms while providing a maximum gain of approximately 20 dB. In operation, however, its gain can be controlled through a 60-dB dynamic range by the application of AGC voltage from 0 to 1 volt dc. Since the basic IC’s effective frequency response is determined by the value of its output load and distributed circuit capacitances, an emitter follower stage (Q1) is used as a buffer amplifier to provide an over-all bandwidth of better than 1 MHz.

Assembled in a 16-lead dual-in-line ceramic package, the MC1594L used as the heart of the AGC amplifier is a monolithic silicon integrated circuit. Essentially a variable transconductance multiplier with an output voltage which is the linear product of its two input voltages, the device has internal level-shift circuitry, permitting its input and output offsets and scale factor to be adjusted by means of external potentiometers. A pair of built-in complementary voltage regulators serve both to simplify the offset adjustments and improve power supply rejection. Designed for operation on a dual 15-volt dc source, the basic device has a 3-dB frequency response to 1 MHz. The MC1494L is essentially similar to the MC1594L except for linearity tolerances and offset voltage and current characteristics.

Aside from the MC1594L, relatively few components are needed for project assembly. Motorola recommends that cermet multturn potentiometers be used for offset controls R6 and R7 to permit precise adjustments, but all other resistors are conventional half-watt types. Needed to insure adequate input bias, input load resistor R1’s size is not critical, and values up to 100,000 ohms may be used, depending on the im-

Fig. 3. One of the many uses for the four-quadrant multiplier is this exceptionally linear AGC system having a 60-dB range via application of a 0-1-volt signal on pin 10. Bandwidth is 1 MHz.
pedance of the signal drive source. As a general rule, however, $R_t$'s value should be as low as practicable for minimum noise and optimum temperature performance.

Circuit layout and lead dress are fairly critical and, therefore, care must be taken to keep signal carrying leads short and direct and, for maximum frequency response, distributed wiring capacities at a minimum. As long as these precautions are observed, the agc amplifier may be assembled either breadboard fashion or on a suitable etched circuit board. At the builder's option, the circuit could be used either in a self-contained agc instrument amplifier (with suitable power supply, of course) or incorporated into more complex equipment as a functional subsystem.

**Pulsar—Phase II.** The all IC solid-state digital readout wristwatch discussed in our September 1970 column (Watch That Watch!) has moved a giant step closer to commercial availability with the announcement that Electro/Data, Inc. of Garland, Texas, has placed a million dollar order with RCA's Solid State Division (Somerville, N. J.), for the integrated circuits to be used in production versions of the watch. Electro/Data developed the original prototype in cooperation with the Hamilton Watch Co. (Lancaster, Pa.), which is marketing the instrument under the trade name “Pulsar.”

**Booklets and Other Tidbits.** The Semitronics Corporation (265 Canal St., New York, NY 10013) has published a new and revised edition of its popular “Semiconductor Replacement and Interchangeability Guide.” Carrying a nominal 25 cent price tag, the 40-page booklet lists thousands of domestic and foreign semiconductor devices by their original type numbers, together with recommended Semitron replacement types.

All major IR semiconductor devices are presented in an easy reference format in a new 20-page, full color, illustrated “Short Form” Semiconductor Device Digest released recently by International Rectifier's Semiconductor Division (233 Kansas St., El Segundo, CA 90245). Accurate dimensional case drawings and terminal connections are given, with each category of semiconductor devices presented in compact tables and charts giving ratings, parameters, and other important specifications. Among the items covered are such devices as—SCIT's, power logic trics, high power silicon rectifiers, selenium rectifiers, zeners, low power silicon rectifiers, silicon assemblies, light sensitive devices, and heat exchangers.

Unisem (P.O. Box 11569, Philadelphia, PA 19116) is now offering a unique r-f power transistor guide. A three-fold chart printed...
on heavy card stock, the guide has been designed so that it can be used either as an insert in a loose-leaf binder or as a handy wall chart. High-frequency power transistor package outlines and condensed electrical characteristics are presented in the guide, together with a useful applications table. One of the most interesting features, in our opinion, is a unique graph-like chart correlating transistor types with power ratings and frequency capabilities, thus permitting a designer to choose a suitable device almost at a glance, given the power level needed and operating frequency.

**New Developments.** GE's Research and Development Center (Schenectady, N. Y.) has announced the invention of a new solid-state circuit element which has been dubbed a *surface-charge transistor*. Based on a unique concept involving the transfer of electrical charges between insulated electrodes, the new device has a potential information storage capability of a million bits per square inch.

The basic surface-charge transistor is a sandwich-like device consisting of a silicon substrate, a thin insulating film, two metallic electrodes separated by a narrow gap, a second insulating film, and a third metallic electrode positioned so that it overlaps the thin slit between the other two electrodes. The first two electrodes are identified as the *source* and *receiver*, the third as the *transfer gate*.

In operation, an electrical charge applied to the transfer gate serves to control the transfer (or movement) of a much larger charge through the gap between the source and receiver electrodes, referenced to the semiconductor substrate, thereby providing a substantial signal gain.

Still in the experimental stage, the surface-charge transistor might well be the first in a whole new class of semiconductor.

Motorola's recently introduced line of low-cost Functional Circuits now totals twenty devices, including flip-flops, voltage regulators, general purpose and audio amplifiers and an electronic attenuator. Unit prices range from a low 92 cents for the type MFC-4040 Single Toggle Flip-Flop to only $3.81 for the type MFC9000, a 4-watt audio amplifier complete with an integral preamplifier. Simpler than complex integrated circuits, the devices provide common circuit functions at less cost than designs using discrete components. The relatively low prices are achieved by the use of high-volume TO-92 stripline production facilities.

RCA Electronic Components (415 South Fifth St., Harrison, NJ 07029) has expanded its popular line of IC project kits to include four interesting units that will convert any standard AM broadcast band receiver into a VHF receiver by simply placing a loop of wire around the radio. The four new kits, shown below are the KC 4007 Aircraft IC Converter Kit, tuning 118-136 MHz; the KC 4008 Ham, Government and Space Research IC Converter Kit, tuning 134-150 MHz; the KC 4009 Marine, Mobile, Fire and Police IC Converter Kit, with an expanded range from 148 to 164 MHz; and the KC 4010 Police and Fire IC Converter Kit, covering the 160-174-MHz band. All four kits are priced at $10.95 each and are available through RCA franchised outlets.

That’s our Solid State story, for now—happy April Showers, everyone!  
—Lou.

If you want to snoop around various VHF bands at reasonable cost, RCA is now offering four kits covering 118-136-MHz; 134-150-MHz; 148-164-MHz; and 160-174-MHz. Output is inductively coupled to an ordinary AM receiver unit.
Recorder heads accumulate the oxidized coatings of tapes and if they are not cleaned periodically, the heads will wear excessively and eventually ruin the tapes themselves. Some technicians still use alcohol to clean tape heads, but this is not a good idea. Alcohol is flammable, is not a particularly good cleaner, and has an adverse effect on some plastics. Even today, some commercial tape head cleaners are based on the use of isopropyl alcohol, but the better products use blends of fluorocarbons (Freons).

Cleaner chemical manufacturers are at odds as to whether or not a tape head cleaner should include a lubricant. At least one manufacturer has a cleaner containing a minor amount of silicone. The claim is made that this product leaves a thin coating which permits the tape to slide freely across the head, but other manufacturers, while acknowledging this good effect, say that lubricants tend to accumulate excessive oxide coating particles. Oddly enough, tape equipment manufacturers appear to have no firm views on the subject saying that any good effect may result from a lessening of wear from excessive tape tension (a mechanical defect).

Tape head cleaners are available both bottled and in aerosol cans. It is generally preferable to use a bottled compound and to apply it with a clean cotton swab and then wipe the tape head clean. Where space is not available (in compact cassette recorders, for example) a high pressure aerosol cleaner will do a fairly good job of flushing away oxide without leaving residue.

As above, choose your tape head cleaner by the smell and feel. Reject anything that feels abrasive or smells like alcohol.

**Chemicals for Cleaning R-F Circuits.**

Many hams and SWL's tolerate erratic band-switches when these defects could be readily cured through the application of a TV tuner spray cleaner. Generally speaking, although these products are advertised for TV tuners, they will obviously have the same beneficial effect in a receiver, transceiver, or transmitter.

Tuner sprays usually fall into one of four relatively distinct categories:

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CIRCLE NO. 11 ON READER SERVICE PAGE

“wash” cleaners, these products are generally
based on a blend of Freons and may be
sprayed on TV tuner contacts or band
switches with the assurance that they will
leave no residue. These cleaners are especially
recommended where foreign matter of any
kind might unbalance a critical r-f circuit.

2. Cleaners with light lubricants. It’s prob-
able safe to say that these are the traditional
TV tuner spray cleaners. These products work
reasonably well, but may need to be reapplied
to the same switching or contact area within a
year.

3. Cleaners with heavy lubricants. This
type of spray cleaner is becoming increas-
ingly popular. They may usually be distin-
guished by the “foaming” action. Many tech-
nicians believe these products to be preferable,
since they tend to keep tuners and band-
switches in good operating condition for
longer periods of time.

4. Cleaners with heavy lubricants and pol-
ishing agents. This is a relatively new cat-
egory and may well eventually replace those
cleaners mentioned above in category 3.

Any cleaner should be applied to a tuner
or a bandswitch with care and the degree of
care should follow the numerical order indi-
cated above with category 4 being applied
only to switching contact surfaces. Virtually
any bandswitch or tuner cleaner will tempo-
rarily detune an r-f circuit, but if the cleaner
is a good one, the chemical preparation will
evaporate in about three minutes and unless
the cleaner has been misapplied, no touching
up or slug tuning adjustments should ever be
necessary.

A follow-up article will describe the use of
highly specialized chemicals for electronics—
including insulating compounds, coolers, etc.
with emphasis on troubleshooting techniques.

ANNUNCIATOR
(Continued from page 52)

of cardboard over LDR2; now K1 should im-
mediately be energized.

Alternately exposing and covering LDR2
should cause K1 to open and close. Leaving
LDR2 covered, illuminate LDH1; K1 should
remain energized. Removing the cover from
LDR2 should cause K1 to deenergize.

The reverse of this procedure to test K2 is
as follows: cover LDH2 (K1 and K2 open);
cover LDR1 (K2 closes); illuminate LDR2 (K2 remains energized); illuminate LDR1 (K1 and K2 open). While the system is operating properly, it should be impossible for both relays to energize simultaneously.

Although the system employs two LDR sensors, it is not necessary, in most cases, to use two light sources. A single light source and a flashlight reflector can be used to illuminate both LDR's satisfactorily if the distances are reasonable. Of course, if the distance between light source and Annunciator is excessive, a two-light source system would be required.

When you get ready to set up your system, orient it so that the minimum amount of ambient light reaches the LDR sensors. Avoid pointing the LDR's toward windows or bright room lighting, and do not set up the system so that an opening door will trigger it. Finally, when counting people passing by, it is a good idea to locate light sources and sensors about 54° from the floor so that swinging arms will not produce multiple counts.

Now, turn on the system and orient the set-up for maximum illumination of the LDR's. If necessary, you can use mirrors to bend the light beam around corners so that more than one area can be surveyed.

Adjusting R5 and R6 is simple. Rotate both controls fully counterclockwise (viewed from the front of the case). Temporarily mask LDR1 from the light source and rotate R6 until K1 pulls in; then back off until K1 just opens. Interrupt the beam to LDR2 once or twice with your hand to check that K1 opens and closes properly.

Remove the mask from LDR1 and place it in front of LDR2. Rotate R5 until K2 energizes; then back off until the relay just de-energizes. The controls are now set for maximum sensitivity.

The relay contacts can be used to activate a variety of alarms or counters. In simple one-way systems, use the normally open contacts of the appropriate relay to turn on the system. A slightly more elaborate system, using both relays and a dual door chime is shown in the wiring diagram in Fig. 3. People passing in one direction will cause the chime to sound once; people passing in the opposite direction will cause the chime to sound twice. This same basic arrangement can be used as a secure area monitor by substituting two counters. Anyone entering the area will be registered on one counter, while those leaving the area will be registered on the other counter. In this way, you can tell if someone has gone into the area and has not come out.

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*April, 1971*
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**LIBRARY**

(Continued from page 16)

There are close to 500 diagrams, dozens of tables, over 200,000 words of explanation, a virtual absence of mathematics, and a modest index.

More than likely, the author has little to do with the choice of the book title—since it is a definite misnomer. True, the major emphasis is on amateur radio circuits and construction, but the ideas cut across all lines of the art of communications electronics. Certainly no one working with transmitters and receivers can afford to be without a personal copy of this refreshing and stimulating tome.

Published by Radio Society of Great Britain, 35 Doughty St., London, WC1, England. Soft cover. 208 pages. $3.75.

**RECENT ARRIVALS**

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Years. Such headphone jacks make listening corrective device (called the CC-1) that restored loudspeaker perspective to headphone listening through a complex cross-channel feed and frequency alteration. However, this problem seems to have been corrected by many disc manufacturers and the Jensen CC-1 is no longer marketed. It seems reasonable to assume that microphone recording techniques have swung more and more to the multi-microphone, studio-remix situation that is not aiming for a realism in concert hall sound. This does create some "strange" effects where instruments pop in and out of the "space" according to what the recording director decides is the most exciting scenario.

Pop and rock category music (broadly defined) has moved almost wholly into the domain of the recording director. Nevertheless, with typical pop music, headphones can produce exciting effects and in many instances much more effective than those heard through speakers—in the view of the younger listeners.

**Using Headphones.** Amplifier manufacturers have acknowledged the headphone boom by putting one or two phone jacks on the front panel of nearly every amplifier and stereo receiver marketed in the past two years. Such headphone jacks make listening dead easy—you simply plug in the headphones, put them on your head and listen. If all of this appears a little too easy, you are right. Headphone users soon realize that to obtain full bass note response with some headphones, they must be fitted to the listener's head to make a relatively tight seal around each ear. Any air leakage around the headphone rims will cut down the low frequency response. A few headphones may not require a perfectly tight seal and the response curve of these few headphones has been altered to increase the normal bass response output by the order of 6-10 dB. Obviously, an alternative to a snug headphone fit is turning up the bass control on your amplifier.

Most stereo amplifiers and receivers provide one or two headphone jack outputs. If two headphones are to be used, it is considered preferable to be sure that they are of equal sensitivity—hence, from the same manufacturer and of the same type. Stereo headphones can usually be paralleled without adversely affecting the stereo amplifier receiver. There are also several outlet boxes for multiple headphone listening and these are described in the 1971 Stereo Hi-Fi Directory.

If you are one of the few people with an amplifier or receiver that has no phone jack output, you can wire your own headphones to the speaker terminals (through a four pole, double throw switch) being sure to insert a 100-ohm 2-to-5-watt resistor in series with each "hot" leg of the headset. Using these two resistors ensures that the headset cannot be overloaded and simultaneously because it is a "loss" arrangement, the hum and noise level that might be passed along to the headset is virtually eliminated. Should you hook up the headphones without the series resistors you are taking your life—and your amplifier—in your hands and could well be blasted into kingdom come.
hours. Cells should have been discharged to 1.1 volts before recharging. To recharge nickel-cadmium multicell batteries, run leads to J1 and J2 and observe the correct polarities of the leads and battery terminals.

Recharge Mallory SA-15AA, SA-14C, and SA-13D cells in the VLTC mode using S3 set for the appropriate cell size. For a single cell, use either the B1 or B2 battery holder and charge for 12 to 14 hours. The built-in voltage limiter permits each cell to take what it needs at the maximum rate. Therefore, the cells need not be discharged nor in the same state of charge before placing them on charge. The meter indicates the total current to the VLTC circuit and cell and not the cell current alone. A quick way to check the charging progress is to connect a voltmeter across the cell with S1 off. If the voltage is above 1.65, the cell is fairly well charged. As cells age, the final voltage drops to below 1.7.

Although only three VLTC charge rates are provided, other cells may be recharged by using the nearest lower rate to that actually required and increasing the charging time accordingly.

**Drifting.** Due to the base-emitter characteristics of Q3 there is a certain amount of drift during warmup. For instance, with a load of 1 ampere (output terminals shorted), there may be a drift of 7% for the first 20 minutes. At ½ ampere, drift is about 4%, essentially finished in 10 minutes. At 100 mA, drift is about 1%, with stabilization in about 5 minutes. Although drifts of these magnitudes are of no consequence in battery charging, the current may have to be reset after a short warmup period.

Charger “backleak,” or cell discharge back into the circuit when S1 is off, is less than one microampere, which permits storage of the cells in the charger. Nickel-cadmium cells may be placed on continuous trickle charge, but only as specified by the manufacturer.

**Constant-Current Use.** The Charge Now may be used as a constant-current source for values up to one ampere. The current is taken from J1 and J2 with S3 in the CC position. Tests may then be made on various types of semiconductor and other circuits.

April, 1971
VR12 REGULATOR

(Continued from page 70)

setting of R10. The lamp may also glow slightly with heavy electrical loads at low engine speeds. Neither of these should be considered to be malfunctions.

Installation. Mount the regulator as close to the battery as convenient for good temperature tracking. Wire it into the system (in place of the old regulator) using the appropriate circuit in Fig. 3. Note that the S and R terminals of the alternator are not used with this voltage regulator. An additional lead may have to be added to accommodate the “IGN” terminal on the regulator. Any convenient point that is “hot” when the ignition is on is acceptable—except the coil-ballast connection point.

For generator systems, the D1 heat sink assembly is required. This may be mounted at any convenient location close to the voltage regulator. The heat sink must be insulated from ground and sprayed with a moisture resistant before installation. All interconnections must be made with oil-resistant, flame-retardant wire not smaller than #14 AWG for the IGN, LAMP, FLD, and GND connections; #10 AWG for BAT, ARM, and D1 connections.

After installation, recheck the lamp circuit (if used) so that the lamp is lit when the engine is not running and out when the engine is charging the battery.

Incidentals. The VR12 is a switching regulator which operates very rapidly. In ammeter installations, some hunting of the meter needle may occur. This is due to the long time constant of the alternator field. The hunting is preferable to high power dissipation in an analog series regulator.

The current drain of the VR12 when the ignition is off is about 15 mA—a reasonable value if the car is not left in long-term storage. If desired, the current drain can be reduced by increasing the value of R1 and R2 by a factor of 2 and of R3, R4, and R5 by a factor of 10.
GIANT BRAINS
(Continued from page 33)

Now the time had come to decide which design was best—the Mark I, the Model V, or the ENIAC. The direction computer design was to take lay in the balance. Debate was based on arguments of component reliability, problem set-up time, error-free operation, self-checking ability, and maintenance costs. The builders of ENIAC based their stand on the fundamental advantage of speed, which really meant decreased cost of computing—and this attribute far outweighed ENIAC’s disadvantages.

The deciding argument was given by Dr. Mauchly when he said that the life of a computing device should not be based on time alone but on the number of operations it can be expected to perform before failure. A good relay may average 100,000,000 operations before failure. A vacuum tube may be expected to operate reliably at a pulse rate of one operation per microsecond for 5,000 to 10,000 hours. Thus the tube may perform more than $10^{12}$ operations compared to $10^8$ for the relay.

Not only did great speed mean cheaper computing, it also offered hope of fulfillment of the cybernetist’s dream of real-time control of complicated events. The ENIAC could calculate the trajectory of an artillery shell in half the time of the shell’s flight.

The strength of ENIAC’s success can be seen in changes made by other builders of digital computers. Harvard followed the electromechanical Mark I with a relay Mark II. A twelve-fold increase in speed was achieved. Since this was still not a serious challenge to the ENIAC, there followed the Mark III, which got on the electronic bandwagon. The interest of Bell Labs in computer manufacturing was too heavily tied to the use of telephone equipment to convert to electronics. Their contribution to computer technology was to be with the invention of the transistor, not by the direct manufacture of computers.

The Eckert-Mauchly team went commercial and designed the Binac and their small company was absorbed to form the basis of Univac. And what of IBM, the builder of Harvard’s Mark I? Suffice it to say that they too recognized the potential of electronic digital computers.

April, 1971
NON-DISPLAY CLASSIFIED: COMMERCIAL RATE: For firms or individuals offering commercial products or services, $1.25 per word (including name and address). Minimum order $12.50. Payment must accompany copy except when ads are placed by accredited advertising agencies. Frequency discount: 5% for 6 months; 10% for 12 months paid in advance. READER RATE: For individuals with a personal item to buy or sell, 80¢ per word (including name and address), No Minimum! Payment must accompany copy.

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GENERAL INFORMATION: First word in all ads set in bold caps at no extra charge. All copy subject to publisher's approval. Closing Date: last of the 2nd month preceding cover date (for example, March issue closes January 1st). Send order and remittance to: Hal Cymes, POPULAR ELECTRONICS, One Park Avenue, New York, New York 10016.

FOR SALE

FREE! Giant bargain catalog on fiber optics, transistors, diodes, photo cells, rectifiers, SCR's, zeners, parts, Poly Paks, P.O. Box 942, Lynnfield, Mass. 01940.

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LOWEST Prices Electronic Parts. Confidential Catalog Free. KNAPP, 3174 8th Ave. S.W., Largo, Fla. 33540.


INVESTIGATORS, LATEST ELECTRONICS AIDS, FREE LITERATURE. CLIFTON, 11500 W. 77th Ave., Miami, Florida 33168.

ELECTRONIC PARTS, semiconductors, kits. FREE FLYER. Large catalog $1.00 deposit. BIGELOW ELECTRONICS, Bluffton, Ohio 45817.

RADIO-T.V. Tubes—36¢ each. Send for free catalog. Cornell, 4213 University, San Diego, Calif. 92105.

PSYCHEDELIC catalog. Posters, lighting, etc. Send 50¢ for handling to: Hole In The Wall, 5055PE Lankershim, North Hollywood, Calif. 91604.

CLEANER SALE rectifiers, transistors, 1000's other items. Catalog 15¢. General Sales Company, 254 Main, Cloth, Texas 77531.


BURGLAR ALARM SYSTEMS and accessories. Controls, bells, sirens, hardwires, etc. OMNI-GUARD radar intruder detection system, kit form or assembled. Write for free catalog. Microtech Associates, Inc., Box 10147, St. Petersburg, Florida 33733.

SENCORE, B&K TEST EQUIPMENT UNBELIEVABLE PRICES. FREE CATALOG AND PRICE SHEET. FORDHAM RADIO, 265 EAST 149TH STREET, BRONX, N.Y. 10451.

ELECTRONIC COMPONENTS—Distributor prices, Free catalog, Box 2581, El Cajon, California 92021.

JAPAN & HONG KONG DIRECTORY. Electronics, all merchandise. World trade information. $1.00 today. Ipanno Kaisho Ltd., Box 2666, Sockane. Washington 99207.


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Dealer Inquiries Invited

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KIT, Three channel audio-controlled Color Organ. $8.95. Includes all parts, instructions, and postage. Kustom House Electronics, 8530 Westminster Avenue, Westminster, CA. 92683.

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April, 1971


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Electro-Voice, Inc., Dept. 412P, 630 Cecil Street, Buchanan, Michigan 49107

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