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Popular Electronics

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Crystal-Controlled Time Base Generator

(see page 33)

DIGITAL CLOCK READS TO 6 FIGURES

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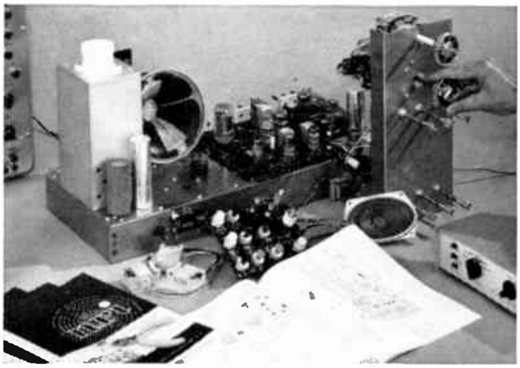

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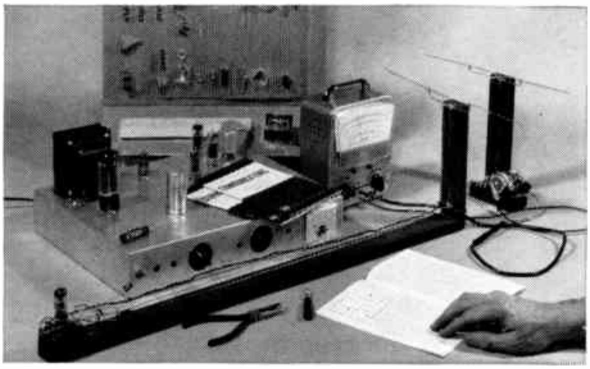

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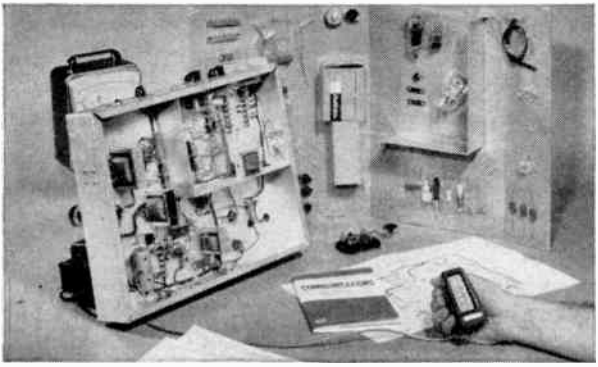

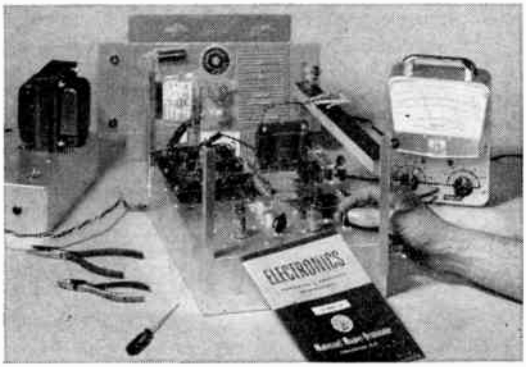

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VOLUME 34 NUMBER 1 **JANUARY 1971**

Popular Electronics

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FEATURE ARTICLES

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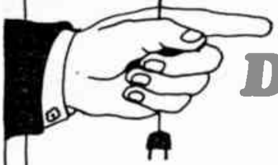


DIRECT & CURRENT

Fifth in a Monthly Series by Oliver P. Ferrell, Editor

UNDER ANOTHER GUISE

To my amazement a number of long-time readers of this magazine have asked why I permitted a minor electronics hobby publication to steal my thunder about a "Communicator's License" (see "The CB Dilemma—A Solution," November 1964, p. 78). These faithful readers refer to a petition before the FCC known as RM-1633 that would set aside a major portion of the 220-225-MHz radio amateur band for use by electronics hobbyists and radio communicators. Dozens of other interested POPULAR ELECTRONICS readers (unaware of my 1964 statements) have asked for my opinion in regard to the proposals offered in RM-1633.

My opinions about CB are well-known (see this page, October 1970 issue) and I feel that there is still a need for a portion of the radio spectrum to be allocated to private citizens for radio communications. I do not feel that it is in the best interest of those most concerned to have a magazine publisher/editor petition the FCC for another citizen's band. Such a petition is tainted and suspect since it has the appearance of commercialism riding roughshod over the public good.

Between 1964 and 1971, the Citizens Band became unmanageable and I see no reason to believe that expropriation of a radio amateur band by CB'ers would solve any problem other than channel congestion. It may be a stimulus to certain radio equipment manufacturers, but as RM-1633 reads, it is simply a method of diverting off the 27-MHz band the flood of illegal CB operators mentioned in my October editorial.

The FCC will give due consideration to RM-1633 and the matter may go before a public hearing. However, there can be no justification for Rule Making in favor of this petition. Too strong a case can be made against RM-1633 by every radio service—especially the hams who have the most to lose. In 1964, I thought otherwise, but a small group of CB manufacturers that pander "linears" and a vocal group of idiots with CB equipment (not even licensed CB'ers) have managed to cast a pall over an otherwise worthwhile radio system.

Although its timing is debatable, I cannot help but wonder if CB might not be salvageable if: (1) more channels were made available to CB'ers around 27 MHz; (2) the FCC undertook a massive enforcement campaign; and (3) a new Part 95 Rule were put into effect to "register" all CB transceivers.

INTERFACE

ABOUT READER MAIL

I suggest that reader inquiries that must be answered be submitted with a nominal fee (possibly $1.00). This would probably reduce the volume and keep inquiries on a meaningful basis—while defraying costs.

N.W. Schaaf
Livermore, CA

P.S. Consider this my bill for $1.00 as it is being mailed in response to a publisher's inquiry.

I'll handle all answerable inquiries at $1.00 a head—no fee if no answer.

L.J. Casselman
Stockton, CA

If the authors don't feel morally obligated to answer all letters addressed to them or do not have enough interest to do so, then I feel that their articles shouldn't be published.

A.G. Barry
Auburn, AL

Why not a volunteer reader inquiry column with names and addresses and areas of expertise. Let the readers write to these volunteers when they need help.

G. La Belle, WB6YZZ
San Francisco, CA

Turn your mail over to book publishers if the query is covered in a book. Use rubber stamps that say, "NO FREE SUBSCRIPTIONS" and "EDITORIAL FORMAT CHANGE". Don't answer any mail with a typewritten letter—scrawl an answer in red ink at the bottom of the inquiry—most people would rather have a quick answer than none at all.

P. Dworsky
Scarsdale, NY

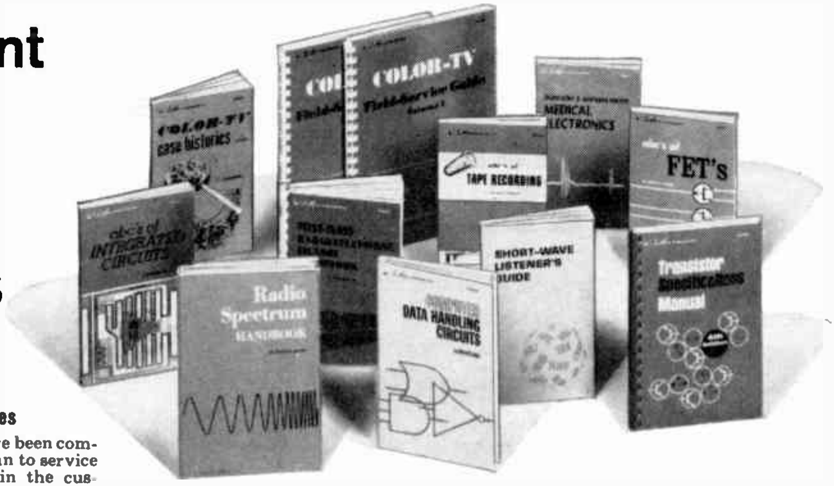
P.S. How about a free subscription?

Thanks to the dozens of readers who submitted suggestions in response to the "Direct & Current" editorial in the November issue. Several are being given consideration as potential solutions to an aggravating problem.

CB—THE BAD, BEAUTIFUL AND UGLY

You are approaching the CB problem ("Direct & Current", October issue) as many

Important New SAMS Books



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These invaluable guides have been compiled to enable the technician to service color-TV more efficiently in the customer's home. Charts provide chassis layouts showing type, function, and location of all tubes and/or transistors used in a particular chassis, ratings and locations of fuses and circuit breakers, location of service controls and adjustments, etc. Specific field-adjustment procedures are shown on page opposite chassis layout. Index provides instant reference to the proper chart for any particular TV chassis. Each volume contains 80 diagrams covering over 3,000 chassis.

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CIRCLE NO. 16 ON READER SERVICE PAGE

INTERFACE

(*Continued from page* 8)

people do—research has failed to give you any insight.

The FCC should crack down right now. To allow CB'ers to expand into other frequencies and add more channels to this junkyard of the airwaves is unrealistic. The FCC is not in a cul-de-sac; CB is—let it stay right there.

D.C. Fall, WB6OLJ
Fullerton, CA

It's encouraging to see a magazine offer an intelligent, concise and realistic description of the problems facing the CB service.

David Thompson, Pres.
Linear Systems, Inc.
Watsonville, CA

A WORKING READER

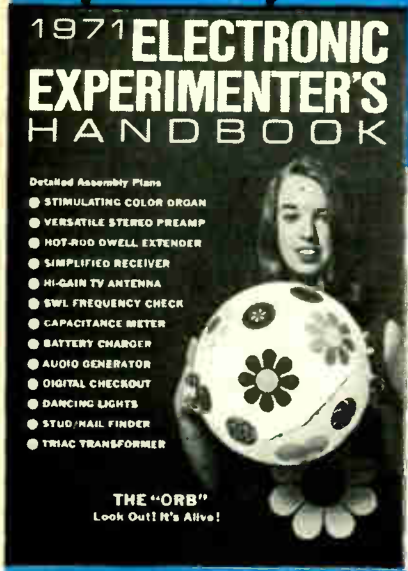
Congratulations on your new magazine format and outlook. I find it quite refreshing in the light of other experimenter magazines that flourish on the newsstands.

At present I am constructing the "Super Tiger" amplifier and "Two-by-Two" stereo preamplifier and all seems to be proceeding well. I especially like the construction project evaluations and the operational theory presentations. Since I rarely have the funds to build the more sophisticated circuits, I find that because of the presentation, I can rip them apart and experiment with them mentally!

P. Newley
Niagara Falls
Ontario

What else can we ask? A reader who examines, studies, and experiments.

You get 26 EXCITING ELECTRONICS CONSTRUCTION PROJECTS



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STEREO/HI-FI DIRECTORY. Giant buyer's guide complete with photos, specs, prices. 1970 #98; 1969 #82.

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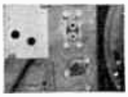
Adjustable tone control lets you choose the sound you prefer ...from deep, rich bass to clean, pronounced highs.



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Designed to be owner serviced. The new Heath solid-state color TV's are the only sets on the market that can be serviced by the owner. You actually can diagnose, trouble-shoot and maintain your own set.

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Easy, enjoyable assembly... the Heathkit way. The seven-section manual breaks every assembly down into simple step-by-step instructions. With Heath's famous fold-out pictorials and simple, straightforward design of the sets themselves, anyone can successfully complete the assembly.

Heathkit Solid-State Modular Color TV represents a significant step into the future...with color receiver design and performance features unmatched by any commercially available set at any price! Compare the specifications. Then order yours today.

Kit GR-270, all parts including chassis, 227" picture tube, face mask, UHF & VHF tuners, AFT & 6x9" speaker, 114 lbs. **$489.95***

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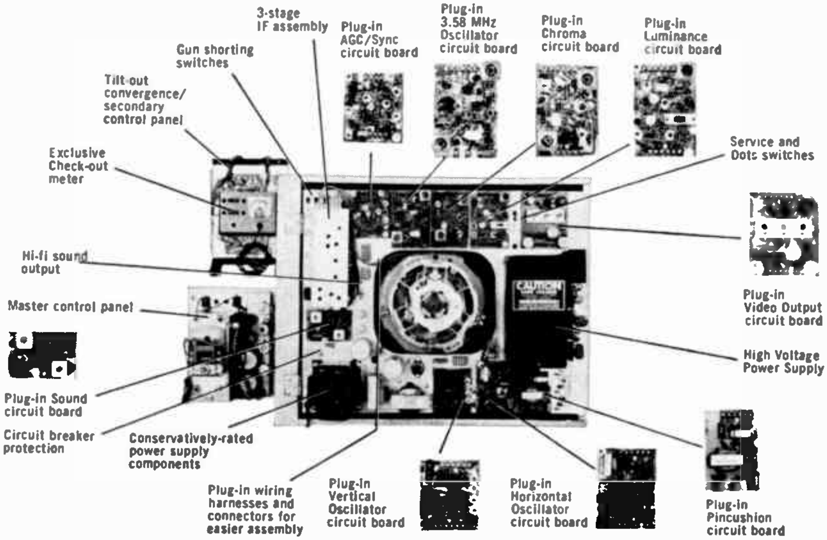
GR-270 AND GR-370 SPECIFICATIONS — PICTURE TUBE SIZE: GR-370 Approximate Viewing Area: 295 Sq. In. GR-270 Approximate Viewing Area: 227 Sq. In. **DEFLECTION:** Magnetic, 90 degrees. **FOCUS:** Electrostatic. **CONVERGENCE:** Magnetic. **ANTENNA INPUT IMPEDANCE:** VHF 300 ohm balanced or 75 ohm unbalanced. UHF: 300 ohm balanced. **TUNING RANGE:** VHF TV channels 2 through 13. UHF TV channels 14 through 83. **PICTURE IF CARRIER:** 45.75 MHz. **SOUND IF CARRIER:** 41.25 MHz. **COLOR IF SUBCARRIER:** 42.17 MHz. **SOUND IF FREQUENCY:** 4.5 MHz. **VIDEO IF BANDWIDTH:** 3.58 MHz. **HI-FI OUTPUT:** Output impedance — 1 k ohm. Frequency response — ±1 dB 30 Hz to 10 kHz. Harmonic distortion — less than 1% at 1 kHz. Output voltage — 0.3 V rms nominal. **AUDIO OUTPUT:** Output impedance — 4 ohm or 8 ohm. Output power — 2 watts. **POWER REQUIREMENTS:** 110 to 130 volts AC, 60 Hz, 240 watts. **NET WEIGHT:** GR-370, 114 lbs.; GR-270, 101 lbs.

Modular Color Television!

Exclusive Modular Design . . . Circuit Boards snap in and out in seconds for easy assembly, simple servicing



New Expedited 48-Hour No-Charge Warranty Service Plan for Solid-State TV Modules! Special service facilities have been established at the factory and all Heathkit Electronic Centers to expedite service and return of Solid-State TV circuit modules within two working days. During the 90-day warranty period, TV modules will be serviced or replaced with no charge for labor or parts. After the initial 90-day warranty period expires, TV modules will be serviced or replaced at a fixed charge of $5.00 per module for labor and parts for a period of two years from date of original kit purchase.

Add extra convenience and versatility to your new GR-270 or GR-370 Solid-State Color TV with this new ultrasonic remote control kit. Lets you turn the set on and off, adjust volume, change VHF channels and adjust color and tint from the comfort of your chair. Assembles and installs complete in just a few hours and the built-in meter on the receiver makes final adjustment a matter of minutes.
Kit GRA-70-6, 6 lbs. $64.95*

Choose One Of These Handsome, Factory Assembled Cabinets

3 models in 295 sq. in.

Luxurious Mediterranean Cabinet . . . factory assembled of fine furniture grade hardwoods and finished in a flawless Mediterranean pecan. Statuary bronze trim handle. 30-1/32" H x 47" W x 17¾" D. **Assembled GRA-304-23**, 85 lbs. $129.95*

Deluxe Early American Cabinet . . . factory assembled of a special combination of hardwoods & veneers and finished in classic Salem Maple. 29-21/32" H x 37¼" W x 19¾" D. **Assembled GRA-303-23**, 67 lbs. $114.95*

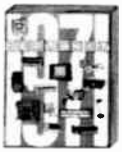
Contemporary Walnut Cabinet . . . factory assembled of fine veneers & solids with an oil-rubbed walnut finish. 29-17/32" H x 35-13/16" W x 19⅞" D. **Assembled GRA-301-23**, 56 lbs. $74.95*

3 models in 227 sq. in.

Exciting Mediterranean Cabinet . . . assembled using fine furniture techniques and finished in stylish Mediterranean pecan. Accented with statuary bronze handle. 27-31/32" H x 41⅞" W x 19-9/16" D. **Assembled** GRA-202-20, 70 lbs. $114.95*

Contemporary Walnut Cabinet and Base Combination. Handsome walnut finished cabinet sits on a matching walnut base. Cabinet dimensions 20-31/32" H x 31-7/16" W x 18⅝" D. Base dimensions 7⅜" H x 27¾" W x 18⅝" D. **Assembled GRA-203-20** Cabinet, 45 lbs. $49.95* GRS-203-6 above cab. w/ matching base, 58 lbs. $59.95*

Handy Roll-Around Cart and Cabinet Combination. Features the GRA-203-20 walnut cabinet plus a walnut-trimmed wheeled cart with storage shelf. **Assembled GRA-203-20 Cabinet**, 45 lbs. ....$49.95* **GRA-204-20 Roll-Around** Cart, 18 lbs. ...$19.95* **GRS-203-5, Cart & Cabinet Combo**, 58 lbs. $59.95*



NEW

FREE 1971 CATALOG!

Now with more kits, more color. Fully describes these along with over 300 kits for stereo/hi-fi, color TV, electronic organs, guitar amplifiers, amateur radio, marine, educational, CB, home & hobby. Mail coupon or write Heath Company, Benton Harbor, Michigan 49022.

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☐ Please send FREE Heathkit Catalog. ☐ Please send Credit Application.

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*Mail order prices; F.O.B. factory. Prices & specifications subject to change without notice. CL-392R

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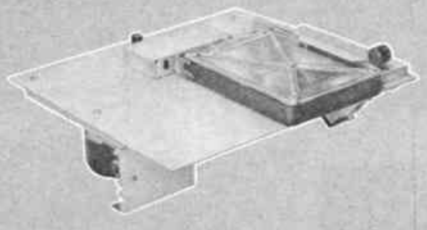

NEW LITERATURE

To obtain a copy of any of the catalogs or leaflets described below, fill in and mail the Reader Service blank on page 15 or 95.

A colorful brochure presenting product information on their complete CB line is being offered by *Midland International Corp.* The selection of CB equipment includes 25 transceivers ranging from low-cost walkie-talkies to sophisticated hand-held and base/mobile transceivers. Three compatible SSB models are shown, including a 3-channel hand-held, 23-channel mobile, and 23-channel base model. The brochure also gives information on such CB accessories as power supplies, microphones, speakers, antennas, and crystals.

Circle No. 75 on Reoder Service Poge 15 or 95

A completely new, redesigned line of the famous "Concert Series" loudspeakers is described in Catalog 1090-E available from *Jensen Sound Products.* Speakers described range in size from 3" to 15" round types and from 2" x 6" to 6" x 9" oval configurations. All speakers are full-range types, including the dual-cone models. Included are the Jensen special application speakers for aircraft, automobiles, communications, intercoms, etc. A complete line of loudspeakers for electronic musical instruments is also featured.

Circle No. 76 on Reoder Service Poge 15 or 95

An impressive line of instrument amplifiers, audio systems, and accessories for the artist and concert producer is described in a new catalog available from *Ovation Instruments.* The catalog listing covers preamplifiers, self-contained amplifiers, speaker systems, voice and music systems, sound projectors and emphasizers, and an extensive line of audio accessories. Illustrations, specifications, and application information are included.

Circle No. 77 on Reoder Service Poge 15 or 95

A four-page, two-color catalog that describes the complete line of CRX "Portamon" monitor receivers for use on the Public Service, business and commercial, 10-meter ham, and CB bands is being offered by *The Hallicrafters Co.* The receivers are designed to operate in the VHF portion of the AM and FM bands. Both hand-held and table model receivers are described.

Circle No. 78 on Reoder Service Poge 15 or 95

Popular Electronics

READER SERVICE PAGE

free information service:

Here's an easy and convenient way for you to get additional information about products advertised or mentioned editorially (if it has a "Reader Service Number") in this issue. Just follow the directions below... and the material will be sent to you promptly and free of charge.

1. On coupon below, circle the number(s) that corresponds to the key number(s) at the bottom or next to the advertisement or editorial mention that is of interest to you. (Key numbers for advertised products also appear in the Advertisers' Index.) Print or type your name and address on the lines indicated.

2. Cut out the coupon and mail it to: POPULAR ELECTRONICS, P.O. Box 8391, Philadelphia, PA 19101.

note: If you want to write to the editors of POPULAR ELECTRONICS about an article on any subject that does not have a key number, write to POPULAR ELECTRONICS, One Park Avenue, New York, N.Y. 10016. Inquiries concerning circulation and subscriptions should be sent to POPULAR ELECTRONICS, P.O. Box 1096, Flushing, N.Y. 11352.

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Electronics LIBRARY

USE OF THE OSCILLOSCOPE
A Programmed Text

by Charles H. Roth, Jr.

The format of this book is arranged so that it breaks down the process of operating an oscilloscope into a series of logical steps. Understanding the operation of the scope, rather than mere control manipulation, is stressed at each step. The book is divided into four parts. Part I introduces the scope. In Part II, the relations between triggering signals, triggering controls, the sweep waveform, and the waveform displayed on the scope's CRT are discussed. Proper use of the scope and probe to avoid measuring errors is emphasized in Part III, while Part IV deals with phase measurement by the triggered sweep and ellipse methods. Each part is divided into preparation, which presents the basic theory, and lab exercises. The exercises require prediction of scope settings and waveforms followed by experimental verification.

Published by Prentice-Hall, Inc., Englewood Cliffs, NJ 07362. 222 pages. $8.95 hard cover; $5.95 soft cover.

HANDBOOK OF MAGNETIC RECORDING

by Finn Jorgensen

The latest information on magnetic recording covering applications from home audio to weather surveillance data recording is given in this book. Beginning with the basics of magnetic recording, the text explores the differences between recorder types, transport designs for specifications, magnetic head design, how to judge tape quality, how tape is made, and the best type of tape to use for a given purpose. Some of the topics covered include: amplifiers and equalization, tape recorder care and maintenance, specialized taping techniques, and tape recorder measurements and standards.

Published by Tab Books, Blue Ridge Summit, PA 17214. 192 pages. $7.95 soft cover; $4.95 hard cover.

INTRODUCTION TO ELECTRIC CIRCUITS, Third Edition

by Herbert W. Jackson

While the principles of electric circuit theory do not change much from year to year, methods of teaching them do. The author dedicated the Second Edition of this book to students in electrical and electronics technology. In its Third Edition, this book is

(*Continued on page 97*)

You build your own digital computer step-by-step, circuit-by-circuit. You really get involved as you learn computer organization, operation and programming with this remarkable new training aid. It performs the same functions as bigger commercial computers—and it's yours to keep and use.

NEW exciting home training to be a COMPUTER TECHNICIAN

NRI program includes a complete, operating computer, with memory, to make you thoroughly familiar with computer organization, design, operation, construction, programming, trouble shooting and maintenance.

What better way to learn all about computers than to actually build and use one? That's exactly what you do in NRI's new Complete Computer Electronics home training program.

What you see illustrated may very well be the most unique educational aid ever developed for home training. This is not simply a "logic trainer." It is literally a complete, general purpose, programmable digital computer that contains a memory and is fully automatic. It's a small-scale model of larger, expensive commercial computers. Once you build it and it is operational, you can define and flow-chart a problem, code your program, store your program and data in the memory bank. Press the "start" button and, before you can remove your finger, the computer solves your problem and displays the results.

NRI is offering this new course because this is only the beginning of the "Computer Age." The computer industry continues to leap ahead. Qualified men are urgently needed, not only as digital technicians and field service representatives, but also to work on data acquisition systems in such fascinating fields as telemetry, meteorology and pollution control. Office equipment and test instruments also demand the skills of the digital technician. This exciting NRI program can give you the priceless confidence you seek to walk into a technician's job and know just what to do and how to do it.

You learn with your hands as well as your head

Planned from the beginning to include training equipment in the pioneering NRI tradition, this exceptional new course combines kits with educator-acclaimed NRI "bite-size" texts in an easy-to-understand package. But, unlike other home training, this is not a general electronics course. Lessons have been specifically written to stress computer repair. You perform a hundred experiments, build hundreds of circuits, use professional test equipment. You build and use your own solid-state, transistorized volt-ohmmeter and your own oscilloscope in addition to your digital computer. Because you work with your hands as well as your head, your training is as much *fun* as it is education.

Train at home with the leader

There is so much to tell you about this latest NRI "first" in home training, you must fill out and mail the coupon today. Get the full story of Complete Computer Electronics and the amazing digital computer you build and use as you learn. The free NRI Catalog you receive also tells you about other NRI training plans in Color TV Servicing, Communications, Electronics Technology. There is no obligation. No salesman will call on you. NATIONAL RADIO INSTITUTE, Washington, D.C. 20016.

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JUST THINK HOW MUCH in demand you would be if you could prevent a TV station from going off the air by repairing a transmitter...keep a whole assembly line moving by fixing automated production controls...prevent a bank, an airline, or your government from making serious mistakes by repairing a computer.

Today, whole industries depend on electronics. When breakdowns or emergencies occur, someone has got to move in, take over, and keep things running. That calls for one of a new breed of technicians–The Troubleshooters.

Because they prevent expensive mistakes or delays, they get top pay–and a title to match. At Xerox and Philco, they're called Technical Representatives. At IBM they're Customer Engineers. In radio or TV, they're the Broadcast Engineers.

What do you need to break into the ranks of The Troubleshooters? You might think you need a college diploma, but you don't. What you need is know-how–the kind a good TV service technician has–only lots more.

Think With Your Head, Not Your Hands

The service technician, you see, "thinks with his hands." He learns his trade by taking apart and putting together, and often can only fix things he's already familiar with.

But as one of The Troubleshooters, you may be called upon to service complicated equipment that you've never seen before or *can't* take apart. This means you have to be able to take things apart "in your head." You have to know enough electronics to understand the engineering specs, read the wiring diagrams, and calculate how a circuit should test at any given point.

Now learning all this can be much simpler than you think. In fact, you can master it without setting foot in a classroom and without giving up your job!

AUTO-PROGRAMMED™ Lessons Show You How

For over 30 years, the Cleveland Institute of Electronics has specialized in teaching electronics at home. We've developed special techniques that make learning easy, even if you've had trouble studying before.

For one thing, our AUTO-PROGRAMMED™ lessons build your knowledge as you'd build a brick wall–one brick at a time. Each piece rests securely on the one that came before it.

In addition, our instruction is personal. When your teacher goes over your assignment, no one else competes for his attention. You are the only person in his class. He not only grades your work, he analyzes it to make sure you are thinking correctly. And he returns it the day it's received so that you can read his comments and corrections while everything is fresh in your mind.

Always Up-To-Date

To keep up with the latest developments, our courses are constantly being revised. This year CIE students are getting new lessons in Laser Theory and Application, Microminiaturization, Single Sideband Techniques, Pulse Theory and Application, and Boolean Algebra.

In addition, there is complete material on the latest troubleshooting techniques including Tandem System, Localizing through Bracketing, Equal Likelihood and Half-Split Division, and In-circuit Transistor Checking. There are special lessons on servicing two-way mobile equipment, a lucrative field in which many of our students have set up their own businesses.

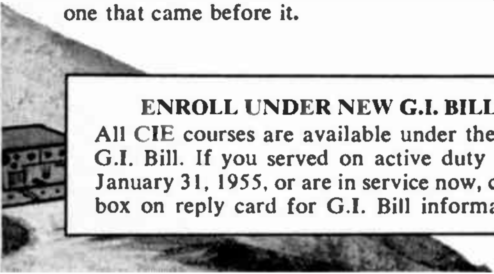
Your FCC License–or Your Money Back!

Two-way mobile work and many other types of troubleshooting call for a Government FCC License, and our training is designed to get it for you. But even if your work doesn't require a license, it's a good idea to get one. Your FCC License will be accepted anywhere as proof of good electronics training.

And no wonder. The licensing exam is so tough that two out of three non-CIE men who take it fail. But CIE training is so effective that 9 out of 10 of our graduates pass. That's why we can offer this warranty with confidence: *If you complete one of our license preparation courses, you'll get your license–or your money back.*

Mail Card for 2 Free Books

Want to know more? Mail the postage-paid reply card bound here. We'll send our 40-page catalog describing our courses and the latest opportunities in Electronics. We'll also send a special book on how to get a Commercial FCC License. Both are free. If the card is missing, just send us your name and address.



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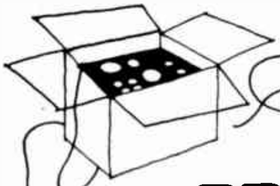
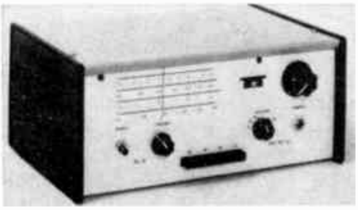


NEW PRODUCTS

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.

LAMBDA POWER SUPPLY KITS—The engineer or experimenter working on a breadboard, pre-production or production model can now build his own ac-dc power supply to avoid hidden flaws, burned-out rectifiers and capacitors, transistors that go into second breakdown, etc. Over 200 pre-designed circuits of commonly required voltage and current combinations are offered "off-the-shelf" by *Lambda Electronics Corp.* Voltage ranges are from 5 to 48 dc, current ranges from 0.25 to 50 A, and regulations from 20% to 0.01%. Circuits range from simple capacitor-choke input filters to IC regulated supplies.

Circle No. 79 on Reader Service Page 15 or 95



TEN-TEC COMMUNICATIONS RECEIVER—Designed primarily for beginners, the *Ten-Tec Inc.* RX10 communications receiver is also priced to make it attractive. The RX10 covers the 80-40-20-15-meter amateur radio bands and employs a "Synchrodyne" circuit for direct conversion which eliminates images and "birdies" usually found in low-priced receivers. Performance is said to meet the requirements of today's crowded band conditions. A built-in oscillator can be used for code practice as well as a side-tone monitor.

Circle No. 80 on Reader Service Page 15 or 95

KNIGHT-KIT DELUXE RHYTHM CONSOLE—Now you can add ten perfect rhythms to your band's sound, or provide a precise percussive accompaniment for backing a soloist with the KG-393 Deluxe Rhythm Console made by *Knight-Kit.* The console is an electronic device that creates the sound of bass drum, snare drum, claves, cowbell, maracas, and high and low bongos with amazing realism through a microphone or instrument amp. At the touch of a button, you can select rhythms for swing, twist, slow rock, rhumbas, mambo, beguine, cha-cha, bossanova, tango, or waltz. You can also control the level and tempo of the beats, and the sound of cymbals can be added.

Circle No. 81 on Reader Service Page 15 or 95

METROLOGIC OPTICS EDUCATION KIT—A low-cost optics education kit, complete with instructions for conducting more than 20 classroom experiments using the unique features of laser light to study physical and geometrical optics has been developed by *Metrologic Instruments, Inc.* What the buyer gets for his investment is an optics workbench, precision adjustable laser mount, ultra-sensitive wide-range photometer, a hologram, diffraction slides, lenses, prisms, and other equipment for setting up experiments. Materials are even provided for Michel-

The sensibly priced tape cassette ...from MALLORY.

Just what you've been waiting for. The new Mallory DURATAPE® Cassette.

You get the quality and performance of expensive tape cassettes at a nice, lots-less price. But not the poor performance or the problems of the special-discount cheapies.

And since they're from Mallory — a company long known for quality electronic products—you can expect high fidelity, smooth operation, and long reliability. And get it . . . every time!

They'll fit any cassette recorder, player, cassette-radio. Even the new cassette changers. And you pick the recording time: 30, 60, 90, 120 minutes.

Our DURATAPE® Cassettes are tough but we put them in unbreakable, easy-to-stack containers just for extra protection. Like in the rain or through the mail.

And we make a head cleaner that's perfect for Cassette Recorders, too.

You'll find this great new thing in sound wherever Mallory products are sold.

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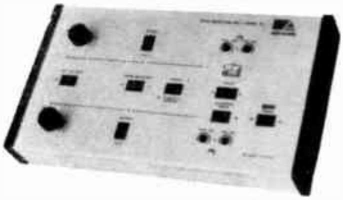
Batteries • Capacitors • Cassette Tapes • Controls • Resistors • Semiconductors • Sonalert® • Switches • Timers • Vibrators

CIRCLE NO. 9 ON READER SERVICE PAGE

son interferometer experiments. Also included in the kit is a loose-leaf manual that outlines the teacher-written experiments. Lasers are not supplied with the kit but are available as separate options.

Circle No. 82 on Reoder Service Poge 15 or 95



ADVOCATE NOISE REDUCTION UNIT—A tape recording control center employing the patented Dolby Audio Noise Reduction System is being marketed by *Advocate Products* as their Model 101 Noise Reduction Unit. When connected to a good-quality home tape recorder, the 101 dramatically reduces the hiss inherent in the tape recording process—without in any way changing the musical integrity of the signal being recorded. The Noise Reduction Unit accomplishes the same noise reduction regardless of the brand or type of tape deck and tape with which it is used, and it can be used on all good tape decks except those with non-defeatable automatic record level controls. When used with a good tape recorder, the Model 101 reduces high-frequency noise by 10 dB, or 90 percent.

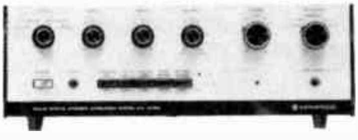
Circle No. 83 on Reader Service Poge 15 or 95

CONCORD COMBINATION TAPE RECORDER—Containing its own built-in amplifier and stereo speakers, the *Concord Electronics Corp.* Mark 8 is a versatile reel-to-reel and eight-track cartridge record/playback system by itself. The unique feature of the system is the ease with which it makes possible the duplication of eight-track cartridges from original or prerecorded 7" open-reel recordings; no external connections are required. The whole process is accomplished simply by pushing a single button. The Mark 8 is said to contain all the features of a professional tape recorder, and in the eight-track cartridge section is an automatic stop with an indicator light.

Circle No. 84 on Reoder Service Poge 15 or 95

JERROLD ALL-CHANNEL SIGNAL SPLITTER—For the more-than-one-receiver family, *Jerrold Electronics Corp.* has a Model FS-1314-FM color-rated VHF/UHF/FM 300-ohm signal splitter that allows you to use a single antenna to feed two color or monochrome TV, two mono or stereo FM, or one of each receiver. The splitter, when connected to the lead-in from any all-channel antenna, produces separate, non-interacting output signals without mismatching the system.

Circle No. 85 on Reoder Service Poge 15 or 95

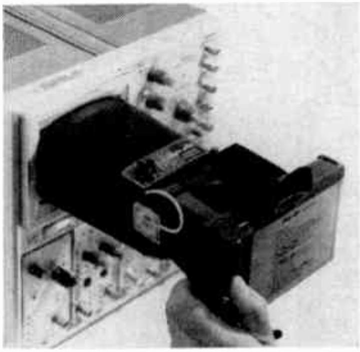


KENWOOD INTEGRATED STEREO AMPLIFIER—True-blue audiophiles who feel that each component should stand on its own merit will be attracted to the *Kenwood Electronics, Inc.,* KA-4002 solid-state integrated amplifier. This amplifier has the "look" of expensive equipment with its attractive controls and push button function switches, but it sells for a price in the modest well-under-$150 range. All silicon transistor circuit design provides the KA-4002 with a 95-watt output and a frequency response of 20-40,000 Hz ±1.5 dB. Power bandwidth is 18-30,000 Hz (IHF) and harmonic and IM distortion are less than 0.5%.

Circle No. 86 on Reoder Service Page 15 or 95

E. F. JOHNSON "ANTENNA MATE"—A combination antenna tuner and SWR meter which contains everything needed to measure and correct antenna line mismatches is *E.F. Johnson Company*'s newest CB accessory. Called the "Antenna Mate," it can correct antenna line SWR's of up to 5:1 to less than 1.1:1. A built-in meter indicates the standing wave ratio from 1:1 to 10:1 as well as relative power output from a CB rig. By correcting antenna mismatches the Antenna Mate is said to improve receiver performance as well as provide maximum transmitted signal to the antenna.

Circle No. 87 on Reader Service Page 15 or 95



INTEGRATED CONTROLS SCOPE CAMERA SET—Capable of fitting 3"-5" round or rectangular oscilloscope CRT faces, the *Integrated Controls, Inc.*, low-cost Model SCO1 "Scope-Mate" camera set can capture and record one-shot or recurring trace pattern data on film. The set utilizes a standard Polaroid Colorpack II or III camera in conjunction with the Scope-Mate hood to give high-quality, high-contrast monochrome waveform photos in just 15 seconds. The object-to-image ratio is 1:1.

Circle No. 88 on Reader Service Page 15 or 95

ALPHA TONE-CODED SQUELCH FOR CB—The AM Citizen's Band user can now enjoy the same quiet operation in his system as does the commercial FM user by employing a new tone-coded squelch device available from *Alpha Electronic Services Inc.* Called the TEN-10 "Silencer," the squelch device is an all-solid-state subaudible continuous tone generating system that automatically selects mobile or base stations only in your own system or group, while eliminating noisy interference from all other rigs using your channel. The TEN-10 can be quickly deactivated for full-channel monitoring with the flip of a switch.

Circle No. 89 on Reader Service Page 15 or 95

MARANTZ STEREO FM RECEIVER—Billed as the "finest piece of stereo equipment in the world," and tagged with a $1000 list price, the *Marantz Co., Inc.*, Model 19 receiver is obviously designed to appeal to the no-price-too-great audiophile. Familiar items to look for on the Model 19 are a gyro-touch control and a built-in oscilloscope which work together to provide extremely accurate tuning capability. An exceptionally sophisticated multiplex circuit in the receiver is said to provide an unprecedented stereo separation in excess of 45 dB at 1000 Hz and in excess of 30 dB at 15,000 Hz. Butterworth filters in the i-f section reduce distortion and maintain better high-frequency stereo separation.

Circle No. 90 on Reader Service Page 15 or 95

INGENUICS ENVIRON MICROPHONE—A new microphone, "Environ," made by *Ingenuics, Inc.*, has a pair of dynamic cartridges coupled through a distance discriminating network in the housing. Controlled by a switch on the microphone, it will pick up either near and far sounds or only those originating a few inches away while noise more than 3 feet away is rejected. Frequency response is from 40 Hz to 15 kHz and output impedance is either 250 or 50,000 ohms.

Circle No. 91 on Reader Service Page 15 or 95

Now it costs less to own the best VOM you need.

The New RCA WV-510A Solid-State Master VoltOhmyst®

*Inexpensive Quality
†Optional Distributor· Resale Price

RCA

The best you need is the new solid-state RCA WV-510A Master VoltOhmyst®. The most functional VOM we've ever produced, the 510A has all the features you'll ever need no matter what your requirements may be.

And we've added some extra features you won't find in any competitive VOM, at any price...features designed to make your work easier, help you get the job done faster.

For example: RCA WV-510A operates from batteries or AC. Remove the detachable AC line cord while you're taking a measurement and the batteries take over immediately without a flicker of the pointer. And you'll get maximum life from the batteries because they're always on trickle charge during AC operation. Stability? Switch from range to range and watch a whole series of measurements without constantly zero-adjusting the meter.

Some statistics:

Current:
  0.01 milliampere to 1.5 amperes in 8 ranges.

Resistance:
  0.02 ohm to 1000 megohms in 7 ranges.

DC Volts:
  0.01 volt to 500 volts in 8 ranges.

AC Volts:
  0.2 to 1500 rms AC volts in 7 ranges plus peak-to-peak voltages of complex waveforms.
  21 megohm resistance on all DC ranges.

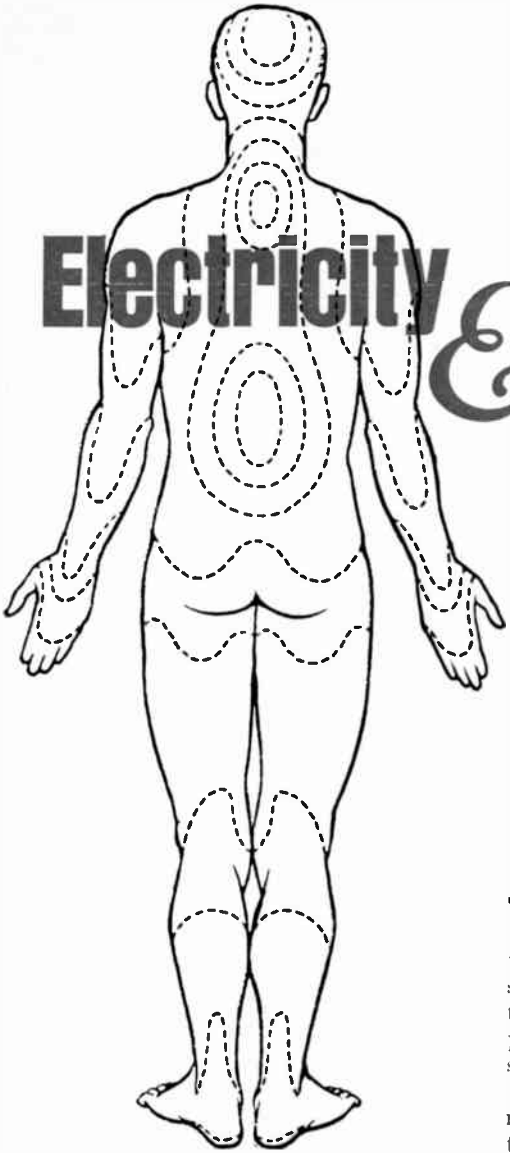
And it's only $128,† complete with DC/AC ohms probe and flexible shielded input cable with BNC connector, and removable AC line cord.
Some statistics! For complete details, contact your local RCA Distributor.

RCA|Electronic Components|Harrison, N. J. 07029

CIRCLE NO. 15 ON READER SERVICE PAGE

BY WEBB GARRISON

Electricity & Physiology



From Quackery to Speculation to Programmed People

This is a state-of-the-art report on the progress being made to unravel the relationships of all the electrical systems in the human body. Some aspects of this research—such as the so-called brain waves—are highly developed, but other areas are just being investigated—for the first time—by reputable scientists. This is the first of a new series on electricity as viewed in 1971 to be published in POPULAR ELECTRONICS.

THIRTY OR FORTY years ago, few scientists who valued their reputations dabbled with far-out uses of electricity. Before the scientific viewpoint (which requires results that can be repeated) took hold, dabblers in physics and chemistry and medicine had all sorts of odd-ball notions about electricity.

So many different kinds of electrical treatments and cures were tried by eager amateurs and outright quacks that for 125 years after the death of Franz Mesmer in 1815, all ideas about electricity in the human body were suspect.

Within the past few months, Dr. Robert O. Becker, Chief of Staff for Research at the Veterans Administration Hospital, Syracuse, New York has predicted that within 20-30 years it will be possible to grow new parts of the human body to replace those lost as a result of injury or surgery by means of electricity! (The diagram of the body above, developed by Dr. Becker, shows what are known as the slow dc systems in the body.)

Animal studies already under way have produced startling results. By stimulating cells with minute electrical charges, Dr. Becker and his colleagues have caused these cells to produce masses of blastocytes—the initial building blocks of the human body.

Controlled growth of human tissue and bone, including limb regeneration, might prove far more fruitful than transplantation of organs.

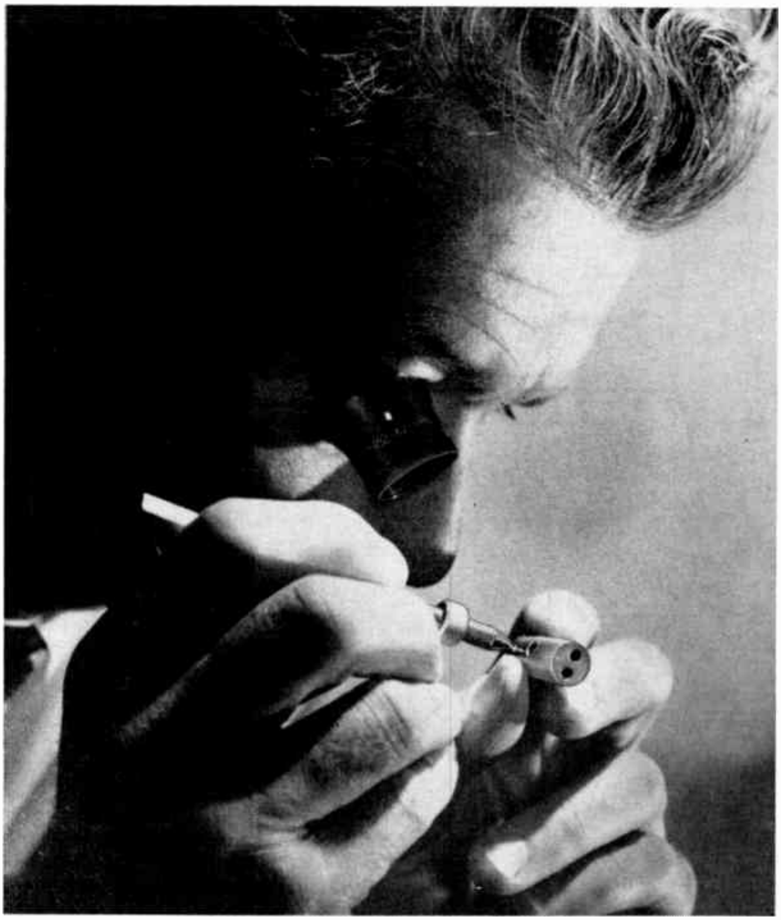
Hints that electricity could be the force behind regeneration of bodily parts was first noticed in the mid-1940's. That's when repeated trauma brought about regeneration of a limb in an adult frog. A localized electrical field—produced by trauma—acted on target cells in such a fashion that the cells were stimulated to form blastocytes which developed into a new limb.

Some creatures—notably salamanders—naturally regenerate lost parts. All known mammals do not. Dr. Becker thinks that the evolutionary processes have concentrated electrical activity in the brain and central nervous system and that mammals now lack the ability to produce electricity vital to the regeneration of bodily parts. All the necessary cells are there, but the required energy is not.

Although some fellow scientists scoff at Dr. Becker's ideas, there is a surge of fresh interest in bioelectricity and biomagnetism.

Basic To Life. Wherever there is life, you will find electricity. The electrical effects are as pervasive and essential as chemical reactions once thought to hold all answers to all riddles about the organization and operation of living things.

The minute bones of your inner ear respond to every change of position with respect to gravity and send tiny pulses of electrical current to somehow inform the brain about every



Dr. James Zimmerman adjusts his Superconducting Quantum Interference Device (SQUID) a transducer he invented to monitor electrical activity in the body. It permits external monitoring by means of the measurable fields. (NBS photograph.)

change in your orientation. Your eyes not only require electricity; they are so incredibly sensitive that hardly anything was known about electrical currents in the eyes until sophisticated electronic measuring devices were developed in the past decade.

As your eyes trace this line of type, you trigger reactions that can be measured in terms of the evoked potentials at your scalp. A brain wave monitor—already operational—can feed these electrical signals into a computer that has been programmed to determine what color you are seeing at the moment.

The electroencephalogram (EEG), or tracing of brain waves, has been in use since the 1930's. Measuring devices for EEG are still in the process of refinement, primarily because we are dealing with very low frequencies (0.5-50 Hz) and minute voltages (0.401-0.402 volts).

Today, measurement of brain waves is just a start towards full-scale electrical analysis of what goes on inside your head and body. Electrocardiographic (EKG) tracings reveal some of the things happening in the heart. Skin galvanometers record changes in potential at the surface of your body. Other instruments provide a record of eye movements—including duration and intensity of dreams. Electromyograms depict velocity and intensity of muscular contractions.

Varied Processes. Your body is a beehive of electrical activity and has built-in generators, transmission systems, receptors, and even biological rheostats. There is growing evidence that the body has a reasonably well defined dc system for transmission of "large" amounts of current. However, most electrical activity takes place at the level of the individual cell.

At the Institute for Enzyme Research of the University of Wisconsin, Dr. David E. Green has been studying the mechanism by which charged particles, or ions, are transported across cell membranes by donut-shaped carriers, or ionophores. These potassium or sodium ions are retained by an electro-chemical potential gradient; when the membranes are de-energized, the ions are released. Viewed under the electron microscope, physical changes in the membranes are clearly visible.

Enzymes serve as catalytic agents to speed up chemical reactions without themselves being affected. No one knows for sure how many different enzymes your body includes, but an educated guess places the number at about 10,000. Until 1970, no one knew why enzymes function, but at the University of California in Berkley, Dr. Daniel E. Koshland, Jr. has shown that enzyme activity is electrical.

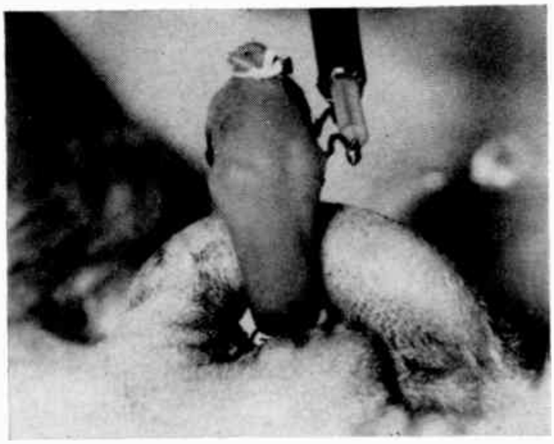
The German "Dormed" electro-therapeutic sleep inducer is not available in the USA. It generates 12-to-200-Hz square waves (15 V at 3 mA) which are applied to the patient's temples and forehead. (Photo courtesy the Robert Bosch Corporation.)

It now appears that every enzyme in your body is a mini-micro electronic pilot. At the atomic level it maneuvers "orbital steering" of components and hastens their combination. This catalytic process of nature may be as much as 1,000,000 times as fast as catalytic processes employed in industry. Each enzyme is specific for a particular set of atoms.

Deprive your body of enzymes that guide the atoms together, of cell membranes that are self-adjusting to permit two-way flow of charge particles, or the electrical pulses that keep your heart working and you'd be like an elaborate machine with the power switches pulled open.

To Cure and to Kill. Luigi Galvani discovered that electric current can cause the muscles of a dead frog to twitch. This pioneer finding, made in 1791, established a rough relationship between electricity and magnetism and self-styled healers had a field day using magnets to "draw illness from the body." Quacks devised a variety of instruments guaranteed to cure anything from gout to consumption. This movement reached a peak in the era when Mesmer developed the art first called mesmerism and later hypnosis.

Because so many phonies and rogues dabbled with electricity and magnetism in futile



To achieve an "electrical" coupling, Dr. S. R. Topaz perfected a skin tunnel transformer that eliminates chance of irritation and infection. The coaxial cable (note size) feeds in energy and it also permits data to be readout.

The National Research Council of Canada is investigating the electrical impulses that activate the leg musculature when walking. Data is computer programmed.

efforts to work miraculous cures, reputable scientists turned their backs on all attempts to use these forces in healing.*

Rival of Drugs. Properly applied, electricity will do some things better than any known drug or chemical. This fast growing rival is at the interface where biology, chemistry and electronics intermingle.

Electroconvulsive shock (ECS) has been used in the treatment of psychiatric disorders. ECS works with many patients—but not with all. The amnesia-producing effects of ECS are difficult to produce in some patients. Just why ECS works at all is not wholly understood, but most theories suggest that taking just the right amount of current and applying it in the proper fashion at the right time interferes with the consolidation of "memory traces."

European psychiatrists and others have been experimenting with electrosleep therapy and reporting good results. In the United States the medical profession apparently believes that investigation into possible side effects on nerve centers, pituitary glands, and enzymatic systems through the introduction of an electrical current into the brain has not gone far enough.

At the University of Texas Medical School, Dr. Saul H. Rosenthal and colleagues have announced some astonishing results from low-intensity electrostimulation of the brain. Tested on a group of insomnia sufferers, there appear to be no side effects; and although sleep was not induced, the patients relaxed and then slept better at night.

Individual treatments usually last for half an hour. The equipment used by Dr. Rosenthal produces a squarewave of one millisecond's duration at a rate of 100 Hz. The current yield is less than 1.2 mA. The report indicates that after as few as two or three treatments, some habitual users of sleeping drugs have found themselves able to go to sleep without barbituates.

It is now considered possible that electroanesthesia may become an important adjunct to the battery of chemical compounds now used in operating rooms to shield patients from the pain of the surgeon's scalpel. Tests made by anesthesiologists from the Indian Army suggest that sine waves between 1200-1500 Hz help maintain a surgically satisfactory state of anesthesia for operations ranging from simple tonsillectomies to complicated internal surgery. But here too, many U.S. physicians brush away reports of electroanesthesia as pure unadulterated nonsense.

Electrical Stimulation. Although electrosleep and electroanesthesia are frowned upon in the U.S., it is an entirely different

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*Strangely enough, the electricity applied to the human body found its first significant triumph in the taking of a life. William Kemmler, convicted of murder, was sentenced to death by means of electrocution. Publicity about the impending execution attracted rival bids for the job of making the first "electric" chair. In the competition, a plan involving use of ac won out over Thomas Edison's dc system. Edison had insisted that ac was too dangerous for use in the ordinary American household. But when Kemmler was hit by 1700 volts on August 6, 1890, he began to revive a few moments after having been pronounced dead. After two more lengthy shocks—while one reporter fainted—the killer succumbed. When the public got over its indignation at so barbaric a manner of execution, opinion swung toward the use of ac for home use!

ball game in the case of electrical stimulation of both muscles and brain cells.

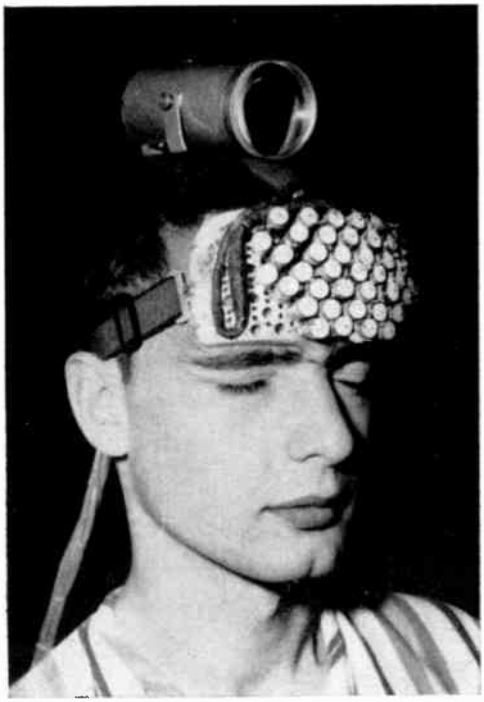
Implanted peripheral nerve stimulators have already proved highly effective. Using these devices, therapists seek to put into the body electricity needed for particular functions and usually provided for biologically under normal circumstances.

Most persons who have received peripheral implants are victims of strokes, cerebral palsy, or similar disabilities. A few have even suffered spinal cord injuries. Electricity fed into the body is used to stimulate peripheral nerves so that muscles will contract at appropriate times.

The complexity of "normal activities" is incredible as indicated by work in progress at various Canadian research centers. One such program is attempting to analyze precisely the characteristics and timing of the human gait. It is hoped that a computer-programmed input system will eventually enable paralyzed persons to walk by synchronized stimulation of the nerves involved.

Experiments involving electrical stimulation of the brain (ESB) have been in progress for several decades. Use of miniaturized radio receivers have given patients complete mobility. In addition, Dr. Steven R. Topaz and colleagues have developed a "skin tunnel" transformer that permits efficient coupling, but eliminates the problem of irritation and infection. Once a skin tunnel transformer has been implanted, it can be used to transmit energy into the body and simultaneously permit readout of telemetry data regarding the electrical processes within the patient's body.

Respiratory rate, heartbeat, gastric secretions, and many other bodily functions can be absolutely controlled by ESB.



Sight is replaced by touch in the "Elektroftalm" recently developed in Poland. Image is scanned by photoelectric camera atop blind patient's head and "displayed" on forehead. Vision is rudimentary.

Electronic Vision. A crude, but functional method of electronic vision for the blind is the most ambitious and elaborate project presently involving the use of electricity applied to the body from the outside.

At the University of London, a self-taught expert in electronics has constructed an elaborate implant consisting of 80 individual radio receivers wrapped in silicone and placed under the scalp of a blind nurse. Radio signals activate the implanted receivers—singly or in groups—causing corresponding electrode stimulators to feed minute voltages to the surface of the nurse's brain. It has been demonstrated by Dr. Giles S. Brindley that this system creates the impression of perceived light. Eventually, Dr. Brindley hopes to give patients an elementary electronic vision, in which all of the optical systems used in normal vision are bypassed.

Polish researchers have taken a different path. Sight is replaced by touch, a usually highly sensitive effect in blind people. Developed by Dr. Witold Starkiewicz and Wiktor Kuprianowicz the device uses a camera, photocells and a system of 60 tiny stimulators. Objects seen through the camera are scanned and displayed on the patient's skin.

All researchers working in the area of electronic vision report that the blind will "see" within two decades. In all probability, one or more of several highly sophisticated systems will give functional sight to most blind people.

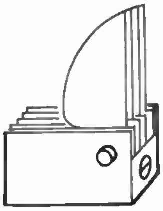
From the cardiac pacemaker to nerve stimulators, electricity is the key to much of tomorrow's medicine. However, is it not also possible that, by the use of implanted electrodes, some future super-dictator will make electronic slaves of the human race? Instrumentation for such a system is practically within our grasp. Only time will tell whether the wonders of electricity will be used to liberate man from his handicaps or to create nightmares of the future. -30-

What Do You Know About Capacitors?

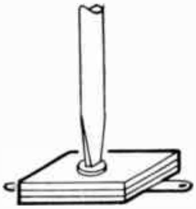
BY ROBERT P. BALIN

For the designer or builder of electronic circuits, capacitors can sometimes be the most baffling part of the project since they come in various shapes and sizes and perform many different functions. Test your "capacitance" by filling in the blanks below.

(Answers are on page 96)

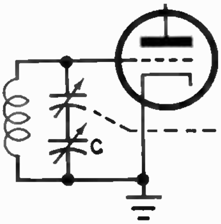


1. When a tuning capacitor in a receiver is wide open, is the receiver tuned to the low ___ or high ___ end of the band?

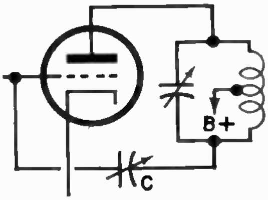


2. Does tightening the adjusting screw on a compression-type capacitor increase ___ or decrease ___ its capacitance?

What is the function of the capacitor, C, in each of the circuits shown below?



3. ________



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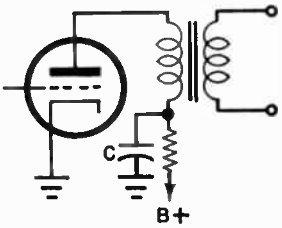
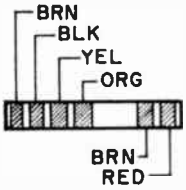
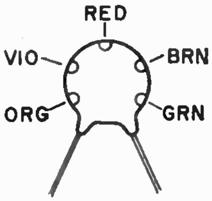


5. ________

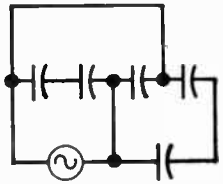


6. What does the color code on this molded tubular paper capacitor indicate about its value ___, tolerance ___, and voltage rating ___?

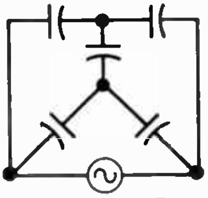


7. What are the value ___, tolerance ___, and temperature coefficient ___ of this ceramic disc capacitor as indicated by the color coding?

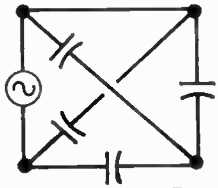
What is the total equivalent capacitance for each of the circuits shown here if all capacitors are identical and rated at 6 pF?



8. ______ pF



9. ______ pF



10. ______ pF

BUILD A TIME BASE CALIBRATOR

CLEAN SQUARE WAVES FROM 1 HZ TO 1 MHZ

This is a laboratory-style electronic construction project that would have been impossible to build without integrated circuits. With IC's, it becomes relatively simple and easy to duplicate. Uses for this project are deceptively varied and range from research to short-wave listening.

A SQUARE WAVE of known frequency is one of the most useful waveforms that the serious electronics experimenter, audiophile, or engineer can have in his workshop. It can be used to check out audio systems, align probes and check attenuators of oscilloscopes. When it is differentiated, a square wave can be used to generate accurate time markers on a scope trace for making precise measurements. It can also be used to keep tabs on the accuracy of a triggered sweep scope. In experimenting with logic circuits, a square wave makes an ideal trigger.

The time base, square-wave generator or calibrator described here is crystal controlled and can deliver any of 13 selected timing periods from 1 microsecond to 1 second. Other specifications are given in the Table.

Theory of Circuit Design. The circuit of the calibrator is shown in Fig. 1. Field-effect transistor *Q1*, with *XTAL1* and other components, forms a 1000-kHz oscillator. The signal generated at the junction of *L1* and *R2* feeds a shaper (*Q2*) which is biased to operate in the saturation region. The shaper provides the necessary square-edged signal for driving the DTL (diode-transistor logic) frequency divider chain.

The divider chain, consisting of 12 dual-JK flip-flops, is arranged to divide in a series of 2 and 5. The basic logic circuit for such division is shown in Fig. 2, which is similar to the actual division using the IC's.

The output of each divider is fed to one position of a 13-position rotary switch (*S1*). The selected signal from the switch is coupled to an output buffer (*Q3*), which also operates in the saturation region. The output is split by *R5* and *R6* to provide an output termination of 50 ohms.

Construction. Because of the high fre-

COVER STORY BY RICHARD J. VALENTINE

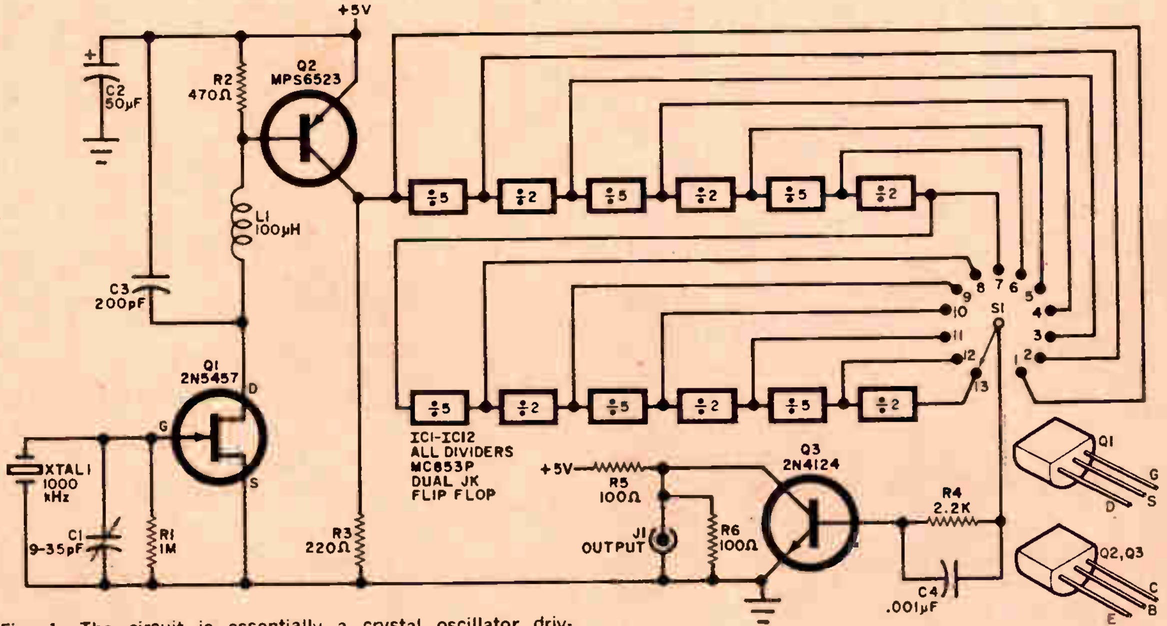


Fig. 1. The circuit is essentially a crystal oscillator driving a shaper circuit, fed to a string of digital dividers. If desired, other frequencies can be obtained either by changing the crystal frequency, the divider chain arrangement, or both.

S1 POSITIONS

1— µS, 1 MHz
2—5 µS, 200 kHz
3—10 µS, 100 kHz
4—50 µS, 20 kHz
5—100 µS, 10 kHz
6—500 µS, 2 kHz
7—1 mS, 1 kHz
8—5 mS, 200 Hz
9—10 mS, 100 Hz
10—50 mS, 20 Hz
11—.1 S, 10 Hz
12—.5 S, 2 Hz
13—1 S, 1 Hz

PARTS LIST CALIBRATOR

C1—9-35-pF miniature trimmer capacitor
C2—50-µF, 6-volt electrolytic capacitor
C3—200-pF disc capacitor
C4—0.001-µF disc capacitor
IC1—IC12—Dual JK flip-flop (Motorola MC853P)
J1—BNC jack and mating plug
L1—100-µH molded choke
Q1—2N5457 transistor
Q2—MPS6523 or HEP57 transistor
Q3—2N4124 or HEP53 transistor
R1—1-megohm
R2—470-ohm
R3—220-ohm
R4—2200-ohm
R5,R6—100-ohm
} all resistors ¼-watt
S1—13-pole rotary switch
XTAL1—1000-kHz crystal
Misc.—Suitable chassis, knob, stand-offs, wire, solder, etc.

quencies involved, the use of a printed circuit board is recommended. An actual size foil pattern and component installation diagram are shown in Fig. 3.

The power requirements are 5 volts dc at about 220 mA, which can be obtained either from a power supply such as that shown in Fig. 4 or, for a portable unit, from three D cells connected in series. If you build the ac supply, use a 2 sq in. heat sink for *Q1*.

The completed PC board and power supply can be mounted in any type of metal chassis, with the power switch, frequency selector switch and output jack on the front panel.

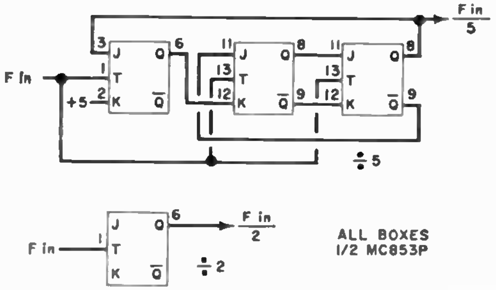
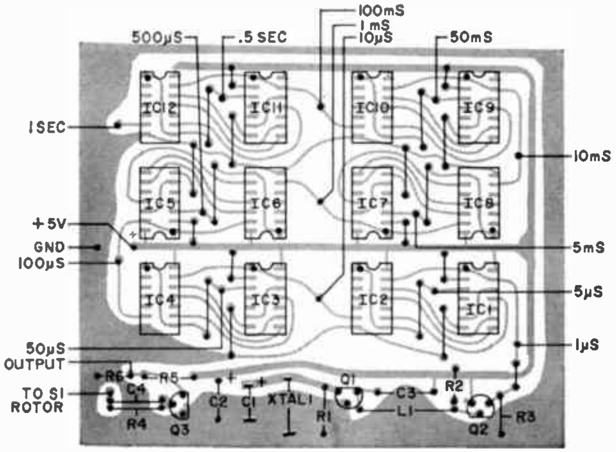
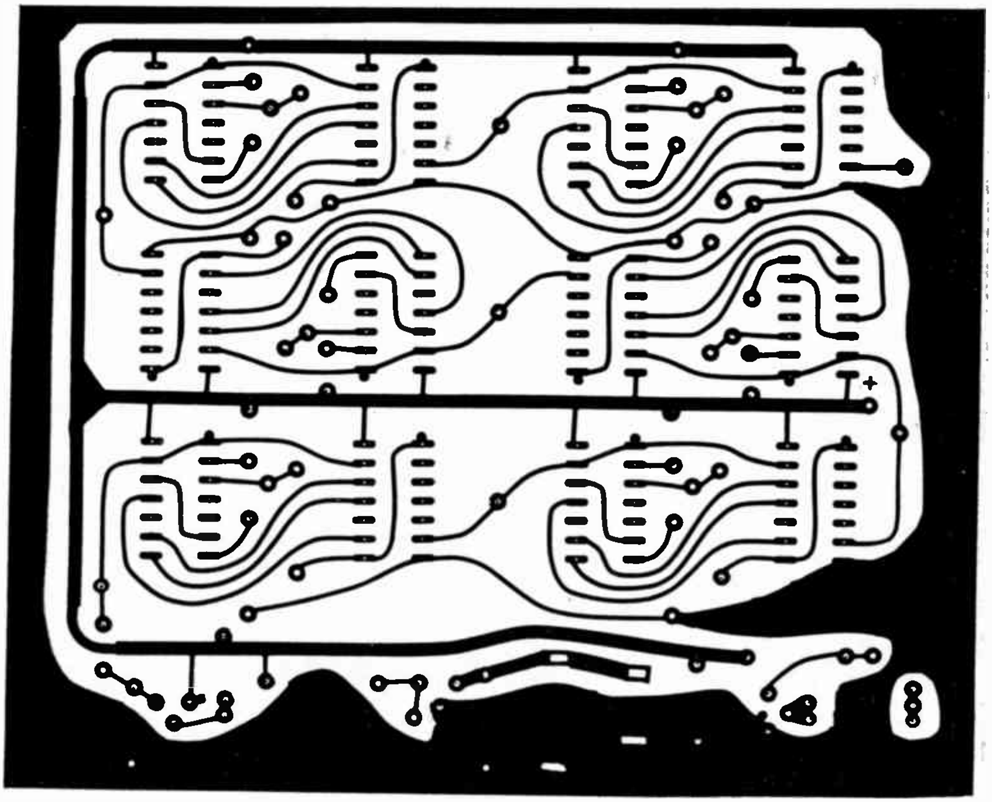
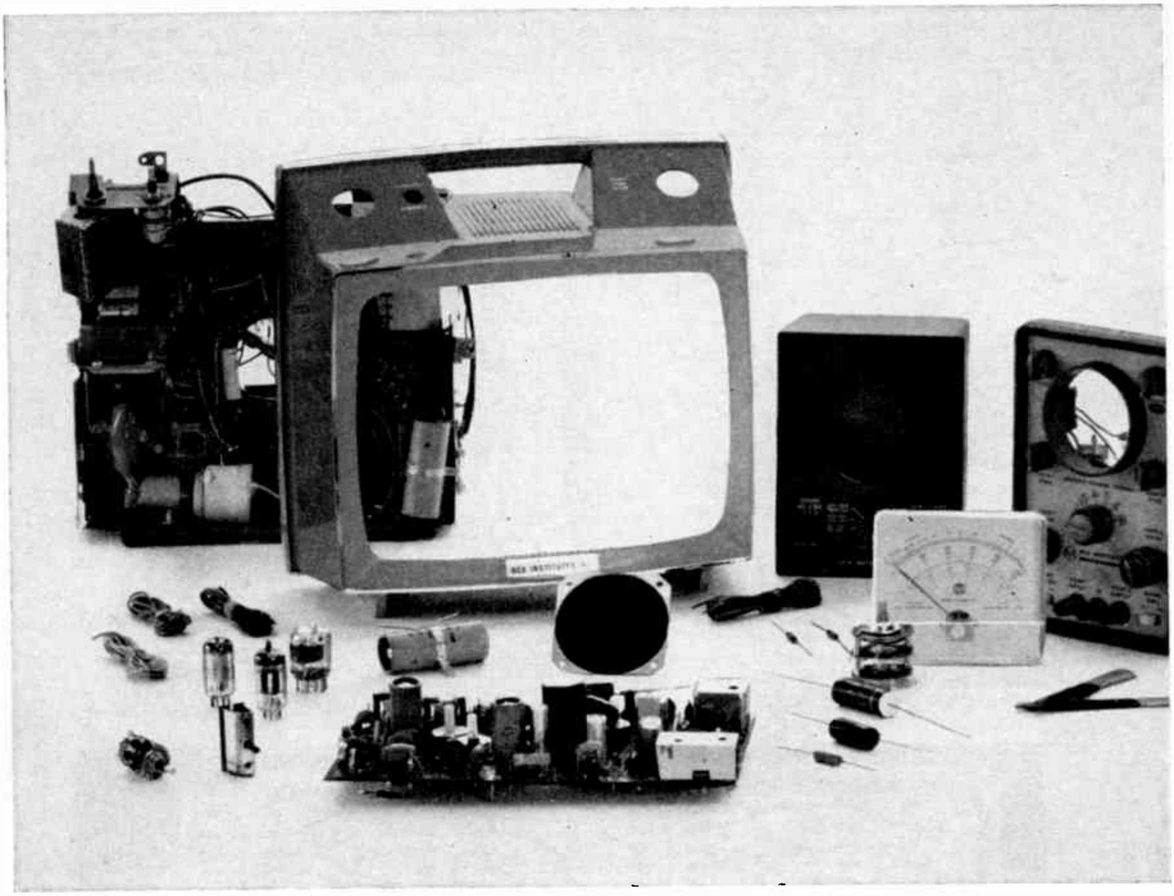


Fig. 2. Minimum hardware divide-by-5 and divide-by-2 circuits used in the calibrator. Because each IC contains a pair of JK flip-flops, a pair of IC's contains the two divide circuits shown at the left.

Fig. 3. The actual size PC board foil pattern shown below simplifies the wiring of the calibrator. Once fabricated, the components are installed as shown at the right. Observe the coding of all components, and make sure that all jumpers are placed properly. Due to the delicacy of this PC pattern all of the drill holes for installing the IC's may not show in this reproduction. Drill holes in each of the 14 contact points for all 12 IC's.







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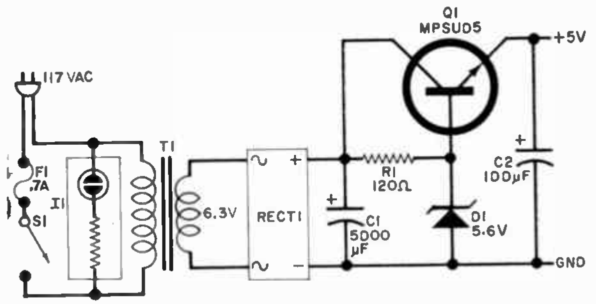


Fig. 4. This regulated power supply can easily handle the calibrator. If you want portability, use three 1½-volt D cells in series for the power supply. The slightly reduced voltage will not affect operation.

PARTS LIST POWER SUPPLY

C1—5000-μF, 10-volt electrolytic capacitor
C2—100-μF, 6-volt electrolytic capacitor
D1—1N5232 diode
F1—0.7A fuse and holder
I1—120-volt neon lamp indicator assembly
Q1—MPSU05 transistor
R1—120-ohm, ½-watt resistor
RECT1—MDA920-1 or HEP175 25-volt, 1A bridge
S1—Spst switch
T1—Filament transformer, secondary 6.3 volts at 600 mA
Misc.—optional power-on indicator, heat sink, terminal strip, mounting hardware, line cord, grommet, etc.

Operation. To calibrate the generator accurately, put *S1* in the 1 MHz position and connect a short length of wire to the output jack. With the wire and the calibrator near a shortwave receiver tuned to WWV (5, 10, or 15 MHz), adjust capacitor *C1* to obtain a zerobeat between the generator and WWV. If you have a frequency meter, adjust *C1* to obtain an exact 1-MHz indication on the meter. However, if you have neither a WWV receiver nor a frequency meter, the inherent accuracy of the 1-MHz crystal will be sufficient for most purposes.

In using the calibrator, the output connection should be made through a 50-ohm coaxial cable terminated in a 50-ohm load.

Spiker. If you need a sharp spike signal of known frequency, use the circuit shown in Fig. 5 to develop the required signal. The input impedance is 50 ohms; the output is 1000 ohms. The switch is used to select the proper capacitor for each group of frequencies.

Applications. Although primarily designed for the calibration of oscilloscopes with triggered sweeps, this square-wave generator and spiker combination has a number of other important laboratory and experimental applications.

First, the generator makes an excellent frequency calibrator for use with general purpose shortwave receivers. For this application,

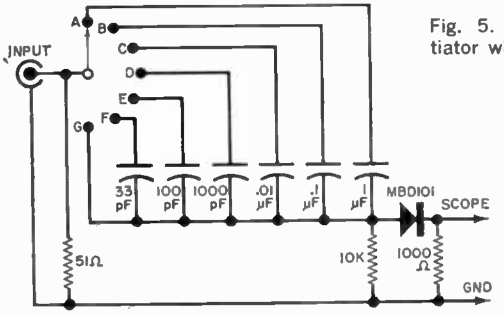


Fig. 5. The spiker is essentially a differentiator whose series capacitor can be selected.

SWITCH POSITIONS

A—1 S-50 mS
B—10 mS-5 mS
C—1 mS-500 μS
D—100 μS-50 μS
E—10-μS-5 μS
F—1 μS
G—direct

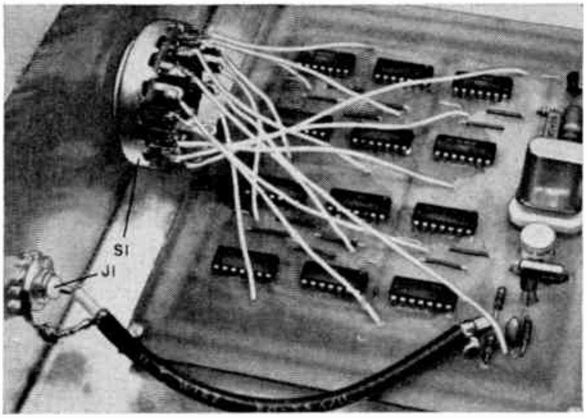
TECHNICAL SPECIFICATIONS

Rise and fall times: 25 nanoseconds
Time period: 13 selectable times in 1 and 5 steps from 1 μs to 1 second
Accuracy: 0.005%
Amplitude (output): 1 volt into 50 ohms
DC offset: less than 0.3 volt
Noise and ripple: 20 mV
Power required: 5 volts at 220 mA

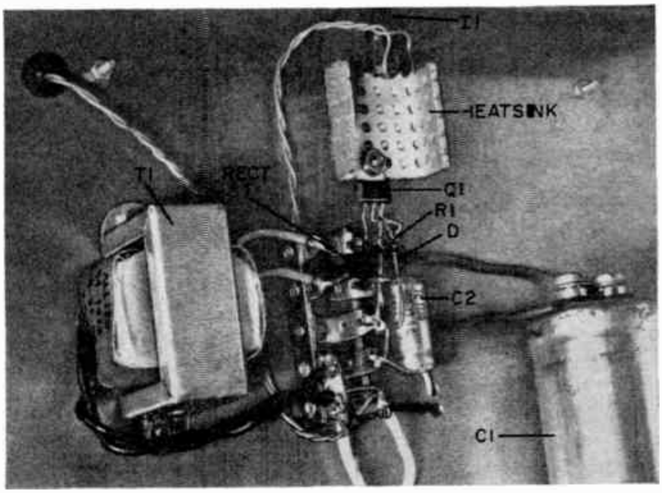
connect the spiker to the generator and attach a short antenna to the spiker output. Set the front panel switch to 1 MHz (1 μS). This will produce a train of "birdies," 1 MHz apart. With the receiver tuned to WWV on 5, 10, or 15 MHz, the crystal oscillator in the generator can be trimmed to the exact frequency. Use other dial positions and the calibrator will generate the frequencies shown in Fig. 1. Suitable selection of frequencies will permit a very accurate determination of the frequency of an incoming signal.

Due to the fact that the square waves generated have very rapid rise and fall times, they can be used as a source of pulses for triggering many types of IC logic, especially RTL, where steep edges are required. Having complete control of the output frequency means that the logic can be triggered at almost any desired rate.

The square waves are also ideal for testing amplifiers—from conventional audio to broad-bandwidth video. High- and low-frequency response, as well as ringing, can be detected when using the square-wave generator in conjunction with a wideband scope. Simply driving the amplifier under test with a square wave of suitable frequency and observing the changes (if any) that the amplifier produces on the square wave will show the characteristics of the amplifier. For example, to provide a clean square-wave output, the amplifier response must be from about 1/10 to 10 times the fundamental frequency of the square wave. Thus, if an amplifier can cleanly reproduce a 10-kHz waveform, then its response is good from about 1 kHz (usually much lower) to about 100 kHz. —30—



The connections from the PC board to the selector switch should be made as short as possible. A short length of coaxial cable serves as the output lead.



Use a 2-square-inch piece of scrap aluminum as the heat sink for Q1. Isolate the heat sink from the chassis using an insulated spacer.

BUILD A CRYPTO-LOCK

ELECTRONIC SECURITY: SMALL IN SIZE AND BURGLAR PROOF

This unusual electronically activated lock is the simplest—yet one of the most difficult to "break"—circuits examined by the Editors in the past few months. Its simplicity is deceptive and we urge anyone having a use for such a device to peruse this article carefully.

THERE ARE almost as many varieties of electronic combination locks as there are combinations to operate them. Most are complex pieces of solid-state wizardry—often employing dozens of costly components in elaborate circuits to provide burglar-proof "one-chance-in-1,774,385" combinations.

By contrast, the "Cryptolock" is a simple device, that is inexpensive, easy to build, and small enough to give you electronic lock protection on such things as medicine cabinets, power tool chests, gun racks, desks, and even strong boxes. Or you can use it to safeguard the doors of your home and garage as safely as the best mechanical lock.

The Cryptolock's three-digit combination is deceptive. Numerical grouping, two timing circuits and a penalty feature make "cracking" it a difficult task. Yet, when one knows the combination, it can be opened in less than two seconds. The Cryptolock can be powered by batteries or by a low-voltage dc power supply. Thus it is suitable for both fixed and portable installations.

On the "key" panel for the Cryptolock are six miniature, momentary-contact, pushbutton switches—each identified by number. The switches are connected to the electronic circuit, which is housed in a small, molded-plastic box mounted inside the area to be protected.

The combination of the unit shown in Fig. 1 is 1/5-4. This means that, to open the lock, switches 1 and 5 must be pressed simultaneously, followed immediately by the pressing of switch 4. Most people find that it is quite easy to press the two initial switches at the same time with their index and middle fingers. Since these two switches are wired in series, they must be closed at the same time for a fraction of a second in order to enter the first part of the combination. Then when the 4 switch is pressed, the solenoid on the lock is energized.

That seems pretty simple, but there is a catch. After the first two numbers are pressed, you have only about one and one-half seconds to press the third. After that time,

BY JAMES G. BUSSE

nothing happens when the third number is pressed. It is then necessary to start over with the first two numbers. This two-digit/one-digit combination is enough to confuse most would-be "safe-crackers" who expect to try no end of one-number-at-a-time combinations. That's not the end of the thief's problems, however. If, at any time after he has chanced to press 1 and 5 simultaneously, he chances to press 2, 3, or 6, the lock is automatically deactivated for about 25 seconds. Until the circuit comes to life again, even the correct combination won't open it. What's more, if 2, 3, or 6 is pressed again during this period, the waiting time is extended to the full 25 seconds. The fact that there is no way to tell when he has deactivated the circuit by pressing the wrong number is enough to discourage even the most persistent burglar.

Of course, the combination of the Cryptolock can be changed to any two-digit/one-digit code in a matter of minutes with a soldering iron. It can also be made more complicated by adding four or more switches in parallel with the penalty switches (2, 3, and 6). The combination—while sufficiently complex to foil most attempts to open it illegally—is still simple enough for a child to remember and use.

Construction. Using the circuit shown in Fig. 1, the prototype was built in a 2⅛" × 3¼" × 1⅛" molded plastic box. This makes the unit as small as possible for use in a limited space. However, a larger enclosure can be used. The circuit can be located some distance away from the key panel and the solenoid latching mechanism. The components were mounted on perf-

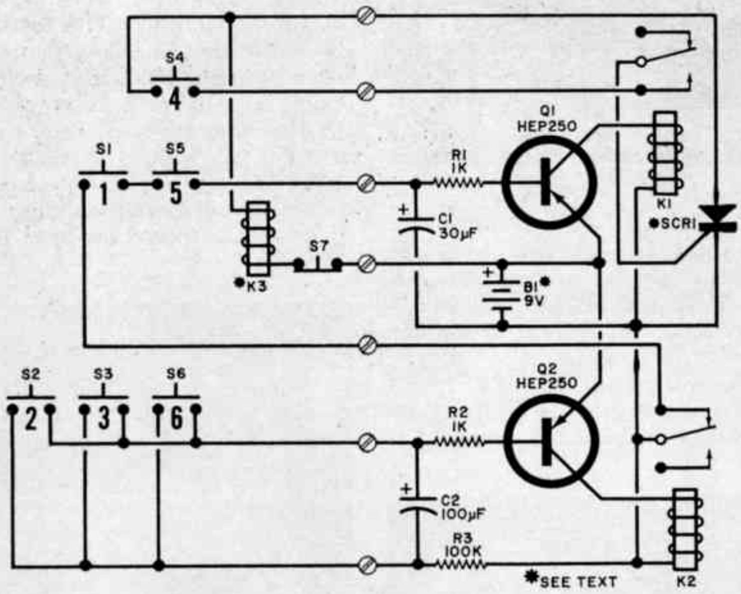
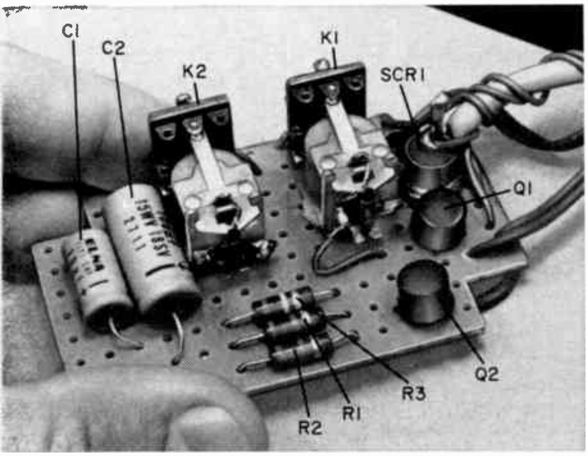


Fig. 1. If desired, circuit can be extended by adding more switches in parallel with S2, S3, and S6; in series with S1 and S5; or in series with S4. To change combinations, rearrange the switch positions on door or plate.

PARTS LIST

B1—9-volt dc source
C1—30-µF, 15-volt electrolytic capacitor
C2—100-µF, 15-volt electrolytic capacitor
K1,K2—5000-ohm miniature dc relay (Lafayette Little Jewel 99E60915 or similar)
K3—6-to-9-volt dc solenoid or relay (see text)
Q1,Q2—SK3004 or HEP250 transistor
R1,R2—1000-ohm, ½-watt resistor
R3—100,000-ohm, ½-watt resistor
SCR1—Silicon controlled rectifier (GE-X1 or similar, see text)
S1-S7—Spst normally open miniature pushbutton switch (Switchcraft 961 or similar)
Misc.—Test lamp (6-to-9-volt), perf board, plastic case, power relay (optional), interconnecting multi-lead cable.

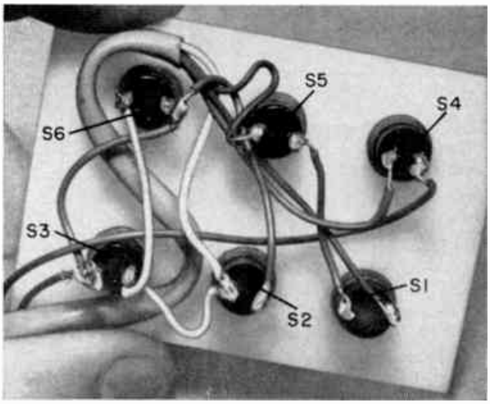
board. Parts placement is not critical, as long as each component is isolated from the others and free movement of the relay armature is assured. Point-to-point wiring is acceptable if leads are kept short and neat. Use a needle-nose pliers or a clip-type heat sink to protect *Q1* and *Q2* when soldering. The *SCR* is bolted to the perf board by its threaded anode. Bolt or cement the two miniature relays to the perf board. They should be mounted so that they are upright and relatively level. Their performance will be affected if they are mounted on their sides or inverted.



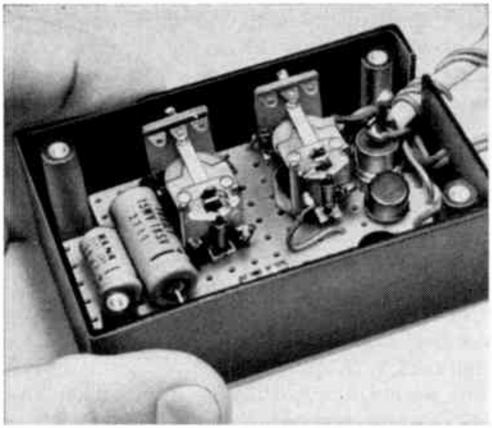
If you build the lock on perf board, you can follow layouts used by the author on prototype model.

The components chosen for *SCR1, K3* and the power source must be properly related. Start with the selection of solenoid *K3*. There are many low-current dc solenoids on the market, so select a 6- or 9-volt type that is spring-loaded to remain locked unless the coil is energized. Then choose an SCR that can carry the coil current and a power source that can handle this load. As another option, a 6-to-9-volt relay (with contacts rated to carry the load) can be used instead of *K3* if you wish to activate some form of alarm. With dc applied to the SCR, once it is fired, it will remain on unless the supply

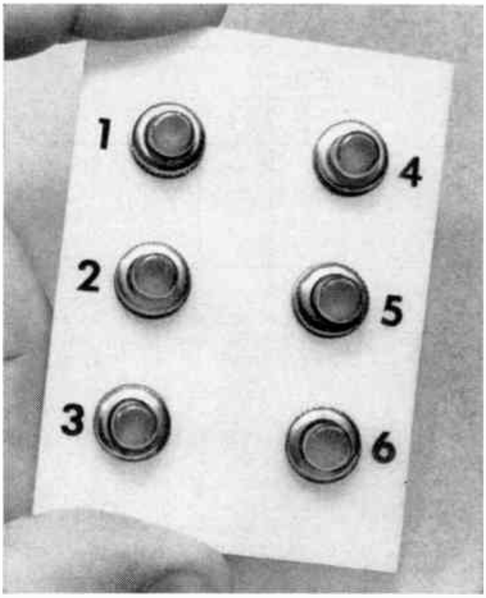
(*Continued on page* 94)



In finished version, the six pushbuttons would be mounted directly on the door being protected.

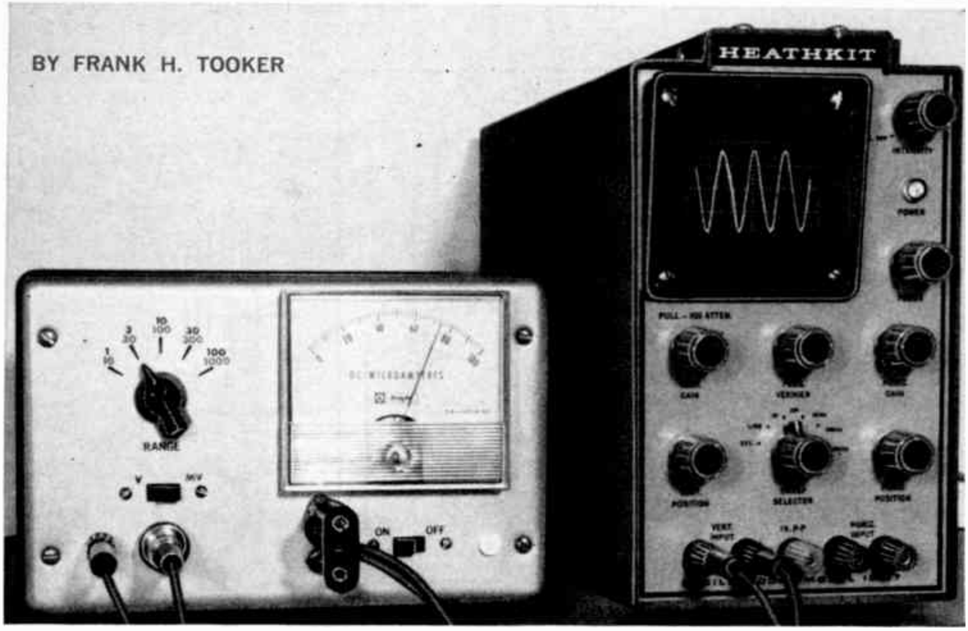


To protect the relays, in the prototype, the unit was mounted in a conventional plastic enclosure.



The six pushbuttons can be marked in any fashion with numbers, letters, symbols, or left just plain.

BY FRANK H. TOOKER



MILLIVOLTMETER FOR FET CIRCUITS

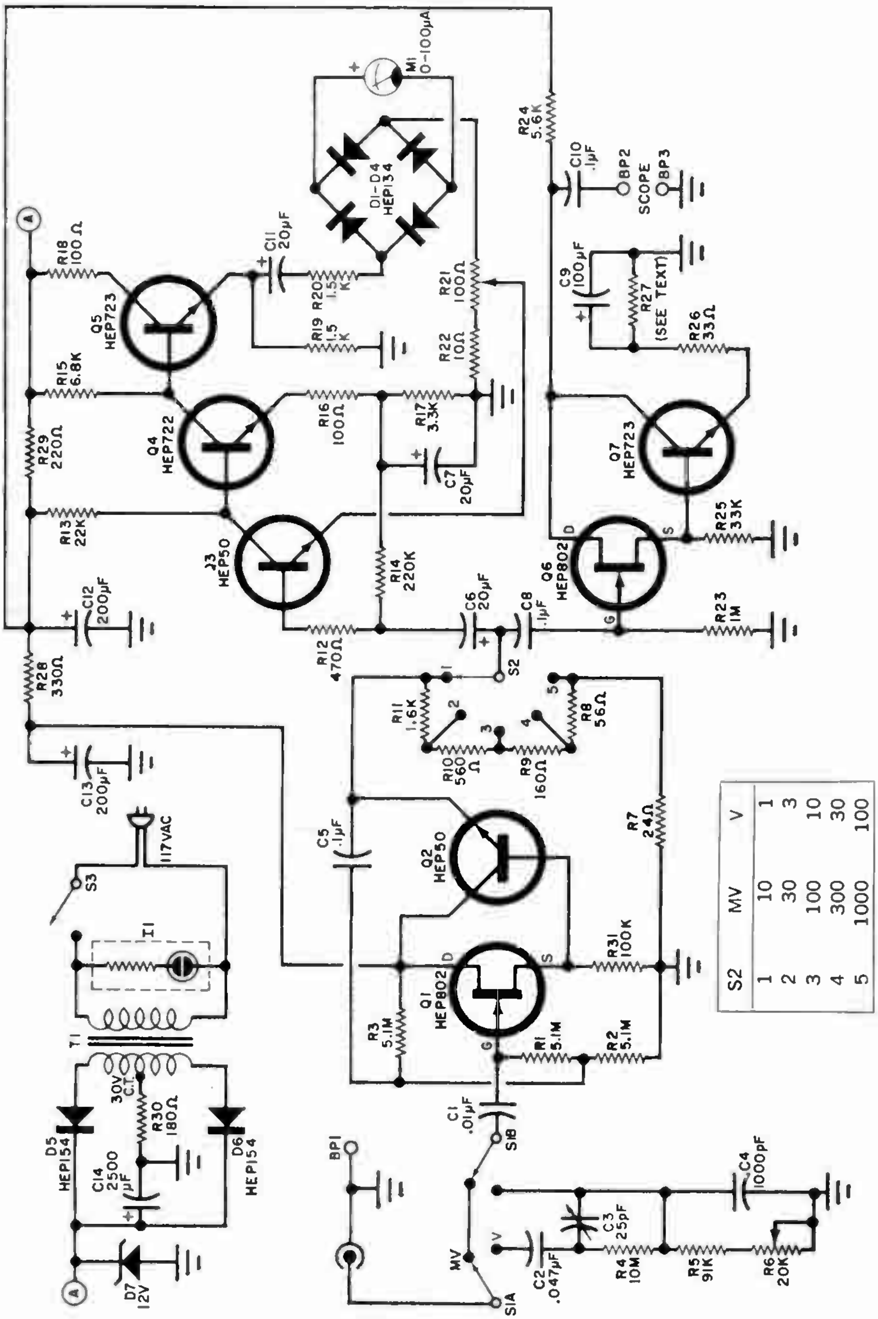
ULTRA-HIGH VALUE DRAIN RESISTORS REQUIRE MINIMUM-LOADING 100-MEGOHM INPUT mV METER

It may appear to be a vicious circle, but as FET's, MOSFET's, and IGFET's become more common in experimental circuits, the test equipment necessary to check performance must be dramatically improved. This millivoltmeter was designed to measure FET circuits without loading. The input resistance is 100 megohms with a capacitance of 12-15 pF. Complete instructions for assembly are included in this article.

As ELECTRONICS TECHNOLOGY advances, so must the characteristics of our measuring instruments improve in order to keep pace. Consider how firmly entrenched the FET is in amplifier circuitry and how rapidly behind it are the MOSFET or IGFET. The output impedances of any of these new devices is so high that for many practical applications it is practical to build amplifier stages with drain resistors having values in the Megohm range.

The question now arises: Just how does one go about checking with any guarantee of accuracy the signal-voltage gain and the waveform or distortion level at the output of such an amplifier stage? Conventional test instruments do not provide this guarantee since, in most cases, they disturb the operating conditions of the circuit under test.

One cannot connect a 1-megohm ac millivoltmeter to the drain circuit of any type of FET circuit and ask for accuracy. Such a connection drops the amplifier's drain resistor to one-half its original value. Worse, accuracy will suffer by 50 percent. Even a 10-Megohm millivoltmeter connected across a



S2	MV	V
1	10	1
2	30	3
3	100	10
4	300	30
5	1000	100

Fig. 1. Function switch S1 allows user to measure 0-1000 mV or 0-100 volts rms in alternate positions. Range selection is accomplished with switch S2.

1-megohm circuit will give accuracy of no better than 90 percent, not counting the inaccuracies inherent in the measuring instrument itself. In the latter case, the total inaccuracies can add up to as much as 14 percent.

Obviously, our 10-megohm ac mV meter can no longer be justifiably called a "negligible loading" device when used on any circuit we might have occasion to test. If we are going to make measurements across resistances on the order of 1 Megohm, without having to take into consideration the loading effect, the time has come to make another ten-fold increase in the input impedance of our measuring equipment.

This is the principle behind the "High-Input-Resistance AC Millivoltmeter" described in the following pages. The schematic diagram of the mV Meter is shown in Fig. 1. It has a 100-megohm input resistance for minimum loading effect. It is capable of measuring ac voltages from as low as 0.2 mV to as high as 1000 mV (1 volt) rms. In the mV range, the input resistance of the mV Meter is 100 megohms, while in the V range, input resistance is a standard 10 megohms.

One more feature of the mV Meter—and one that can be used independently if desired—is the inclusion in the instrument of an oscilloscope preamplifier. This circuit is used in conjunction with the voltage measuring circuit to provide the all-important visual indication of the waveform being measured.

PARTS LIST

BP1-BP3—Five-way binding post (one red, two black)
C1—0.01-µF, 100-volt Mylar-paper capacitor (Sprague Type 225P)
C2—0.047-µF, 100-volt Mylar-paper capacitor (Sprague Type 225P)
C3—25-pF, zero-temperature coefficient, ceramic trimmer capacitor (Centralab No. 822-AZ)
C4—1000-pF, 100-volt, 5% tolerance, ±0.05% capacitance-drift silver-mica capacitor (Elmenco No. DM-15-102J)
C5,C8,C10—0.1-µF, 100-volt Mylar-paper capacitor (Sprague Type 225P)
C6,C7,C11—20-µF, 12-volt electrolytic capacitor (Sprague No. TE-1130)
C9—100-µF, 3-volt electrolytic capacitor (Sprague No. TE-1059.5)
C12,C13—200-µF, 15-volt electrolytic capacitor (Sprague No. TE-1164)
C14—2500-µF, 15-volt, low-series-resistance electrolytic capacitor (Sprague No. 39D-258G015GP4)—Do not substitute
D1-D4—HEP134 germanium diode (Motorola)
D5,D6—HEP154 silicon rectifier (Motorola)
D7—12-volt, 5% tolerance, 1-watt zener diode (Izt = 21 mA)
I1—Miniature neon pilot lamp (Leecraft No. 36N-2313 or similar)
M1—0-100-µA dc shielded meter movement (Allied Radio Shack No. 52A7202)
Q1,Q6—HEP802 field-effect transistor (Motorola)
Q2,Q3—HEP50 bipolar transistor (Motorola)
Q4—HEP722 bipolar transistor (Motorola)
Q5,Q7—HEP723 bipolar transistor (Motorola)

R1-R3—5.1-megohm
R4—10-megohm
R5—91,000-ohm
R12—470-ohm
R13—22,000-ohm
R14—220,000-ohm
R15—6800-ohm
R16,R18—100-ohm
R17—3300-ohm
R19,R20—1500-ohm
R22—10-ohm
R23—1-megohm
R24—5600-ohm
R25—33,000-ohm
R26—33-ohm
R28—330-ohm
R29—220-ohm
R30—180-ohm
R31—100,000-ohm
R27—See text

***All** resistors ½-watt, 5% tolerance*

R7—24-ohm
R8—56-ohm
R9—160-ohm
R10—560-ohm
R11—1600-ohm

All precision resistors 1% tolerance (IRC Type AS-2)

R6—20,000-ohm, ⅕-watt, 15-turn potentiometer (Bourns Type 3068-S)
R21—100-ohm, ½-watt, 15-turn, wire-wound potentiometer (Bourns Type 3067-S)
S1—Dpdt slide switch
S2—Single-pole, five-position shorting-type miniature rotary switch
S3—Spst slide or toggle switch
T1—117-volt primary/30-volt at 150 mA, center-tapped, secondary power transformer
1—Bud No. CU-585 utility cabinet
Misc.—Panel-type microphone connector (Amphenol No. 75-PC1M); microphone cable-type connector (Amphenol No. 75-MC1F); 3-ft. length of low-capacitance coaxial microphone cable; 2⅛" crocodile clip (Mueller No. 85); control knob; power cord and strain relief; aluminum-alloy sheet for shields; epoxy-glass circuit boards (see text); 1/16"-diameter buss bar wire; terminal strips; ¼" cable clamp; heat-shrinkable tubing (optional); #4 and #6 machine hardware; rubber grommets (4); No. 20 solid hookup wire; solder; etc.

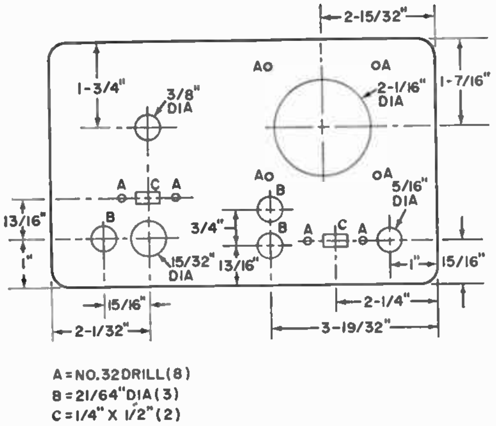


Fig. 2. Before machining front panel, carefully and accurately locate all hole centers as shown.

The above features, combined with the technical specifications given on page 51, show that this is an advanced instrument for the serious user, whether he be an experimenter or professional engineer.

Construction. This is an advanced construction project and, unless you have successfully assembled and calibrated other sensitive test instruments in the past, it is recommended that you do *not* attempt to build the mV Meter. Any number of problems can beset the beginner. In assembling the mV Meter you must not only be aware of what you are doing, but *why* you are doing it every step of the way. Also, do not substitute for any of the components specified in the Parts List unless you are fully cognizant of the extent to which such substitutions can affect the accuracy and stability of the instrument.

The mV Meter should be assembled in a Bud No. CU-585 steel contour utility cabinet exactly as described in this article. Referring to Fig. 2, first machine the front panel as shown. Then, using the drawings in Fig. 3, fabricate the center shield, input circuit shield, power supply shield, and the shield support bracket from sheet aluminum. It is on these shields and the front panel of the cabinet that all parts and assemblies are to be mounted. So, be careful when machining the parts. Assemble the shields and check them for fit on the front panel via the meter's

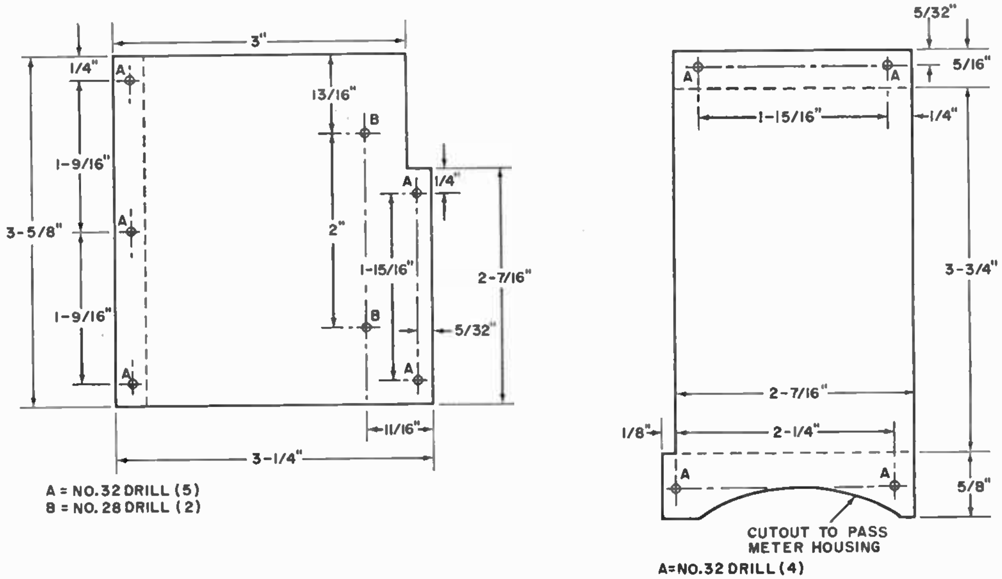


Fig. 3. Identified from left to right across both pages are power supply shield, shield support bracket, center shield, and input circuit shield. All shields should be fabricated

mounting hardware and the shield mounting bracket.

You will notice in the drawings that the hole locations for the mounting hardware for the circuit boards are not given. These holes are best located by marking through the appropriate board holes (before the components are mounted on them). Holes for the rubber grommets can be reasonably positioned, since their exact locations are not critical. However, the objective here is to keep the leads which pass through the grommets as short as possible. Also, when assembling the instrument keep the input and output leads of each assembly well separated from each other.

Most of the small components that make up the mV Meter assemble on four small printed circuit boards, the etching guides for which are given in Fig. 4.

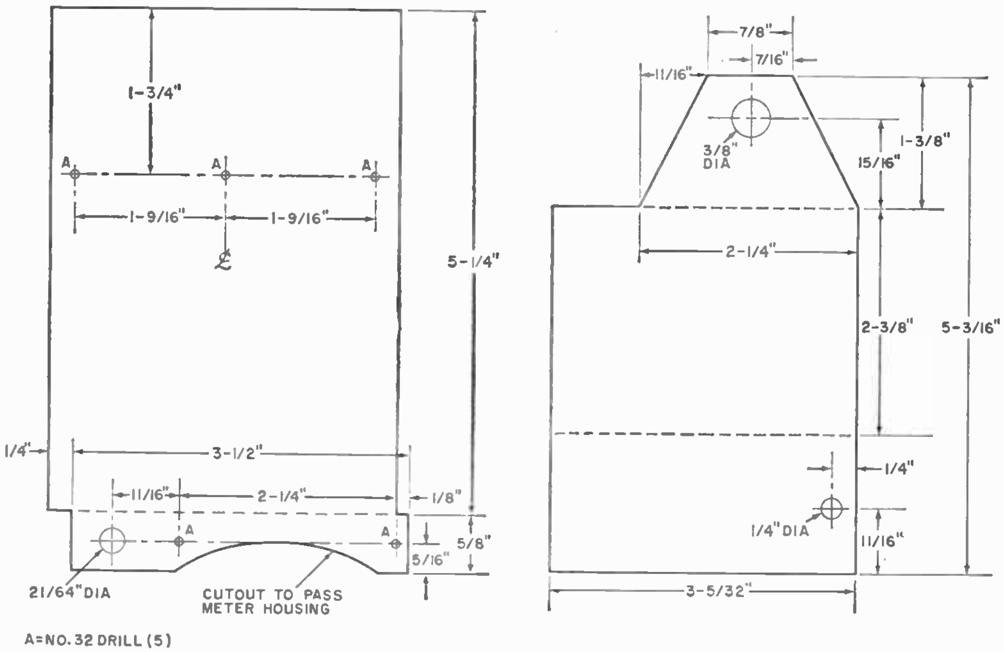
Each of the first three circuit board assemblies mounts on a pair of 4-40 × 1" machine screws with three nuts to each screw. One nut anchors the screw to the shield, while the remaining nuts serve as the spacers and board anchors. The meter rectifier assembly mounts directly on the meter terminals, foil side facing the meter housing.

Mount the input circuit assembly on the input circuit shield, foil side facing the shield. Then mount the meter amplifier and scope preamp assemblies on the meter side of the center shield. When mounting these circuit boards orient them so that the foil side on the scope preamp is toward the shield and the foil side on the meter amp faces away from the shield.

Power supply components *C14*, *D5-D7*, *R30*, and *T1* mount on the power supply shield located at the right rear corner of the instrument assembly. The leads between power switch *S3* and the power supply proper should be lengths of plastic-insulated lamp cord.

The lead lengths on pilot lamp assembly *I1* require only slight shortening. Twist these leads together, and with the leads to *S3*, pass them through a ¼" cable clamp. Then secure the cable clamp to the shield support bracket. Caution: keep these leads as far as possible from the meter amp and scope preamp assemblies.

The power supply filter assembly (*C12*, *C13*, *R28*, and *R29*) mounts on a terminal strip secured to the left rear of the center shield. Note that separate leads from the filter must be routed to each circuit board assem-



from 0.050"-thick sheet aluminum alloy to exact dimensions indicated in diagrams. Once fabricated, metal pieces should be bent along dashed lines; far right piece into Z shape.

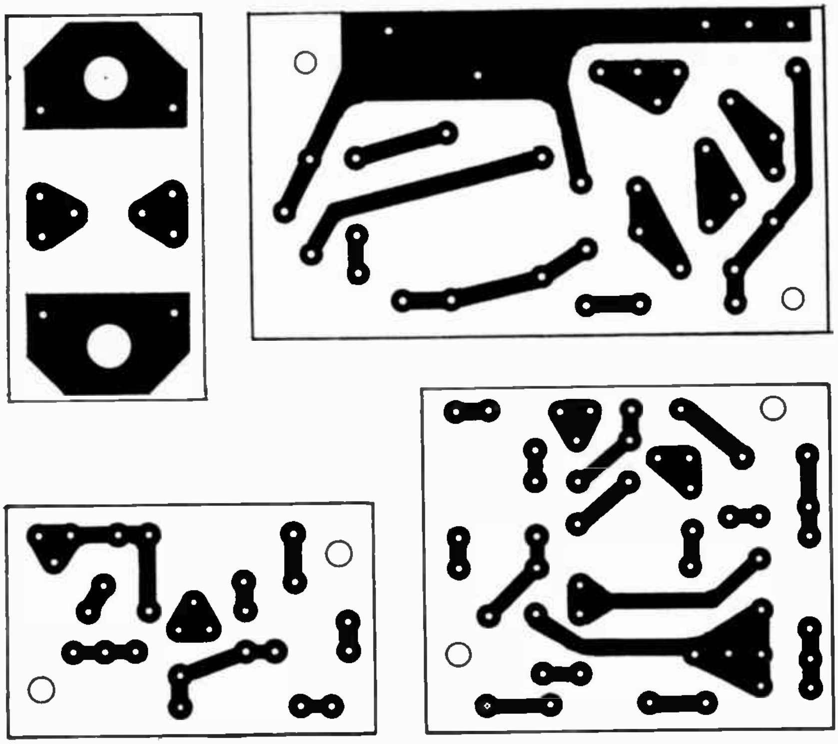


Fig. 4. When reproducing printed circuit boards, using actual size etching guides shown here, best results are obtained if an epoxy-fiberglas base material is used.

bly (except the meter rectifier board). This is necessary to avoid common-lead coupling between the amplifiers.

Now, mount the components in their respective locations on the four circuit boards according to the diagrams provided in Fig. 5. When assembling board (1), mount *R4* on the foil side of the board, across the terminals of *C3*. Then, for board (2), solder *R17* across *C7*, close to the body of the capacitor and use the resistor leads to make the solder connections to the foil on the board.

On board (3), temporarily leave *C9* out of the circuit. Preset a 5000-ohm potentiometer to the midpoint of its rotation, and lightly tack the pot into the *R27* location. Connect the board to an 11-volt dc power supply and use a 20,000-ohms/volt VOM or a VTVM to check the potential between the collector of *Q7* and the common ground foil conductor on the circuit board. Adjust the pot until the meter indicates a 5.5-volt level. Remove the meter, disconnect the power supply, and, without disturbing the final setting of the pot, remove the pot from the circuit. Now, use an ohmmeter to check the resistance value of the pot setting (it should be in the neighborhood of 1000 ohms). Select a 5 percent tolerance, ½-watt fixed resistor as close as possible to the value obtained from the pot, and solder this resistor in the *R27* location, first connecting it across *C9* as described for *R17* and *C7* above.

A properly designed grounding scheme is of the utmost importance in any sensitive measuring instrument, and the mV Meter makes no exception to this rule. Improper grounding can result in greater than normal hum and noise level, regeneration or instability in the amplifier circuits, and meter indication nonlinearities.

The mV Meter employs a wired ground, and the following procedure is recommended. Run a 1/16″-diameter copper bus bar wire from one ground-level binding post to the other (*BP1* to *BP3*), routing it through the grommets as shown in the photos. Then run another bus from the first to the lower ground terminal lug in the filter assembly. (This should be the lug to which the negative end of *C12* is connected.)

The remainder of the wiring in the Meter is accomplished with solid #20, plastic-insulated hookup wire. Use only high-quality, brightly-tinned hookup wire in all instances.

Run a wire from *R30* to the lug to which the negative end of *C14* is connected. Run another wire to this point and the ground lug of the terminal strip, and still another wire from the same point through a grommet in the center shield to the ground lug of the filter network to which the bus wire is soldered. Then run a final wire from this lug to the ground lug at the upper end of the filter assembly. *These two ground lugs, plus the ground lug on the filter network terminal strip, are the only direct electrical connections to be made between the circuits and the instrument case and shields.*

Insulate the body of the microphone connector from the front panel with the insulating washers supplied with the connector. Run a wire from the ground lug of the connector to *BP1*. Then connect another wire between *BP1* and the ground foil conductor on the input circuit assembly board.

TECHNICAL SPECIFICATIONS

Ranges: 0-10, 30, 100, 300, 1000 mV rms full-scale; 0-1, 3, 10, 30, 100 volts rms full-scale

Input Resistance: 100 megohms on mV ranges; 10 megohms on volt ranges

Frequency Response: within 0.5 dB from 10 Hz to beyond 100 kHz on both ranges

Accuracy: within 3% of full-scale

Stability: drift from cold start through one hour continuous operation is negligible; drift due to temperature variations between 50° and 90° F is negligible; drift due to line-voltage variations between 90 and 130 volts is negligible

Spurious Signals: internal leakage from ac power line to millivoltmeter open-circuit input is 40 dB below 10 mV

Scope Preamplifier: signal voltage gain is 50; frequency response is within 1 dB from 40 Hz to beyond 100 kHz, down 5 dB at 10 Hz; total harmonic distortion, including hum and noise, is 0.1% at 400 Hz

Power Consumption: 5 VA or less at 117 VAC

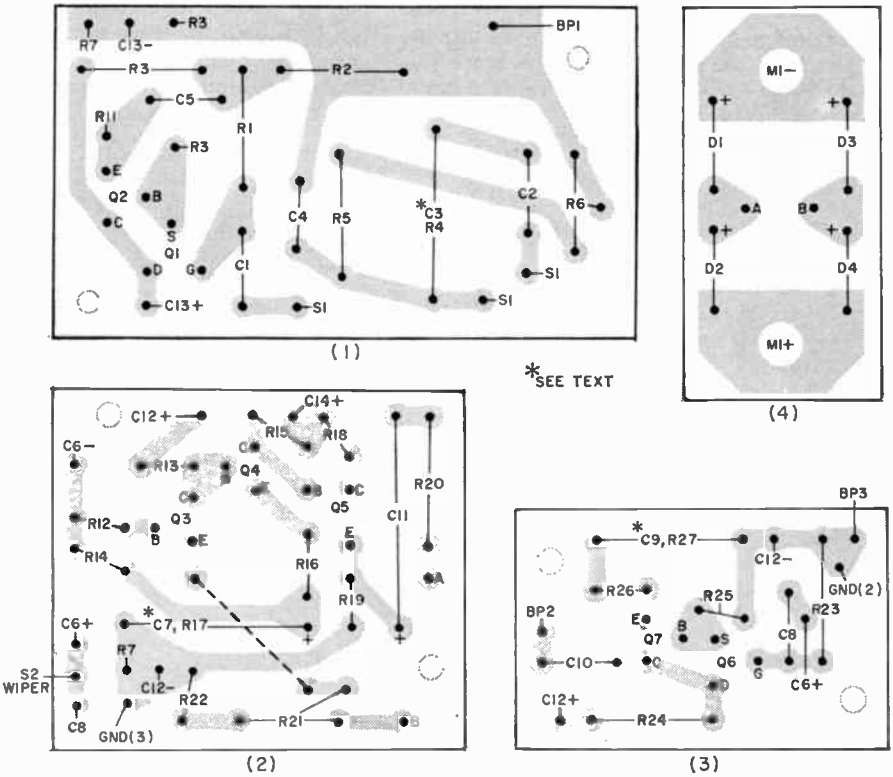


Fig. 5. Circuit board assemblies are identified as follows: (1) input circuit and 100:1 attenuator network; (2) meter amplifier; (3) scope preamplifier; and (4) meter rectifier.

Twist together a pair of wires. Connect one end to the ground conductor (black wire) and the emitter of *Q2* (any other color). Connect and solder the other ends of the wires to the appropriate lugs on range switch *S2* (to which the ends of precision resistors *R7* and *R11* are first connected), passing the free ends through a grommet in the top of the input circuit shield.

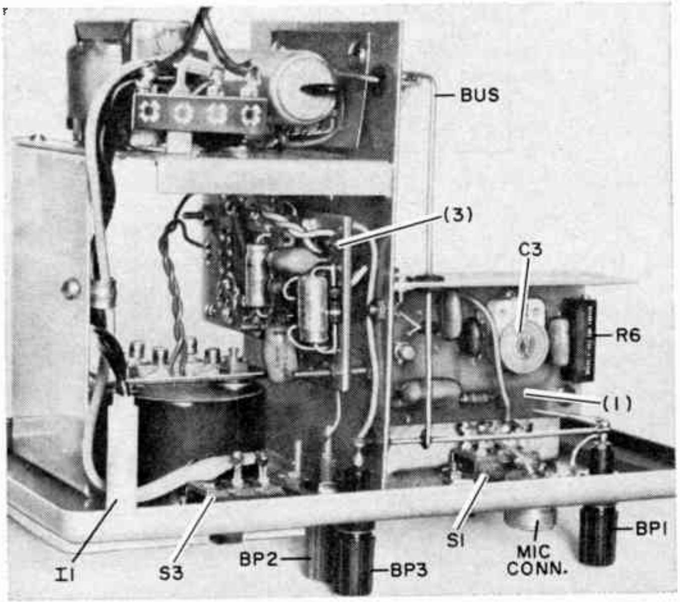
Again using the color coding scheme, twist together another pair of wires and run it from the same lug to which *R7* is connected and the rotor lug on *S2* close to the shields and through a grommet in the center shield to the input and ground conductor of the meter amplifier board. Then connect a short twisted pair from the input and ground conductor of this board to the input and ground conductor of the scope preamp board. Connect one more wire between the ground conductor on the scope preamp board and *BP3* to complete the signal circuit ground wiring.

Power supply ground leads going to boards (1)-(3) should all be twisted together with their respective positive leads and then dressed against the center shield. Connect the ground leads from boards (2) and (3) to the *lower* ground lug of the filter network terminal strip and the ground lead from board (1) to the *upper* ground lug (to which the negative lead of *C13* is also connected).

Make absolutely certain that all connections are cleanly and thoroughly soldered. If any connection appears to be "grainy" or otherwise doubtful, resolder it. Also, make certain that there exists a solid electrical connection between the shields and front panel of the cabinet. To insure good contact, you might try placing an internal lock-washer between the metal members at each hardware location. This done, slip the circuit assembly into the cabinet and bolt it in place.

Finally, prepare a shielded test lead as follows. From one end of a 3-ft length of low-capacitance coaxial microphone cable, strip away ¾" of insulation to expose the braided shield. Trim away ⅜" of the braid and only 3/16" of the plastic insulation from the center conductor. Loosen the set screw on the microphone connector. Then slip the prepared end of the cable into the spring end of the connector and seat it so that the center conductor protrudes through the connector's center contact. Solder the conductor to the contact and tighten the setscrew.

From the other end of the cable, strip away 1" of insulation, all of the exposed wire braid, and ⅝" of insulation from the center conductor. Slip onto the cable a 1" length of heat-shrinkable tubing (optional). Pass the center conductor through the opening in the rear of the crocodile clip until the insulation sits



Bus-type wired ground routes through metal parts via rubber grommets. Rectifier assembly mounts directly on terminals of meter movement.

squarely in the opening. Wrap the center conductor around the clip's contact screw and, if possible, crimp the clip around the insulation. Slide over the rear of the clip the tubing and heat shrink it. For details, see Fig. 6.

Calibration. When all assembly and wiring steps have been completed and double checked for errors, set *R6* and *R21* to their mid-positions, *S1* to MV, and *S2* to 1000. Connect a precision audio generator with a

THEORY OF CIRCUIT DESIGN

Although basically a millivoltmeter with a 100-megohm input impedance, the mV Meter is by no means restricted to use only in the millivolt range. As can be seen in Fig. 1, the Meter is capable of measuring ac potentials, in five ranges, up to 100 volts rms with an input impedance of 10 megohms.

Mode switch *S1* permits selection of either the volt **(V)** or millivolt **(MV)** ranges. A 100:1 RC attenuator network made up of *C2-C4* and *R4-R6* accurately drops the input signal level when the volt ranges are being used. Components in both the capacitive and resistive elements of the attenuator are adjustable so that the 100 division ratio can be set precisely.

A bootstrapped field-effect transistor Darlington circuit (*Q1/Q2*) is used to obtain the 100-megohm input impedance with actual resistor values no greater than 5.1 megohms. And the range attenuator, made up of precision resistors *R7-R11* and range switch *S2*, is located in the output side of the Darlington pair, rather than at the input where electrical and mechanical design and assembly might prove difficult. The input to the Darlington circuit is dc biased to locate the operating point where a high order of linearity is obtained so that negligible distortion of the ac signals takes place in this amplifier, even at a peak-to-peak signal level of 2.8 volts, and dc stability of the operating point is rigidly maintained. (For a detailed explanation of how the Darlington amplifier circuit is capable of a 100-megohm input impedance when small value resistors are used, refer to the sidebar on page 58.)

The output of the range attenuator is never allowed to exceed 10 mV rms, regardless of the signal level at the input of the mV Meter (this 10-mV signal represents full-scale pointer deflection of *M1*). The signal voltage and power amplification required to drive *M1* is developed by meter amplifier circuit *Q3-Q5* and associated components. The output from the meter amplifier, at the emitter to *Q5*, is fed through *C11* and *R20* to meter rectifier bridge *D1-D4*.

The prime requisites of the meter amplifier are a high order of signal-gain stability, high stability in the dc operating point, and near-perfect cancellation of the nonlinearities inherent in *D1-D4*. Particularly careful design of the meter amplifier gives the instrument a stability and bandwidth consistent with a high order of accuracy through the use of both ac and dc negative feedback techniques.

Transistors *Q3* and *Q4* operate as a two-stage cascaded, direct-coupled amplifier, while *Q5* is used to develop the power required to drive *M1*. The dc bias for *Q3* is obtained through *R14* from the emitter of *Q4*. This is a dc negative feedback arrangement which provides a high order of stability in the dc operating point of *Q3* and *Q4*. Capacitor *C7* bypasses the dc biasing circuit to ground to prevent ac negative feedback—which would tend to decrease the signal input resistance of *Q3*—via this route. The input resistance to *Q3* is maintained fairly high to prevent any significant loading of the range attenuator. The dc operating point of *Q5* is stabilized by virtue of its emitter-follower configuration which provides very nearly 100 percent negative voltage feedback.

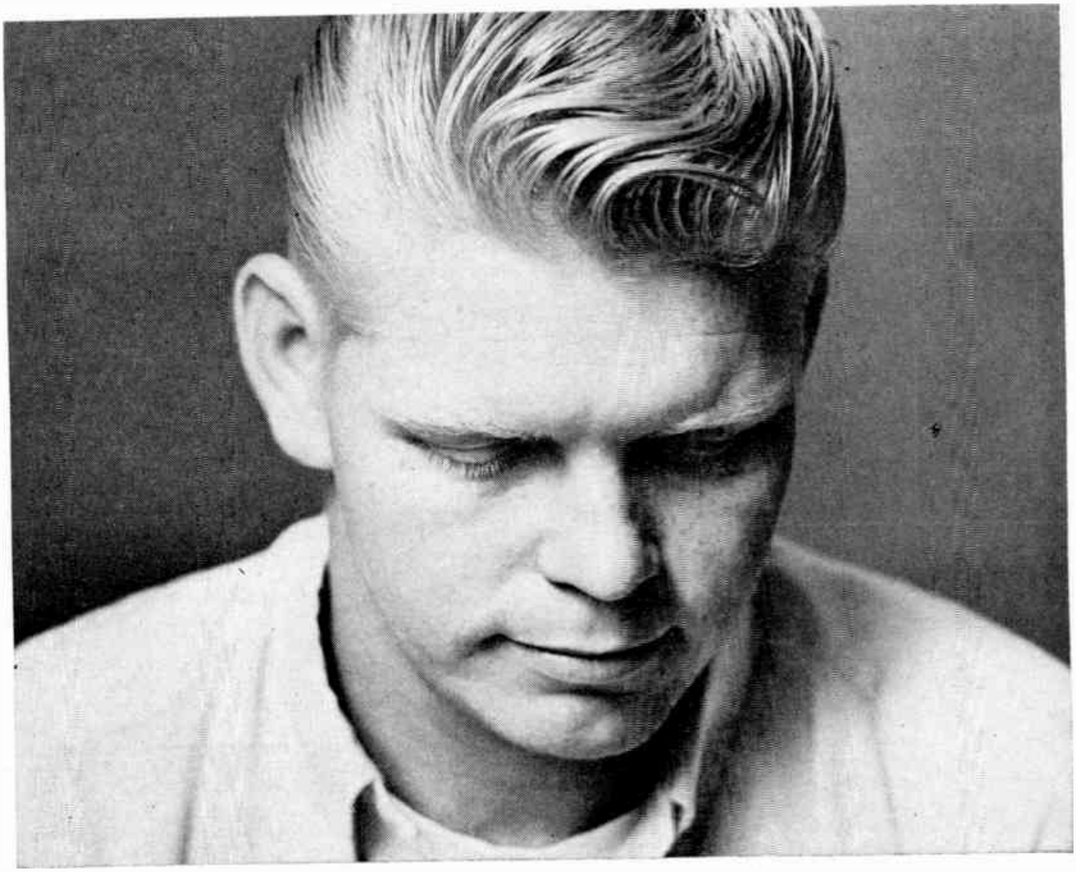
Negative ac feedback is obtained from the meter circuit through potentiometer *R21* and applied to the emitter of *Q3*. This feedback circuit not only gives the meter amplifier a high order of gain stability, but because *D1-D4* are included in the feedback loop, it also provides near-perfect compensation for the nonlinearities in the meter rectifiers. Without this compensation, the linearity of the meter pointer deflection could be adversely affected.

Resistor *R12* is part of the negative feedback loop. It provides a more constant load into which the ac negative-feedback signal works as *S2* is operated through its positions. Without *R12* in the circuit, the negative feedback factor would tend to vary as the setting of the range switch is varied.

Since it is impractical to connect a conventional general-purpose oscilloscope across a circuit that requires the use of a measuring instrument with a 100-megohm input impedance, and since waveform observation is important to the accuracy of the meter reading, a sample of the mV Meter's input signal waveform is obtained at the output of the Darlington circuit. This sample signal is coupled through *C8* into the *Q6/Q7* scope preamplifier circuit.

The requisites of the scope preamp are a signal voltage gain of 50 and a low total harmonic distortion level, the latter being far more important than the former. The gain derived from the preamp need be only enough to produce a trace of convenient height on the oscilloscope screen with the minimum of distortion.

The output at the collector of *Q7* is coupled through *C10* to binding post *BP2*, where the sample signal is available for the scope input. Negligible power output from the circuit is required since the input impedance of a good oscilloscope is on the order of at least 1 megohm.



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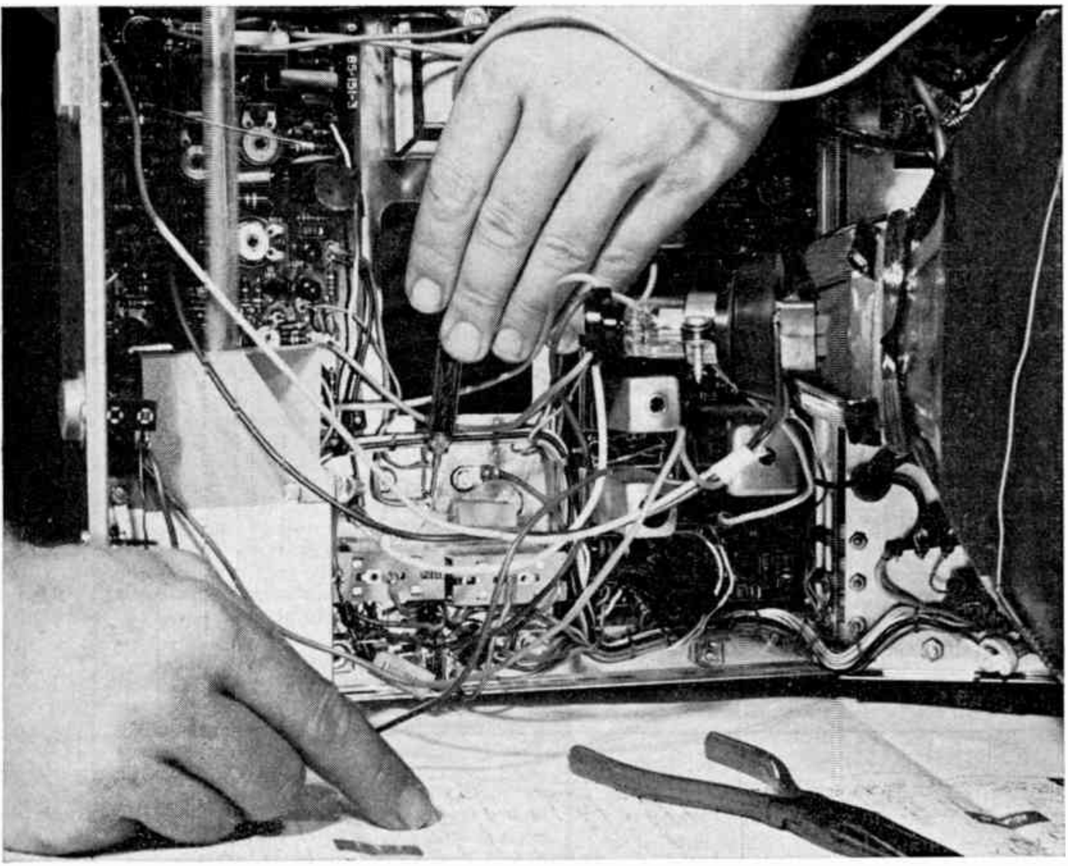

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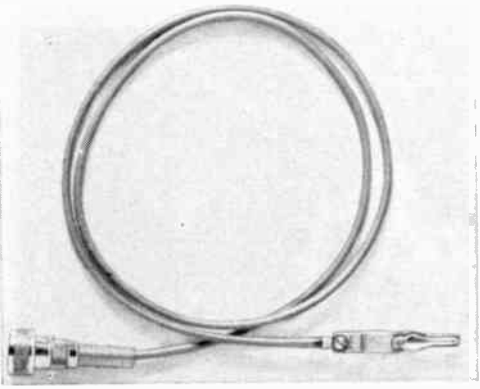


Fig. 6. Signal cable is made from crocodile clip, low-capacitance microphone cable, and mike connector. Use ordinary test lead for the ground cable.

600-ohm output impedance and an accurately calibrated voltage level meter to the input of the mV Meter and an oscilloscope to *BP2* and *BP3*.

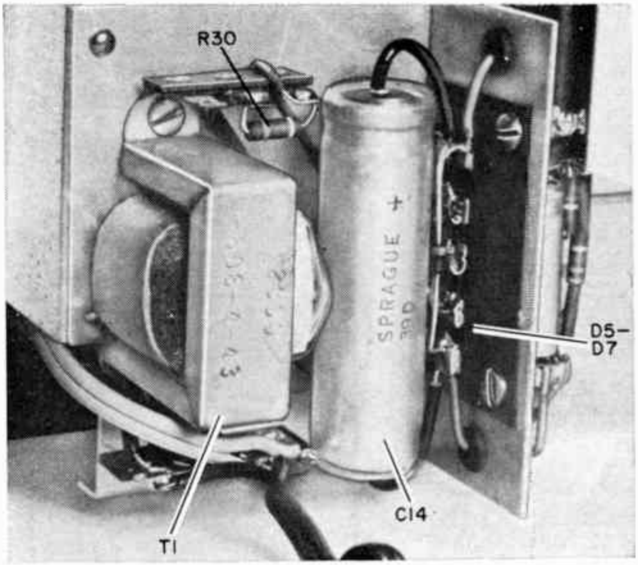
When the mV Meter is connected to *any* circuit for measurements, *always make the ground-to-ground connection first* (use any cable with a banana jack at one end and an alligator clip at the other for this, connecting it via *BP1*), *then the "high-side" connection—never the other way around.* Also, always set *S1* to V before making or breaking any connections with the mV Meter turned on. Because the Meter has negligible drift, it is feasible and a great deal safer in most cases to switch it off when changing input connections.

HOW BOOTSTRAPPING WORKS

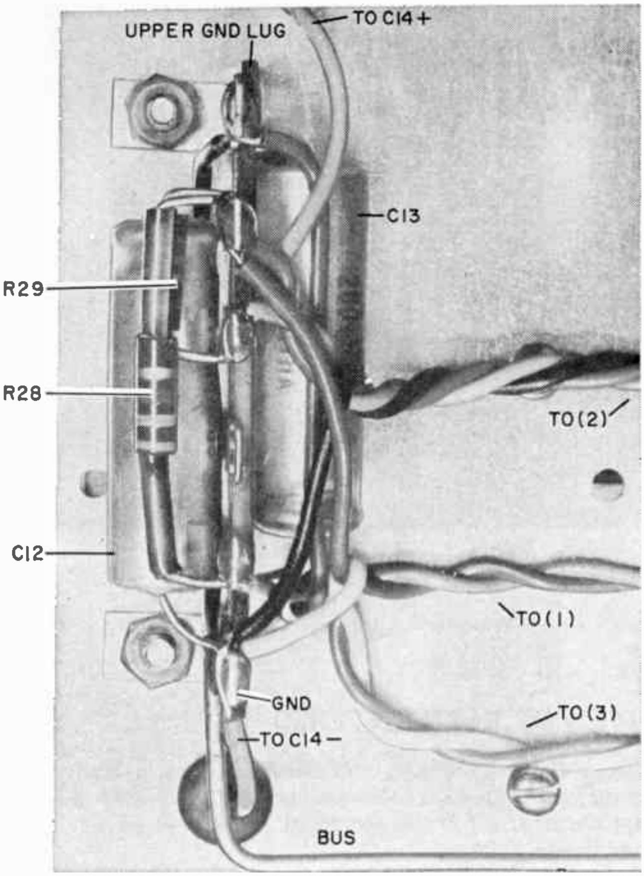
The following explanation is provided for the benefit of those who do not know how the bootstrapped Darlington circuit operates to increase its own effective input resistance. Consider first the biasing arrangement used for the gate of *Q1* in Fig. 1. For dc. *R1* is in series with the gate of *Q1*, and *R2* and *R3* form a voltage divider across the power supply. The ac input signal is applied to the gate of *Q1* through *C1*.

Now, without *C5* in the circuit, the signal being measured would "see" a resistance nearly equal to $R1 + [(R2R3)/(R2 + R3)]$, or about 7.5 megohms for the values specified. During normal operation of the *Q1/Q2* amplifier, the signal voltage at the emitter of *Q2* is very nearly equal to the amplitude of the input signal applied to the gate of *Q1*. In the bootstrap circuit, with *C5* connected as shown, the signal from the emitter of *Q1* is fed back to the junction of *R1*, *R2*, and *R3* in phase with the input signal voltage through *C5*. Hence, the signal voltage at the junction is equal to the signal at the emitter of *Q2*. The amplitude of the feedback signal can easily be as great as 95 percent of the input signal level.

Resistor *R1* now has the input signal applied to it at its upper end, while a signal of the same phase and 95 percent its amplitude is applied to its lower end. The signal voltage drop across resistor *R1* is, therefore, only a small percentage of the input signal level, making *R1* appear to have a value very much higher than its actual value. In fact, *R1* appears to have a value equal to $R1/(1 - 0.95)$, or very close to 100 Megohms!



Point-to-point wiring is employed in power supply subsection. Note use of insulating material between terminal strip on which are mounted D5-D7 and C14 and shield (near left). Line cord connects to terminal strip at bottom.



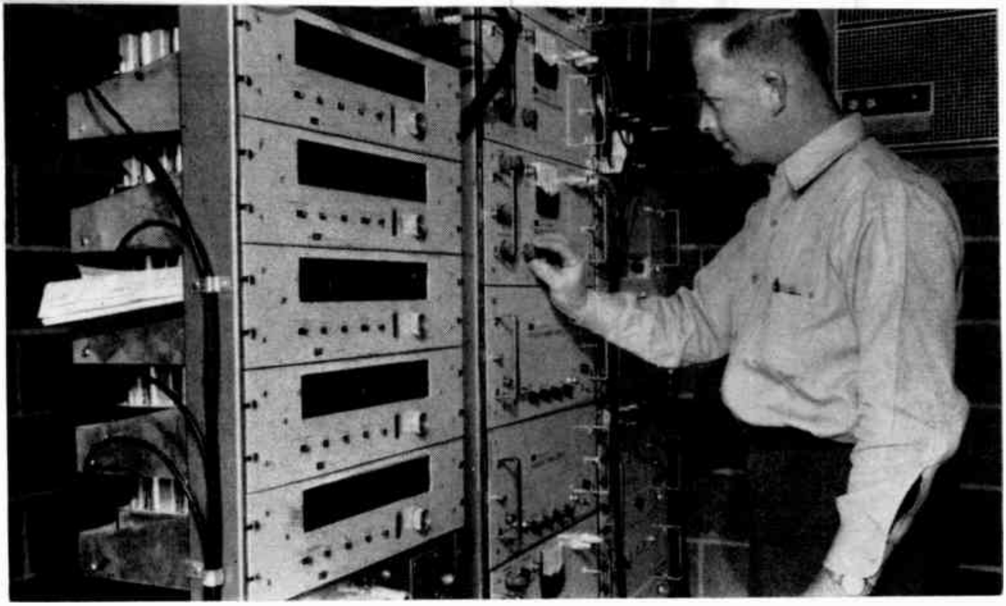
Closeup shows details of terminal strip partially visible in photo at bottom of opposite page. Most connections from power supply to various circuit assemblies are made from this terminal strip, using twisted-together hookup wires.

Once the connections outlined have been made, switch on the mV Meter. The meter pointer should swing to or near its full-scale position a couple of times as the internal electrolytic capacitors charge. Then it should settle back to its zero position. The pointer should come to rest precisely at zero with the instrument connected to the 600-ohm output of the signal generator if the circuit is properly wired and the meter movement's mechanical zero is properly set.

Set the signal generator to 400 Hz and turn its output level control up to where the mV Meter's pointer sits center-scale. Touch your fingertip to the screw-down ferrule of the microphone connector on the instrument; there should be absolutely no deflection of the meter pointer when you do this. Should any deflection occur, switch off the meter and go over your wiring again. The amplifiers in the Meter are stable; so, if you have assembled the instrument properly, there should be little difficulty in tracing down any trouble.

With the signal generator still set at 400 Hz, turn its output level up to precisely 1 volt rms (on the voltage level meter) and adjust *R21* in the mV Meter for an exact full-scale pointer deflection. Tune the generator for a 40-Hz signal and adjust it for precisely a 1-volt rms output level. Now, adjust *R6* for an exact full-scale deflection. Finally, with *S2* still at the 1-volt position (1000), tune the generator for a 20-kHz, precisely 1-volt rms output and very carefully adjust *C3* with a non-metallic screwdriver until the meter pointer again rests at exactly full scale.

Throughout all of these calibration steps, the waveform displayed on the oscilloscope's CRT screen should be a clean sine wave (if the generator's output signal is clean, that is). If not, the calibration is inaccurate. Or, putting it another way, the calibration is accurate for that one particular waveform and no other.



A BONUS FOR CATV SUBSCRIBERS:

★ CABLE FM ★

IF YOU HAVE IT, IT MAY PROVIDE BETTER STEREO

IN HUNDREDS of communities across the country, music lovers are discovering that cable TV has a surprise bonus for them: FM radio, which is piped into their homes on the TV cable but played through their FM sets, completely independent of their TV.

It's FM radio with a difference, however, for cable FM promises listeners the same benefits that cable TV gives its viewers: a choice of several stations, a minimum of multipath distortion, and a comfortable signal-to-noise level for each station.

"As a result of our strategic receiving locations and the use of highly directive and sensitive antennas," reports one leading CATV operator, "our FM signals are far superior to those received by the average FM listener. Even with all the signal processing that occurs on our cables, the FM bandwidth is not altered. The signals are inserted into the system with the same bandwidth, including guardbands, that the broadcaster transmits."

Be forewarned, however, that all CAFM (cable FM) systems are not working this perfectly—at least not right now. Some of them are carrying inferior signals, some do not have stereo signals (because of cross talk problems), and several systems actually cut down on the number of stations you can receive (as compared to a good outside antenna).

The reason for this sad situation is simple: an unintentional neglect by the CATV operators who carry CAFM as a piggyback service. Reasonably enough, CATV system operators feel that they have a lot more important problems than CAFM. To name just a few: new FCC rulings that allow CATV systems to originate their own TV programs, possibilities of a synchronous communications satellite for national networking of cable TV, two-way transmission on the cable, etc.

Robert E. Cowley, manager of Flagstaff [Arizona] TV & Cable Company, expresses the industry's attitude: "We give FM as a bonus, when the TV cable is put in, as an added selling point. Our advertisements do not sell FM, only cable TV."

Despite the lack of promotion, CATV customers do hear about CAFM, ask for it, and then like what they get. As a result, CAFM is one of the fastest growing businesses in commercial broadcasting, reports Harry E. Maynard, in *Stereo Quarterly*.

Most 12-channel CATV systems have the

BY EDWARD A. LACY

necessary band-width for carrying FM signals as well as TV signals. If they are not now carrying CAFM, it's probably because of disinterest, rather than some major technical problem.

A quick count of the 2400 or so CATV systems listed in *Television Factbook* shows 58% of them carrying FM. Of these 1413 systems, 236 did not state how many stations they were carrying, but 587 had between 1 and 10, 138 between 10 and 20, 59 more than 20, and 383 were carrying "all band."

Imported FM. For some systems, in areas where there are few if any local FM stations, it's necessary to "import" out-of-town stations. Flagstaff Television & Cable, for example, carries five stations, all of which are imported by mircowave. Obviously, importing FM signals gives a listener several more choices than are possible through his own antenna, even if the antenna is highly directional and has a rotor.

On the other hand, most local FM broadcasters consider imported signals to be unfair competition. With half of the FM stations now losing money, it's no wonder they are touchy. What particularly worries them is that some CAFM stations carry imports but do not carry the locals. Nation-wide, the FM industry has not yet agreed if importing is good or bad, and so the National Association of FM Broadcasters has not taken a position, one way or the other.

The National Association of Broadcasters, however, is quite concerned. In a filing with the FCC, they stated:

> "Many CATV operators bypass local FM stations to bring in multiple FM signals from outside the area, usually from large metropolitan areas some distance from the CATV community.
>
> "The deleterious effects of such leapfrogging have begun to be evidenced in communities where CATV has made significant penetration. In addition to badly fragmentizing local FM audiences, this practice actually denies local FM stations the opportunity to compete for cable listeners."

What does the FCC say about importing FM? Well, back in 1965 they asked for comments on the problem, but apparently never acted, probably because they have been so tied up with other problems concerned with CATV.

Other government agencies, it should be noted, have almost openly encouraged importing. For instance, the President's Task Force on Communications Policy, reported in 1968 that "The history of broadcasting indicates that complete reliance cannot be placed on a system of local over-the-air stations to achieve our goals. The regulation of radio on the basis of the local station concept limits the program choices available to the listener."

And, they noted, ". . . national policy has carefully sought . . . to develop a legal and economic framework for a communications policy which allows many voices to compete in the market place of ideas and of taste."

Whether they import or not, CAFM probably will eventually be forced to carry all local stations, just as CATV.

Taped FM. Rather than get involved with the trouble and expense of importing, some CAFM stations have taped their own music for use where there are few or no FM stations.

In Riverton, Wyoming, about 100 miles from the nearest FM station, a young college instructor, Richard L. Doering, has started what is probably the nation's first CAFM station, simply because he missed the good FM stereo music he enjoyed back east.

Doering's station, "Radio 95," is carried to Riverton cable TV customers by Community Television of Wyoming, Inc., which houses the playback tape transport, stereo generator, and rf exciter. Doering tapes his programs and then sends the tapes to the cable company.

Since November 1968, Doering has been broadcasting in stereo 7 days a week, 8 a.m. to 11 p.m., with classical, popular, jazz, and country-and-western music rotating in half-hour segments. Fourteen minutes of uninterrupted music is provided for each 15 minutes of broadcast time, and advertising time is limited to 2 minutes per hour. Incidentally, advertising is the sole support of Radio 95.

Doering points out that cable FM is the perfect answer for communities too small to support an on-the-air station of their own.

Signal Processing. With the exception of locally generated signals such as Doering's, how many stations you will receive on CAFM depends not only on availability, but also on which signal processing technique the CAFM system uses: either all-band or discrete signals.

One metropolitan CATV system told us

this about their experience with all-band processing: "Our original system for FM used an omni-directional antenna on top of a 350-ft building. All the signals received on this antenna were dumped into the FM band on the cable. But the results were unsatisfactory: too many channels with too great a variation in levels.

"We are now installing 20 discrete signal processors to include all of the city's FM broadcast transmitters and those closest to the city limits. Signals from directional antennas will be processed individually and controlled so that all channels are carried on the cable at the same level."

For discrete signal systems, FM stations are equally spaced across the dial with separations of 500 to 800 kHz. Each station is rebroadcast at a CAFM frequency different from that of the off-the-air frequency; this creates a minor nuisance when tuning, but it's necessary to cut out interference between the cable signal and possible leakage from the off-the-air signal. How many signals are processed depends on availability as well as the CAFM operator's budget.

Theoretically, there should be no noticeable degradation of the signals.

The "delivered" signal strength can vary from 200 to 1800 microvolts across 300 ohms, depending on the system. Unfortunately, there is no industry or FCC standard for signal strength. The Canadians have specified a minimum signal level of 200 microvolts and a maximum of approximately 300 microvolts for carriers between 88 and 90 MHz and a maximum of 1000 microvolts for signals with carriers 90 MHz and higher.

The lower FM band signals are limited to prevent interference to channel 6 TV stations. The overall FM band signal limitation is designed to cut down on the background noise on the TV channels.

While CAFM signals are considerably better than those received with an indoor folded dipole at many urban locations, it must be admitted that such reception is not nearly as good as reception with say a 6-element FM antenna at a nearby suburban location.

CAFM—Where To From Here? With some prodding of the CAFM systems, CAFM manufacturers, and the FCC, audio enthusiasts may be able to get the minimum signal level set much higher. Since the FCC has not yet established technical standards for cable FM, now is the time for action by CAFM subscribers.

COST

Typical charges for cable FM are $7.50 to $10.00 for installation and a monthly charge ranging from free to $1.

FM's FUTURE

The Chase Manhattan Bank predicts that FM-equipped receivers will replace AM-only sets as the dominant type of radio sold by the early 1970's and that four out of every five sets sold in 1975 will be capable of FM reception.

On July 1, 1970 the FCC issued a Notice of Proposed Rule Making on the establishment of technical standards for CATV. In the notice they said, "We are not at this time proposing standards applicable to the carriage of FM broadcast signals on CATV systems. We may find it necessary to do so in the future . . . We welcome comment on these points."

Considering the present and the expected improvements in FM reception brought about by CAFM, you might expect that an FM set could incorporate a few compromises in order to cut costs. Unfortunately, it can't be done.

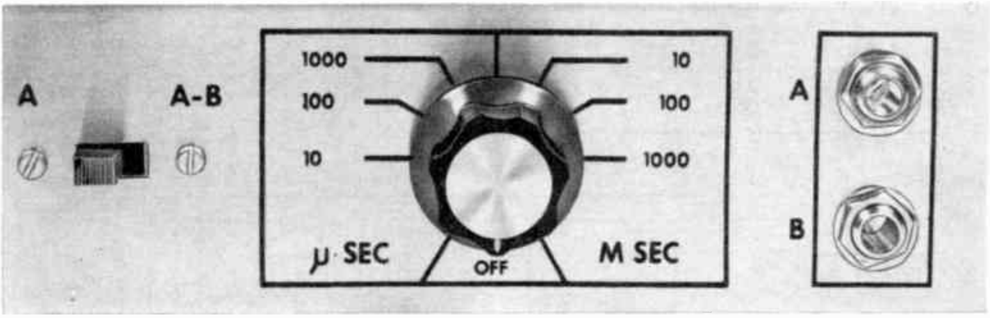
Daniel R. von Recklinghausen, technical director for H. H. Scott, Inc., says: "For high-quality listening, a 60-dB signal-to-noise ratio is definitely desirable and this is the reason for using a high-quality tuner, even on a CAFM system. If you did not have a high-quality tuner, other performance characteristics most likely would be degraded and perhaps the expected signal-to-noise ratio would not be as great. For this reason I do not see any reason for connecting a 'cheap' FM tuner to a CATV or a CAFM system."

What type of tuner you do connect may be limited only by the imagination of the audio engineers. For example, with almost unlimited bandwidth available for CAFM, new techniques such as 4-channel stereo should be a breeze.

"Several organizations are working on special audio systems for cable FM," says one prominent CATV consultant. "Some will be in the FM band, but others are expected to use special tuners OUTSIDE the present FM band to give additional channels and special features." -30-

(Lead photo courtesy Jerrold Electronics Corp.)

Time-Period Module for the Digital



Measurements Lab

ELAPSED TIME MEASURED DOWN TO 0.01 SECOND

This is the second plug-in module designed to be used with the Digital Measurements Lab described in our November 1970 issue. Easy to assemble, it has many applications in sporting events, photography, and electronics experiments. A 1.00-MHz crystal-controlled oscillator provides the timing base.

IN NOVEMBER, we began a series of articles on the construction of a group of test instruments to be used with a common main frame. This issue's contribution to the Digital Measurements Lab is a Time-Period module. As with the readout assembly and Frequency Counter plug-in presented earlier, the Time-Period module takes advantage of TTL integrated circuits.

The Time-Period module is similar to the Frequency Counter in some ways. However, its function is the inverse of the counter in that it is designed to measure accurately the duration, rather than the frequency, of an event. The function is 1/F and it is often used to measure very-low-frequency signals which would have to be counted for an excessive length of time to obtain an accurate readout with a frequency counter.

The Time-Period module can be used as a timer, for velocity measurements, and any other related start/stop function. The wide range of the module makes it possible to time events occurring within a range of 0.01-15 seconds with a 0.1 percent accuracy.

The practical uses for the Time-Period module include measurements of bullet velocities, slot car lap times, and camera shutter speeds. In fact, the Time-Period function can measure the duration of any event that can be converted into an electrical signal. This is done by switching the counter input into one of the six scaled outputs that are generated

BY DANIEL MEYER

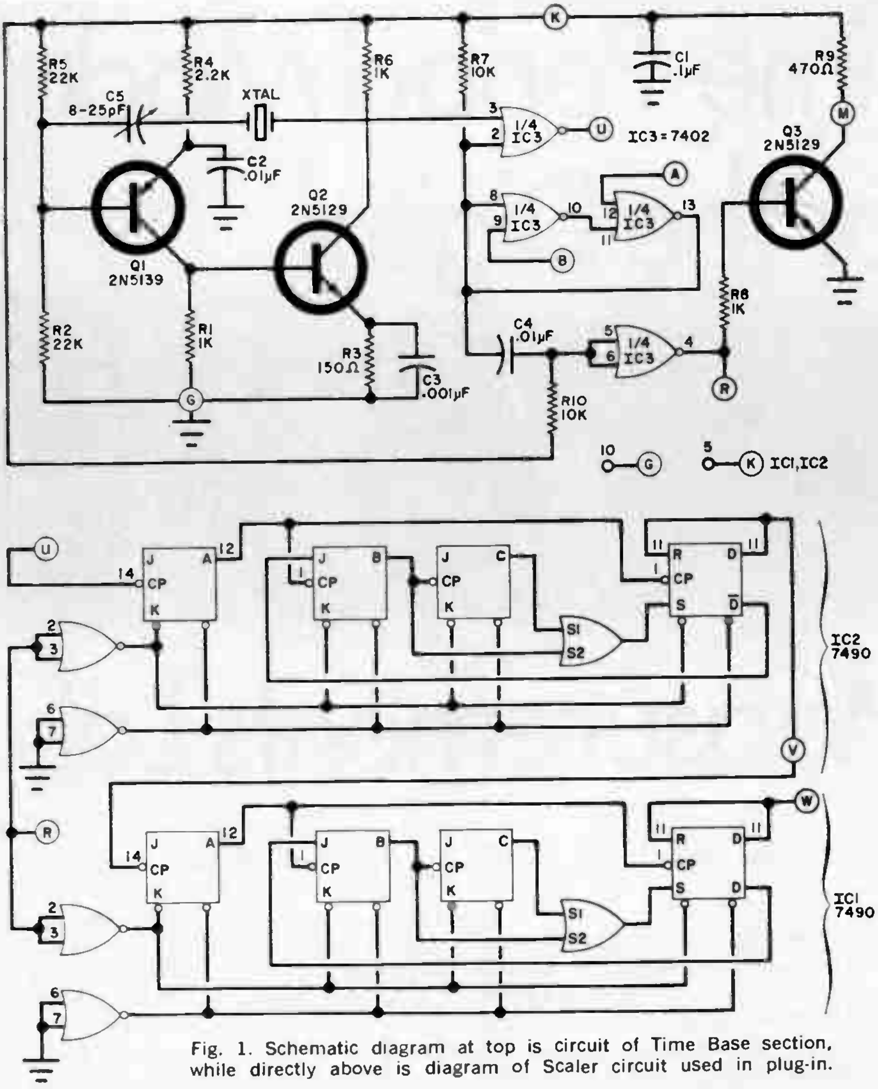


Fig. 1. Schematic diagram at top is circuit of Time Base section, while directly above is diagram of Scaler circuit used in plug-in.

PARTS LIST

C1—0.1-µF disc capacitor
C2, C4—0.01-µF disc capacitor
C3—0.001-µF disc capacitor
C5—8-25-pF trimmer capacitor
IC1, IC2—7490 integrated circuit
IC3—7402 integrated circuit
J1,J2—Two-circuit phone jack (insulated)
Q1—2N5139 transistor
Q2, Q3—2N5129 transistor
R1, R6, R8—1000-ohm
R2, R5—22,000-ohm
R3—150-ohm
R4—2200-ohm
R7, R10—10,000-ohm
R9, R11, R12—470-ohm
R13—33,000-ohm
All resistors ½-watt, 10% tolerance
S1—Two-pole, 10-position rotary switch with spst attachment (S1 in main frame power supply)
XTAL—Crystal (1.00 MHz or 100.00 kHz as desired—see text)
1—Scaler kit
Misc.—15-contact connector; control knob; printed circuit boards for time period and scaler circuits; chassis; spacers; solid and stranded hookup wire; #4 machine hardware; solder; etc.
Note—The following items are available from Southwest Technical Products Corp., Box 16297, San Antonio, TX 78216: Time Period board No. RPTb for $2.35; all Time Period circuit parts including 1.00-MHz crystal but minus Scaler, chassis, switch, etc. for $21.50; Scaler circuit board No. SC-10-4b for $1.90; circuit board and parts for Scaler for $14.55; complete kit of parts for Time Period plug-in module includes all above parts plus switch, chassis, etc. for $38.75 plus postage on 3 lb. and insurance.

by a 1.00-MHz crystal-controlled oscillator. Thus, the frequencies that can be counted (in terms of time) range from 100 kHz to 1.0 Hz. The circuit has an automatic reset which properly sets up the system every time a new count or measurement is made. Operation can be from a mechanical switch, microphone, photocell, or break wire.

Theory of Circuit Design. The basic timing circuit consists of a 1.00-MHz crystal-controlled oscillator made up of *Q1* and *Q2* in Fig. 1. The frequency can be set precisely with trimmer capacitor *C5* with the aid of an accurate 1-MHz signal source or by zerobeating with WWV.

The output of the oscillator goes to one input of a dual-input gate (part of *IC3*). However, the oscillator's signal cannot pass through the gate until the second input on this gate goes to ground or logic "0." The gate is controlled by a latching circuit consisting of two more of the gates in *IC3*. This latch, or set-reset, circuit is, in turn, controlled by the input signal or signals.

A positive signal at input A in the form of a logic "1" opens the gate and allows the oscillator pulses to pass into the scaler chain, continuing to do so until a positive-going signal is applied to the B input to close the gate again. If a positive signal is permanently applied to input B, the A input becomes a duration gate. This input will open the gate and allow oscillator pulses to pass into the scalers as long as the A input is at logic 1. When the input is removed from gate input A, however, the gate again closes.

The remaining gate in *IC3* and *Q3* are used to reset the circuit and the counter at the beginning of each cycle. When the output of the latch circuit goes to a logic 0 to open the gate, capacitor *C4* causes the reset gate to generate a pulse which resets *IC1* and *IC2*, two divide-by-ten circuits. This pulse is connected to the scaler circuit at point R.

The counter is reset by an inverted pulse at the output of transistor *Q3*. This is necessary if the counter is made up of individual flip-flop and gate packages as in the "Utilogic" decade counting system in the main frame. If,

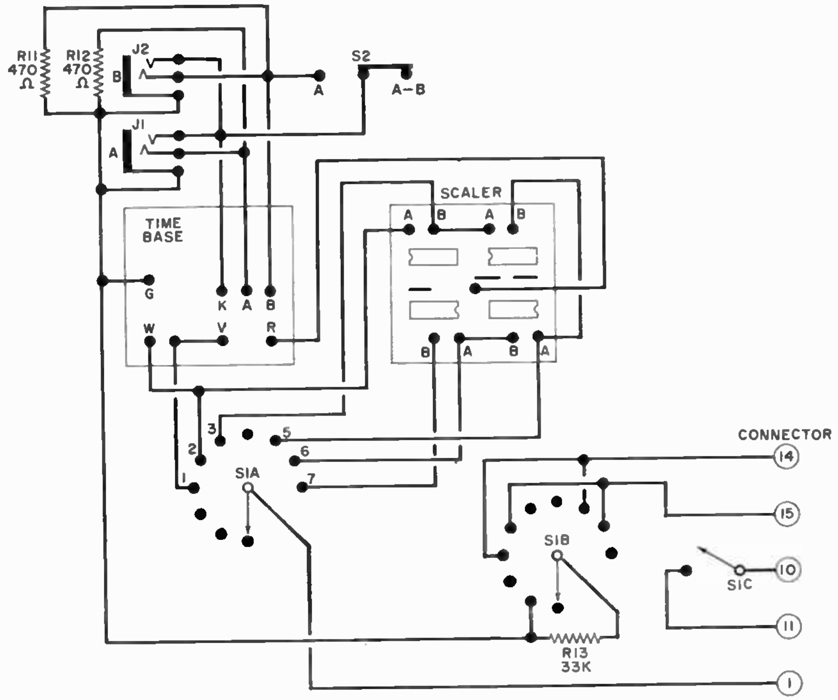


Fig. 2. All on- and off-board connections, including those to connector are shown in wiring diagram. Current limiting for DCU decimal points is provided by R13.

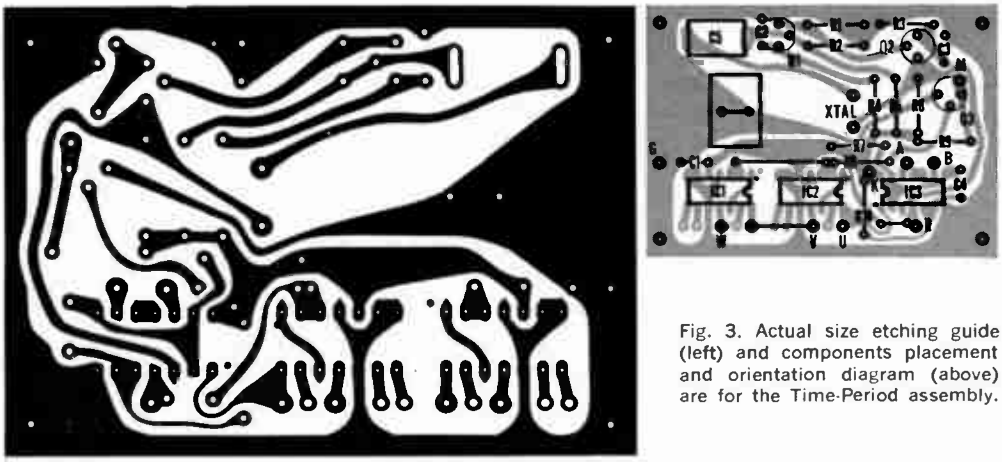


Fig. 3. Actual size etching guide (left) and components placement and orientation diagram (above) are for the Time-Period assembly.

however, the readout system uses medium-scale IC's of the 7490 type, then the reset would be taken directly from point **R** (these decade counters require a positive reset pulse).

Rotary switch *S1* (see Fig. 2) selects the pulse frequency to be fed into the counter and also switches the decimal point to the proper position. Resistor *R13* is the ground return for the decimal point and limits the current to the proper level for this part of the readout.

Construction. Most of the assembly work involved in the Time-Period plug-in is performed by wiring the Time-Period and Scaler circuit boards. An actual-size etching guide and a components placement and orientation diagram for the Time-Period assembly are given in Fig. 3. (See Frequency Counter Module in last month's issue for Scaler information.) When mounting the IC's, transistors, and electrolytic capacitors on the circuit boards, make sure that they are properly oriented.

Once the boards are assembled, turn them foil side toward you and compare their foil patterns against the etching guides for solder bridges. If you are satisfied that all is in order, interconnect the boards via rotary switch *S1* and the 15-contact connector as shown in Fig 2. If possible, use #22 stranded hookup wire for the connector cable assembly.

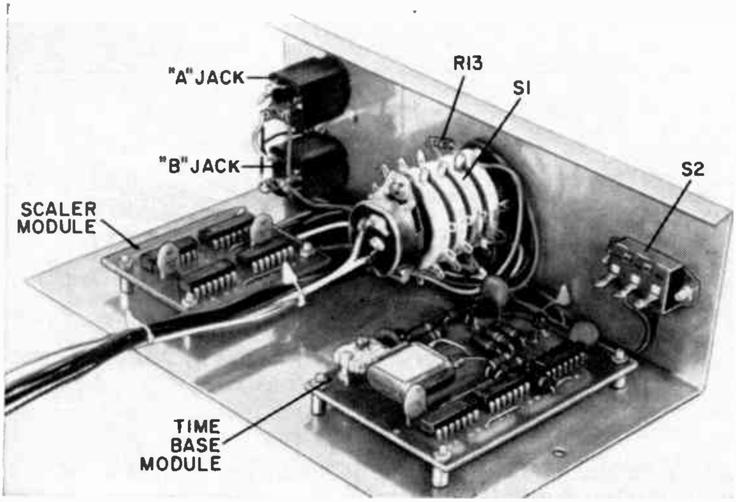
Next, mount the boards to the floor of the chassis with eight sets of #4 machine hardware and eight ¼"-⅜"-long spacers. Then mount the switches and jacks to the front panel and complete the wiring. Neatly bundle the wiring together and lace it.

Now, connect the Time-Period module to the main frame via the connector assembly and turn on the system by rotating the range switch in the plug-in one or more positions to the right. Use a high-impedance voltmeter to check the potential at point **K** on the Time Period board and the +5-volt point on the Scaler board. In both cases, you should obtain readings of exactly +5 volts dc; if not, adjust the setting of the appropriate control in the power supply. Then adjust trimmer capacitor *C5* so that the oscillator is operating at exactly 1.00 MHz. Use an accurate signal source (WWV, for example) to beat against the oscillator signal. This done, seal the adjustment of *C5*.

Set the range switch on the Time-Period plug-in to the 1000 M SEC position and the mode switch to position A. Insert a phone plug in jack A and connect the input to the +5-volt power supply source. The counter should begin to count at a rate of one count per second for as long as the +5 volts is applied to the input. Moving the range switch to any other position with the input still connected to the 5-volt source, the counting rate should increase until the numbers in the readout tubes are just blurs.

Set the mode switch to the A-B position and the range switch to the 1000 M SEC position. Start the counter by connecting the A input to the +5-volt source. The counter should begin counting and stop only when the +5-volt source is connected to the B input. If everything checks out, the Time-Period module is ready to use.

Applications and Use. To test the speed



Controls and input jacks mount on front panel and circuit boards fasten to floor of chassis with 4-40 hardware and spacers.

of a camera shutter with the Time-Period instrument, a high-speed photo pick-off of the type shown in Fig. 4 is required. Note that the pickup device is a photo Darlington because of its rapid response to stimulus. Do not attempt to substitute a cadmium-sulfide cell in place of the photo-Darlington pickup since such devices respond far too slowly.

The pickup should be mounted in an opaque tube to exclude as much ambient light as possible. When the circuit is assembled, connect the negative output of the pickoff circuit to the A input of the Time-Period module. Open the camera's shutter and direct the beam of a flashlight through the lens into the photo pickup. With the mode switch in position A, the counter should begin to run when the light is focused onto the photo-transistor. If it does not, adjust the potentiometer until operation does begin. (The proper setting of the sensitivity control is just slightly beyond the threshold point at which the ambient light causes the counter to operate.)

Most shutter speeds can be checked by the use of the 100-μSEC range position of *S1* in the module. The reading obtained can be converted to seconds by multiplying the display count by the switch position. For example, if the switch is in the 100-μSEC position and a reading of 200 is obtained, simply multiply 200 × 0.0001 for a result of 0.02 second (1/50 second). A reading of 200 on the 10-μSEC range would yield a figure of 0.002 second (1/500 second).

The same pickoff circuit in Fig. 4 can also be used as an input for start-stop applications, such as timing a lap in a race. In this case, the inputs of the Time-Period module would be connected to the positive output of the pickoff circuit. The light beam would be adjusted to keep the counter turned off until

(*Continued on page* 93)

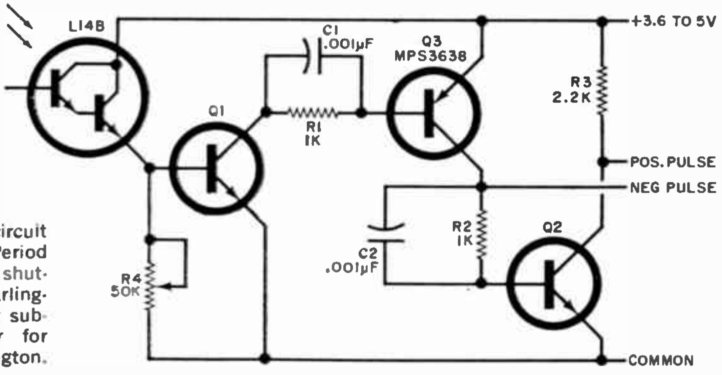


Fig. 4. Photo pickoff circuit of type used with Time-Period plug-in to measure camera shutter speed uses photo Darlington as transducer. Do not substitute a photo resistor for high-speed L14B Darlington.

STEREO SCENE

Fifth in a Monthly Series by J. Gordon Holt

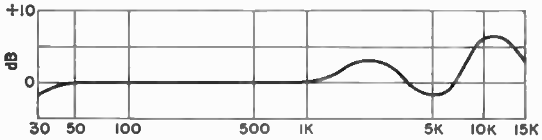
If you can read the writing on the wall, most of the record companies in North America have had it up to here with classical recording. Some months ago a weekly news magazine published a report on the sorry plight of the classical recording business. Classical record sales aren't paying their way and it looks like the big three (Columbia Records, RCA Records, and Capitol Records) will be out of this end of the business within the next few years.

If you follow such things, you are probably aware that the Los Angeles and Chicago Orchestras are working for London Records. The Boston Symphony has left RCA Records (after 52 years of what appeared to be a happy association) and is now recording for Deutsche-Grammophon. The Philadelphia Orchestra is the only major that is still being recorded on a reasonably regular basis (by RCA), but if rumors circulated by RCA executives are any indication, this situation may not continue beyond the expiration of the present contract.

The famous orchestras located in Minneapolis, San Francisco, Pittsburgh, and Cleveland that shared catalog listings with Boston and Philadelphia just a few years ago are rarely recorded. Most American symphonic recording activities have centered around the less glamorous orchestras like the Utah, Hartford, and Rochester. These orchestras work for the smaller companies (Vanguard, Mercury, etc.) which presumably don't expect a Schubert symphony to outsell the latest hot platter from the Hallucinogens. The American classical recording scene is sick—and it brought it on itself.

I don't think it's any secret, but ever since the public fell in love with the idea of hi-fi, the record manufacturers have been selling sound rather than music. If you happen to think that live music sounds pretty good, you can be reasonably assured that you will not particularly like the sound you hear from disc recordings. I think it is safe to assume that when you shell out good money for a stereo system, you do so on the assumption that the better the reproducer, the more realistically will it produce music. Well, you're wrong! A good reproducing system reproduces exactly what is on the recording—and only when that recording is high fidelity will the ultimate reproduced sound be hi-fi.

Rolled-off Bass. Do you pride yourself on the performance of your woofers? Are they flat down to 30 Hz—or even 20 Hz? If so, bully for you! But what does this gain you? Do you realize that practically every American disc recording has a built-in roll-off below 50 Hz—or even higher—and that that roll-off is there by intent rather than accident? A spokesman for one of the major tape recorder manufacturers writing in the respected Journal of the Audio Engineering Society stated, "Although we might have difficulty in finding any one who would admit it, it is not uncommon practice in (cutting) disc masters to use a 70-Hz high pass (bass cutoff) filter, except for organ recordings. It is generally found that the elimination of these very low frequencies gives an improvement in overall sound quality, since the low frequency noises (in and about the studio) are eliminated, and no significant musical content is removed."



Manufacturer's published frequency response curve for a capacitor microphone that is widely used in making professional recordings.

Personally, I feel that a composer's scoring for double-bass and bass drum constitutes "significant" musical content—but then, that's my own opinion. My opinion, however, has no bearing on two recordings I own from a major manufacturer in which the 70-Hz filter was quite evidently used on pipe organ selections.

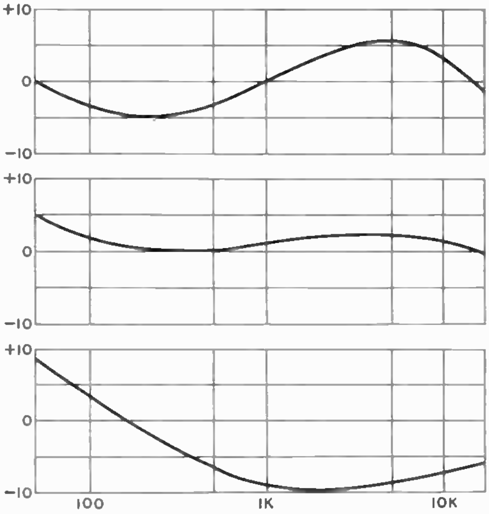
Happily, the blithe admission of low-fi practices mentioned above was originally published in 1962 and things have improved —most bass filtering is now limited to the range below about 45 Hz. It may not be what we think of as hi-fi, but it's at least a step in the right direction and, since the filtering is usually gradual, some 35-40 Hz stuff occasionally trickles through to the super woofer.

An amazing variety of disc recording gear have resonant peaks between 12,000 and 14,000 Hz. Microphones, cutter-heads, pick-ups, and tone arms have such peaks, and, since the peaks are additive, it is no wonder so many recordings sound rough at the top. Of course, high-end peaks in these components can be excused because they don't get there intentionally. The low-end roll-off on recordings does, because recording engineers like to listen to loudspeakers with under damped low-end resonance and then condemn full-range recordings because they sound muddy.

Columbia Went the Other Way. By an odd quirk, Columbia Records is noted for having too much bass in its recordings. A visit to most Columbia Records recording studios will reveal a proliferation of Altec A-7 "Voice-of-the-Theatre" speaker systems. Although these are fine speaker systems, they are not noted for an outstanding deep-bass response. Some environmental response curves that I have seen show the A-7 systems being virtually dead below 45-50 Hz. Thus, during playback, the Columbia engineers discovered a thin sounding bottom and evidently decided to whoop up the low-end response until things sounded "right." It is hardly surprising that many Columbia records have too much bass when reproduced through speaker systems that really plumb the lower depths. This, of course, is the risk that any recording company runs when it tailors sounds by ear. The tailoring corrects imperfections in the playback monitoring speaker systems as well as in the recording itself. Since different speaker systems have different imperfections, the tailoring just doesn't suit most other speakers.

Many Columbia records are characterized by audible gimmicking. Somewhere along the line—possibly as a result of one of those marketing surveys that purport to find out what the public really needs—a few recording directors must have the idea that the average classical record listener is a person of acutely limited perception. Since the listener is incapable of observing anything for himself, the omniscient recording director with his multi-mikes therefore shows the listener what instruments need to be highlighted. So, the woodwinds stay unobtrusively tucked away in the background until they have an "important statement"—introducing the second theme, for instance—at which time a flick of the mixer controls spotlights the woodwinds so they will not be overlooked. After their little act, the woodwinds are pulled back while the violas have their go.

Of course, it's only fair to point out that practically no one records an orchestra with two or three microphones hung in strategic spots. The musicians' union has forced hourly pay scales so high that experimental recording sessions to find out the optimum microphone recording locations have become uneconomical. It is now deemed better to use a technique that allows maximum flexibility after the recording session. Thus, orchestral recordings are made with one microphone for each instrumental section, plus a few extra mikes for hall-reverb pickup and soloist spotlighting. Each microphone has its own mixer and often its own equalization. The tape master is multitrack that allows much of the final mixing to be done when the pay-scale pressure is off. The resulting mix then becomes the prerogative of the recording director and while multi-miking can yield musically realistic-sounding recordings if the director has a good ear and judgement (Deutsche-Grammophon does quite well) it can also yield sonic monstrosities, particularly when the recording



Dynagroove's continuously variable "loudness compensation" at high volume (top), medium volume, and low volume. We defy anyone to try to correct for these variations with ordinary tone controls.

director gets it into his head to out-conduct the orchestral conductor.

Most recording companies do some of this gimmicking and it frequently escapes the listener's attention because it is done subtly. One wonders if someone at Columbia Records forgot the meaning of subtle. They have produced some of the most shocking recordings I have heard with instrumental groups zooming back and forth like the slides of a trombone ensemble.

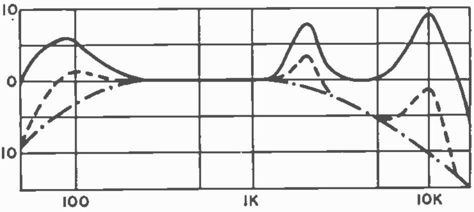
RCA Tells All. Columbia Records did have the discretion not to publicly admit audible gimmicking, but RCA Records was somewhat less discreet. In fact, RCA publicized gimmickry in their massive advertising campaign to introduce the "Dynagroove" system.

As I interpret Dr. Harry Olson's description of the Dynagroove system, it involves "modifying" the original sound so as to compensate for deficiencies in the average home hi-fi reproducing system—as well as the deficiencies of the average listener! These modifications include compression of musical dynamics and a continuously variable loudness compensation system predicated on the contention that the human ear's frequency response curve varies with the volume level of the sound being heard. Thus it becomes necessary for the Dynagroove system to correct for these deficiencies every time the orchestra plays more loudly or softly. It is undeniable that the ear's response changes as sound level changes, but like it or not, this is *the way* human beings hear sounds. The changing response of the ear contributes to the sound we think of as the "real thing," and any attempt to make the ear more efficient by adding corrections simply falsifies the original sonic content. Not too happily for RCA, Dynagroove was not a smashing commercial success—possibly because so many of the early releases sounded ghastly!

You don't need market researchers to show that while hi-fi stereo may be on every tongue, it isn't in every ear. Listeners with Magnavoxes, Philcos and Zeniths vastly outnumber listeners with Dyna-Kits, Sherwoods, Scotts, etc., and the cheap portable stereo is scarcely extinct. When record manufacturers sell sound, they sell ultimate sound and if this means turning up the treble to overcome the mellowness of the average home reproducer, then so be it. Of course, that extra treble boost is added to the boost required to complement the RIAA equalization curve, which is one reason why so many 1960-70 disc recordings are impossible to track cleanly. The high frequency groove modulations become so sharp and emphasized that the grooves get narrower than the playback stylus tip, which rattles across the tops of the modulations. I scarcely consider this high fidelity.

This columnist cannot help but note with amusement the ploy of record critics who, seeking to dull the edge of a cavil about a disc recording's miserable frequency response, will add the statement, "Of course, judicious use of tone controls can remedy the problem." I say—hogwash! Tone controls will never straighten out a fouled-up disc recording any more than a pair of yellow-tinted sunglasses can turn a cloudy day into sunshine.

What Your Tone Controls Can't Do. Every audio enthusiast must initially realize that tone controls are not the equivalent of a professional recording studio equalizer. The recording engineer can, if he wishes, add a sharp peak at 3000 Hz for the sake of "presence," a 10 dB-per-octave boost from 8 to 10 kHz (for "overtones"), and a sharp cutoff above to keep the stylus from jumping out of the groove. The engineer can also add a broad bump at 80 Hz so that the listener imagines that he's hearing bass notes and the hi-fi enthusiast won't be too aware of the roll-off below 60 Hz. An engineer can add this sort of equalization on any selective basis to any one or more of the 18 channels he might be mixing. And once he has prepared his master and you have it on two-channel stereo disc or tape, the equalized and unequalized channels are irrevocably and inextricably combined. The listener can't "de-equalize" the violin section without adding unwanted equalization to the woodwinds.



What a recording engineer can do with his equalizers (solid line) versus what you can do with ordinary tone controls (dashed line). The resulting frequency response is shown by the dotted line.

Realizing the built-in deficiencies of tone controls, we are seeing the introduction of multiband equalizers such as the Advent Frequency Balance Control, Citation 11 and Infinity preamps. These equalizers can make the average mixed-down recording somewhat more listenable. But nothing can overcome the continuously-varying "loudness compensation," of a Dynagroove recording.

How does the listener get realistic sound from recordings? Well, with electronically-

(Continued on page 96)

Assemble the SIX-DIGIT Popular Electronics DIGI-VISTA

ELECTRONIC READOUT TO THE TENTH OF A SECOND

TRUE ELECTRONIC digital clocks are hard to find these days—most digital clocks work electrically with some type of mechanical readout. In the December 1970 POPULAR ELECTRONICS, we introduced the "Digi-Vista" clock, a completely electronic unit using transistor-transistor logic and Nixie® readout tubes. Described in detail in that article was a four-digit clock, which indicates hours and minutes and has a blinker to indicate every other second.

This month, we will describe the six-digit Digi-Vista. Since some of the details of theory and construction will not be repeated here, we suggest you consult the December article before assembling the six-digit clock.

The six-digit clock indicates hours, minutes, *and* seconds. The logic-flow diagram of the clock is shown in Fig. 1. The circuit is essentially the same as the four-digit version, except for the addition of a seconds decade counter and a tens-of-seconds modulo-6 counter. Theses two counters are the same as those previously dsceribed for the minutes and tens-of-minutes counters. And since the six-digit version actually counts the seconds rather than indicating them by a flashing lamp, only two IC's (*IC2* and *IC4*) are used on the scaler module. The one-pulse-per-second output of *IC4* drives the seconds decade counter.

The circuits of the pushbutton controls have been changed slightly and a new HOLD pushbutton has been added. When the latter is depressed, counting is stopped and does not start again until the button is released. This permits the user to set the clock to some pre-

BY CHARLES G. KAY AND DANIEL MEYER

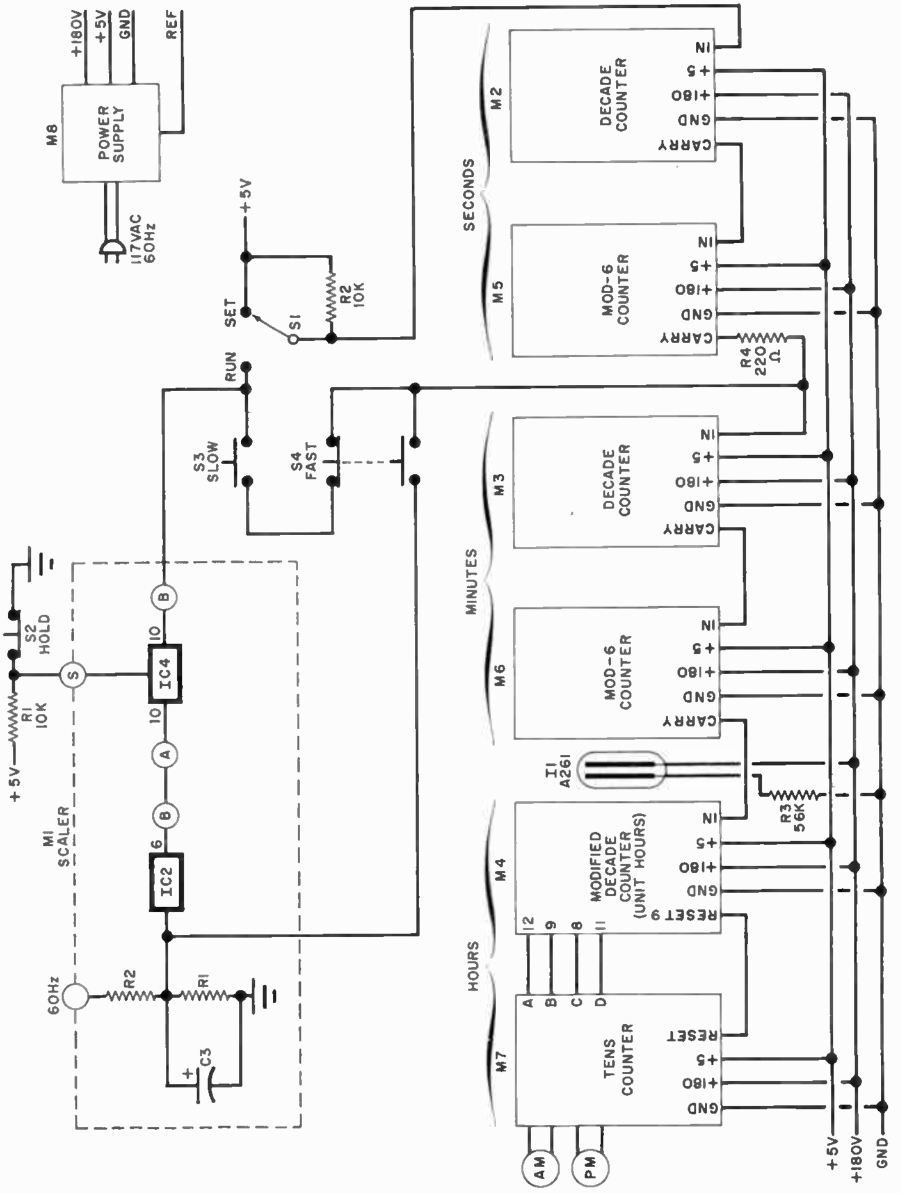
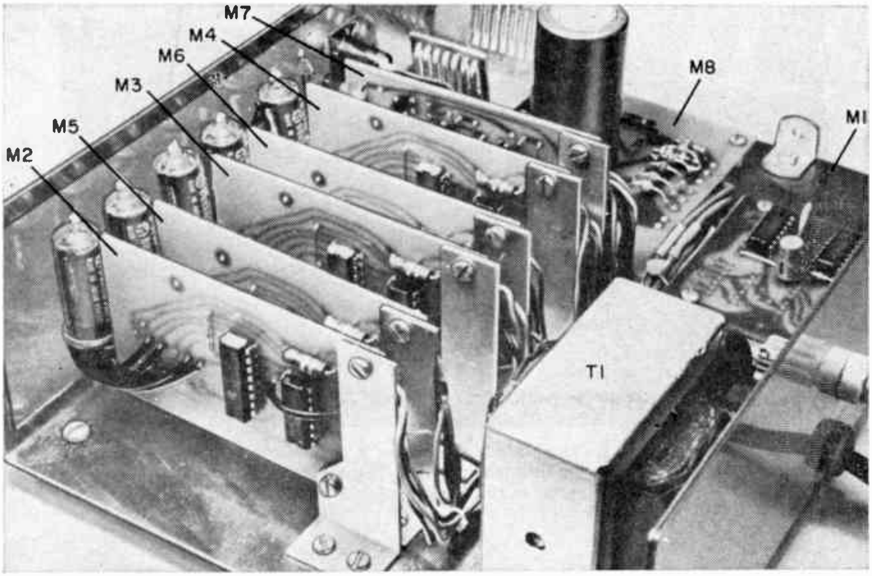


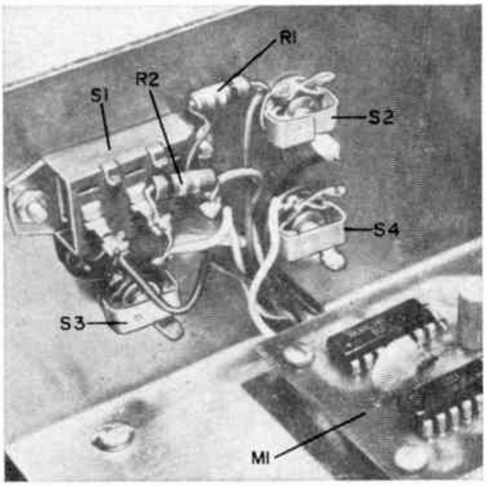
Fig. 1. The logic flow of the six-digit clock is essentially the same as the four-digit clock previously described. Because of the addition of the seconds readouts, only two IC's are used in the scaler module.



Although the prototype was built into a metal cabinet with the arrangement shown here, it could be mounted within any type of cabinet deep enough to accept the modules. The power supply and scaler can be above or below the readouts, and the operating controls hidden away.

PARTS LIST

I1—Neon lamp (optional) (Signalite A261 or similar)
M1—Scaler module
M2-M4—Decade counter module
M5,M6—Modulo-6 counter module
M7—Tens counter module
M8—Power supply module
R1,R2—10,000-ohm, ½-watt resistor
R3—56,000-ohm, ½-watt resistor
R4—220-ohm, ½-watt resistor
S1—Spdt slide or toggle switch
S2—Spst normally closed pushbutton switch
S3—Spst normally open pushbutton switch
S4—Dpdt no/nc pushbutton switch
Misc.—Suitable chassis, polarized plastic glare shield, spacers, mounting brackets, hook-up wire, etc.
Note—The following are available from Southwest Technical Products Corp., 219 W. Rhapsody, San Antonio, TX 78216: decade counter module NX-10 at $15, postpaid; modulo-6 counter module NX-6 at $15, postpaid; tens counter module CL-1 at $8.50, postpaid (specify neon or incandescent lamp); scaler module SC-6 at $8.75, postpaid; power supply module 169 at $11.55, plus postage for 4 lb: polaroid plastic at 25¢/sq in. (specify size required).



The operating controls can be mounted anywhere desired. Once the clock is set, the controls are not used, so they can be hidden from sight on the rear apron, or concealed in chassis.

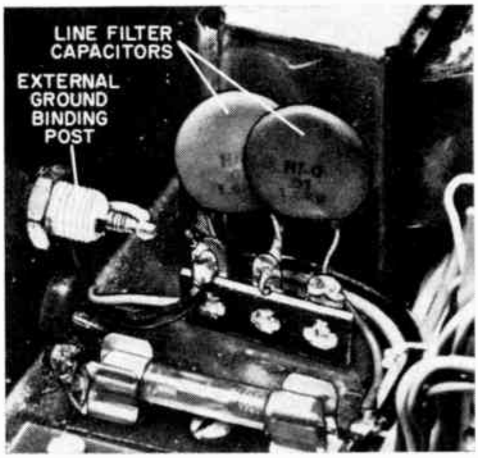
The colon is made by painting black bands on a neon lamp. If desired, another colon may be used between the seconds (the two readouts on the right) and the adjacent unit minutes indicator. In this time example, the tens hours neon is not lit.

determined time and, when the standard time source (WWV, CHU, or other form of time tick) is correctly indicated, start the clock at the desired point.

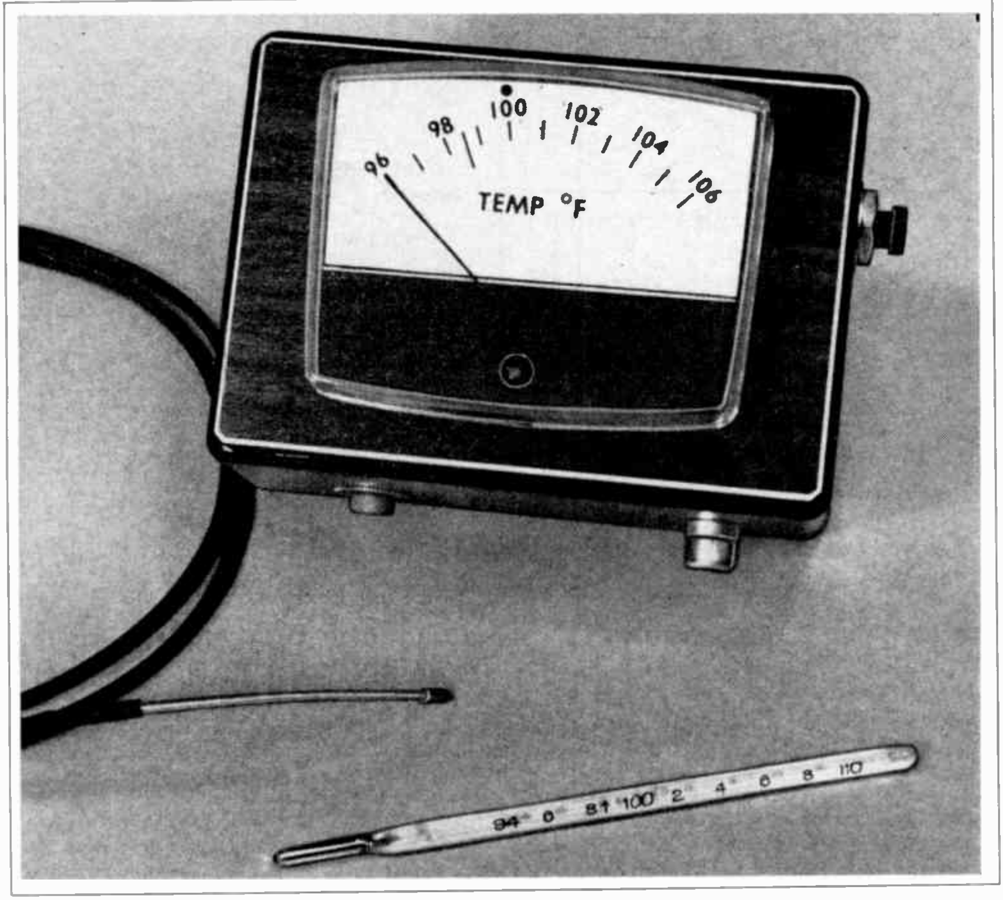
Like the four-digit unit, this clock has an a.m./p.m. indicator and can be fitted with an optional alarm circuit. If desired an additional A261 neon lamp, with parts blanked out to make it look like a colon, can be mounted between the minutes and seconds to separate the readings. All modules are the same as those used in the four-digit clock readout.

To reduce the possible effects of line transients, each side of the input ac line can be decoupled to an external ground through a pair of 0.1-μF capacitors with the common capacitor point connected to a five-way binding post. The binding post is connected to a good ground. —30—

Operating controls should be clearly identified wherever they are located. Ordinary press-on type (available at all art stores) can be used for this.



If you experience erratic timekeeping due to a noisy ac line, connect a capacitor from each side of the line to a good ground, via a binding post.



BUILD AN

Electronic Clinical Thermometer

FAST, EASY-TO-READ AND ACCURATE

There is no mystery to the construction of an electronic clinical thermometer. Besides accuracy and measurement repeatability, the thermistor reaction time is of prime importance. POPULAR ELECTRONICS believes that this project offers the most practical solution to these problems.

THE OLD mercury-glass thermometers that we have all used for so long have many disadvantages. They have to be shaken down before each use, they're hard to read, and they are all too easily broken. Modern electronic technology now permits us to build a small, portable, self-powered, electronic thermometer that provides a temperature indication in about 30 seconds, is easy to read, and is practically indestructible.

Temperature is sensed by a tiny precision thermistor mounted in a small metal enclosure and connected to the electronics and indicating unit through a length of very flexible cable. The diameter of the thermistor probe is considerably less than that of a

BY J. R. LAUGHLIN

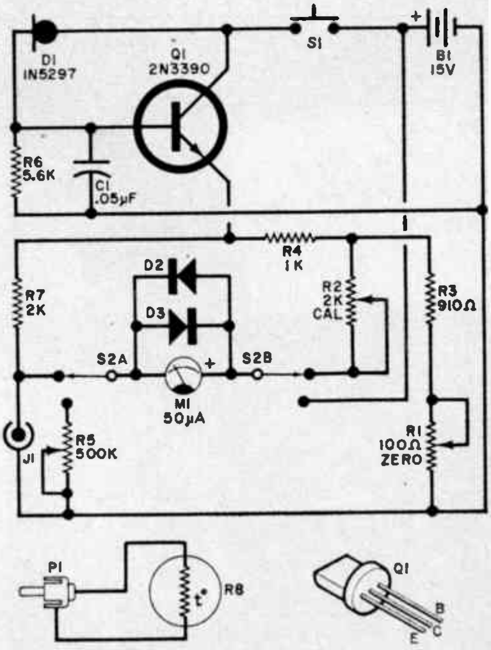


Fig. 1. The thermometer is essentially a Wheatstone bridge powered by a regulated battery power supply. Potentiometer R5 is used to set the meter to full scale with a new battery.

PARTS LIST

B1—15-volt battery (Eveready 411 or similar)
C1—0.05-μF, 20-volt ceramic capacitor
D1—Constant-current diode (Motorola 1N-5297)
D2,D3—Silicon rectifier diode (1N4001 or similar)
J1—Phono jack
M1—50-μA meter (Calectro D1-910 or similar)
P1—Plug to mate with J1
Q1—2N3390 transistor
R1—100-ohm, PC-type trimming potentiometer (Spectrol 84-3-8 or similar)
R2—2000-ohm, PC-type trimming potentiometer (Spectrol 84-3-8 or similar)
R3—910-ohm, 5% resistor
R4—1000-ohm, 5% resistor
R5—500,000-ohm potentiometer
R6—5600-ohm, 5% resistor
R7—2000-ohm, 5% resistor
R8—300-ohm at 25°C, 1% thermistor (Yellow Springs Instrument 44005 or similar)
S1—Spst normally open pushbutton switch (Switchcraft 903 or similar)
S2—Dpdt pushbutton switch (Switchcraft FF-1006 or similar)
Misc.—Plastic case (4" x 3" x 1½", Calectro J4-725 or similar), length of two-conductor cable (RG-174U, Belden 8216, or similar), press-on type, heat shrinkable tubing, spaghetti tubing, battery clip, wire, etc.

conventional glass clinical thermometer and is thus less uncomfortable for the patient. The probe is difficult to damage by accidentally biting. Its small size also allows it to respond rapidly to temperature changes and the low thermal mass of the housing does not affect the environment of the surroundings when temperature is being taken.

Thermistors generally have better long-term stability than thermocouples, and they tend to become more stable with age. In one test, thermistors varied in temperature indication by only 0.03°C per year, over a 12-year period. The resistance value, at any

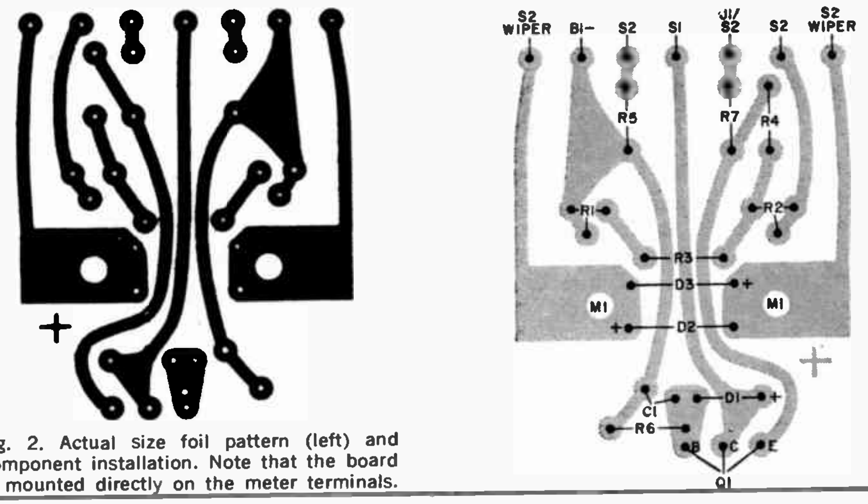
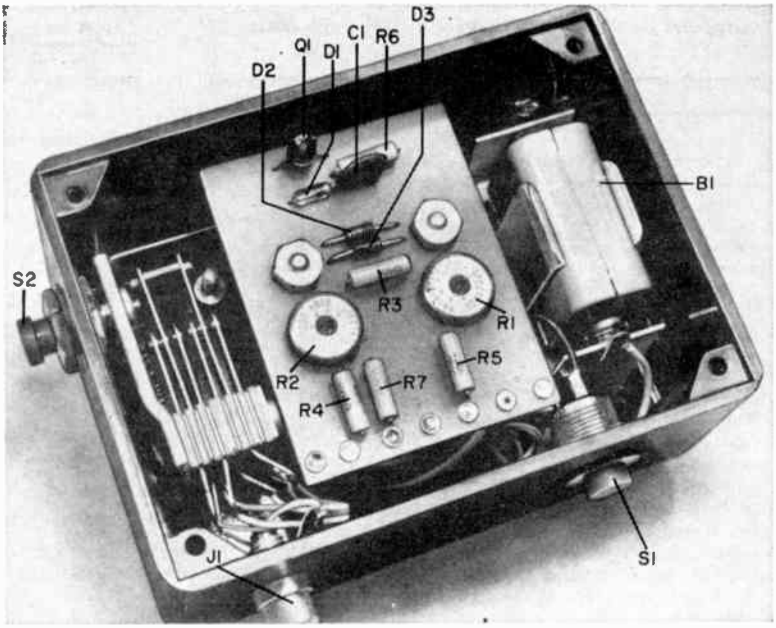


Fig. 2. Actual size foil pattern (left) and component installation. Note that the board is mounted directly on the meter terminals.



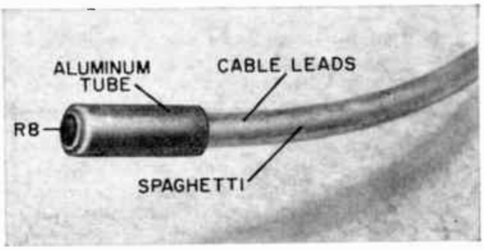
Completed thermometer fits in a small plastic case, including battery. Observe that meter is mounted in the "bottom" of case so that removing the cover allows access.

given temperature, for the thermistor used in the thermometer is accurate to less than 1%. This tolerance represents less than 0.18°F variation in temperature indication, which permits the use of any number of probes interchangeably.

Construction. A schematic of the thermometer circuit is shown in Fig. 1. It can be constructed on a small PC board (see Fig. 2) and mounted directly on the meter terminals. The two large holes shown in the foil pattern should be drilled just to fit the meter terminals without sliding around.

Very carefully remove the cover of the meter to expose the scale. Place the meter movement in a dust-free enclosure while modifying the scale. Using a light eraser, remove the numerals and the small division markers, leaving only the six large division markers. Using india ink and ruling equipment, add five matching division markers exactly between the six original markers. This results in ten equal divisions across the scale, each indicating one degree Fahrenheit. Using some form of press-on type, mark the left-hand marker 96. Number every other mark as shown in the photograph. Place a small dot over the 100 mark to indicate the battery cutoff voltage and draw a red line at 98.6 to indicate "normal" temperature. A "TEMP °F" notation can be added below the scale if desired. Reassemble the scale and meter, taking care that the zero screw engages the proper slot in the movement.

The thermometer can be assembled in a small plastic instrument case measuring 4" × 3" × 1½" with the meter mounted on the bottom of the case so that the rest of the assembly can be reached by removing the cover. You can dress up the unit by removing the feet on the bottom of the case and covering it with contact paper. Once the meter is secured, fit the PC board in place and locate the holes for the two switches and probe jack. They must not interfere with the circuit board. Also locate a suitable spot for the battery clip and mount it.



Great care must be used when making up the probe. Use a non-toxic glue to mount the thermistor in the aluminum tube. Observe the Caution on page 78.

To make the probe, obtain approximately two feet of light, flexible two-conductor cable (RG-174U or similar) and terminate one end with a plug that matches the jack on the case. Cut a piece of slender aluminum tubing just large enough in diameter to allow the thermistor and connections to be inserted. The edges of the tube should be slightly rounded at each end. If you are using RG-174U cable, trim back the outer plastic cover and the braid for about two inches. The insulated center lead of the cable is connected to one thermistor lead (cut very short and insulated) while the other thermistor lead is brought down the outside and connected to the braid. Slide a length of spaghetti tubing down this pair until it contacts the braid. Use a small piece of heat-shrinkable tubing to secure the spaghetti in place. Insert the thermistor and connections into the aluminum tubing with the aluminum just touching or slightly covering the spaghetti. Flow epoxy into the space between the thermistor and tubing and allow to harden. Use an abrasive paper to make the completed probe smooth.

HOW IT WORKS

The circuit is essentially a Wheatstone Bridge powered by a well-regulated supply. The resistance values for the two legs of the bridge were selected to produce a linear output of desired amplitude for the temperature range covered.

Resistor *R7* is connected in series with the thermistor (*R8*) to form a voltage divider which is one arm of the bridge. The voltage at the junction of these two components is a function of the resistance value of the thermistor, which varies with the temperature. This voltage is applied to the negative terminal of the meter. The other arm of the bridge consists of resistors *R1*, *R3*, and *R4*, with the voltage at the junction of *R3* and *R4* capable of being set to equal exactly the voltage at the meter negative terminal when the thermistor probe is at 96°F. In this condition, no current flows through the meter and it indicates at the left end of the scale.

As the thermistor temperature increases, the voltage at the meter negative terminal goes down with respect to that at the positive terminal which is fixed by the resistor network. A probe temperature of 106°F produces a voltage difference sufficient to deflect the meter full scale. Precise adjustment is made with *R2*.

A well-regulated supply is mandatory for accuracy even though the battery voltage drops with use. The regulator circuit used is superior to a zener regulator in two respects: regulation is better (especially as the battery voltage approaches the cutoff point) and it does not require a minimum current to function with a low dynamic resistance.

Operation of the regulator is based on the constant-current diode. The latter is actually a FET transistor with the gate connected internally to the source. It is carefully selected to obtain the most desirable characteristics. The constant-current diode functions in a manner just the opposite of the zener diode. Instead of maintaining a constant voltage drop, it maintains a constant current for a wide range of impressed voltages. A resistor connected in series with the diode (*R6*) then has a constant voltage across it. In the thermometer, this voltage is 5.6 volts, which is applied to *Q1*. The latter is connected as an emitter follower to supply power to the circuit. The circuit not only provides excellent regulation, but draws only about 1 milliampere. Capacitor *C1* insures that the transistor will not oscillate, which may be a problem with high-gain transistors.

Diodes *D2* and *D3* protect the meter from excessive voltages when the unit is operated without the probe or with a shorted probe. Voltage across the meter is limited to 0.6 volt.

Resistor *R5* is used to test the battery by causing a full-scale indication for 20 volts. The battery should be replaced when it falls to 8 volts.

Calibration. To calibrate the electronic thermometer, you will need an accurate bulb-type thermometer. Adjust the meter zero screw until the needle is directly on the 96 mark. Fill a large pot with water and heat to a temperature slightly over 96°F. Remove the heat, place the probe and bulb thermometer in the water, in close proximity, and stir the water continuously. When the water cools to exactly 96°F as indicated by the bulb thermometer, adjust *R1* so that the meter indicates exactly 96. Heat the water to slightly above 106°F, keep stirring and turn off the heat. When the water cools down to exactly 106, adjust *R2* to obtain this indication on the meter. As the water continues to cool, check the mid-scale marks.

CAUTION

Great care must be exercised in fabricating the thermistor probe. A non-toxic epoxy must be used to keep the thermistor in place (particularly at the lead end of the thermistor); and the user must be cautioned not to bite or break the tube while it is in the mouth. Excessive strain should not be placed on the thermistor leads. Some people are allergic to the epoxy that covers the thermistor and can develop a rash when this chemical comes in contact with the sensitive areas within the mouth.

Cleanliness is as important in the use of this thermometer as it is with any other clinical instrument. Always sterilize the probe (with alcohol) before each use.

COMMUNICATIONS

RESEARCH

What Are They Up To?—The mysterious time signal station on 13.56 MHz has been identified as KC2XIO. Licensed for tests by the Department of Commerce, it appears that this station may be the forerunner of the WWV to come. Users of the WWV signals will recall being surveyed in 1969. Unofficial results indicated that two changes were most requested: more voice announcements (including ionospheric information) and getting rid of the binary coded transmissions. Rumors persist that the 440- and 600-Hz tones will also go and that time ticks with voice announcements every minute will be made.

CITIZENS RADIO (CB)

The "Too Much" Base Station—*A manufacturer of CB equipment has a base station console design on the drawing board that will probably sell for $2000! Custom-built, the CB console will include every operating convenience imaginable—phone patch, tape recording, multiple antenna switching, selective calling, etc. Plans call for 100 consoles to be partially assembled against delivery in late 1971. Get your order in early!*

MILITARY

Almost Unbelievable—At the 1970 convention of the Antique Wireless Association, Continental Electronics revealed some of the startling statistics about its work in building the super-power low-frequency (17.8-kHz) transmitter and antenna at Cutler, Maine. Actually, two identical antennas have been erected so that one is always in use when the other is de-iced. The r-f amperage going into the antenna is about 2500 and the voltage nodes exceed 250,000! To radiate efficiently at this low frequency, an enormous ground screen was buried and the antenna Q was raised to such a value that, to transmit frequency shift keying (FSK) RTTY, the whole antenna system must be slightly detuned (with saturable reactors)—the shift is plus or minus 25 Hz.

SHORTWAVE LISTENING

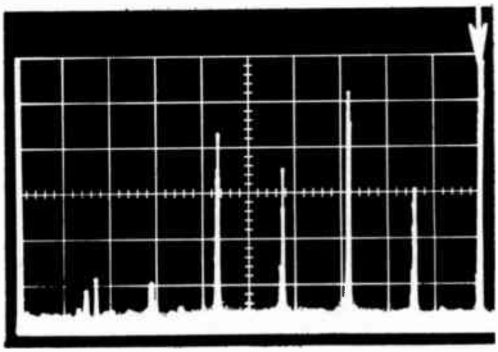
Illegal Taping—*Strictly interpreted, Section 325(b) of the 1934 Communications Act makes it unlawful to tape record program material if there is any possibility that the recording might be radio transmitted back to or heard in the U. S. Waiver of this requirement may be obtained from the FCC, but enforcement since World War II has been almost non-existent. Some SWL's are obviously breaking the law, but since they are non-professionals, no effort is made to enforce the letter of the law. The appropriate Section reads "No person shall be permitted to locate, use or maintain a radio broadcast studio, or other place or apparatus from which or whereby sound waves are converted into electrical energy, or mechanical or physical reproduction of sound waves produced, and caused to be transmitted or delivered to a radio station in a foreign country for the purpose of being broadcast . . ." (Submitted by the Short Wave News Service)*

(Continued on next page)

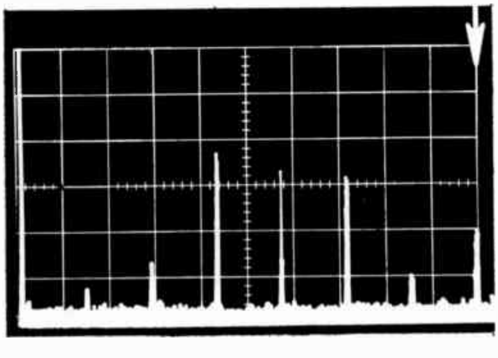
To make in-the-field measurements, General Motors Research Laboratories has a van (below left) fitted with 20-1000-MHz interference intensity receivers, automatic plotters, photo-recording scopes and outdoor periodic antenna. Polarization of the antenna is adjustable.

RESEARCH

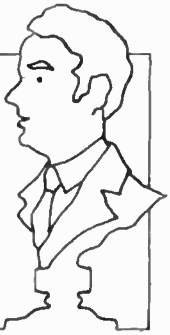
Reducing Spark Plug RFI—The General Motors Research Laboratories has a continuing program in the study of radio frequency interference from automotive ignition systems. Besides using graphite-based ignition cable, bonding and "ACnitor" resistor spark plugs (in all GM 1969-71 cars), GM feels that improved results can be obtained with lossy ferrites and ceramics. Apparently much work also needs to be done in bonding and there is some evidence that commonly used braided copper straps, one quarter to one half inch wide are not as effective as solid copper strapping with 5:1 length-to-width ratio. (Extracted from *Research*, Vol. 5, No. 2)



Spark plug r-f radiation at 245 MHz is displayed in these scope prints. The base line is the timing interval for firing of a V-8 engine with the pulses indicating plugs in the firing order 1:8:4:3:6:5:7:2. The arrows point to the pulses of plug 2. In the print above, the amplitude is much greater than that below because the ignition wire was moved slightly further away from the engine block.



OPPORTUNITY AWARENESS



Thoughtful Reflections On Your Future

Ninth in a Monthly Series by David L. Heiserman

Home Study Courses in Medical Electronics

After reading your column on medical electronics (July 1970), I became enthusiastic about the possibility of learning medical electronics through home study. As suggested, I wrote to several electronics home study schools, asking them to start courses in medical electronics. I received polite replies, but haven't seen any positive action. What good does it do to suggest new courses if the schools don't do anything about it?

● The fact that electronics home study schools are cautious about starting a new kind of course is understandable. Designing and writing new courses requires time and money, and the schools' administrators must be certain they will get a good return on their investment before they develop a new program—even one that would seem to be as popular as medical electronics.

Apparently letters from individuals interested in medical electronics courses haven't made a case strong enough to impress the home study schools. To coordinate our efforts, we have called upon the National Home Study Council, the most influential organization for private home study schools. Mr. Robert Taylor, the Administrative Assistant for NHSC and editor of the "NHSC News", will be working with us to build a strong case for starting home study courses in medical electronics. If you are interested in helping make home study courses in medical electronics a reality, duplicate the form letter below and mail to: (Please note that it isn't necessary to include your name and address.)

Mr. Robert Taylor, Administrative
Assistant
National Home Study Council
1601 Eighteenth Street, N.W.
Washington, D.C. 20009

Electronics Training After High School

I am enrolled in a technical-vocational high school, and will graduate next year. I would like to get a job as an electronics technician, but I'm not interested in going to college or a two-year technical school to get an engineering degree. Where can I go from here?

● I suggest you think about taking some

MEDICAL ELECTRONICS HOME STUDY POLL

I would like to take the following home study course related to medical electronics: (Check as many blanks as you like.)

- _____Medical Electronic Instrumentation
  - _____Theory of Operation
  - _____Maintenance and Repair
  - _____Design
- _____Physiology for Medical Electronics Technicians
- _____Other (please specify)__________

Name (optional)________________

Address (optional)________________

Occupation________________

I am now taking or have taken a formal course in electronics.

_____Yes
_____No

Comments:________________

electronics courses from a reputable resident or home study school right after graduation from high school. Although your high school may prepare you for a job in the electronics industry, high school graduates taking post-high school electronics courses generally get better jobs and higher starting salaries than those who rely only upon their high school diplomas.

There are several reasons why you can expect a better job and higher pay if you're taking electronics courses after graduation from high school:

1. Post-high school electronics courses give you a chance to review the material you have been taught, and they can lead you into more specialized training. Employers recognize this fact and are willing to reward you for your efforts.
2. By taking post-high school electronics courses, you will be associating and competing with men who are older and have some electronics job experience. Dealing with these people in an enthusiastic and professional manner in the classroom or through the mail shows your prospective employer that you will be able to get along with the many different kinds of men and women working in the electronics industry.
3. Pressures from society, teachers, and parents encourage most students to complete their high school training. These pressures, however, aren't so great for students taking post-high school courses. Keeping up with your post-high school studies and showing a sincere interest in completing them will prove you are the kind of man who takes his career seriously.

You should begin looking for an electronics school before graduating from high school. You can get a free list of nationally accredited home study schools by writing for "A Directory of Accredited Private Home Study Schools." The address is:

National Home Study Council
1601 Eighteenth Street, N.W.
Washington, D.C. 20009

If you are interested in attending classes at a local resident school, be sure to check the school's programs and business methods. Do these things:

1. Visit the school while classes are in session to see how the instructors and students conduct themselves.
2. Get the names and addresses of recent graduates living in your community, and ask them how they feel about the school and the training they received.
3. Write to your State Department of Education, and ask about the school's academic standing.
4. Contact your local Better Business Bureau to see if they have any complaints on file about the school.

College Courses by Home Study

I have heard that some colleges and universities offer home study courses in college-level subjects. Where can I get a list of these schools and the courses they offer?

● For the benefit of readers who haven't heard of these programs, many well-known American colleges and universities do, indeed, offer college-level home study courses. It is possible for a home study student to get full college credit for successfully completing some of these courses. Most of the credit courses are on the freshman and sophomore levels, however, so it isn't possible to get a college degree strictly through home study. Many students begin their college careers with these home study courses, though, and complete their requirements for a degree by attending classes at a later time.

These colleges and universities also offer full-credit high school home study courses as well as non-credit vocational, technical, and general interest courses.

For a listing of the schools and the home study courses they offer, send fifty cents and a request for the "Guide to Correspondence Study" to:

National University Extension
Association
900 Silver Spring Avenue
Silver Spring, Maryland 20910

(This information comes from the "National Home Study Council News", November 1969 Supplement.)

SOLID STATE

One Hundred Seventy-Sixth in a Monthly Series by Lou Garner

JANUARY—named after the two-faced Roman god, *Janus,* who looked forwards and backwards at the same time—a new month and the beginning of a new year. As Janus, we, too, must look in two directions . . . back to our January, 1970 column, in which we made predictions of solid-state developments for 1970, and ahead to our forecasts for 1971.

First, a look at the past twelve months. One year ago we predicted:

Light-emitter diodes (LED's) at prices comparable to those of long-life incandescent lamps. Home run! Monsanto Electronic Special Products (10131 Bubb Road, Cupertino, CA 95014), Motorola Semiconductor Products (Box 20912, Phoenix, AZ 85036), and Hewlett-Packard (1501 Page Mill Road, Palo Alto, CA 94304) all have introduced inexpensive LED's. Monsanto's type H-1 is offered to experimenters at two for $2.98, or less than $1.50 each.

Linear IC's with built-in special in-put devices, such as sensors or pick-ups. Home run! RCA's (Harrison, NJ 07029) type TA5371B (now type CA-3062), reported in our June column, is a linear IC amplifier with an integral light sensor.

Moderate power (5 to 10 watts, or more) IC amplifiers at prices competitive with discrete component designs. Home run! Several firms are now producing moderately priced multi-watt IC amplifiers. GE's (Electronics Park, Syracuse, NY 13201) PA246 is a typical device. Capable of delivering 5 watts rms (10 watts peak) to a 16-ohm load, the PA246 is an 8-transistor, 5-diode IC which nets for only $5.00 each in unit quantities. Try matching that at the same price with a discrete component assembly!

A virtually complete switch-over to solid-state circuitry in consumer products. Home run! Although vacuum tubes are still used in some TV sets, virtually all other consumer (electronic) products use solid-state circuitry exclusively, including variable-speed blenders, power tools, cassette players, receivers, CB gear, burglar alarms, dictation equipment, etc. One firm has even introduced a solid-state controlled soldering iron!

The introduction of rf IC's with integral, rather than external, inductance elements. Home run! Many commercial UHF/VHF IC's now feature built-in inductors, and at least one company (Epitek Electronics, Ltd., 19 Grenfell Cres., Ottawa 12, Ontario, Canada) offers a standard line of chip type inductance devices for use by hybrid IC manufacturers.

Actually, the conventional inductor may soon become obsolete as far as IC's are concerned. A number of special purpose circuits and devices have been developed which can serve as substitutes for bulky inductance coils, including unique monolithic quartz crystals, the capacitor-loaded gyrator, various active filters, and the versatile phase-locked loop.

The formation of a new corporation offering a broad range of specialized semiconductor-operated products at the consumer level. Home run! Several such firms started operations during the year. One, North American Electronics (Rockford, IL 61108), offers a wide line of consumer-oriented electronic products and components, including semiconductor-operated standard and wireless intercoms, telephone amplifiers, door answering communicators, battery chargers, and amplifier modules.

The use of lasers as production tools in the manufacture of solid-state devices. Home run! Serving as standard production equipment, medium-to high-power lasers are now being used by major manufacturers for such tasks as scribing semiconductor wafers, trimming IC resistors to value, and welding microminiature contact leads.

The introduction of an unusual new solid-state device—perhaps an IC opto-coupler or monolithic microwave circuit. Home run! Not one, but several unusual new solid-state devices were announced during 1970. On the West Coast, engineers at the Boeing Company in Seattle developed a unique monolithic silicon gyrator—a circuit capable of simulating the operation of a sizeable inductor. Down South, TI engineers developed a pair of monolithic silicon microwave circuits —an experimental 100-watt Ku-band phase shifter and a single-ended X-band mixer.

And in the East, RCA announced their new adaptive ferroelectric devices, as reported in our April column.

The production of "all-IC" consumer items with few, if any, discrete components, except for electro-mechanical devices, such as loudspeakers and controls, or physically large units, such as transformers. While we could legitimately score a "homer" for this prediction, we feel that a "double" is more realistic —a "homer" only through error. True, several "all-IC" products were introduced during the year, including receivers, phonographs, hearing aids, and various specialized controls, but, quite frankly, we had anticipated a much broader use of IC's in consumer products in making our original forecast. Reluctantly, then, but honestly, just a double.

The development of a new solid-state memory system suitable either for a computer or, possibly, an "electronic" camera. Home run—with the bases loaded! Although, truthfully, we had considered this the "wildest" of our forecasts for 1970, we were able to score late in the game with an assist from the scientists at the Bell Telephone Laboratories. As discussed in our October column, BTL scientists and engineers were successful in developing a completely new type of memory—a solid-state device called a *ferpic* which can store picture images until electronically erased or changed.

Final score for our 1970 predictions, then, 9 home runs, 1 double in ten times at bat.

Things to Come. Each year at this time, we feel inclined to discontinue our annual predictions. After all, why spoil a good record? But, trembling and with apprehension, we suggest you expect the following during 1971:

The production of relatively inexpensive solid-state computers suitable for student use in public schools. . . the introduction of a solid-state oscilloscope in the $100 to $150 price range, perhaps as a kit. . . *LED's priced at less than one dollar in unit quantities. . .* medium- to high-power (10 to 50 watts, or more) IC audio amplifier devices in the "under $10" price range. . . *an expanded use of linear IC subsystems by both engineers and hobbyists, as well as the introduction of new subsystem devices comparable to gyrators and PLL's. . .* a unique solid-state microwave device based on a technological breakthrough. . . *the development of a new semiconductor manufacturing technique. . .* despite inflation and increased labor costs, a continuing drop in the prices of both IC's and discrete solid-state devices. . . *an interesting new semiconductor sensor. . .* a significant increase in the use of solid-state electronic equipment in bio-medical research and medical applications.

Reader's Circuit. Designed to switch off a conventional tape recorder/player automatically at the end of a reel, the control circuit illustrated in Fig. 1 was submitted by Richard F. Serge, ETR-2, aboard the USS Columbus (CG-12). Although intended for a specific purpose, the basic circuit is reasonably versatile and, with a little ingenuity, could be modified for more general applications.

Referring to the schematic diagram, common-emitter amplifier *Q1* normally is held in a conducting state by the base bias established by voltage-divider *R4-R5*, thus energizing *K1* (4- to 30-mA pull-in current) and permitting equipment operation. At the same time, base diode *D1* is held in a high resistance (non-conducting) state by a reverse bias obtained from a voltage-divider

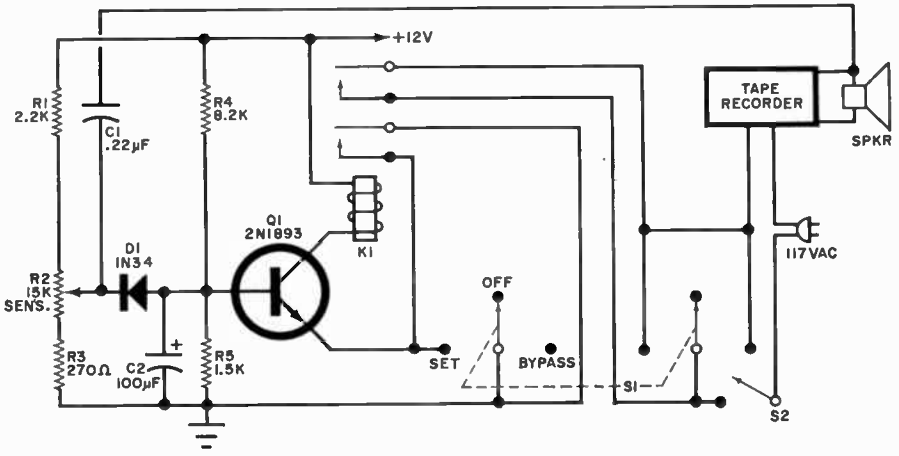
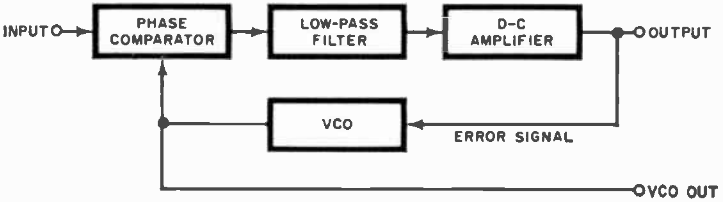


Fig. 1. The control circuit can be used with a battery-operated recorder with the same effect.



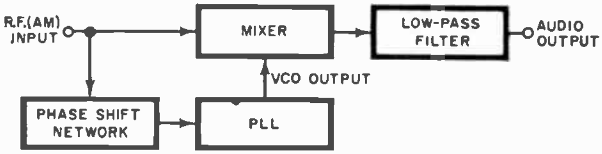


Fig. 2. "Innards" of a phase-locked loop (above) show how the voltage-controlled oscillator is kept in step with varying frequency input signal.

Fig. 3. The simple circuit shown at the left illustrates the use of the PLL as a synchronous AM demodulator.

made up of *R1*, *R3* and *sensitivity* control *R2*. If the tape player's output signal, coupled back through *C1*, rises to sufficient amplitude to overcome *D1*'s reverse bias, however, the diode will conduct, reducing *Q1*'s base bias and allowing *K1* to drop out, thereby switching off both the control circuit and the tape player. In practical operation, "switch off" action is initiated by a pre-recorded high level signal at the end of the tape.

Neither layout nor lead dress are critical, and the control device can be assembled on an etched circuit board, small chassis, or perf board. If space is available, the unit may be mounted within the tape player's cabinet—if not, in a small metal or plastic case as an outboard accessory.

A nominal 12-volt dc supply is required for circuit operation. In his installation, Richard utilized an existing 35-volt source within the tape recorder, relying on a voltage-dropping regulator circuit to reduce this to approximately 12 volts. Naturally, an independent power supply can be used, if preferred.

For optimum circuit performance, the tapes used with the recorder/player must have a pre-recorded control signal at the end of the program material, with this signal of greater amplitude than the maximum level of the regular program. Richard suggests that a 12-kHz, high-level tone be recorded at the beginning of each tape and repeated at the end of the reel for approximately a half-second. Initially, this tone is used for adjusting the unit's *sensitivity* control, serving, later, to trigger "switch off" operation.

The unit's set-up is straightforward. Switch *S2* is closed and *S1* turned to its "set" position. Next, sensitivity control *R2* is adjusted so that *K1* remains energized on program material, but drops out on the high-level control signal. Finally, with the tape playing, *S1* is turned to its "off" position. Thereafter, operation is automatic, with the equipment turning itself off when the control signal is played at the end of the reel.

The Phabulous Phase-Lock Loop. Would you believe a system *without tuned circuits* which can: (a) detect AM signals, (b) demodulate FM signals, (c) isolate tones, (d) reconstitute signals, (e) track unstable signals, (f) synthesize precise frequencies, and serve as a frequency selective (g) multiplier or (h) divider? Moreover, a circuit with superb noise immunity and exceptional selectivity.

Would it be a design engineer's pipe dream? An experimenter's fantasy?

Neither! Just such a circuit concept—the phase-locked loop, or PLL—has been around since the early 1930's and has been widely used in a number of special applications. Unfortunately, the basic system is quite complex and, therefore, costly to reproduce with discrete components. As a result, the PLL's past applications have been justifiably limited to expensive precision equipment requiring exceptional noise immunity and very high selectivity.

Today, however, two major semiconductor manufacturers—Motorola Semiconductor Products (P.O. Box 20912, Phoenix, AZ 85036) and the Signetics Corporation (811 East Arques Ave., Sunnyvale, CA 94086)—are offering PLL IC's at comparatively low prices, thus providing a new and exciting field for both the equipment designer and the advanced experimenter.

A simplified block diagram of the basic phase-locked loop is given in Fig. 2. In operation, an external (input) signal and a locally generated signal obtained from a voltage-controlled oscillator (VCO) are applied to a phase comparator which, in turn, develops an output error voltage proportional to the phase difference between the two signals. This error signal, after filtering and amplification, is coupled back to the VCO as a control signal, thus establishing a feedback loop. The error signal acts to shift the VCO's frequency in such a way as to reduce the phase difference between it and the input signal. If the VCO's "natural" free-running

(*Continued on page* 90)

THE PRODUCT GALLERY

Fifth in a Monthly Series by "The Reviewer"

WELL, kiddies, it's color TV kit building time!

How time flies and how the color TV kit building art has progressed since the first kit was introduced in 1963. Five color TV kits later, the Heath Company is now offering its first solid-state modular color TV receiver kit. I am going to let the Heath Company advertising tell you about most of the refinements and conveniences in this new kit while I concentrate below on the essential differences between the solid-state concept and the, say for example, GR-681, the comparable Heathkit color TV with all vacuum tubes.

Heathkit GR-370. The Heath Company has introduced three solid-state color TV kits. All three share some of the same features, but this report concentrates on the GR-370 (295 sq in. picture) available with the new matrix tube for $569.95, or the regular 23VARP22 picture tube for $10 less.

Besides the modular construction so well described in the Heath Company advertising, I was particularly attracted to the "instant-on" philosophy which means that the three filaments in the picture tube are kept warm at all times. This should prolong picture tube life since most tube failure is confined to turn-on surges. The GR-370 also contains an adjustable pulse noise limiting circuit, gated agc, and an adjustable peaking control in the circuits between the i-f strip and the luminance PC module.

Servicing, one of the primary reasons for investing in a kit is simplified through the use of the solid-state modules* and the inclusion of a simple VOM as part of the GR-370 kit.

The weighty assembly manual—such as that accompanying the GR-681—has been dissected and expanded so that the builder receives 6 or 7 separate manuals—depending on whether or not he has remote controls. Most of the manuals may be filed away after use and only Book 5 retained for servicing and maintenance information.

Book 1—Introduction and Circuit Boards. The heart of the GR-370 comprises 9 plug-in printed circuit boards that are assembled according to the detailed wiring plans in this book. In order of construction the boards contain the circuits for the following systems: sound (1 IC and 1 transistor), luminance (6 transistors including 1 Darlington pair), video-output (1 IC and 4 transistors), chroma (6 transistors), 3.58-MHz oscillator (1 IC and 2 transistors), agc-sync (8 transistors), vertical oscillator (4 transistors), horizontal oscillator (2 transistors), and the pincushion and convergence boards (no solid-state components required).

Soldering in the components on these 9 boards is far from a difficult task. It is time consuming, but scarcely what this reviewer would call tedious since each board becomes an integral unit and your work may be safely interrupted between boards. Sockets are used for all IC's and transistors and there is little opportunity for heat damage to these components. My only suggestion in the assembly process is to feel free to reverse the order of installation—install capacitors before resistors (rather than vice versa) if you find it convenient. Also, use heat sinks on all diodes when soldering—just in case.

My work total for Book 1 was 12 hours and 35 minutes which I feel is about average. I did use a soldering iron with variable heat (Heathkit GH-17A) and was particularly careful about solder bridges between foil patterns. In fact, it is a good idea to go over each foil pattern after the soldering operation has been completed and examine it with a magnifying glass. Check for cold solder connections and solder bridges.

Book 2—Chassis Assembly. By and large, all of the mechanical assembly and wiring steps detailed in this book go smoothly. I think that a very fast kit builder could tear through this book in 8 hours—possibly a little less. However, I would expect the amorphous "average" builder to spend at least 9 hours.

You will be delighted to find that the

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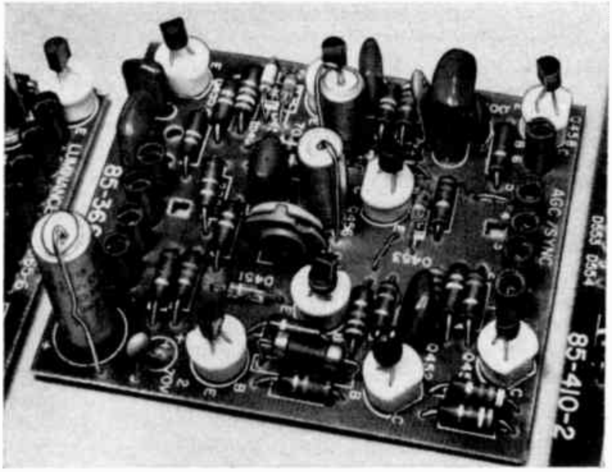
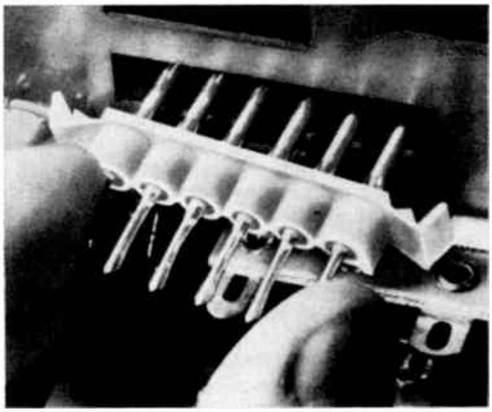
*Within the 90-day warranty period, the GR-370 builder may have the modules serviced or replaced at no charge for parts or labor. After the warranty expires, modules will be serviced or replaced at $5 per module for parts and labor for a two-year period from the date of purchase.

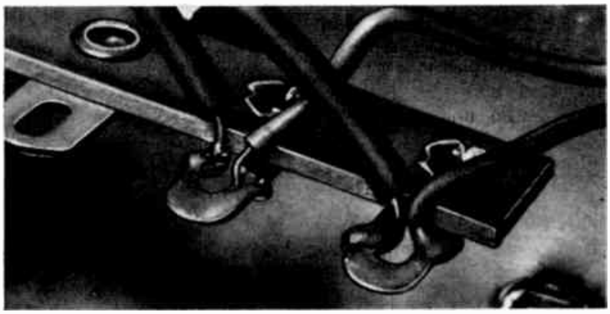
HEATHKIT SOLID-STATE COLOR TV GR-370



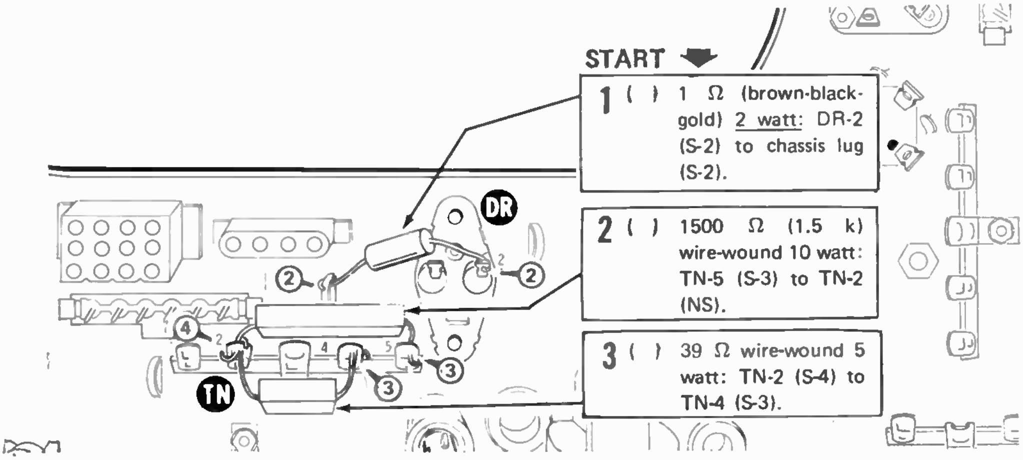
EASIER CONSTRUCTION/SERVICING. Major assets of the GR-370 are convenience of modular construction and ease of troubleshooting. Builder assembles 9 modules similar to that above containing agc and sync circuits. Note use of sockets for transistors and clear identification of leads.



SNAP INTO PLACE. Each printed circuit board or module is suspended between two 6-contact circuit board connectors. Each connector is snapped into place in the pre-punched chassis. Modules are easily removed for checks and servicing. This view is from the inside of chassis looking out.



SOLDER TACKING HELPS. Your reviewer feels that each connection (whenever possible) should be tack-soldered when made. If the connections are lightly touched with solder when made, they cannot spring loose and a well-soldered "final" connection is assured—regardless of number of wires to be soldered.



1 ( ) 1 Ω (brown-black-gold) 2 watt: DR-2 (S-2) to chassis lug (S-2).

2 ( ) 1500 Ω (1.5 k) wire-wound 10 watt: TN-5 (S-3) to TN-2 (NS).

3 ( ) 39 Ω wire-wound 5 watt: TN-2 (S-4) to TN-4 (S-3).

NEW WIRING PROCEDURE. This reduced example of the two-color assembly diagrams in Book 2 illustrates the "flow" of instructions (sequential and boxed) as well as the finished soldered terminations (the circled numerals). Use of this type of system virtually eliminates chances of making wiring errors.

4-transistor i-f assembly is delivered preassembled and prealigned. It is simply fastened into place and phono cable connections made to the sound circuit and luminance boards. The automatic fine tuning (aft) assembly with its two IC's is also preassembled and has been partially aligned.

This book introduces the Heathkit builder to the two-color wiring diagram with the new expanded—but, single page—wiring diagram. Be careful of page 2-13—it is a SAMPLE page—not an actual wiring diagram. Step-by-step wiring instructions are made a part of each pictorial and the red numerals tell how many wires are finally soldered into place at a particular terminal.

Book 3—Front Panel Assembly. The "guide word" for following instructions in this part of the GR-370 assembly process is —look before you leap. Particularly note that this book is in two distinctly separate sections and that they are nonconsecutive. Both parts of this book deal with the front panel: one section about the panel assembly WITHOUT remote controls and the second section WITH remote controls. Don't go pell-mell into the assembly unless you're at the right starting page; which is page 3-3 if you have NO remote and page 3-25 if you HAVE remote controls.

The front panel is that part of the GR-370 where you mount two tuners, motors on the color and tint controls (if used), and all of the usual viewers' controls: color, tint, volume, brightness, contrast, etc. Wiring is straightforward and there are very few rough spots. There is a lot of cabling (supplied) to be connected and I think that 4 hours total assembly time is just about the minimum you might expect.

Book ??—Picture Tube and Shield Assembly. I guess the numbering of this instruction manual was lost in the shuffle, although it obviously belongs between Books 3 and 4. As the title indicates, this is the procedure for mounting the picture tube to the face mask, assembling the shield, placing the automatic de-gaussing coil into position around the neck of the tube and finally hanging the chassis (it is hinged) and making the 9 different cable assembly interconnections. Be careful to do step number 9 on page 14 (Pictorial 1-11) since it is "hidden" in the lower lefthand corner and I missed it first time around.

This is the most laborious part of the GR-370 kit and also the one requiring the most muscle. I would normally allocate over 4 hours—although an experienced builder (someone who has built a 1968-70 color TV kit) might run through everything in under 3 hours and 30 minutes.

Book 4—Adjustments and Operation. Before starting on the steps detailed on the charts in the first part of this Book, you should assemble the little Heathkit "Troubleshooter." This is a 20,000-ohms-per-volt VOM with two voltage measuring ranges (0-50 and 0-500 volts) and two resistance ranges (RX1k and RX10k). I suspect that many builders with previous kit experience may skip this part of the project; but if they do it may well be to their grief. Putting the simplified VOM together is a matter of about 50 minutes and the checkout tests take just under another 30 minutes. This is not bad for the feeling of competence a successful run-through will impart when all of the resistance tests match the predicted results shown in the charts.

Should any resistance measurement not be up to snuff, the charts indicate what steps to take to isolate the trouble—which most frequently at this stage would be a solder bridge on one of the PC boards or a wrong value resistor inserted in error on one of the boards. If absolutely nothing else, these tests tell you in advance that the GR-370 is not going to go up in smoke the first time it is turned on.

Also in Book 4 are short sections on Normal Operating Characteristics (a very good idea if you worry about strange buzzing and crackling noises), De-Gaussing, Final Assembly (pole pieces, speaker and Trim Panel), and Tests and Adjustments. The latter includes setting vertical size, making static and dynamic convergence, purity, pincushioning, etc. adjustments.

Remote Control Assembly—For an extra $64.95 you can obtain from Heathkit a "Wireless" (ultrasonic in the spectrum 34-44 kHz) remote control that greatly enhances the armchair viewing pleasure of color TV. Although the remote control facilities may be added to the GR-370 at any time, I think everyone will find it easier to make the initial investment when buying the GR-370 and build the control units (transmitter, receiver, and motor drives) before starting on Book 3.

The remote control (kit GRA-70-6) can be assembled in 3½-4 hours and presents no difficult problems—just use a modest amount of care in soldering the transistors to the PC board (no sockets used here).

To reach this point I had spent 34 hours building the GR-370 with remote control facilities. Still to go were all of the steps incidental to convergence and final mounting of the receiver in its cabinet. A good full raster has been obtained at first turn-on and my comments on TV picture quality and operating conveniences will appear in next month's column.

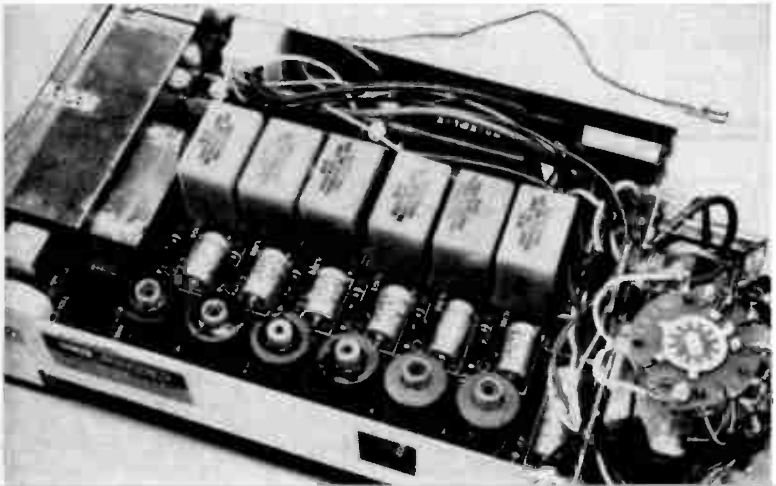
Circle No. 92 on Reader Service Page 15 or 95

TOOLS WHEN YOU NEED THEM. The Heath Company has supplied solder with its kits and your reviewer observes that a number of important tools are now packaged. In the GR-370 kit there are two nut drivers and a miniature end wrench. This is the PC board of the convergence assembly being attached to the metallic bracket with some sheet metal screws.

SPARK GAP CAPACITORS. Nine special high-voltage capacitors are wired into the GR-370 around the picture tube. Although ceramic, they are distinguished by an elongation that has what appears to be a cut in the edge away from the leads.

EVEN A VOM—As part of the overall GR-370 kit package, the builder receives the plans and parts for a small VOM. This instrument is used to check the receiver before first turn-on and may be used to service the set in case of difficulty. The meter scale is imprecise and the readings are very approximate.

YOU WOULN'T EXPECT TO FIND—The concentric fine tuning knob on the VHF tuner has disappeared from the GR-370 and has been replaced by a separate knob and chain drive. The object in the left foreground is motor for the color potentiometer.



NO CHANGE HERE—The ultrasonic remote control receiver is still the very sturdy and practical GRA-70-6. A six-channel system, it is slug-tuned between 34 and 44 kHz. Enclosed relays (the six rectangular objects) activate color and tint motors or pull in the stepping relay (which is the right-hand wafer switch visible).

HEATHKIT SOLID-STATE COLOR TV GR-370

SOLID STATE

(Continued from page 85)

frequency is close to that of the external signal, it will "lock" with the input and follow it over small frequency variations.

Once the PLL is "locked-in" (or synchronized) with the external signal, it acts as a type of signal-tracking filter, precisely duplicating the frequency of the input signal and developing a low frequency signal voltage representing the instantaneous phase (or frequency) difference between the input and VCO signals. These are the essential features of the circuit's operation which account for its great versatility.

The PLL may be used as an *FM demodulator,* for example, simply by abstracting the amplified error voltage (OUTPUT, Fig. 2), for this represents the detected FM signal.

On the other hand, if an output signal is obtained from the VCO, the PLL becomes a *frequency-selective signal conditioner,* since the VCO's output duplicates the input signal frequency at a higher power level and with a far superior signal/noise ratio.

Furthermore, since the PLL can—and will—lock-in on multiples (or submultiples) of the input signal, the circuit can be used as an accurate tuned *frequency divider* or *multiplier.*

The addition of a mixer and a phase-shifting network will permit the PLL to be used as a synchronous *AM detector,* as illustrated in Fig. 3. Here, the PLL "block" represents the complete circuit given in Fig. 2. In operation, the PLL locks on the r-f carrier, developing a reference signal at the same frequency, but without modulation. When combined with the AM r-f input signal in the mixer, a difference signal is developed representing the modulation (audio) components. This detected signal is then abstracted through a conventional low-pass filter network.

A practical application for a commercial PLL IC is shown schematically in Fig. 4. Many, but not all, FM stations broadcast uninterrupted (SCA) background music for business outlets, using a 67-kHz frequency modulated subcarrier. This circuit, obtained from a technical bulletin for the Signetics type SE/NE565 phase-locked loop IC, permits the subcarrier to be abstracted and demodulated, thus furnishing a commercial-free source of background music. The SCA decoder can be duplicated quite easily in the home workshop and used as an accessory with a conventional FM broadcast band receiver. (Another such circuit was described in "Build an SCA Adapter for FM Reception," POPULAR ELECTRONICS, Dec. 1970, p 53.)

Referring to the circuit diagram, the demodulated signal obtained from the FM receiver is coupled to the PLL through a dual high-pass filter consisting of *C1*, *R1*, *C2* and *R4*. Voltage-divider *R2-R3* establishes input bias, while variable resistor *R7* serves as the internal VCO's fine tuning control. The detected output signal is obtained through a triple-stage low-pass L-type filter network, *R8*, *C5*, *R9*, *C6*, *R10* and *C7*, which provides de-emphasis and, incidentally, serves to attenuate the high-frequency noise which sometimes accompanies SCA broadcasts.

Except for potentiometer *R7*, all resistors are half-watt types, while the capacitors are small mica, ceramic, or high quality tubular paper units. A 10- to 24-volt dc power supply is required. With an input signal of 80 to 300 mV, from a 10,000-ohm source, the PLL SCA decoder will deliver an output signal of approximately 50 mV with a frequency response to about 7 kHz.

In addition to the applications outlined above, phase-locked loops may be used for frequency shift keying, motor speed control, time base generation, frequency synthesis, tone decoding, and data locking. If you'd like to explore the PLL in greater depth, detailed application notes and technical specification bulletins for commercial PLL IC's are available from both Motorola and Signetics.

Device News. A number of new products have been introduced recently by Motorola Semiconductor Products, Inc., including several new complementary MOS IC's, five new series of complementary Darlington power transistors, and two new npn silicon r-f power transistors.

Featuring quiescent power consumption in the nanowatt range, Motorola's new MOS IC's are monolithic digital logic devices. The

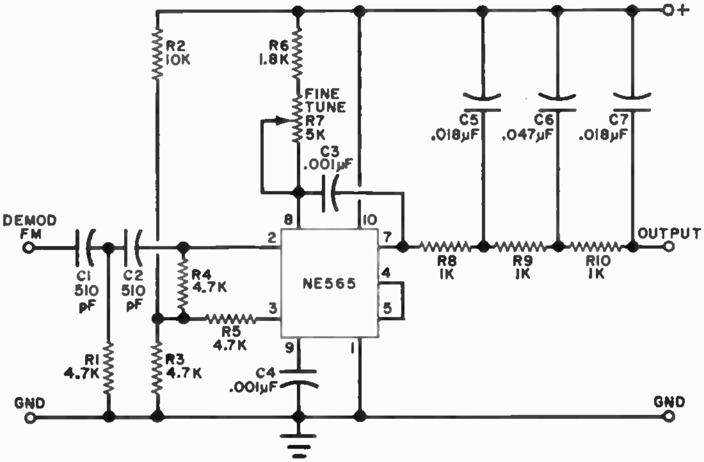


Fig. 4. Note that this 67-kHz SCA adapter has no LC circuits as tuning is adjusted by R7. To change the center frequency, capacitor C4 and total resistance of R6 and R7 will have to be changed. Bandpass is 7 kHz.

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A. Total No. Copies printed (Net Press Run)	476,247	472,136
B. Paid circulation		
1. Sales through dealers and carriers, street vendors and counter sales	67,583	63,000
2. Mail subscriptions	309,445	308,300
C. Total paid circulation	377,028	371,300
D. Free distribution (including samples) by mail, carrier or other means	5,882	5,883
E. Total distribution (Sum of C and D)	382,910	377,183
F. Office use, left-over, unaccounted, spoiled after printing	93,337	94,953
G. Total (Sum of E and F—should equal net press run shown in A)	476,247	472,136

I certify that the statements made by me above are correct and complete.

WILLIAM L. PHILLIPS, Assistant Treasurer

series includes the MC2501L Quad 2-Input NOR Gate, the MC2502L Dual 4-Input NOR Gate, and the MC2503L Dual type Flip-Flop, all in 14-pin dual in-line ceramic packages, as well as the MC2597G Dual 2-Input NAND Gate and the MC2598G "D" Flip-Flop, both in 10-pin metal cans. Typical quiescent power dissipations range from 10 nW for the gates to 50 nW for the flip-flops.

Providing gains of up to 2500 and with current ratings of from 4 to 16 amperes, Motorola's new complementary Darlingtons are available in both 60- and 80-volt BV_{CEO} versions, except for the 16 ampere series, which also includes a 100-volt type. The devices incorporate both driver and output transistors, plus any necessary resistors, in a single monolithic structure. Requiring drives in the milliampere range, the full line includes the 16-ampere MJ4030/4033 series, the 10-ampere MJ2500/3000 series, the 5-ampere MJE1090/1100 series, the 5-ampere MJ900/1000 series, and the 4-ampere MJ 4000/4010 series. Except for the MJE1090/1100 series, which are supplied in 70-watt plastic thermopad-type packages, all the devices are assembled in standard TO-3 cases.

Utilizing balanced-emitter construction, Motorola's new npn silicon r-f power transistors are intended for use as high-power class C amplifiers in the 100-175-MHz VHF range. Identified as types MM1552, a 65-volt device, and MM1553, a 100-volt unit, the transistors are assembled in strip-line packages. The MM1552 is rated at 90 watts peak power output for 18 W input at 150 MHz, with a 27-volt dc source, permitting close to 100-percent modulation with a 25 W carrier at V_{CC} of 13.5 volts dc. In FM or CW service, both devices are capable of continuous 75 W output at 150 MHz.

Fairchild Semiconductor (313 Fairchild Drive, Mountain View, CA 94040) has announced a new line of low-cost power transistors assembled in distinctive plastic TO-66 packages. The new transistor family consists of true npn and pnp complements. All the devices operate at collector currents of up to 4 amperes maximum and have power ratings of 36 watts at case temperatures of 25°C. Voltage capabilities range from 40 to 80 volts. Type numbers are 2N5293 through 2N5298 for the npn's and 2N6021 through 2N6026 for their pnp complements, plus seven complementary pairs identified by single type numbers with special "SD" prefixes.

Also from Fairchild comes news of substantial price reductions on some seventy dual transistors as well as on its entire line of MSI 9300 TTL integrated circuits.

That completes our solid-state story for January . . . but, if it isn't too late—*HAPPY NEW YEAR!*

—*Lou.*

TIME-PERIOD

(Continued from page 67)

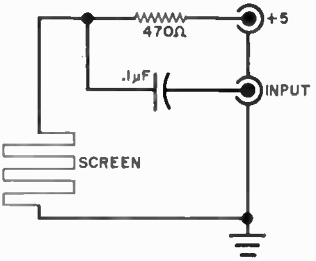

Fig. 5. Transducer circuit used for determining bullet velocity employs a continuous-conductor break screen.

the beam is blocked or interrupted. A simple mechanical switch or a break-wire arrangement can also be used in timing applications.

A system for measuring the velocity of a bullet is shown in Fig. 5. When the bullet breaks the wire at the start screen, a positive pulse is generated by the charging action of the capacitor. Similarly, a positive pulse is generated at the stop terminal (where a duplicate circuit is employed) when the stop screen is broken by the bullet. The bullet's velocity is then equal to (screen spacing in feet × 1000)/(counter range × readout value) in feet/sec.

For example, if the screens were 4 ft apart and a reading of 200 were obtained with the selector switch in the 10 M SEC position, velocity would be equal to (4 × 1000)/(0.01 × 200), or 2000 ft/sec. Since the counter is accurate to within 0.1%, the screen spacing must be quite accurate to prevent this from affecting the accuracy of the reading obtained. At a 4-ft spacing, the screens must be placed within 1⁄32 in. of the correct distance.

The Time-Period circuit board assembly can also be combined with a readout system to produce a "Sports Timer" (POPULAR ELECTRONICS, Oct. 1968). Changing the crystal to a 100.00-kHz type will produce pulses at 1⁄1000 second intervals at the output of the second scaler. This output can be applied directly to a 4½-digit readout to give readings up to 10 minutes with an accuracy of ±0.001 second.

The circuit could also be used as a portable time base for electronic digital clocks that would normally be driven by the 60-Hz ac line. In this case, both the Time-Period and Scaler circuits would be needed to produce pulses at exact 1-second intervals. —30—

CRYPTOLOCK

(*Continued from page 44*)

is interrupted. This is the purpose of the normally closed pushbutton *S7*. When *S7* is depressed, the SCR is cut off.

Checkout. When all components have been secured in place and wired in accordance with Fig. 1, substitute a 6-to-9-volt lamp for *K3*. Depress pushbutton switches 1 and 5 and note that relay *K1* closes. If it does not, recheck all wiring, including the connections to the pushbuttons on the key panel. It's easy to wire them incorrectly since you are working from behind and they are in reverse order. Once assured that the wiring is correct, press 1 and 5 again, followed quickly by 4. The test lamp should light, indicating that SCR has been triggered and the lock is open. If not, use needle-nose pliers to bend the metal tab (carefully) to which the armature spring of *K1* is attached. Bend it upward to decrease the tension on the spring. Try the combination again. An additional adjustment of *K1*'s spring may be necessary. Switch *S7* is used to de-activate the system.

Now press 2, 3, or 6 on the key panel. Relay *K2* should close and remain closed for 20 to 30 seconds. During this time, it is impossible to activate *K1*. If *K2* doesn't close, repeat the adjustment procedure specified for *K1*. Generally speaking, you won't have to adjust *K2* because it closes with much more force than *K1*. There are a number of types of miniature, 5000-ohm dc relays on the market and their response times vary considerably so be prepared to switch relays if necessary. Once *K1* and *K2* are adjusted, no further adjustments should be necessary. Just be sure they remain in an upright position while the Cryptolock is being activated.

In the typical home or garage installation, it's a good idea to provide a key switch backup to the electronic locking system. Simply wire a spst key switch so that it bypasses the electronic lock and (when closed with a mechanical key) applies power directly to the solenoid latch to open the door. The key switch can be located some distance from the electronic key panel and concealed. This will enable you to open the door in the event the key panel is damaged as a result of an attempted burglary. Also remember to keep pushbutton *S7* within the protected area. —30—

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STEREO SCENE

(Continued from page 70)

made or electronically-augmented music, you play games with your tone controls until it sounds reasonably "good." That's about all you can do for there was no reality here to start with. When playing classical and orchestral music, there is substantial reality and you can work it over until the result is reasonably realistic, or better still, look around for the better grade of European-made disc recordings—many of which are made to sell music rather than sound.

Possibly, if you write letters to RCA and Columbia Records and Capitol Records, you might convince them to let classical recordings suffer from benign neglect. Isn't it worthwhile to suggest that these record manufacturers could save all the money that they spend on equalizers and compressors, recording directors that are frustrated conductors and simply produce the best average simulation of a live concert hall sound? Perhaps if American record manufacturers could get back to basics and simply record music and not supersonics, they could recover the prestige and dignity they so rightfully deserved in the mid-1950's. —30—

CAPACITOR QUIZ ANSWERS

(Quiz is on page 32)

1. High end
2. Increase
3. Padder
4. Neutralizing
5. Decoupling
6. 0.1 μF
   ±3 percent
   1200 volts
7. 720 pF
   ±5 percent
   −150 PPM/°C
8. 12 pF
9. 6 pF
10. 10 pF

LIBRARY

(*Continued from page* 16)

dedicated to the instructors. Basically, this book covers technician-level fundamentals; the content is indistinguishable from most others of the same genre. The big difference is in the easy-to-follow format and the contrasting graphics used for the illustrations.

Published by Prentice-Hall, Inc., Englewood Cliffs, NJ 07632. Hard cover. 720 pages. $13.50.

125 ONE-TRANSISTOR PROJECTS

by Rufus P. Turner

Here is a book that will interest just about any hobbyist or experimenter in electronics, but especially the neophyte. This collection of useful, practical one-transistor circuits covers a wide range of projects, from audio amplifiers to radio receivers and transmitters. Each of the circuits provided is accompanied by a thorough description and a complete schematic diagram, and each is designed to take advantage of only easy-to-obtain components. All of the circuits listed are designed to serve a practical application. And for more sophistication, several can be combined.

Published by Tab Books, Blue Ridge Summit, PA 17214. 192 pages. $6.95 hard cover, $3.95 soft cover.

DISCIPLINES IN COMBINATIONAL AND SEQUENTIAL CIRCUIT DESIGN

by R. M. M. Obermon

The aim is to provide graduate students with a textbook on the design of combinational and sequential circuits as they are used in all kinds of automatic equipment. The book first develops the mathematical concepts of switching theory (Boolean algebra) and uses them in the design of combinational circuits with different types of components as contacts and semiconductor devices. The same mathematical concepts are used in the theory of memory elements and applications in counting, shifting, ordinary mathematical operations, transmission of BCD information, and the design of sequential circuits. This massive work is well worth the investment.

Published by McGraw-Hill Book Co., 330 West 42 St., New York, NY 10036. Hard Cover. 754 pages. $19.50.

LINEAR INTEGRATED CIRCUITS, IC-42

The latest linear IC manual from RCA has been extensively revised and expanded to cover innovations in IC technology and provide broader, more detailed general information on modern IC's. Circuit descriptions and application information are provided for a broad family of RCA integrated circuits for use in a variety of general- and special-purpose linear applications. Also, the manual has a new application guide which indicates circuit types recommended for specific uses and technical data and outlines sections provide ratings, characteristics, and package details for RCA linear integrated circuits.

Published by RCA Solid State Division, Somerville, NJ 08876. Soft cover. 416 pages. $2.50.

INTRODUCTION TO COMPUTER ENGINEERING

by B. S. Wolker

Although primarily intended for use by undergraduate engineers and technologists, this book will also appeal to the scientific-minded individual who is curious about computers. The text carefully dissects the fundamental principles and philosophies underlying the concept of computers and their applications to make the logic of technical advances easier to follow. A non-mathematical approach is used to explain what the computer is, what it does, and how it performs its various operations. The only math you can expect to find is in Chapter 4, headed "Arithmetic," in which basic computer language is discussed.

Published by Hart Publishing Co., Inc., 510 Sixth Ave., New York, NY 10011. Hard cover. 385 pages. $12.

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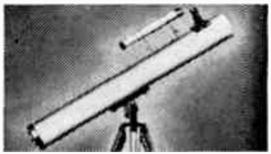

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No. 85,105AV (4¼") $94.50 F.O.B.
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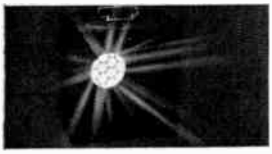
CHROMATIC "MACHINE-GUN" STROBE



Red, Green, Blue & White light barrage the eyeballs every 6 seconds with this low-cost mechanical strobe that can run continuously without fear of burning up. Devastating effects over 500 ft. sq. area. Created by rotating color wheel in front of 100W, 120v reflector floodlamp (incl.)—elements seem to flash on & off as colors fluctuate. Turns store windows, posters, parties into flashing, pulsating productions. Convection cooled. Walnut cabinet. Brass handle. Reg. house current.

Stock No. 71,271AV . . . . (9x10x6¼") . . . . $28.50 Ppd.

PSYCHEDELIC LIGHTING HANDBOOK

100 information packed pages! Fully explains latest in psychedelic lighting equipment, techniques, developments. Covers all facets of psychedelic light-show production including strobes, black lights, projectors, crystals, organic slides, mirrors, color organs, polarized color, light boxes, MusicVision, etc. Shows how to "psychedelize" parties, musical groups, shows or how to set up "electric trips" for private gatherings. 8½" x 11" looseleaf paper for 3 rings.

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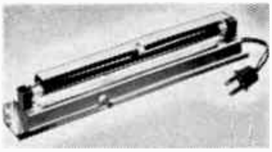
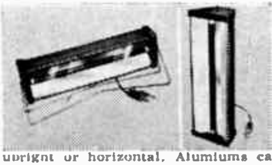
LONG-WAVE BLACKLIGHT FIXTURE



Extremely versatile, compactly designed, long wave (3200-4000 angstroms) black light (ultraviolet) fixture. Has 6-watt, 110-V lamp with built-in filter—eliminates harmful shorter wave ultraviolet rays. Use to identify minerals, fungi, bacteria—check for surface flaws, oil and gas leakage—perfect for displays with fluorescent paper, paints, chalk, crayons, trace powder, incl. adjustable aluminum reflector. Mount vert., horr., or on corner. 10" L., 1½" W., 1¼" H.

Stock No. 70,364AV . . . . $12.50 Ppd.
Stock No. 60,124AV . . . . . . REPLACEMENT BULB . . . . . $4.75 Ppd.

BLACK-LIGHT MIGHTY MITES



Relatively small (12") fixtures give surprisingly bright blacklight. Mirror-finished reflector makes instant starting 8-watt, high-intensity bulb look like 40-watter. Up to 5,000 hours of safe, long-wave (3660A) blacklight to really turn on parties, light & theatrical shows, psychedelic decors, holiday decorations. Shockproof end-caps remove for safe, easy replacement of bulb and starter. Stands upright or horizontal. Alumiums case.

Stock No. 71,274AV . . . . $14.95 Ppd.
DELUXE OUTDOOR/INDOOR MODEL
Stock No. 71,299AV . . . . $19.95 Ppd.

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NEW DIMENSIONS IN BEAUTIFUL LIGHTING

All create illusion lamps are moving. Turn on any one of four new style lamps, and the room "turns on" with whirling, ever-changing patterns and colors. Table-top 8", 12" heat-driven glass ATMOSPHERES or motor-driven 16" and 24" plastic models (table-top or hanging versions). COLOR COLUMN Patterns loop and roll around 23" tall, 7" dia. plastic and motor-driven unit. Illusions swirl up on block . . . down the next brightly colored plastic section of the 14" high, heat-driven PAGODA. COMBO LIGHT's 3-way switch turns on glass, read-by globe, the plastic "action" column, or both. Heat-driven and 22½" high. Six additional and interchangeable masks are available for each sensational decorator lamp.

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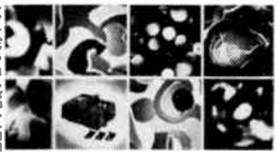

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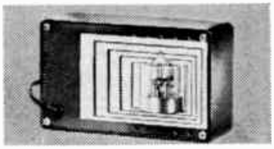

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Van De Graaff low-amp type, 2,000,000 volt potential, yet completely safe. Demonstrates lightning, St. Elmo's fire, repulsion of charges, electrostatic dust collection, many other electrical wonders. Meter. 110v, 60-cycle, AC. Humidity range, 0-90%. Current, 1.5 to 2.5 microamps. Aluminum base, frame and charge collector. Unbreakable plastic. Insulating column. Ht. 17" dia. 6¾". Full instructions.

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Absolutely no previous knowledge of radio or science is required. The "Edu-Kit" is the product of many years of teaching and engineering experience. The "Edu-Kit" will provide you with a basic education in Electronics and Radio, worth many times the low price you pay. The Signal Tracer alone is worth more than the price of the kit.

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You do not need the slightest background in radio or science. Whether you are interested in Radio & Electronics because you want an interesting hobby, a well paying business or a job with a future, you will find the "Edu-Kit" a worth-while investment.

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The Progressive Radio "Edu-Kit" is the foremost educational radio kit in the world, and is universally accepted as the standard in the field of electronics training. The "Edu-Kit" uses the modern educational principle of "Learn by Doing." Therefore you construct, learn schematics, study theory, practice trouble shooting—all in a closely integrated program designed to provide an easily-learned, thorough and interesting background in radio.

You begin by examining the various radio parts of the "Edu-Kit." You then learn the function, theory and wiring of these parts. Then you build a simple radio. With this first set you will enjoy listening to regular broadcast stations, learn theory, practice testing and trouble-shooting. Then you build a more advanced radio, learn more advanced theory and techniques. Gradually, in a progressive manner, and at your own rate, you will find yourself constructing more advanced multi-tube radio circuits, and doing work like a professional Radio Technician.

Included in the "Edu-Kit" course are Receiver, Transmitter, Code Oscillator, Signal Tracer, Square Wave Generator and Signal Injector Circuits. These are not unprofessional "breadboard" experiments, but genuine radio circuits, constructed by means of professional wiring and soldering on metal chassis, plus the new method of radio construction known as "Printed Circuitry." These circuits operate on your regular AC or DC house current.

THE "EDU-KIT" IS COMPLETE

You will receive all parts and instructions necessary to build twenty different radio and electronics circuits, each guaranteed to operate. Our Kits contain tubes, tube sockets, variable, electrolytic, micra, ceramic and paper dielectric condensers, resistors, tie strips, hardware, tubing, punched metal chassis, Instruction Manuals, hook-up wire, solder, selenium rectifiers, coils, volume controls and switches, etc.

In addition, you receive Printed Circuit materials, including Printed Circuit chassis, special tube sockets, hardware and instructions. You also receive a useful set of tools, a professional electric soldering iron, and a self-powered Dynamic Radio and Electronics Tester. The "Edu-Kit" also includes Code instructions and the Progressive Code Oscillator, in addition to F.C.C. Radio Amateur License training. You will also receive lessons for servicing with the Progressive Signal Tracer and the Progressive Signal Injector, a High Fidelity Guide and a Quiz Book. You receive Membership in Radio-TV Club, Free Consultation Service, Certificate of Merit and Discount Privileges. You receive all parts, tools, instructions, etc. Everything is yours to keep.

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You will learn trouble-shooting and servicing in a progressive manner. You will practice repairs on the sets that you construct. You will learn symptoms and causes of trouble in home, portable and car radios. You will learn how to use the professional Signal Tracer, the unique Signal Injector and the dynamic Radio & Electronics Tester. While you are learning in this practical way, you will be able to do many a repair job for your friends and neighbors, and charge fees which will far exceed the price of the "Edu-Kit." Our Consultation Service will help you with any technical problems you may have.

FROM OUR MAIL BAG

J. Stataitis, of 25 Poplar Pl., Waterbury, Conn., writes: "I have repaired several sets for my friends, and made money. The "Edu-Kit" paid for itself. I was ready to spend $240 for a Course, but I found your ad and sent for your Kit."

Ben Valerio, P. O. Box 21, Magna, Utah: "The Edu-Kits are wonderful. Here I am sending you the questions and also the answers for them. I have been in Radio for the last seven years, but like to work with Radio Kits, and like to build Radio Testing Equipment. I enjoyed every minute I worked with the different kits; the Signal Tracer works fine. Also like to let you know that I feel proud of becoming a member of your Radio-TV Club."

Robert L. Shuff, 1534 Monroe Ave., Huntington, W. Va.: "Thought I would drop you a few lines to say that I received my Edu-Kit, and was really amazed that such a bargain can be had at such a low price. I have already started repairing radios and phonographs. My friends were really surprised to see me get into the swing of it so quickly. The Trouble-shooting Tester that comes with the Kit is really swell, and finds the trouble, if there is any to be found."

UNCONDITIONAL MONEY-BACK GUARANTEE

Please rush my Progressive Radio "Edu-Kit" to me, as indicated below:

Check one box to indicate choice of model

☐ **Deluxe Model $31.95.**

☐ **New Expanded Model $34.95 (Same as Deluxe Model plus Television Servicing Course).**

Check one box to indicate manner of payment

☐ **I enclose full payment. Ship "Edu-Kit" post paid.**

☐ **I enclose $5 deposit. Ship "Edu-Kit" C.O.D. for balance plus postage.**

☐ **Send me FREE additional information describing "Edu-Kit."**

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PRINTED CIRCUITRY

At no increase in price, the "Edu-Kit" now includes Printed Circuitry. You build a Printed Circuit Signal Injector, a unique servicing instrument that can detect many Radio and TV troubles. This revolutionary new technique of radio construction is now becoming popular in commercial radio and TV sets.

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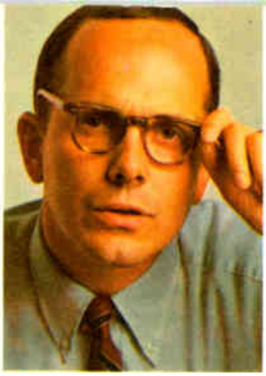

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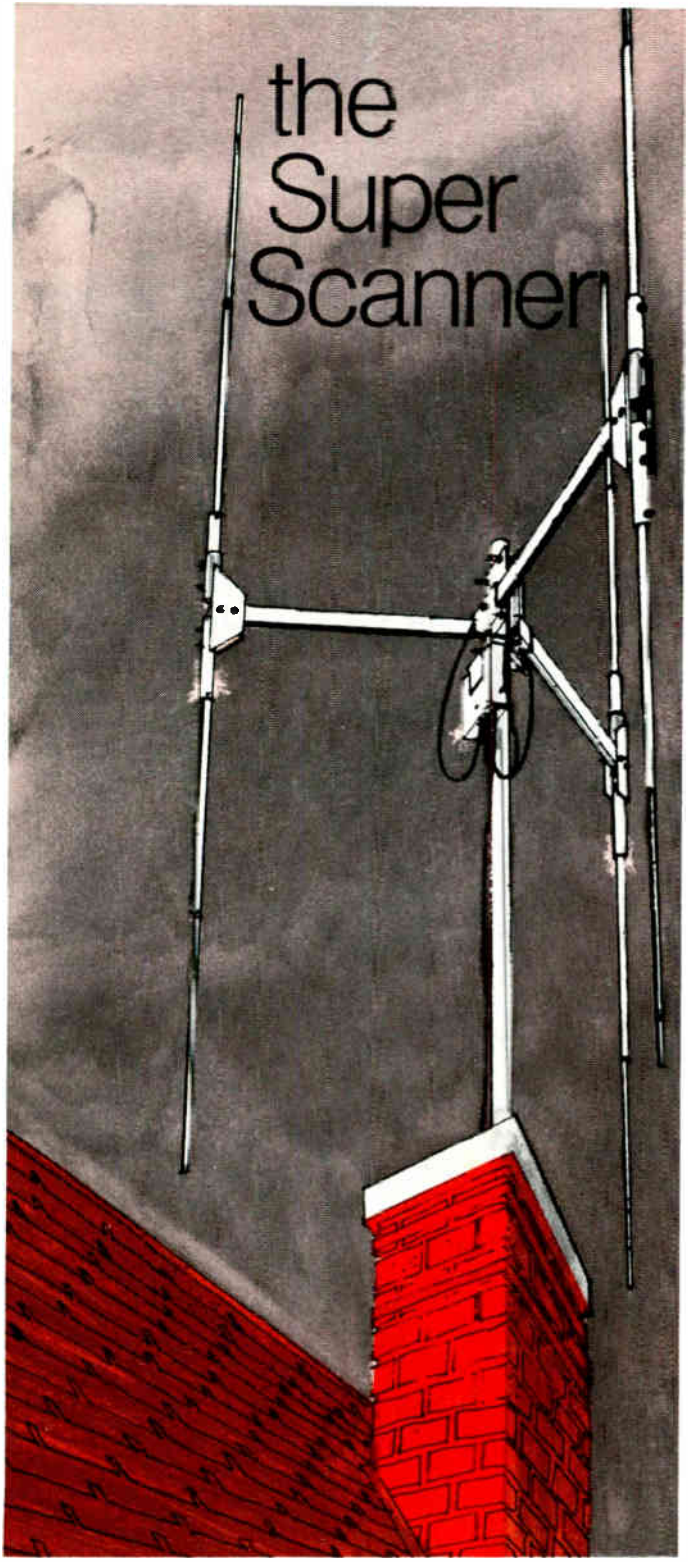
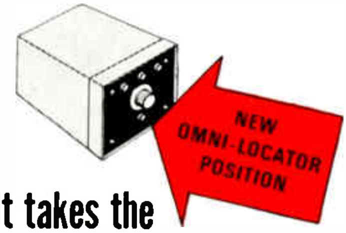


It took us two years to make the CB Scanner scan 360° automatically



It takes the MR119 Super Scanner 1/3 of a second to do it!

- **Beam Mode:** positive electronic "beaming in choice of sectors — no mechanical rotator needed!
- **Omni Mode:** Special position for omni-directional "searching"—just switch to use!
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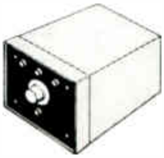
- **Compact design**—beats all beams for size and weight (just 17 lbs.) yet ruggedly constructed to take 100 MPH winds!



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Finds metals, pipes several inches underground. EICO TH-30 Solid State Treasure Hunter locates iron, steel, tin, gold, silver, copper etc. Beep pitch increases as you near object.

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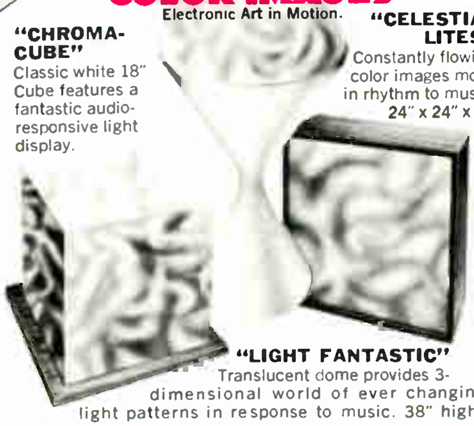

"CHROMA-CUBE" Classic white 18" Cube features a fantastic audio-responsive light display.

"CELESTIAL LITES" Constantly flowing color images move in rhythm to music. 24" x 24" x 6".

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EICO 3300 Silicon Solid State FET AM-FM Stereo Tuner. Kit $69.95, Wired $109.95

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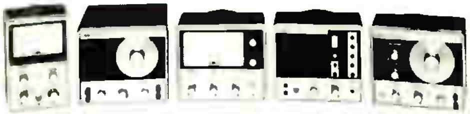

EICO 240 Solid State FET-TVM. Kit $59.95, Wired $79.95.
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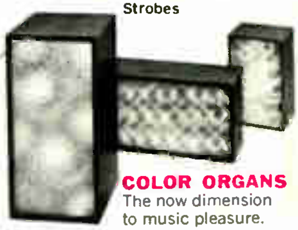
Sound n' Color

Color Organs, Translators, Strobes



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The now dimension to music pleasure. EICO all electronic solid-state Audio-Color Organs transform sound waves into moving synchronized color images.

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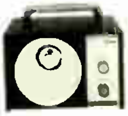
Burst of white light flash in cadence of each beat of audio.



Model 3470 Adjustable Rate. Kit $29.95, Wired $39.95.

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