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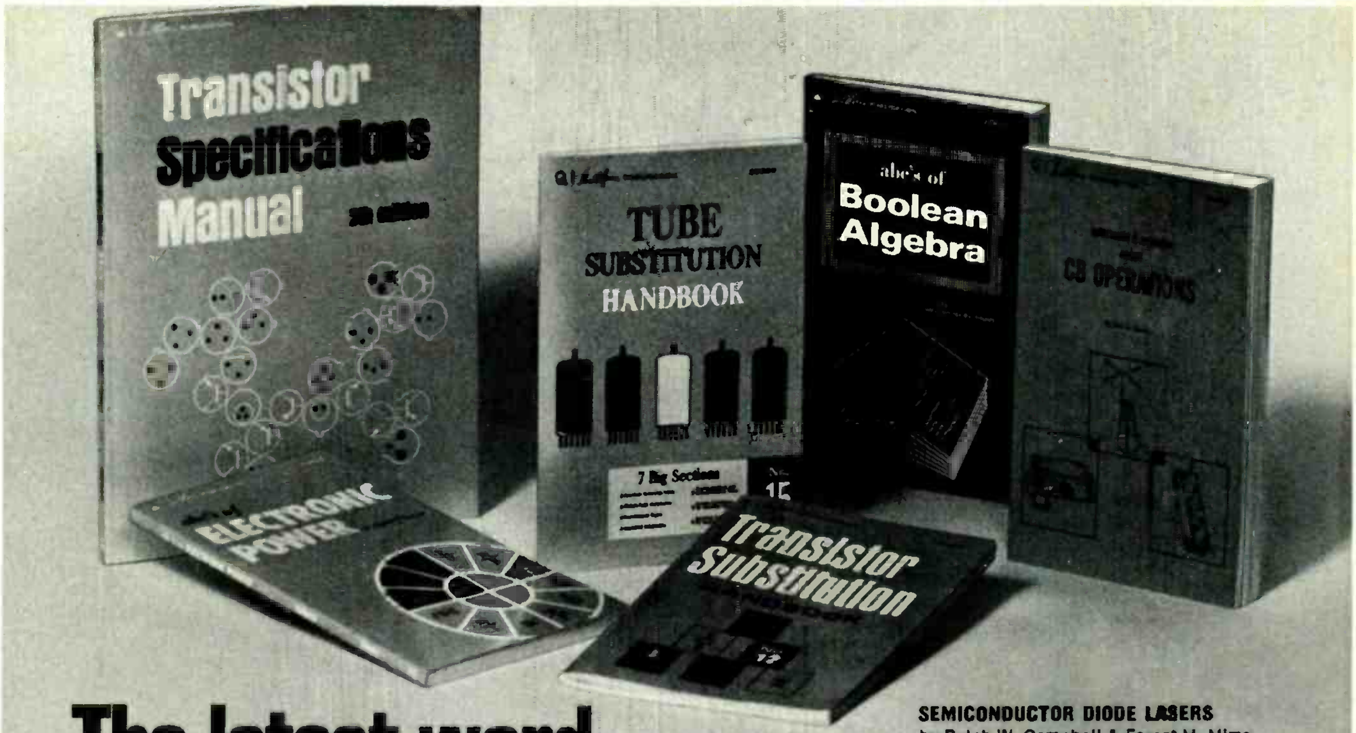

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It stopped the traffic in Times Square.

We took our new ST-5130 FM stereo/ FM-AM tuner to Times Square, where traffic — and ignition interference noise — are at their peak. Then with a flick of a switch, we stopped the noise dead.

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And you'll also like such features as the 5130's oscilloscope output jacks for multipath indication, and it's independently-controlled headphone jack.

Impulse Noise Suppression. Hear the difference it makes, at your nearby Sony Dealer. Sony Corporation of America, 47-47 Van Dam Street, Long Island City, N.Y. 11101.

New SONY ST-5130 FM Stereo/FM-AM Tuner

Circle 3 on reader service card

Radio-Electronics

FOR MEN WITH IDEAS IN ELECTRONICS

April 1972

AUTOMOTIVE ELECTRONICS

33 **Add-On Electronics For Your Car**
They all make your car trips easier and more pleasant. *by Fred Holder*

37 **How The Staar Cassette Operates**
Programmed course explains the system. *by Larry Allen*

54 **8-Track Car Tape Player Repair**
Case histories of actual repair problems. *by Joseph J. Carr*

86 **Facts & Fallacies Of Electronic Ignition**
What will electronic ignition do for you? *by Joe Shane*

STEREO HI-FI AUDIO

57 **Stereo Amplifier Design**
Boundaries of operation. *by Mannie Horowitz*

60 **Omnisonics**
A new system for surround sound. *by S. H. Mann*

BUILD ONE OF THESE

23 **TV Tuner Subber**
$23 unit tells you if the TV tuner is bad. *by Cedric Western*

42 **Digi-Mod-N Frequency Divider**
New portable instrument you'll want to add to your lab. *by Jack Cazes*

50 **Digital Printing Computer**
Build a darkroom enlarging timer that has semiautomatic adjustments. *by Don Lancaster & Leon Schoenfeld*

TELEVISION

32 **Equipment Report**
B&K 1460 scope

62 **Service Clinic**
Amplitude vs tilt controls. *by Jack Darr*

63 **Reader Questions**
R-E's Service Editor solves reader problems

GENERAL ELECTRONICS

4 **Looking Ahead**
Current happenings. *by David Lachenbruch*

22 **Appliance Clinic**
When wiring acts up. *by Jack Darr*

25 **AM Radio Booster**

DEPARTMENTS

16 **Letters**
6 **New & Timely**
7 **New Literature**
70 **New Products**
77 **Next Month**
103 **Reader Service**

ON THE COVER

SURROUNDING THE CUTAWAY view of a 1972 Chevrolet Vega is a variety of automotive electronics. Starting at the top left and going clockwise you'll see an Elco model 888 Engine Analyzer; next is an On-Guard automotive burglar alarm; then a Radio-Shack Realistic 4-Channel 8-Track Stereo Tape Player model 12-1833; dash-mounted tachometer; Lafayette 4-Dimension Auto-Stereo Adapter model 99-85128; Delta Products Mark Ten-B Capacitive-Discharge Electronic Ignition System.

. . . see page 33

HANDY FREQUENCY DIVIDER makes it possible to divide almost any frequency signal by almost any number you wish. . . . see page 42

Radio-Electronics is indexed in *Applied Science & Technology Index and Readers Guide to Periodical Literature.*

Radio-Electronics, April, 1972, Vol. 43, No. 4.
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looking ahead

A new color tube

What may be the first direct competition to Sony's Trinitron color tube has been introduced in Japan by Tokyo Shibaura Electric Co. (Toshiba). Called the "Linytron," the new tube has oblong, rather than round, holes in its shadow mask, arranged in a vertical pattern like bricks in a wall. It has three electron guns, but they are arranged horizontally in an in-line pattern. Among the advantages claimed: Higher brightness (because the shadow mask is more "transparent" to electrons), higher resolution and contrast, freedom from convergence and deflection adjustments, cost savings in chassis components. Although it's claimed that the tube can be built in any size, it is making its first appearance in a 9-inch Sharp set, which will be available in the United States at a list price of about $300. As we observed it, the Sharp set had a bright, pleasing picture with a strong resemblance to that of the Trinitron, except that the new tube lacks Trinitron's cylindrically curved face.

CBS drops EVR

Even before the dawning of that fabled "videoplayer age," CBS has backed out of active proprietorship of the first major cartridge video system to be introduced—EVR, or *E*lectronic *V*ideo *R*ecording. CBS announced that it would close its ultra-modern EVR cassette production and duplicating plant in Rockleigh, N.J., and discontinue its activity as North American licensor for EVR hardware production. EVR Partnership, a European firm with headquarters in London, will take over North American licensing rights from CBS and now becomes the worldwide EVR proprietor. Motorola, the only American producer of EVR Teleplayers, had produced about 2,000 of the machines by mid-January, with some 1,200 in use, and will continue production. When CBS closes its cassette plant in mid-1972, a British facility, already in production, will take over. Several firms in Europe and Japan are also producing EVR players.

Another pay-TV system

With the increase in channel capacity on CATV systems, there's growing interest in programs which can be seen in the home for a special charge. The latest system, whose proponents say "will get tested soon on cable TV" is called "Theatrevision" and is being sponsored by Telepremiere International, headed by former MGM studio chief Dore Schary. Here's how Theatrevision works: The CATV subscriber is given a schedule of first-run motion pictures, sports and special events which are to be presented on the Theatrevision channel—there may be five or more presentations at the same time. He purchases a ticket, either through the mail or from a local store. At show time, he tunes his set to the Theatrevision channel, inserts the ticket in a slot on top of his television set, and the program of his choice immediately appears on the screen.

The ticket-taking box on the set (which is supplied to the viewer free when he buys his first $15 worth of tickets) contains an auxiliary tuner. The ticket itself is a disposable printed circuit. When the ticket is inserted in the box, the set is automatically tuned to the proper channel, which isn't a conventional channel but one between Channels 6 and 7, and the encoded picture is unscrambled. The printed-circuit ticket is automatically shredded in the box to prevent re-use. Theatrevision's proponents say their system has these advantages over other pay-by-the-program systems: It can automatically select a specific program from among many presented at the same time, and it makes possible pre-payment for programs through the conventional method of ticket purchase. Other systems involve billing the viewer after he has seen the show.

End of an era

Ampex Corporation, the first American company to produce tape recorders, has decided to leave the consumer market as the result of financial reverses by its home products operation. The company has had a broad line of open-reel and cassette recorders, which gradually will be phased out. The only consumer recorder to remain in its line will be the semi-professional AX300, which lists at about $695. Ampex will continue in the professional audio and video recorder fields, and, in fact, will step up its efforts on Instavideo, its cartridge-type color TV recorder.

First home videoplayer

The first specific announcement—with availability dates and prices—of a home video tape recorder, has come from a rather unusual source. It's Sears, Roebuck & Co., hardly known as an electronics innovator, but certainly a marketing innovator. This column has noted in the past that Sears was planning to introduce the Cartrivision home color VTR made by Cartridge Television, Inc.

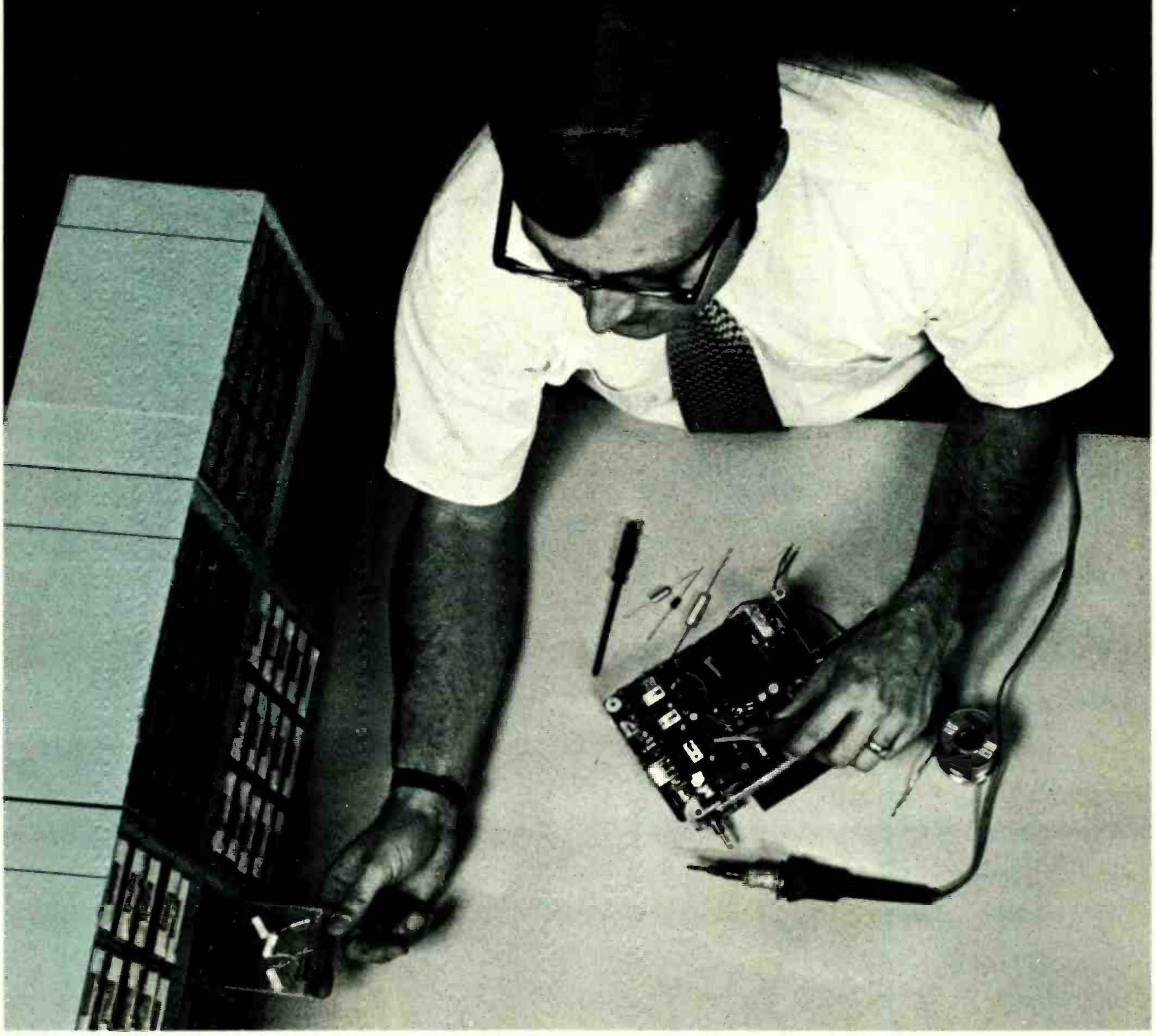
Sears announced that its first model—a combination 25-inch color set, VTR with automatic on-off time clock and black-and-white camera—would be offered in June by 18 of its retail stores in Chicago, with sales gradually going nationwide as more VTR decks are available. The first model will be priced at a rather steep $1,600, or $1,350 without the camera. Future models will include a deck that can be connected to color sets at about $750, and a 19-inch color TV-VTR combination at around $1,000. A color camera of unique design is promised for 1973 at around $400. Sears will also offer blank half-inch video tape at prices ranging from $13 for a 15-minute reel to $40 for two hours. Sears stores will offer rental pre-recorded cartridges—everything from sewing lessons to movies. The price for feature films will be about three to five dollars per day. These tapes are packaged in special non-rewindable cartridges which permit only one showing.

The same Cartrivision system will be available under several other brand names later this year, with most sales probably starting this fall.

4-channel box score

Both of the leading quadraphonic disc formats are gaining powerful adherents. CBS's "SQ" matrix system has received a big boost with its adoption by EMI, Ltd., for its 15 worldwide record labels, including Capitol in the United States. RCA, meanwhile, is working to bring Japan Victor Co.'s "CD-4" discrete disc system into complete compatibility, and was undoubtedly cheered by advertisements in Japan indicating that the Philips group, which includes such labels as Mercury Records and Deutsche Grammaphon, will bring out four-channel discs using the CD-4 system. **R-E**

by DAVID LACHENBRUCH
CONTRIBUTING EDITOR



Circle 4 on reader service card

new & timely

Seminar courses

Special courses to be offered to cable TV personnel are planned by the Magnavox Company, CATV division. The courses from the Magnavox Training Center are given in seminar fashion at seven of the Center extensions located in major cities—New York, Atlanta, Cleveland, Chicago, Dallas, Los Angeles, and San Francisco.

The courses selected for attendance by CATV personnel will be valuable to anyone who must learn general television techniques. Two typical courses require only a basic knowledge of electronics and a basic knowledge of black-and-white TV. "Solid-State Components—Their Operation and Application in Solid-State Radios", for example, will run for two days, and requires only a basic knowledge of electronics. "Colorimetry and Color TV Set-Up" will run for one day and requires a basic knowledge of electronics and black-and-white TV.

Dan Mezzalingua, general manager of Magnavox CATV Division, states that they "realize that one of the cable industry's sorest problems is a scarcity of trained technical personnel and we feel that it is our obligation as system and equipment suppliers to offer our aid in this manner." Magnavox plans to build upon the courses now offered until they are able to give a complete seminar program covering the basic elements of cable system design, installation, operation and maintenance.

Schedules for course times and locations for 1972 may be obtained by writing directly to Mr. J. B. Emerson, Manager, Communications, Magnavox CATV Division, 133 W. Seneca St., Manlius, N.Y. 13104.

Discrete 4-channel FM

The prospects for a reasonably quick approval of companion discrete 4-channel stereo-FM to go with RCA Records' disc format is pretty poor, according to inquiries made by TV Digest at the FCC.

Other FCC action now pending is for commercialization of the Dorren multiplex system, and GE is testing its own system but hasn't petitioned the FCC for acceptance as yet. Toshiba has developed a discrete 4-channel FM system, and others will be making their debut from time to time.

But the FCC doesn't feel that the situation is urgent, according to Harold L. Kassens, chief of the Broadcast Bureau's Rules and Standards Division. He says the issue is "way down on the list" because of other priority FCC problems and lack of personnel for such a large proceeding. Not only that, but if and when the proceedings begin, FM broadcasters can't be depended upon to support it and many may actively oppose it, primarily because of the expense involved in relocating the SCA subcarrier, converting receivers to new frequency, and other expenses.

Record companies which go ahead with matrix 4-channel systems also can be expected to oppose new broadcast standards, since matrixed 4-channel material can be transmitted over regular stereo-FM outlets without FCC permission and can be played back through a decoder.

In the end, if the proceedings should start, they will undoubtedly be lengthy, with plenty of systems proposed and field-tested. All of this gives a speedy approval for discrete 4-channel FM a very dim outlook.

Radio energy increases electron temperatures

A report from the National Oceanic and Atmospheric Administration states that powerful radio frequency energy in the 5- to 10-MHz range can increase electron temperatures in the ionosphere up to 35% and cause other significant changes. Man has already modified the ionosphere with atomic bombs, chemical releases, and linear electron accelerators. With the newly developed radio method man may perform experiments from a distance with no harmful after effects. Radio and optical techniques for monitoring the resulting perturbations make possible almost laboratory-type conditions for accurately verifying the distant phenomena.

Emphasis in the work is placed on the major radio-frequency-reflecting substrata of the ionized layer between 250 and 350 km, the F layers. It is expected that results of these studies will be significant for intraterrestrial and space communications, as well as for better understanding of the aeronomy of the natural atmosphere.

Four-channel patent

Peter Scheiber of the Audiodata Company, and Electro-Voice, Inc. announced that U.S. Patent No. 3,632,886 covering encoding and decoding matrix techniques for four-channel recording and broadcasting has been issued to Peter Scheiber. Mr. Scheiber and Electro-Voice have agreed to pool their efforts in the protection of patents, licensing, and manufacture of equipment using developments from both firms.

Howard Durbin, E-V's senior vice president and technical director stated "Our basic interest is in establishing the four-channel concept as an industry with playback equipment in all price classes." The latest development is equipment capable of completely compatible decoding

(continued on page 12)

new lit

All booklets, catalogs, charts, data sheets and other literature listed here with a Reader Service number are free for the asking. Turn to the Reader Service card on page 103 and circle the numbers of the items you want. Then mail the postage-paid card.

NC FLASHER CATALOG, *Winter/Spring 1972,* offers a complete range of quality tools for the technician. 56 page listing of hundreds of tools, precision instruments and workshop needs and accessories, test instruments, publications for photographic equipment specialists, metric screws, screwdrivers, micrometers, calipers, etc.—**National Camera,** 2000 West Union Ave., Englewood, Colo. 80110.

Circle 40 on reader service card

WALSCO CROSS-REFERENCE CATALOG, *No. FR-135-W.* An updated line of exact replacement rubber drives and belts. Included are thousands of possible replacement items, comprised of a variety of phono and recorder drive wheels and pulleys, pinch rollers, round rubber belts, square cross-section rubber belts, spring belts and fabric drive belts. Features also specialized parts such as felt pressure pads, phono mounting "E" and "C" clips in an assortment kit, motor mounting grommets, changer switches, and kit of assorted phono drives and belts. Enlarged cross-reference section, with replacement part numbers listed for equipment made by 194 manufacturers, both domestic and foreign. Charts help in choosing proper size belt for any unusual machine types.—**GC Electronics,** 400 S. Wyman St., Rockford, Ill. 61101.

Circle 41 on reader service card

CAPACITOR REPLACEMENT MANUAL, *No. K-110.* Forty page manual covers over 300 different makes, including TV sets as well as autos, radios, hifi. Lists original part numbers, ratings, recommended capacitor replacements, and prices. More than 2,500 electrolytic capacitors listed.—**Sprague Products Co.,** 81 Marshall St., North Adams, Mass. 02147.

Circle 42 on reader service card

SOLDERING INSTRUMENT BROCHURE, *The Loner.* Full color brochure describes this soldering instrument and explains its difference from a soldering iron. Also shows the thermal guard holder.—**Edsyn, Inc.,** 15954 Arminta St., Van Nuys, Calif. 91406.

Circle 43 on reader service card

REPLACEMENT GUIDE, *#172.* 92-page radio and TV replacement coil cross reference directory for all known domestic and foreign color and black-and-white TV sets, home and car radios. Over 22,000 replacement coils for 327 manufacturers' names are listed.—**J. W. Miller Co.,** 19070 South Reyes Ave., Compton, Calif. 90221. **R-E**

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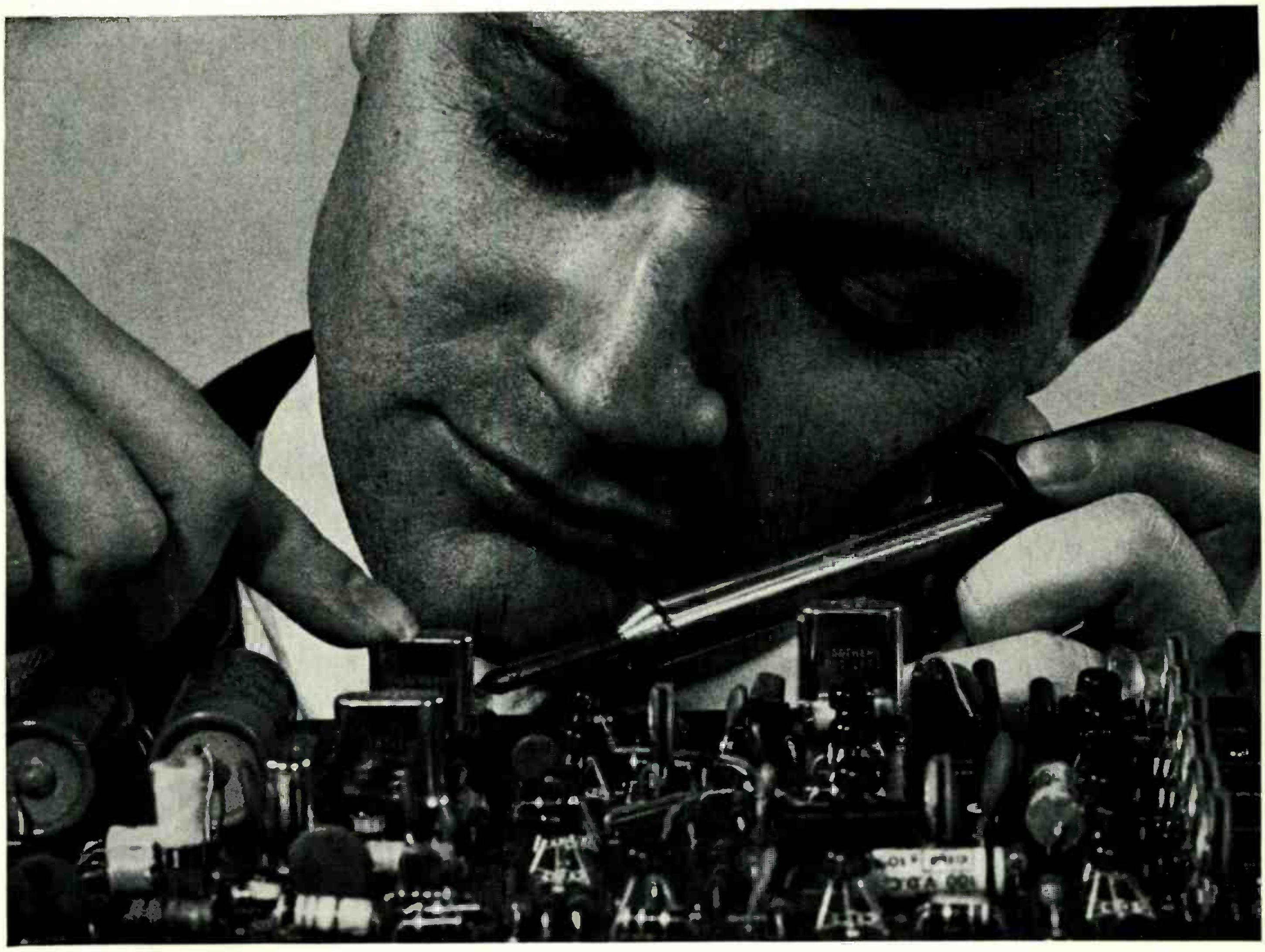

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new & timely (continued from page 6)

using any type encoded material. To Mr. Durbin this "means that the four-channel industry is on a solid basis to enjoy immediate growth and consumer confidence."

Hugo Gernsback scholarship winner

National Radio Institute has selected Earl J. Immel of Toms River, New Jersey to receive the Hugo Gernsback Scholarship Award for 1972. This is a grant of

$125.00 given annually by **Radio-Electronics** magazine to each of eight students learning electronics at home-study schools. He is enrolled in the Marine Electronics with First Class F.C.C. course.

Earl is married and has two small children. He enlisted in the service in 1965, although he had been accepted at the Milwaukee School of Engineering. He studied electronics, including fixed station radio receiver repair and facilities control prior to his twelve month tour of duty in Viet Nam. After he was separated from the service he worked in electronics, doing field and bench repair of facsimile weather chart recorders and business machines, weather Satellite photo machines and ship stabilizers. He is currently doing electronics troubleshooting of long lines circuits for AT&T.

Free access TV

One of the basic issues facing the blossoming cable television industry is the question of "free access"—free air time set aside for any group or individual that wants to put its message across on television. The first, and still the largest, free-access experiment in the country is a non-profit organization called Open Channel, which broadcasts public-service programing to some 90,000 cable-TV subscribers in Manhattan. Its purpose is to give ordinary citizens a chance to express themselves on political, cultural and social issues. Open Channel has given free air time to groups like the Boy Scouts, and local supporters of black radical Angela Davis.

The project seems to be meeting with mixed success, but it is being watched closely by government and broadcasting officials across the country as a showcase for the future of do-it-yourself TV.

The two serious difficulties now faced by Open Channel are funding and public awareness. To deal with the problem of money, Miss Theodora Sklover, the executive director of the program, argues that the city's tax on cable operators—currently 5% of their gross—should be used to finance free access. The problem of lack of public awareness, a major handicap to Open Channel, is less easy to approach. Relatively few groups have taken advantage of the chance to appear on TV, apparently because they don't know about it.

However, Miss Sklover has produced some low-budget shows, very professional in character, and she feels that is crucial to making free access work. "It's not enough to tell people they have free access," she declares, "you also have to help them make the programs."

Jack A. Morton dies

On December 11, 1971, Jack A. Morton, Bell Labs vice president, died at the age of 58.

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Secretary: Bertina Baer

Mr. Morton was a graduate of Wayne University and took his Masters degree in engineering from the University of Michigan in 1936. He went to work for Bell Labs immediately and was associated with the company, until his death, in various capacities, starting in electrical circuit engineering. There he conceived and developed high frequency transmission measuring methods which exceeded the ranges of previously existing means by a factor of ten. Later he aided the development of the grid-return amplifier at microwave frequencies, an achievement which was significant to the war effort in the Pacific during World War II.

Mr. Morton was the author of numerous articles, and a book, "Organizing for Innovation", which was published in 1971. As an inventor and co-inventor, he held 24 patents.

Voice response system

The first solid-state, limitless vocabulary voice response system has been developed by Phonplex Corporation, a subsidiary of Instrument Systems Corporation. It provides an economical and efficient means of accessing a computerized data bank via the telephone. Since any telephone can be converted into a computer terminal, the system is ideal for applications which require rapid, remote verbal information retrieval, such as credit card and bank check verification, reservations control, and stock market quotes.

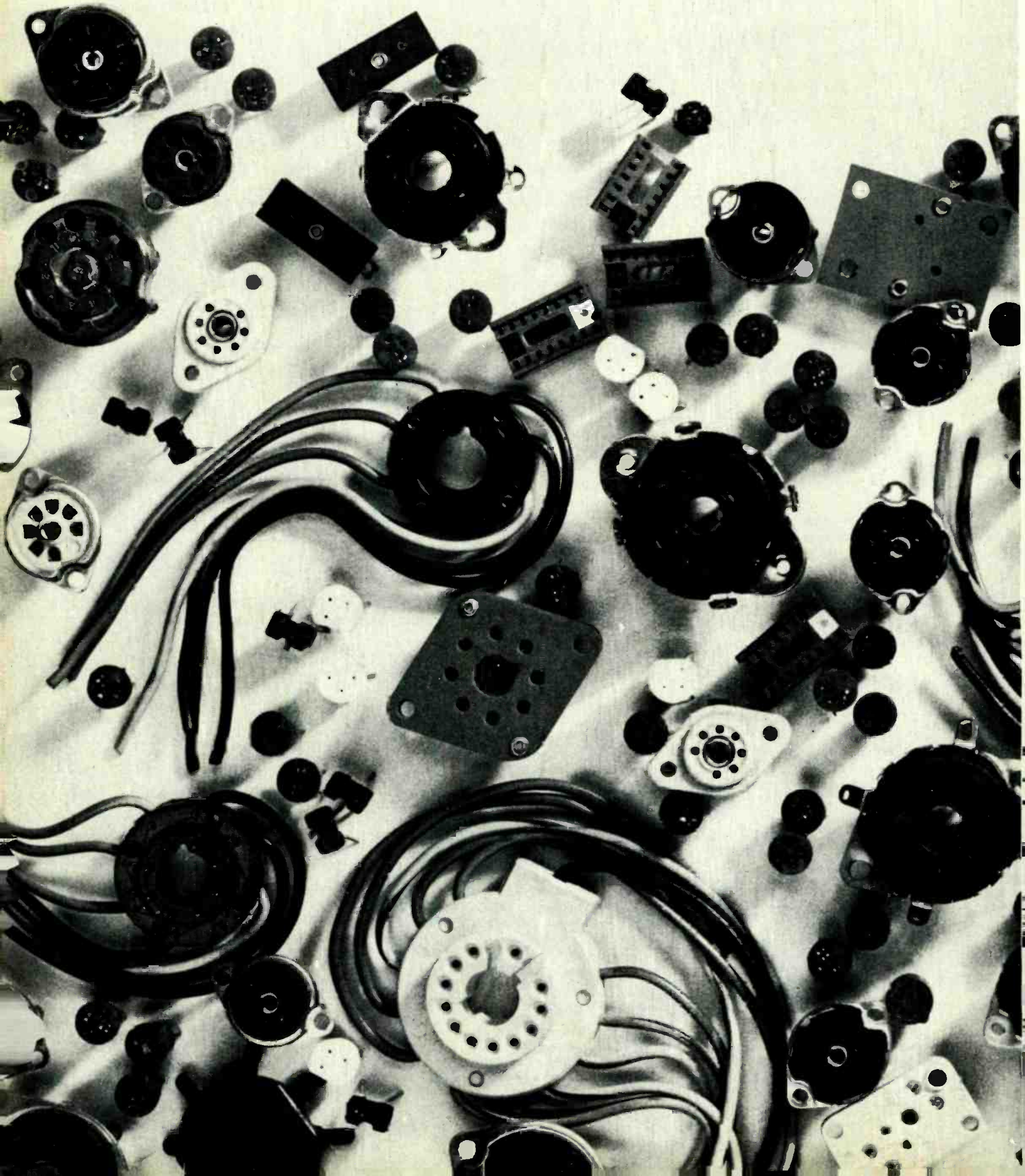
The system can store a nearly unlimited vocabulary because of Phonplex' proprietary development of "phoneme" storage. Phonemes are the smallest units of speech that serve to distinguish one utterance from another in any given language or dialect.

Earlier voice response systems depended on the expensive and restrictive storage of entire words or phrases by prerecording them on bulky and slowly responding tapes, drums or discs. The

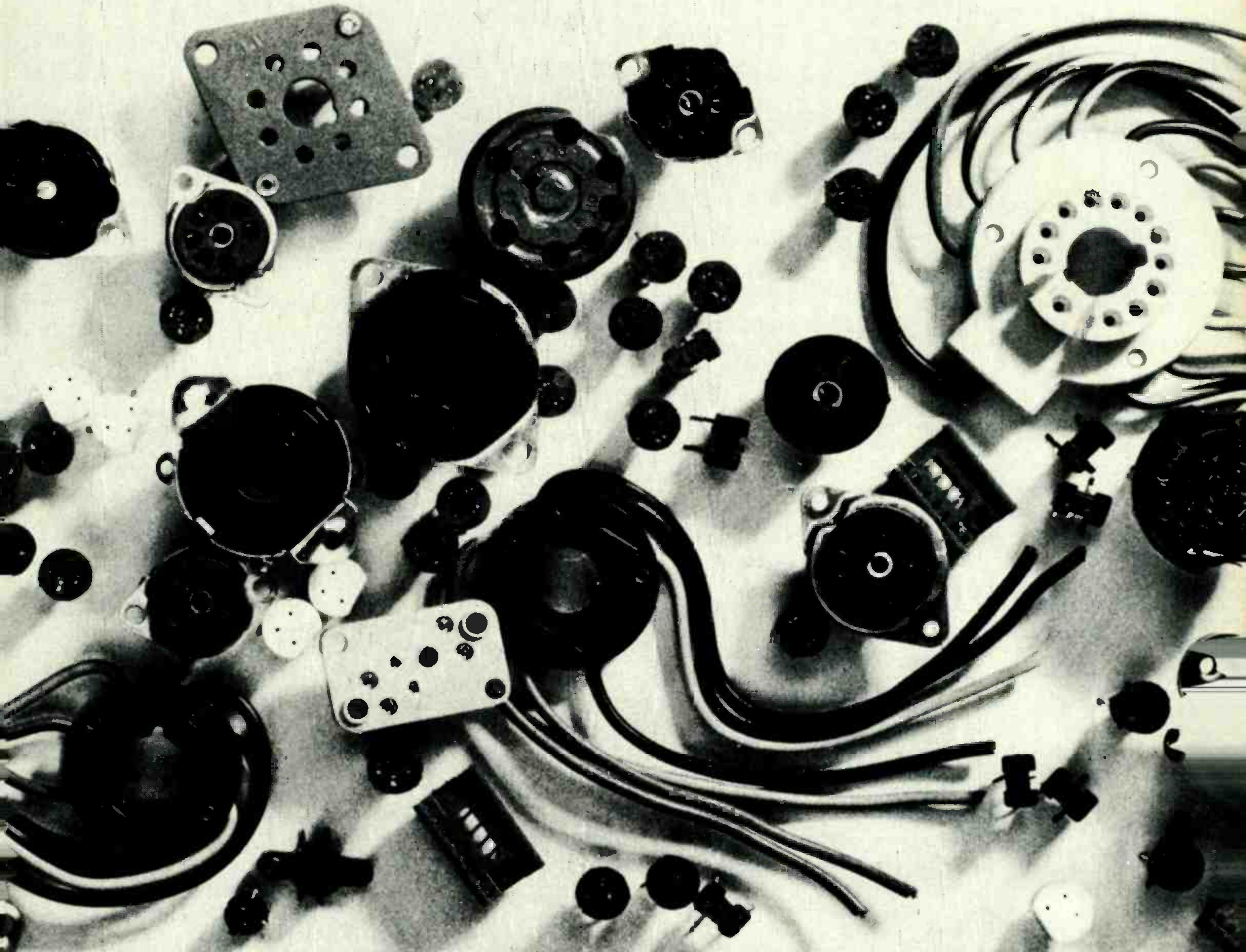
Phonplex breakthrough permits phoneme vocabulary modules to be stored economically in the solid-state memory, thus using only a small fraction of the space required by other systems and giving far greater system reliability. The phonemes, when programmed, combine to speak words, phrases, sentences, paragraphs and even complete stories. Since phonemes are the smallest parts of speech, they permit programming in any language or combination of languages.

THIS RESEARCH VEHICLE was developed by GTE Sylvania to evaluate buried antenna models in a test roadway. It measures signal strength and noise levels. On the basis of test results, antenna models and related equipment and techniques will be recommended to the Federal Highway Administration for developing a highway communications system. R-E

We have a boy



for every girl.



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We publish the Sylvania Technical Manual, which is practically a replacement encyclopedia (32,000 components!).

We have loads of specialized replacement literature. And we help you with any replacement problem.

See your Sylvania distributor and get to know the family.

GTE SYLVANIA

Electronic Components Group, 100 First Ave., Waltham, Mass. 02154.

letters

MULTI-SENSOR ALARM

The semiconductors used in the story "Build A Multi-Sensor Alarm" by C. R. Lewart in the November 1971 issue of **Radio-Electronics** are made by General Electric Company. Electronic Distributors, Inc., (EDI), 4900 N. Elston, Chicago, Ill., 60630, carries a wide range of G-E semiconductor devices. The prices are:

2N6027 - $0.79
C103-Y - 0.75
C122-F - 1.20

EDI has a $3.00 minimum-order policy which will be met by the cost of the five semiconductors needed for the project. When ordering, ask for a copy of their annual catalog. It carries many hard-to-find product lines as well as lots of surplus goodies.

ROBERT F. SCOTT
Technical Editor

WOMEN WITH IDEAS IN ELECTRONICS

I'd like to voice my objections and those of my colleagues to the **Radio-Electronics** tag, "For Men With Ideas In Electronics", which appears on your covers.

May I suggest you redefine your audience. Certainly such a title is an anachronism in today's society where 42.8% of the labor force is female, where the bulk of consumer spending is done by women, and in which more and more areas, professions and occupations, once solely male, are becoming fully integrated. Surely your readership, too, is destined to grow along those same lines.

You would do well to consider the future of your magazine in terms of the men *and* women in your industry, as well as the "people with ideas" who constitute your readership.

TRUDYE CONNOLLY
New York, N.Y.

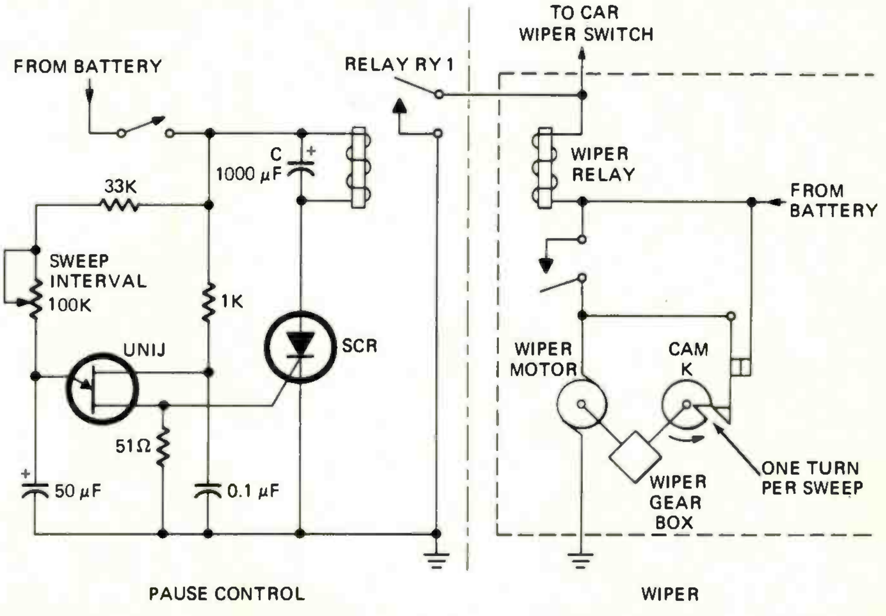
We'd like to hear from more of our women readers. What do you feel would be an appropriate "tag line" on our cover? Or do you like it as is? Attach your subscription address label to your letter and let us hear from you.—The Editor.

PAUSE CONTROL MODIFICATION

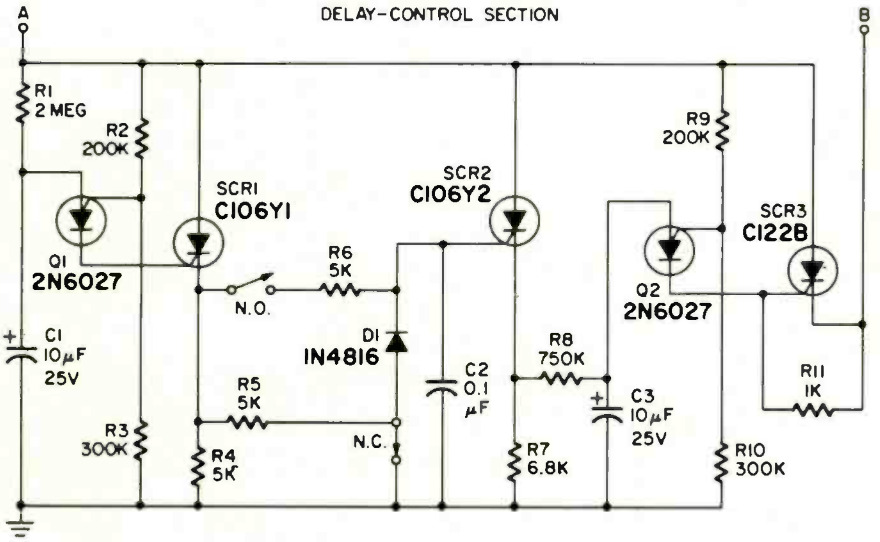
Here is a simpler solution to the "Windshield Wiper Pause Control" problem (December 1971 **Radio-Electronics**) than the author gave. The difficulty arises because the relay RY must stay closed until cam K turns far enough to close its contacts and so keep the wiper going for one sweep. The very large capacitor C does the trick.

My version has been working on our Buick for the past year.

H. A. COURTICE
Rehoboth Beach, Del.



PARTS NOT CRITICAL



ALARM SYSTEM

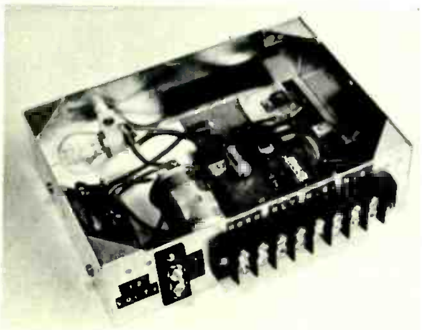
I built the unit described in C. R. Lewart's article, "Multipurpose Alarm System," November 1971 **Radio-Electronics.** Here is the result, with some changes your readers might enjoy.

The most important change is in the tripping part of the circuit. When wired my way, you can use either normally open or normally closed sensing switches, or both types simultaneously.

You'll see that I used C106Y SCR's in place of the C103's. I started out to use C103 but could not get the circuit to work and eventually burned one of them out. So I switched over to the higher amp 106's which work fine.

I changed R1 to 2 megs and R8 to 750K and used 10-μf capacitors for C1 and C3. These suit my needs for the delays. Since I couldn't find a Sorensen horn relay I used a Delco Remy F-1734.

The C122 SCR was first mounted on a small heat sink made from a piece of aluminum, and then mounted on the board along with the other components. The aluminum chassis I used measures 5 x 7 x 2 inches—a more compact size.



My alarm unit is in the garage and I'm planning to build another one for my car with shorter delay times and omit the horn relay by using the one already in the car.

C. R. PETERS
Chicago, Ill.

NEA AWARD

Of the twenty-four awards presented at the recent Convention of the National Electronic Association, only two were presented to electronic companies, and General Electric was one of them. This award was for "Outstanding Service to the Independent Electronic Service Dealers and Technicians."

However, in your November 1971 issue, in the short article "Technicians Meet", you neglected to include any mention of this award.

We at General Electric who through individual effort helped in this achievement are proud of our accomplishments, and we believe that this special recognition should be noted in your pages.

J. J. PISARCZYK
General Electric Company
Philadelphia, Pa.

Editor's Note: We're sorry for the unintentional omission. General Electric is justly proud of this award. **R-E**

The Way to Get Ahead in Electronics is To Get More Knowledge Into Your Head And a Grantham Degree Into Your Pocket!

appliance clinic

WHEN WIRING ACTS UP

by JACK DARR
SERVICE EDITOR

A LOT OF THE TIME, THE SIMPLE THINGS cause all of the trouble. What could be simpler than the wiring in the typical appliance? Yet, this is a very important part of it. In two or three different ways, as we shall see.

Wires are more than long skinny hunks of copper connected between things. Modern wiring has several special characteristics. If we know these and what to do with them, we can save a lot of trouble.

When does a piece of wire need replacing? When you can bend it and see the insulation crack. Worse, when you can move it, and the insulation falls off in your hand. (Also, of course, when your ohmmeter shows no continuity, but this is pretty obvious.)

Don't tape up bad places in the insulation! This is a real no-no. Why? Because; if the insulation has gone bad where you can see it, the chances are it has also gone bad at some place where you can't. And there's always the chance of the tape baking out and going bad in turn. Now, what kind of wire to use for a replacement? That's a good question—let's see if we can find a good answer.

Wire-sizes

The most important thing is to use wire big enough to handle the current. Table 1 shows the ratings for common wire-gauge standards. (Which are a lot different than they used to be. I used to believe that No. 14 wire should never be used for more than 4 amperes! Now look at No. 18! 10 amps!) Check the maximum current, given on the rating plate. Rough guess; divide the wattage given by 100 and you've got the amps.

If the wire is fixed, and doesn't have to bend, solid wire is best. If it must be bent or flexed, stranded wire is necessary. The more flexibility needed, the greater the number of strands you should use. For example, for "moderate flexing" of a No. 14 wire, the recommendation is for a 65 x 30 (65 strands of No. 30). For "service flexing", 165 x 34; 165 strands of No. 34, and so on.

Thanks to the Belden Co. for the data on temperature ratings, etc., and for Table I.

Table 1—Current Capacity of Flexible Wire

AWG	*Rubber and Plastic Wire	*Heater Wire
18	10	10
17	11 (SVT)	12
	12 (SVHT)	
16	13	15
14	18	20
12	25	30
10	30	—
8	40	—
6	55	—
4	70	—

*Ampere ratings for UL and NEC standard 2-conductor and 3-conductor (2-circuit conductors) wire. Wire with 4 to 6 conductors or 3 or more circuit conductors have lower current ratings. No. 27 AWG tinsel cordage rates 0.5 amp.

Insulation(s)

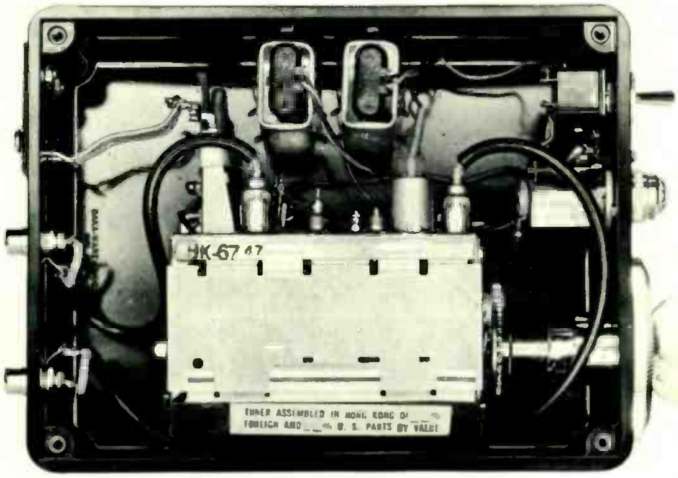
All insulation used was rubber, a while ago. That's all changed now. We have a great many modern materials, in the various plastics. Rubber was good while it lasted, and you can take that either way. It did have a tendency to embrittlement with age. High heat, and especially the presence of ozone, age rubber much more rapidly. So practically all of the new wire you get will have plastic insulation.

The most common will probably be the vinyls and the polyethylenes. They are thermoplastics. They melt easily. Except in very special uses, they are the ones you'll see. The others are thermosetting plastics. This includes rubber, by the way! The new ones are neoprene, and some of the silicone plastics. These are molded by heat, then they "set", and can't be remelted.

The big difference lies in the maximum temperature that each type can withstand. If it gets too hot, many of the thermoplastics will melt and fall off the wires! For a rule of thumb, plain rubber wire can be used in places where the

(continued on page 76)

TV TUNER *SUBBER*



Test unit substitutes the tuner in defective TV receivers to prove whether original tuner is good or bad

by CEDRIC WESTERN

WHERE IS THE SIGNAL LOST IN A RE-ceiver with a "no signal" defect? This simple, self-contained, battery operated test unit enables the TV service technician to eliminate the tuner as the broken link in the signal chain; in most cases without removing the chassis or tuner from the cabinet.

Purpose and construction

The TV Tuner Subber is intended to substitute the tuner in the receiver; either eliminating the tuner as the cause of failure, or indicating that it is probably defective. The subber is designed around a transistor vhf tuner . . . almost any transistor vhf tuner will do. In this case the particular tuner used is a replacement No. RTT-4, complete with knobs, available from Castle TV Tuner Service, Inc. The tuner used **MUST HAVE** it's antenna input isolated from chassis ground by *Capristors* and also have a blocking capacitor in the i.f. output circuit. The tuner used in the unit described meets these requirements.

The power source for the tuner is 18 volts supplied by two 9-volt transistor batteries in series. The tuner B+ requirement is 14 volts to 18 volts; rf transistor forward bias in the range 1 volt to 2.7 volts is required to control rf amplification from maximum gain to just above cutoff. The range of gain control is better than 40 dB. The bias is supplied by divider network R1, R2 and R3 connected across the B supply. Potentiometer R2, mounted on the front panel, sets the rf gain of the tuner, making it independent of the TV receiver agc system. Different transistor tuners used in the subber may require different ranges of bias to properly control the rf gain. Ascertain the range of bias voltage required for the particular tuner selected, then adjust the values of R1 and R3 to furnish this range of voltages across the 500-ohm pot, R2.

To conserve the miniature batteries, we decided that some form of indicator lamp would be necessary to indicate when the subber is on. However, any conventional indicator lamp wired across the battery supply consumes as much power as the tuner itself. This would hardly tend to conserve the batteries. To light the lamp in these power starved conditions the B current drawn by the tuner is used. A low-current lamp (GE No. 1302, 6.3 volts, 35–50 mA) was selected and is connected in series with the tuner B+ terminal and the battery. Connected in this manner the lamp lights dimly as an indicator due to the B-supply current and also doubles as a fuse should excessive current be drawn.

The subber i.f. output terminates in a standard phono jack, which is brought out to the rear of the case for convenient connection. The tunable mixer coil on the subber tuner required very little adjustment for best results; however, other tuners used may require greater adjustment of the mixer coil to find the optimum inductance to match the various i.f. cable capacitances with which the unit will be used. Adjust the coil for best bandpass coupling by using the subber with several popular receivers which are known to be working properly.

The subber is housed in a standard plastic instrument case. Construction time should be less than one hour and no special calibration or alignment is necessary. Construction cost will vary with cost of tuner used and available parts. Parts for the unit described here totalled about $23.00.

The tuner is mounted to the case bottom with angle brackets and flat head screws. The batteries are held in place by a pair of capacitor mounting clips. The 1¼-in. diameter hole for the fine-tuning knob was cut with a hole-saw. It could also be made by drilling a convenient size hole and then enlarging it with a half-round file. The plastic case is easy to work and presents little problem in this respect. It does scratch easily so be careful if you want a good looking unit. The tuner had an unused terminal board already mounted on the chassis which provided convenient wiring tie points for the rf gain control divider network.

Two 12 to 18-inch i.f. extension cables should be made up as shown in the diagram. Connect a phono plug at one end of each cable. At the other end of one cable connect two miniature alligator clips. At the unused end of the other cable connect a cable phono jack. Do not make up excessively long cables, and only use low-capacitance coax.: **Do not use shielded audio cable.** The self-capacitance of this cable is used, in the TV receiver, as the common "C" component of the band-pass circuit coupling the tuner to the i.f. system. Adding excessive cable capacitance will seriously change the bandpass characteristic. The ideal low-capacitance cables for this purpose are RG-62B/U and RG-195A/U, but any good grade low-capacitance coax will suffice.

Using the subber

In use, only two connections have to be made:

1. **Antenna lead-in** to "subber" antenna terminals.
2. **I.f. shielded cable;** disconnect from receiver tuner and connect to output of subber.

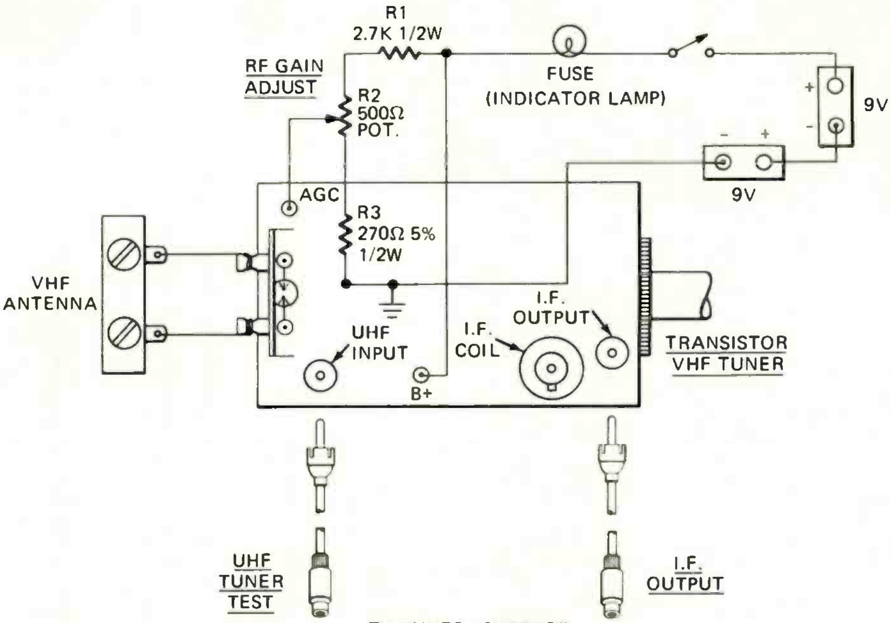
Many TV tuners have their outputs terminated in phono jacks similar to the one of the subber and it is merely necessary to unplug the receiver i.f. cable from the original tuner and plug it into the subber output to use the substitute signal. In receivers where the i.f. cable is too short, the extension cable with the phono plug at one end and phono jack at the other, will be required. Receivers with the i.f. cable soldered permanently to the tuner i.f. output feed-through terminal, require unsoldering this cable and connecting the subber output via the extension cable equipped with alligator clips.

After completing the connections, switch on the subber, select a local vhf TV channel, set the rf gain control to approximate center of it's range and tune the fine-tuning control.

If the receiver is performing normally, except for a defective tuner, it will now work again. It may be necessary to adjust the receiver agc control and subber rf gain control for best performance. In any event the operation of the receiver's agc control should be checked, keeping in mind that it now controls the i.f. amplifier system gain only. Any abnormal operation of the agc should be investigated using accepted analyzing techniques.

Use a bias box to override the agc voltage if the agc system is suspected of supplying improper voltages (refer to TV reciver manufacturer's service literature for proper bias voltages and agc operation). Disconnect the agc line at original tuner to test for a short in the tuner which may cut down available agc voltage.

In some receivers use separate rf and i.f. agc systems, sometimes with independent agc controls. In such a re-



TV TUNER "SUBBER"
WIRING DIAGRAM

BUILDING THE SUBBER is easy. Add seven parts, at most, and you have it.

Parts List

- Transistor vhf tuner: with knobs, Castle RTT-4 **(Castle TV Tuner Service, Inc., 5715 N. Western Ave., Chicago, Ill., 60645)**
- Case and lid: Harry Davis Co. #260 & #261 (or equal)
- Indicator lamp socket: Dialco 502-8136-2131-102 or 502-8140-2131-100 or equal
- Lamp: GE #1302
- Toggle switch, spst
- Phono jacks (2) (Switchcraft 3501 F.P., or equal)
- Two-screw terminal board, vhf antenna.
- 9-volt transistor batteries (2)
- Short, TV tuner coax cables with phono plugs (2)
- 12" to 18" coax cables with phono plugs, for extensions (2)
- Miniature alligator clips (2)
- Cable phono jack (Switchcraft 3503, or equal)
- 500 Potentiometer ohms, miniature
- 270 ohms ½-watt 5% resistor
- 2700 ohms ½-watt 10% resistor
- Assorted hardware: 6-32 screws and nuts, Capacitor mounting clips (2); 9-volt transistor battery connector clips (2); miniature angle brackets (2); drawer pull style carrying handle; hook up wire.

The tuner (model RTT-4) is available from Castle T.V. Tuner Service for $15.95. A complete kit of parts for building the project, including the tuner, is available from the same source for $22.95

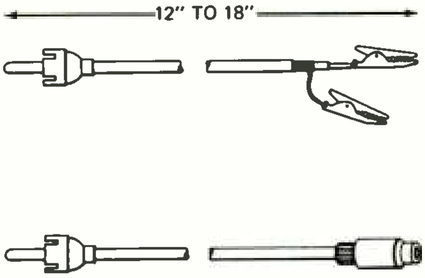
ceiver, the tuner may be shown to appear defective by the subber when the real trouble is a defective rf agc circuit causing a perfectly normal tuner to be inoperative. In these receivers, check the rf agc system thoroughly **BEFORE** removing the tuner. Override the rf agc voltage with a bias box of proper voltage (and polarity), if the bias box restores performance of the tuner—the defect is in the agc system—not the tuner.

The quality of reception when using the subber will vary from as good as the original tuner to smeary, with ringing, no color, poor sync and weak sound. The difference in quality is caused by the change in bandpass resulting from the change in self-capacitance of the i.f. cable (including any extensions used). In the original receiver circuit the self-capacitance of the i.f. cable is used as part of the common, or low side, "C" component of the tuner to i.f. bandpass coupling.

When the original connections are restored after service of the tuner (if service was indicated), the bandpass will also be restored to original. However; if, while servicing the tuner, the mixer coil was adjusted . . . or the tuner has been exchanged or replaced by another (even exact part number), then it will be necessary to adjust the mixer coil, in circuit, for best bandpass. Do not adjust the first i.f. coil (unless complete i.f. realignment is being done using a sweep generator and oscilloscope).

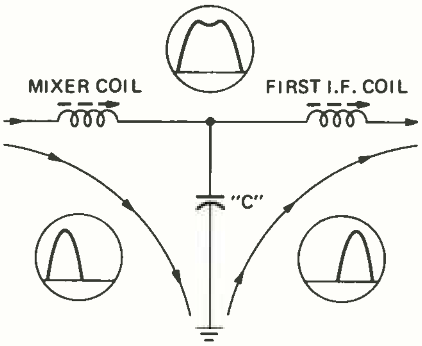
The subber will not check poor or defective operation of automatic fine-tuning circuits of tuners. If such a tuner performs normally manually (when the aft is defeated, or switched off) but does not work with aft on; then the control circuits should be checked to determine if they are supplying the correct control voltages for the aft diode inside the tuner. If the control voltages are as specified by the receiver manufacturer, the aft circuit in the local oscillator section of the tuner is defective and should be serviced. The subber will substitute this type tuner in its manual function and therefor prove if it is defective in some respect other than the aft operation.

Remember, the subber is only in-



I.F. EXTENSION CABLES

CABLES YOU'LL NEED to patch subber into some TV sets. Use low-capacitance coax such as RG-62B/U to maintain TV bandpass curve.



I.F. BANDPASS CIRCUIT WITH COMMON OR LOW SIDE "C" COUPLING.

"C" INCLUDES SELF CAPACITANCE OF CO-AX I.F. CABLE.

CAPACITANCE OF COAX, represented by "C" is part of tuner/i.f. bandpass network. Keep added capacitance low for reliable tuner tests.

tended to prove whether the original tuner works or not. It sometimes may not indicate the quality of performance of a tuner that is working but producing a poor quality signal. It would be wise to replace or service any tuner suspected of such performance.

The subber should be used to check tuners in receivers with sound and video i.f. carriers of 41.25 MHz and 45.75 MHz respectively. It should not be used with older receivers having an i.f. in the 20-MHz range, nor with imported receivers having an i.f. in the 20- or 30-MHz range.

Testing the uhf tuner

Because most modern vhf tuners are equipped with a 40-MHz amplifier function (Channel 1, or UHF position), the 40-MHz UHF input jack of the subber tuner is brought out to a second jack on the rear of the case. By plugging the output of the receiver's uhf tuner into this jack, and switching the subber to the U position, it is possible to test the uhf tuner for normal operation.

In some cases the vhf tuner in the receiver works normally when receiving vhf channels, but the uhf tuner does not work. If the uhf tuner works when the subber is used instead of the TV's own vhf tuner, the 40-MHz amplifier function of the vhf tuner is defective and requires service. For this test the TV's vhf tuner must be switched to the U position because the B supply for the uhf tuner is switched on only in this position.

Battery life

Continuous use battery life has been measured at 4 to 5 hours depending on battery quality. Intermittent use increases this life to over 6 hours with good quality batteries.

Because batteries which have been on the shelf for some time may not be reliable; it is recommended that, when installing new batteries, the available voltage is measured across the series batteries with the subber switched on. The voltage, with switch on, should be close to 18 volts. If voltage is lower than 16.5 volts, replace the batteries.

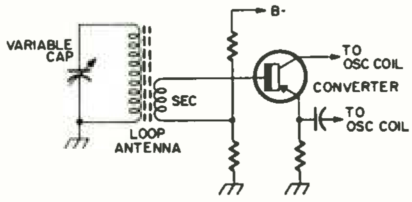
A more elaborate version of the subber could be constructed using tandem uhf/vhf tuners complete with appropriate controls. A larger case would be required to house such a unit and uhf antenna terminals would be added to the rear of the case. The uhf tuner output cable would be brought out through the back of the case and plugged into the UHF TEST jack when used as a uhf tuner substitute; it could then be unplugged to allow testing of the receiver uhf tuner, as previously described. **R-E**

AM Radio Booster

Does your AM radio lack pep and sound weak when compared to other sets? Must you be content only to listen to the stronger stations when you would rather listen to the weaker, but more interesting ones? Than this AM Booster was made for you. Add it to your solid-state radio and watch the AM band come alive! This booster was made to be added to any transistor radio. The parts won't run you more than a few dollars and you can build it easily within an evening.

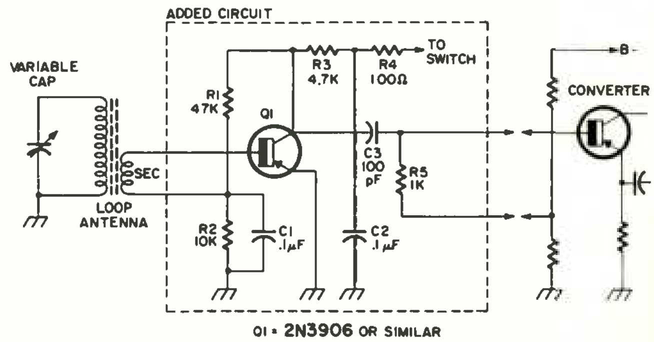
I built my version on a 1-inch square of perfboard and mounted it inside the radio. You may wish to do the same. The only real considerations in building the booster is adapting it to operate off the voltage your radio supplies. My version was made to operate with a 6-volt, positive ground. To operate off the more common 9-volt positive ground, increase R1 to 56,000 ohms, or adjust its value for one-half the supply voltage at Q1's collector. For negative ground sets, substitute an npn transistor (such as the 2N3904) for Q1. The rest of the wiring is noncritical and it needs no comment.

After the booster is built, open the radio and locate the antenna. Trace out the secondary winding (it does *not* go to the variable tuning capacitor!) and snip the leads. Connect these leads to the input of the booster. Run leads from the booster's output to the points where the antenna secondary went. You must finally connect up the power and ground and mount the board to be finished. When that is done, turn on the radio and tune in a weak station above 1400. Adjust the set's antenna trimmer and you are done. Happy listening! *—Gary McClellan*



BEFORE

ADD ONE transistor, five resistors and three capacitors to an AM radio to boost its sensitivity. Before and after of the simple circuit is shown here.

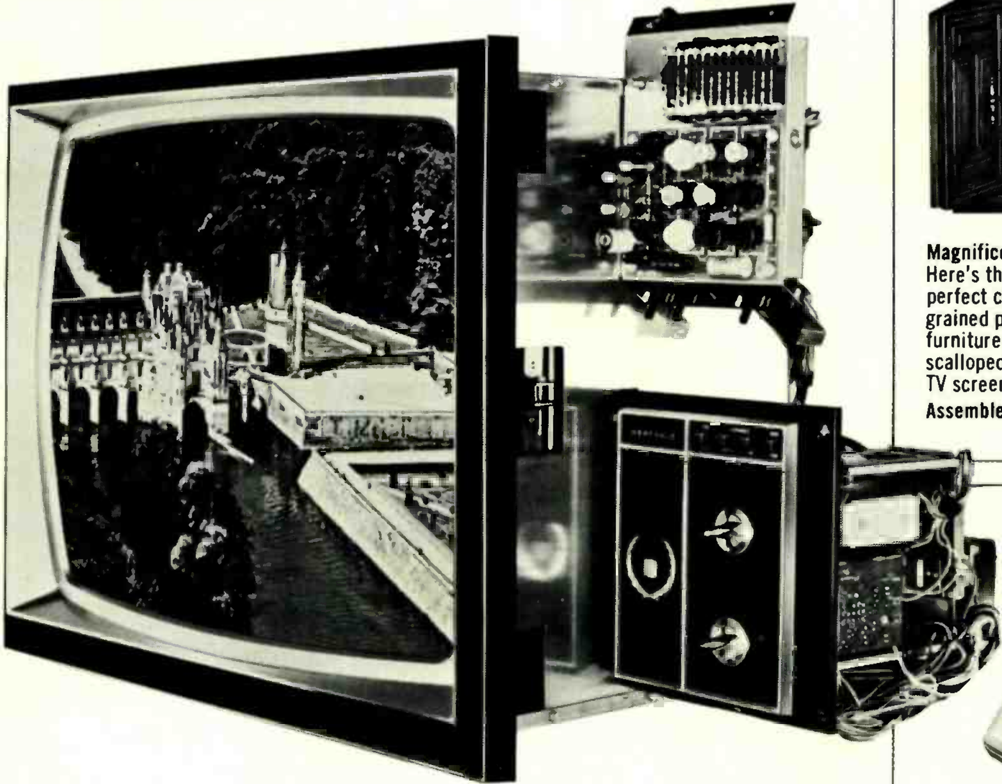


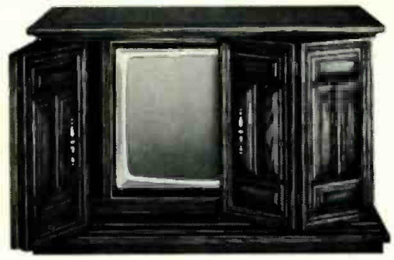
Q1 • 2N3906 OR SIMILAR

AFTER

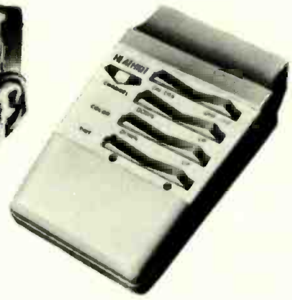
More kits than ever...over 350...all in your

The most advanced color TV kit we've ever offered.





Magnificent Mediterranean Console. Here's the finest TV cabinet we offer, a perfect choice for a GR-900. Has deep-grained pecan veneers on hand-rubbed furniture grade hardwood solids. Two scalloped double-hinged doors hide the TV screen when not in use.
Assembled GRA-405-25, 100 lbs. **179.95***



Wireless Remote for your GR-900. The ultimate in armchair viewing. Gives you eight-function across-the-room control of on/off, three preset volume levels, power tuning (up or down), color, tint, UHF/VHF channel selection. Also activates Custom Wall Mount doors.
Kit GRA-900-6, 6 lbs. **79.95***

New Custom Wall Mount. Touch a button on the frame or on your Heathkit Remote Control unit and the folding tambour doors open to reveal your color TV. Kit includes everything needed to build your Heathkit GR-371MX or GR-900 into a wall.
Kit GRA-402-25, walnut finish, 50 lbs. **114.95***
Kit GRA-407-25, unfinished, 50 lbs. **109.95***

The new Heathkit GR-900 25V Color TV has UHF/VHF detent tuning & varactor UHF tuner, angular tint control – more features than any other color TV kit! Better performance than any other set.

UHF/VHF detent power tuning. Push a button and you scan the channels in either direction with detent action locking in on VHF channels 2-13 and any 12 preselected UHF stations. A pushbutton selects either UHF or VHF mode, and a lighted dial indicates tuner position. And you can have full remote-control selection too for just a few dollars more.

New voltage-controlled varactor UHF tuner and specially designed VHF tuner with MOS Field Effect Transistor contribute to better fringe-area reception, increased sensitivity.

New angular tint control. A switch now gives you either "normal" or "wide angle" color demodulation to reduce tint and flesh tone change when changing stations and when programs change. Other deluxe features include "instant on" operation with override for conventional on/off operation; automatic fine tuning; adjustable tone control, and an output for playing TV audio through your stereo hi/fi system.

Exclusive Heath MTX-5 ultra-rectangular tube. It's the largest color screen you can buy anywhere, with a full 25 inch meas. diag., 315 sq. in. viewing area. You see virtually everything the station transmits, in the corners and at the sides. The specially etched face plate cuts glare, and reflection, increases contrast without sacrificing brightness, and each dot is projected through a matrix screen to stand out crisply against a solid black background.

Modular solid-state circuitry. Plug-in circuit boards and plug-in transistors make assembly, adjustment and servicing easy. There are 46 transistors, 57 diodes and four ICs – making this one of the most reliable sets we've ever designed.

Other features include automatic chroma control, adjustable video peaking, adjustable noise limiting and gated AGC.

Exclusive Heath self-service built-ins. Your Heathkit GR-900 includes built-in dot generator, tilt-out convergence panel for set-up and periodic adjustments. A handy volt-ohm meter included in the circuitry helps you check your work during assembly, and can be used in conjunction with the manual for any servicing. Like all Heathkit color TVs, the GR-900 gives you complete installation flexibility. There are four beautiful Heath cabinets to choose from plus the new built-in electronic wall mount with hide-away tambour doors. Or you can custom install your GR-900. We think you'll agree, the GR-900 is truly the most impressive color receiver we've ever offered.

Kit GR-900, TV less cabinet, 125 lbs. **599.95***

Does your mother-in-

law call you a meatball?

Does your boss?

Maybe even your wife? On payday.

Know what? If you have read this far, you are not meatball material. Because meatballs don't face the present, the future, the facts. They stay put. Dreaming and talking. And today, more than ever staying put means falling behind. Pretty tragic in a time when people with specific aptitudes are so necessary in so many interesting fields.

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B & K precision 1460 triggered-sweep scope

Circle 7 on reader service card

ONLY A FEW YEARS AGO, IF YOU'D wrapped the B & K precision 1460 triggered-sweep oscilloscope in plain paper and told me you had a full-sized scope in the package, I'd have laughed. They just don't make scopes that compact! They do now. When I put this on the bench alongside my own old monsters, I couldn't believe it. It was about half as big. This takes up no more room than a good-sized vtvm.

The 1460 is an all solid-state instrument. Only one tube, the crt, a 130-mm (a little more than 5 inches) type. Inside the neat box are *forty* transistors. 5 FETs and 14 diodes! This is one of the most versatile instruments I've seen. It's a triggered-sweep type; becoming steadily more popular since they've gotten them down out of the very high-price lab-type and into the area where service shops can afford them.

Triggered-sweep means that any pattern can be locked in with the well-known twist of the wrist, on only one (dual) knob. This controls the trigger point, and the stability. By turning the STABILITY control full-on (CW), you get the old standard "recurrent-sweep" just as before. Here it's called AUTOMATIC.

The sweep circuit can be used on any of 19 ranges, from 0.5 msec/cm up to 0.5 sec/cm, *plus* two fixed sweep positions, TV-H (horizontal) and TV-V (vertical). Each of these displays two cycles (lines or frames) of the TV signal. You can flip from one to the other and the 4610 locks in instantly. The last position is EXT (external); also useful, as I found when trying to make a Lissajous figure.

For those of us who have trouble "reading" the "seconds/centimeters" type of calibration, being used to the "frequency" type (including one old goat that I know!), it's easy after a little practice. The calibration actually means "time per centimeter per division" of the graticule. The graticule is divided into 10 divisions each way, 1.0 cm apart, horizontal and vertical. To get the time for one full sweep, multiply the SWEEP-knob setting by 10.

In the vertical gain control department we have another variation. The control is marked VOLTAGE/CM, and works out exactly like the other one. We have 10 divisions on the graticule; so, 1.0 V/cm equals 10 volts p/p for full deflection. This is calibrated from 0.01 V/cm up to 20 V/cm, when the direct probe is used. Switching to the 10:1 attenuator probe multiplies all of these by 10; the top range then becomes 200 V/cm, or 2000 volts full scale. Before we leave these controls, I should mention that each of them has a continuously-variable control.

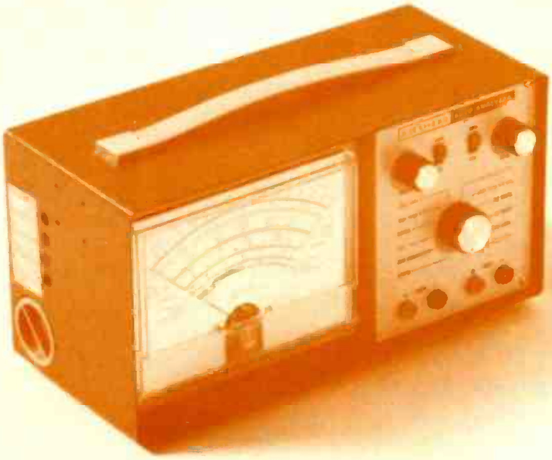
The vertical amplifier has a bandwidth from dc up to 10.0 MHz. You can count the cycles in the burst, or see the VITS (*V*ertical *I*nterval *T*est *S*ignals) in the transmitted TV signal! The probe, even in the direct position, has an input impedance of 1.0 megohm with 35-pF shunt capacitance. In the low-cap position, this too is multiplied by 10, becoming 10.0 megohms and 18 pF.

Due to the very wide bandwidth of both amplifiers, you can use the 1460 as a Vectorscope.

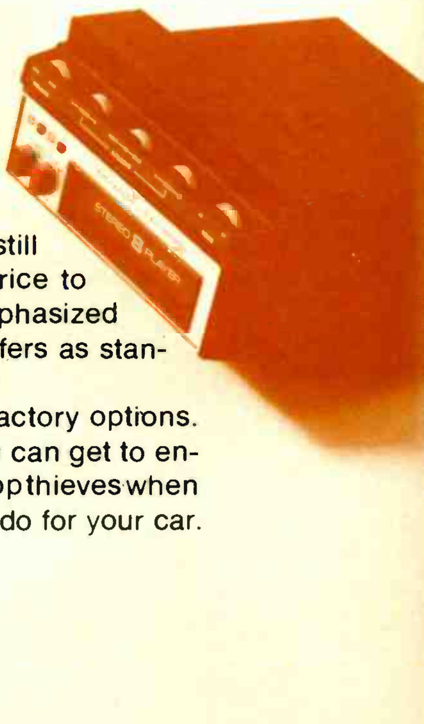
The SYNC-SELECTOR has three slide switches. These can be used to select NOR (normal), TV-V or TV-sinc inputs, INT, EXT or LINE sync (the last for sweep-alignment work), and the + or − slope of the waveform for the triggering. The INTENSITY and FOCUS controls are just below the crt. The two positioning controls just to the right of it, at the top. On the HORIZONTAL POSITIONING control, pulling out on the knob (which is marked PULL 5X MAG) magnifies the pattern 5 times.

All in all, a fine, fast, easy to use piece of test equipment; one that'll make money for you when properly used! **R-E**

ADD-ON ELECTRONICS FOR YOUR CAR



by FRED W. HOLDER



Ten years ago, electronic accessories available to the auto buff were pretty much limited to transistor ignition, electronic tachometers, and AM/FM radios. Transistors were just coming into their own, IC's were being developed, and terms like MOS and LSI were still fiction. Since then, the electronic circuit has shrunk in size and price to provide a multitude of accessories for the modern car. This was emphasized in the April 1971 **Radio-Electronics** article covering what Detroit offers as standard equipment and factory options.

Most of the complex electronic systems are available only as factory options. Nevertheless, there is a formidable list of electronic accessories you can get to enhance performance, entertainment and safety while you drive and to stop thieves when you park. Let's see how some of these items work and what they can do for your car.

Capacitor-discharge ignition system

Several companies manufacture C-D (capacitor-discharge) ignition systems that supply from 30,000 to 40,000 volts to the spark plug for improved starting, better high-speed performance, and increased spark plug life.

All C-D ignition systems work in the same general way: they each have a dc-to-dc converter, a storage element (generally a 1.5-μF capacitor), a switching element (silicon controlled rectifier), a trigger circuit connected to the points, and a high-voltage output transformer (generally your car's existing coil) to generate the spark plug voltage. A brief analysis of the Delta Mark Ten circuit (Fig. 1) will illustrate how the elements work together.

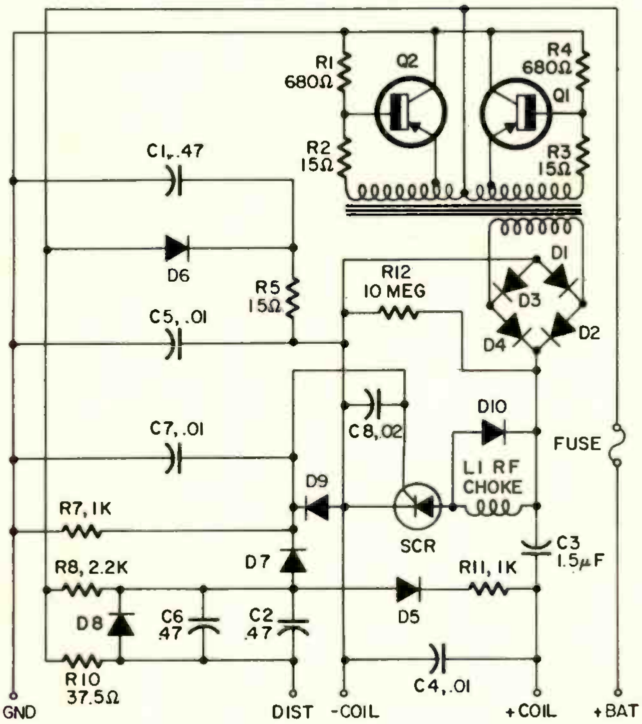


Fig. 1—DELTA MARK TEN is an example of the capacitor-discharge system of ignition.

In Fig. 1, the dc-to-dc converter (consisting of transistors Q1 and Q2, the transformer, and the full-wage bridge rectifier made up of diodes D1 through D4) converts the 12-volt battery voltage to 400 Vdc. The output of the full-wave bridge charges capacitor C3, through the primary winding of the coil, to approximately 400 volts. Assuming the ignition switch is on and the distributor points are closed, current flows from the battery through R10 and the points to ground. When the points open, current then flows through R10, C2, and D7 to trigger the silicon controlled rectifier (SCR); the SCR switches on.

When the SCR turns on, it short-circuits the converter circuit, effectively stopping converter operation, and provides a discharge path for C3 through L1, the SCR, and the primary winding of the coil. The coil primary voltage rises from zero to 400 volts in approximately two microseconds, producing a pulse of around 40,000 volts for the spark plug.

SCR, C3, and the coil form a resonant circuit. The flywheel effect of this circuit restores unused energy to the capacitor as follows: the capacitor discharge-current flows through the SCR and coil primary, creating a magnetic field in the coil. This current continues to flow in the circuit until the capacitor is charged in a reverse direction to approximately 300 volts. At this point, the current attempts to reverse through the SCR, turning it off. The reverse voltage then causes the diode bridge to conduct as a short circuit, discharging the capacitor to zero from its reverse direction and recharging it towards its normal state. When the current supplied by the coil inductance drops to zero, the bridge returns to its normal state and the converter resumes operation.

Diodes D5 and D8, in conjunction with R11, serve to discharge the triggering capacitor C2 completely while the SCR is on. Diode D7 and resistor R8 prevent erratic triggering caused by point bounce. Resistor R7 reverse biases the SCR to prevent erratic triggering due to noise. Diode D10 and the rf choke Li control the turn-on characteristics of the SCR.

What does all this mean to the auto owner? The performance charts of Fig. 2 illustrate what Delta claims the Mark Ten will do for you. According to several auto buffs we've talked with, Mark Ten does everything Delta claims it will.

Recently, Delta brought out a new model, the Mark Ten "B" (Fig. 3), that has an improved input trigger circuit for modern engines with emission control devices. Delta claims their new Vari Spark circuitry controls the spark duration as well as the spark intensity over all ranges of operation.

It is not possible in this article to cover all existing C-D ignition systems. However, it may be beneficial to look

KNIGHT MODEL KG-340 tachometer.

MALLORY'S ENGINE safety control.

C-D IGNITION SYSTEM for stock-cars, dragsters and other types of racers is made by Sydmur-York.

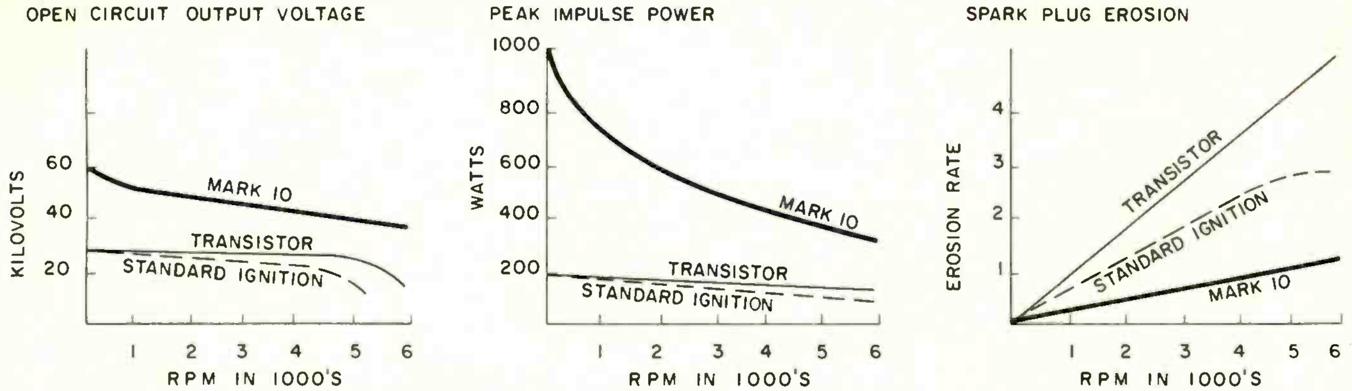
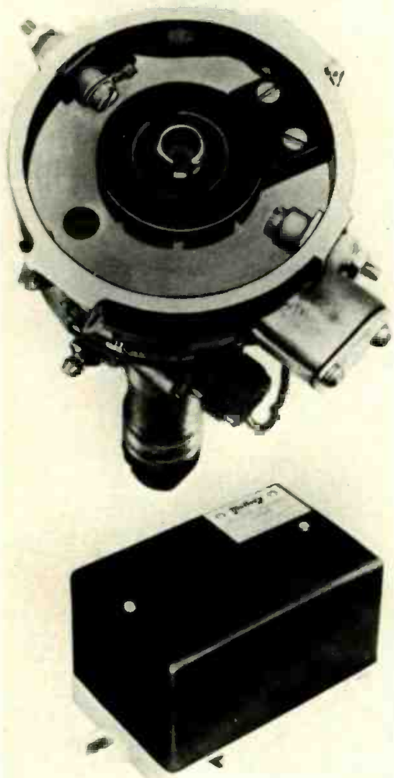


FIG. 2—PERFORMANCE CHARTS compare C-D, transistor and standard ignition systems.

at another, less-complex circuit for comparison. The COMPAC (manufactured by Sydmur Electronic Specialists) is less complex than the Mark Ten. (See Fig. 4.) Nevertheless, it has all of the basic elements necessary to a C-D ignition system. It's dc-to-dc converter is made up of transistor Q1, transformer T1, and diodes D1 and D2. The storage element is capacitor C5 and switching is accomplished by the SCR. Its trigger circuit, coupling the unit to the points, is comprised of diode D3, resistors R4, R5, and R6, and capacitors C3 and C4. The high voltage-output transformer is the car's ignition coil.

THE KNIGHT-KIT delay wiper KG-301 operates wiper from 1 to 60 sweeps per minute.



MALLORY IGNITION IS breakerless.

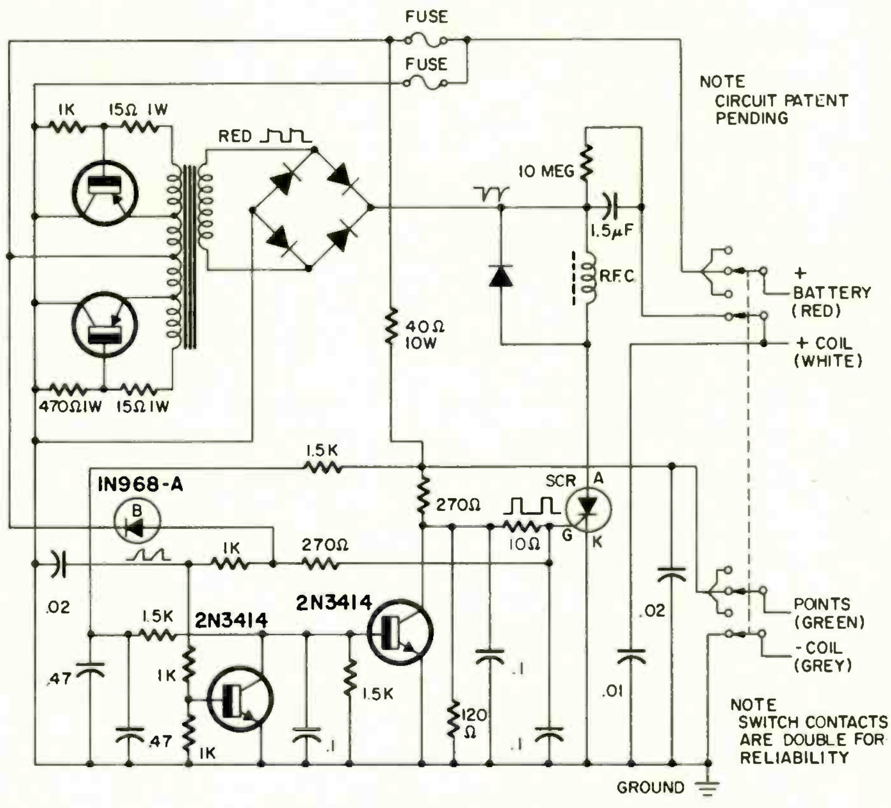


FIG. 3—IMPROVED TRIGGER CIRCUIT of the Mark Ten "B" is for the latest engines.

THE MARK TEN B C-D ignition system.

Breakerless ignition system

General Motors has had breakerless ignition systems available as optional items for several years. The GM breakerless system uses a magnetic pulse device to replace the conventional distributor breaker point. According to Mallory Electric Corporation, such systems have two major faults: first, at low engine rpm, such as during cranking on a cold morning, the unit puts out a weak pulse that results in hard starting; second, the unit does not provide uniform

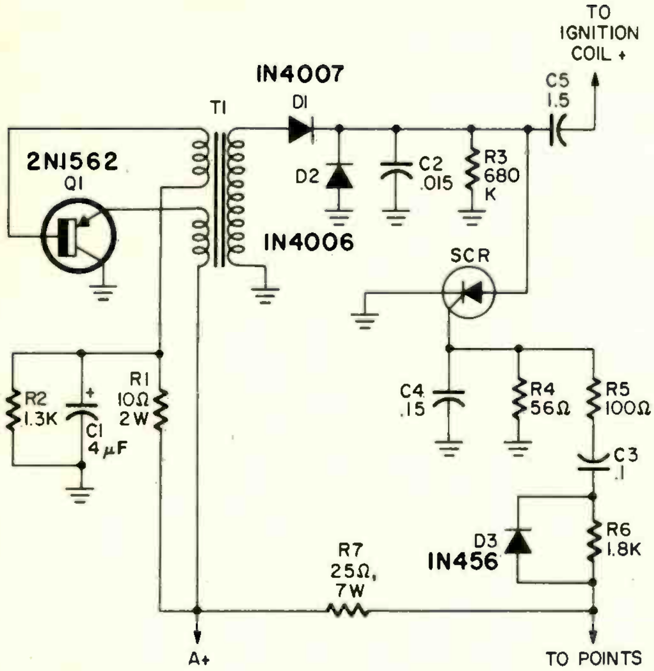


FIG. 4—COMPAC C-D IGNITION system is a less ambitious capacitor discharge type.

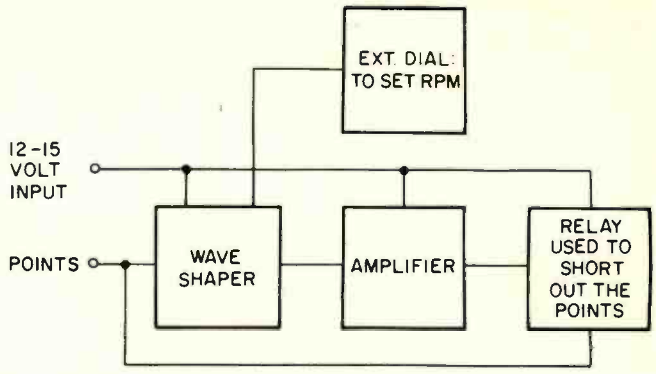


FIG. 5—THE MALLORY ENGINE SAFETY control shuts off the ignition at desired rpm.

timing over the full range of operation.

Mallory has come up with a breakerless system they claim is superior to the magnetic pulse system. Their unit uses a tiny computer lamp and a photocell to generate the ignition timing pulse. In their distributor, the cam is replaced with a shutter wheel, that exposes the photocell to light from the computer lamp at the precise point when the ignition should be triggered. The pulse from the unit is amplified and used to drive the Mallory C-D ignition system. Mallory claims that their breakerless ignition system will operate trouble-free throughout the life of the car.

RPM limiters

Rpm limiters are a class of governors primarily developed for high-performance and racing engines. They are also useful in both marine and industrial applications to prevent engine runaway if the load is removed. This could happen with a broken drive line, or in the case of marine engines, a lost propeller or a propeller breaking water. The rpm limiter must shut the engine down momentarily when it reaches a critical or preselected rpm. Electronics works very well in this application because it responds rapidly and can easily shut the engine down by killing the ignition. There are various units on the market. The Revgard, manufactured by Automotive Research Electronics (ARE), San Jose, California, and the Mallory Engine Safety Control, manufactured by Mallory Electric Corporation, Carson City, Nevada, illustrate two methods of shutting the engine down.

As shown in Fig. 5, the Mallory unit has an external dial to preset the engine rpm limit. The adjustment is calibrated for 8-cylinder battery-ignition applications. For 4 or 6-cylinder engines, it is necessary to use a tachometer to set the upper limit. The unit connects to the ignition-points side of the coil. At a predetermined rpm, set on the dial, the amplifier energizes a relay that grounds the points and turns off the ignition. A few milliseconds later the relay is de-energized and the engine resumes normal operation until it again exceeds the preset rpm.

ARE's *Revgard* rpm limiters are designed primarily for use on high-performance, racing engines. ARE claims that relay operation is too slow for racing engines; they use a thyristor switch instead of a relay. The thyristor shunts the points to kill the ignition. It turns on quickly when the points are open and turns off easily when the points close. ARE will not provide details of how their circuit works; however, they indicate that they do not use a "tachometer-type circuit" to actuate the thyristor.

ARE indicated that most rpm Limiters use a "deadband" of 200 to 500 rpm. (Deadband is defined as the rpm difference between shutting the engine down and restarting it.) Their experiments with a 500-rpm deadband system proved to be "explosive," because quite a bit of unburned gas was allowed to accumulate in both the intake manifold and the exhaust manifold. The explosion resulting when the engine turns on again could be large enough to ruin an expensive blower or a cross-ram manifold. So, they developed what they call the "liveband", which is the range between the point where no ignition pulses are being removed and where all ignition pulses are removed. This is illustrated in Fig. 6. According to ARE, liveband eliminates backfire when the engine restarts.

Another benefit claimed by ARE for their unit is the electrical cure of point bounce. Fig. 7 shows that Revgard does during periods of point bounce. Since point bounce would be interpreted by the unit as excessive rpm, the thyristor will turn on and eliminate the unwanted pulse. ARE claims that this feature will allow the engine to operate at one to two thousand rpm beyond the beginning of point bounce.

There is a calibrated adjustment to set the rpm at which the unit operates. A locknut is provided to prevent

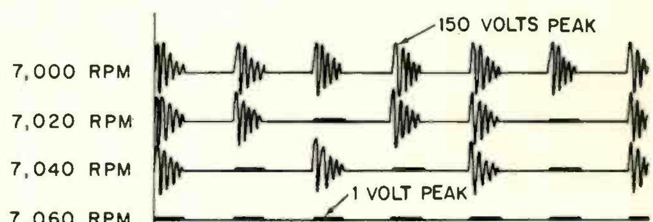


FIG. 6—ARE LIVEBAND control removes ignition pulses selectively as speed increases.

the adjustment control shaft from changing during periods of extreme vibration.

Dwell stretcher

Another problem encountered with high-performance engines is dwell time (time during which the points are closed and current is building up in the primary winding of the coil). A normal single-point, single-coil ignition system will not generally have enough dwell time at high rpm to maintain an adequate spark to the plugs. The result is mis-

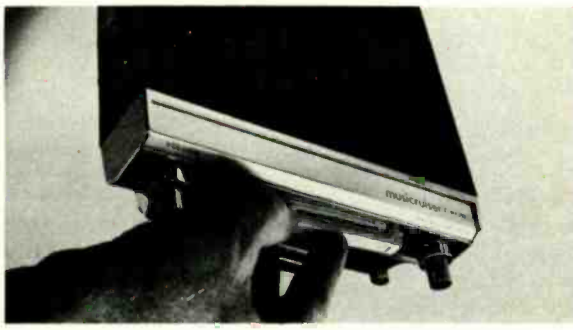
(continued on page 74)

PROGRAMMED

STAAR CASSETTES for the car

by LARRY ALLEN

Just read each easily digested frame of information. Then test your grasp of it by answering a multiple choice question. If you choose correctly, you're guided automatically to the next program capsule. If you miss, don't worry; programed extra information helps you to the correct answer.



1 **Cassettes have grown popular.** No loose end dangling from a reel. No worrying about how to thread the recorder you're going to use. No fretting about where to store tapes—cassettes are extremely compact. Executives like them for dictation because of the ease in handling. Prerecorded music is not all that great on stereo cassettes, but fidelity keeps improving. Music lovers now accept the newest ones.

Compactness is an advantage in automobiles. Eight-track cartridges take up a lot of space, but you can fit several cassettes easily into a glove compartment.

One disadvantage, however, has been the awkwardness of cassette loading. Reel-hub spindles must fit into sprocketed holes in the cassette reels. Also, a capstan drive shaft must extend through its hole in the cassette case. Therefore a cassette machine must normally be loaded from the top. That is, you push the cassette down into a well above the playing mechanism. Then when you punch the PLAY or RECORD button to move the recording/playback and bias/erase heads in against the tape surface. At the same time a pressure roller pinches the tape between itself and the capstan drive shaft.

In a moving car, this top-loading process gets unhandy. So does fumbling around for operating buttons. A Belgian inventor named Theo Staar devised a mechanism which permits slot-loading. It puts cassettes on a par with eight-track cartridges as far as handling convenience is concerned. Once you slide a cassette into the slot, the pressure of pushing it into playing position engages the reel hubs and the tape drive, and turns on the machine. With machines that record, you simply hold in a RECORD button as you slip the cassette into the slot.

Question: What is the purpose of the Staar cassette system?

- ☐ To make the tape run smoother in an automobile. Check your answer in **frame 20.**
- ☐ To eliminate the awkwardness of having to fit a cassette into the machine from the top. Turn to **frame 13** now.
- ☐ To improve the fidelity of cassette recordings by holding the tape in tighter contact with the playback head. Move on to **frame 7.**

2 **Yes and no.** The capstan is part of the movable platform in the Staar system, but the pressure roller is not. The pressure roller (sometimes called *pinch roller*) just sits there until the tape is pushed close to it and the capstan shaft raised up through the hole in the cassette. Then the tape catches between capstan and pressure roller, to be pulled along as the motor turns the capstan. But the idea that the cartridge is part of the platform suggests you may have guessed. Reread **frame 22** and try again.

3 **There may be** an occasional machine that includes fast-forward or rewind in a play-only format, but such a model is rare. If you took a chance on this answer, don't consider yourself completely wrong but do go back to **frame 25** and choose one of the other answers.

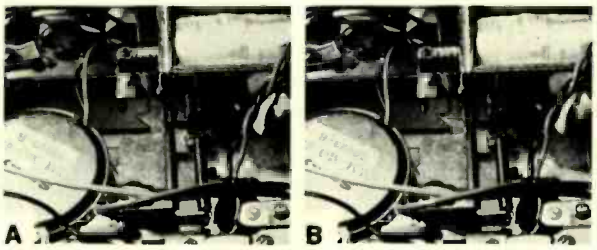
4 **That's right.** Other factors that affect frequency response are cleanness of the heads, lack of residual magnetism in the heads, and—in the case of prerecorded music—how well the cassette was recorded in the first place. You're going along fine now. Keep up the momentum as you move up to **frame 10.**

5 **The solenoid and latching system** of one machine are pictured here. In photo A, you can see the platform latching post locked behind the "sawtooth" projection of the latch bar. The spring-loaded solenoid plunger has a pin through its end that extends down through a slot in the latch bar.

When motion of the takeup reel ceases, the timing circuit allows a heavy-duty switch transistor to conduct. Heavy current flows in the coil of the

5 solenoid. That pulls the plunger of the solenoid inward, moving the latch bar and releasing the platform post.

In photo B, you see the solenoid and latch bar at rest after releasing the platform. The platform has dropped down to its rest position. Notice the comparative positions of the motor in the two photos. In A, with the platform up in the playing position, the motor is high. In B, the platform has dropped down so the motor is hardly even with the stationary mechanism



One other feature of this shutoff mechanism: If power is removed from the machine, enough charge has been stored in the trigger circuit to fire the solenoid. Therefore, the machine is not left in the latched-up position. The latch bar moves a second or two after power is removed, and the mechanism returns to the off position.

Question: The solenoid plunger connects to the latch bar in what manner?

- ☐ A spring. Look in **frame 12.**
- ☐ A coil of insulated electrical wire. Check **frame 26.**
- ☐ A pressed pin through the plunger. See **frame 16.**

---

6 **No,** the eject button has nothing to do with automatic shutoff. Go back to **frame 14** and reread. Then pick a different answer.

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7 **Oops! You are off** on the wrong foot right at the start. As you will discover later, the playing mechanism has little to do with the fidelity of reproduced cassette music. You'd best go back and reread **frame 1** more closely closely and then check another answer.

---

8 **No, yes is wrong.** Or rather, to get a yes here, you should have said no. What I mean is, playback-only machines seldom have fast-forward or fast-reverse. If that's clear to you and you know how the fast forward and reverse work, go to **frame 14.** If not, proceed instead to **frame 27.** After you read that, you should understand the whole idea better.

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9 **Yes,** that's exactly how the automatic reversing mechanism works. And in answering this one correctly you have suddenly reached the end of this course in cassettes. **Congratulations.** **R-E**

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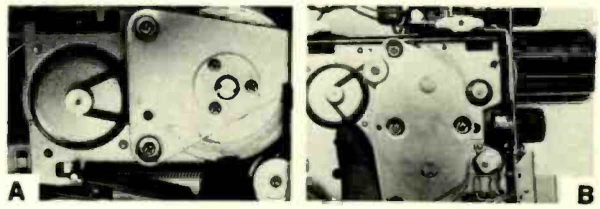
10 

Tape drive in a Staar cassette mechanism hardly differs from that of other tape machines. In fact, few variations occur among cassette machine brands. The motor mounts on the raisable platform, and the motor shaft extends below the platform.

A pulley on the motor shaft, which you can see in photo A, drives a round rubber belt that spins the large, heavy flywheel. The weight and inertia of the flywheel tend to damp out any variations in motor speed.

The capstan shaft, which is part of the flywheel, extends through the platform back to the top side. This is the tiny-diameter shaft tha extends up into the cassette cartridge behind the tape. The pressure roller mashes the tape tight against the capstan. When the motor is on and turning, the rubber belt drives the flywheel. Its capstan shaft spins, turning the pressure roller and pulling the tape along.

Machines for play-only often have an automatic reversing feature so the user doesn't have to slip the cassette over at the end of play. This requires capstans at each end of the tape. Two capstans require two flywheels. Below the platform, as you can see in the photo B, a single rubber belt from the motor pulley drives both flywheels. The two flywheels turn continuously as long as the motor runs. Which one is pulling the tape depends on the pressure rollers, as you'll see in a later frame.

Question: Name the tape-drive sequence of a Staar cassette recorder or playback machine.

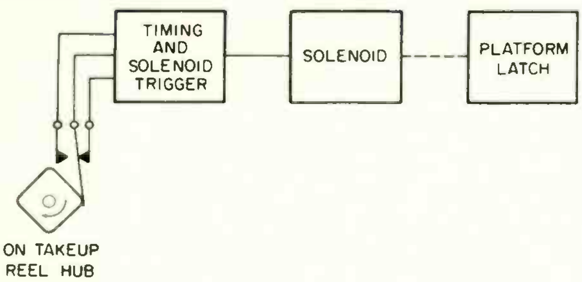
- ☐ Motor, motor shaft pulley, rubber drive belt, flywheel, capstan shaft, and pressure roller. If this is your answer, study **frame 30.**
- ☐ Motor, dual flywheel, capstan, drive pulley, drive belt. Check this answer in **frame 21.**
- ☐ Reel hubs, tape, tape heads, and motor mounting. Look at **frame 15** for additional information about this answer.

---

11 **The speed of the tape does** have an effect on fidelity, but what's important is how fast it goes *past the head.* Height of the head above the platform is important or it might otherwise miss the tape track completely. But head height does not affect fidelity directly. The type of tape base means little to fidelity. So this was the wrong answer choice. Go back to **frame 29,** read it again, and pick another.

12 **No.** The spring is a part of the solenoid and plunger, but it is not what links the plunger to the platform latch bar. Just go back and study the photographs in **frame 5** and you'll probably see the correct answer there.

13 **Correct.** You have grasped **frame 1** and the basic nature of why Teho Staar developed his unique system of handling cassettes. Now turn to **frame 22** and study the basics of how the Staar mechanism accommodates the cassette cartridge.



When a cassette plays all the way to the end of its tape, you take it out and turn it over if you want to play the other side. Since the cassette is hidden away inside the machine, it could sit there jammed up against the end *ad infinitum*. You might forget and leave the set for days with the machine on and the capstan sitting there rubbing a hole through the tape and a lump into the pressure roller. Staar automatic shutoff prevents this.

14 The way it works, a little square cam turns with the takeup reel hub. As the tape moves and the hub turns, the cam flips a leaf-type switch back and forth.

A timing-and-trigger circuit, connected to a solenoid, tries to build up voltage to operate the solenoid. At least it tries while the machine runs. But the little switch clicking back and forth beside the cam keeps the timing circuit discharged and prevents the trigger circuit from actuating the solenoid.

When the tape comes to the end, the takeup reel can no longer turn. With the reel hub stopped, the cam no longer clicks the leaf-switch back and forth. The timing circuit begins building up its voltage. After a second or two, the trigger voltage rises high enough to operate the solenoid.

A latch holds the platform in the operating position. The solenoid plunger jerks inward, letting the latch go. As the platform drops back down to its normal position, the motion flips the cartridge outward and releases the microswitch to shut the machine off.

Question: How long does it normally take for the machine to kick out the cassette and shut off after reaching the end of a tape?

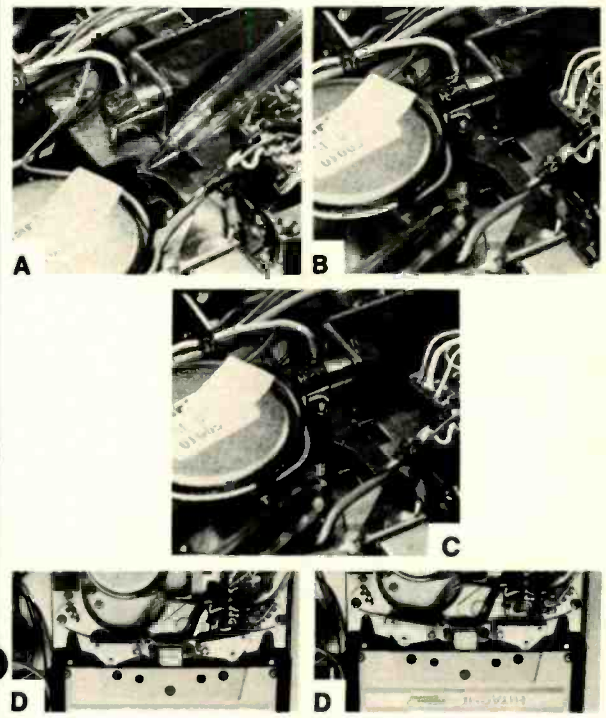
☐ It happens almost immediately. Move on to **frame 24.**

☐ It waits until you have operated the eject button. Check **frame 6.**

14 ☐ Only as long as it takes the timing and trigger circuit to charge up, usually no more than two seconds. See **frame 18.**

15 **You are kidding, right?** You looked here just to see what the frame says. What it says is: Go back to **frame 10** and pick the correct answer.

16



A play-only Staar machine reverses automatically. In photo A, you can see the two latches it takes for this particular job. Here's what happens.

You push the cartridge in, the platform raises, and the platform post latches behind the top latch. Meanwhile, the bottom latch has been pushed back far enough to lock behind the platform post. Photo B shows both latches locked.

Remember the two flywheels and two capstans for automatic reverse? If not, look back at the B photo in **frame 10.** Here in photo 16D, one view shows the left pressure roller pressed in against the left capstan. That's the forward, or side A, position, with both latches locked as in photo B. The turn-on switch activates the motor. The capstan pulls the tape forward.

When the tape comes to its end, the same little cam does what was described in **frame 14** and **frame 5.** A timing circuit builds up bias and lets a trigger transistor actuate the solenoid. The plunger pulls inward on the latch bar.

However, only the bottom latch is tripped. The platform post stays in position, locked behind the top latch, but the bottom latch moves outward and downward (photo C). That latch pushes the rocker bar the pressure rollers are mounted on. The other view in photo D shows the right-side pressure roller is now down against its capstan. This drives the tape in the reverse direction. A switching circuit shifts the amplifier to different gaps on the playback head, and the second program (side B) plays automatically.

When the tape comes to the end of play in that direction, motion of the reels again stops. The timing circuit again actuates the solenoid and this time the plunger releases the top latch. The platform moves back down to its off position. The machine now shuts off completely.

Question: When a cassette comes to the end of play
16 and is ready to recerse, which latch is released to operate the pressure roller rocker arm?

- ☐ The top latch moves forward while the bottom latch moves backward. Move on to **frame 28.**
- ☐ The bottom latch is released and slides forward while the top latch remains in position behind the posts. Check your answer in **frame 9.**
- ☐ The top latch releases and slides forward to push the pressure roller rocker arm, while the bottom latch remains locked behind the posts. If you are correct, **frame 23** will give you the good news.

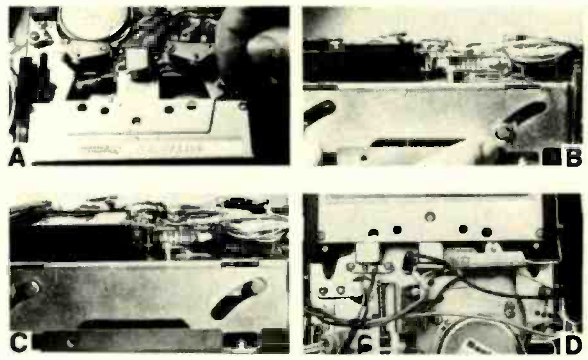
The motor switch is not on the platform, but you can be forgiven for thinking it might be since **frame 22** didn't say. Yes, supports are part of the platform, and the slots guide the platform into the
17 raised positon. But the tape head is not a part of the platform. The tape head is stationary, and pushing the cassette into the machine sets the tape against the face of the head. Try a different answer for **frame 22.**

Yes, it takes about two seconds for the timing circuit to charge up—sometimes more, sometimes less. The little cam and switch keep the circuit dis-
18 charged until motion of the tape stops. Keeping in mind that when the timing circuit builds up enough voltage, it sends a trigger current through a solenoid, turn to **frame 5** and see what the solenoid is actually accomplishing.

This answer was for fun. Go back to **frame 29**
19 and pick one that makes sense.

Smoothness of tape operation depends on the motor and drive system. The main object of the Staar mechanism has nothing to do with whether
20 the tape runs smooth or not. It does, however, relate somehow to operation in an automobile. I suggest you review the text of **frame 1,** which should then guide you to the proper answer.

Some of the parts in that answer are correct. However, the question indicated you should list
21 them in correct sequence. That was not done at all. So turn back to **frame 10** and see if you can list the right parts in correct sequence.



You can follow the steps of Staar operation in the photos. The secret of the mechanism lies in a platform that contains the tape-drive capstan and the reel-drive spindles and hubs. The motor, the drive belts, and the flywheel are on this platform too.

This platform raises and lowers. A cassette, as you slide it into the slot, is guided by Teflon tracks. About halfway in, the corners of the cassette case encounter slide posts (photo A). Applying more pressure, you push the cartridge on back, pushing the posts back also.

Photo B shows the platform supports (on one
22 side) with the platform at rest. The pressure that pushes the slide posts backward lifts the platform upwards, guided by the slots. Photo C pictures the slot guides with the platform raised into playing position. To achieve this, the caesette has been pushed all the way into the machine.

Photo D is a top view of the cassette in playing position. You can see how the heads fit tightly against the tape. Over at the left is the pressure roller, and the capstan drive shaft is in its hole adjacent to the pressure roller. At the bottom of photo D you can see the tops of the reel spindles projecting up through their sprocket holes in the cartridge.

Pushing the cassette this far back trips a microswitch that applies voltage to the motor. The tape starts playing automatically (or recording if you held the RECORD button down).

Question: What parts of the cassette playback mechanism are mounted on the movable platform that raises as you push the cassette into the machine?

- ☐ Capstan and flywheel, motor and drive belt, reel drive hubs and spindle. You'll find out if you're right in **frame 29.**
- ☐ Motor switch, support guide, tape heads. Move back to **frame 17.**
- ☐ Capstan, pressure roller, and cartridge. If this is your answer, turn back to **frame 2.**

23 **Well, the news isn't good** after all. You got mixed up somewhere. If you think you understand the mechanism, go back and try a new answer in **frame 16.** If not, read the frame again.

24 **Not really.** It happens soon afterwards but not immediately. The time it takes is about two seconds. Read **frame 18** and you'll be ready to go on.

25 

A B

Cassette recorders generally include FAST FORWARD and FAST REWIND. Machines using the Staar system are no exception. The fast-forward knob takes any number of shapes; one is pictured in photo A. Play-only machines seldom have the fast-forward or rewind function. Instead, they have automatic reverse.

Photo B shows the fast-rewind pulley. It has a rubber rim, and is coupled to one of the tape reel drive hubs. The REWIND knob lets you hold the pulley against the perimeter of the flywheel. The pulley turns at high speed and spins the tape through in a hurry, from reel B to reel A.

In this particular machine, when you hold the knob the other way, on FAST FORWARD, a different idler pulley (not visible in the photo) presses against the rim of the flywheel. A rubber drive belt turns the idler you see, but in the opposite direction from what it turns for rewind. The tape again runs through rapidly, but forward—from reel A to reel B.

Question: Would you normally expect REWIND or FAST FORWARD among the front panel controls of a Staar machine designed to play prerecorded stereo cassettes?

- ☐ Yes. See what **frame 8** says.
- ☐ No. Read **frame 27.**
- ☐ Sometimes. Move to **frame 3.**

26 **Sorry.** The solenoid has such a coil, for that's what the current goes through to make the magnetism that pulls the plunger inward. However, none of that has anything to do with linking the plunger to the latch. Better go back and read **frame 5** over.

27 **"No" is essentially the correct answer** for the question in **frame 25.** Occasionally a machine breaks the rule, but designers in general put automatic reversing in play-only machines. At least this is true with machines for automobiles, which generally are what use the Staar system. You're getting along fine now. Move on to **frame 14.**

28 **That somehow sounds like** it could be a correct answer, but it's not. Reread **frame 16** and take another stab at it.

29 

Bravo. There's a lot of important information to understand in **frame 22.** Even if you answered correctly the first try, you wouldn't lose a thing by rereading **frame 22.** Simply return to this frame when you finish.

The tape heads are stationary. The cassette holds the tape close to their surfaces. One head is for playback and recording, and the other for bias and erase. The heads are like those in other tape recorders, with minor differences.

Frequency response has been a sore point since cassettes came out. The tape passes the heads at speed—1⅞ very slow speed—1-7/8 ips. That's half the speed of eight-track cartridges and only a quarter the speed used for broadcast-quality tape recordings. Music fidelity at 1-7/8 ips often can't match what audiophiles expect.

But tape heads are improved. The magnetic gap that puts flux lines on the tape oxide has been reduced considerably. With micrometric head gaps, frequency response extends, in some machines, beyond 12,000 Hz.

Machines that record have two heads. One is for erasing and biasing the tape; this head may take a supersonic signal or be actuated by direct current. The other head also serves a dual purpose, being used for both recording and playing back.

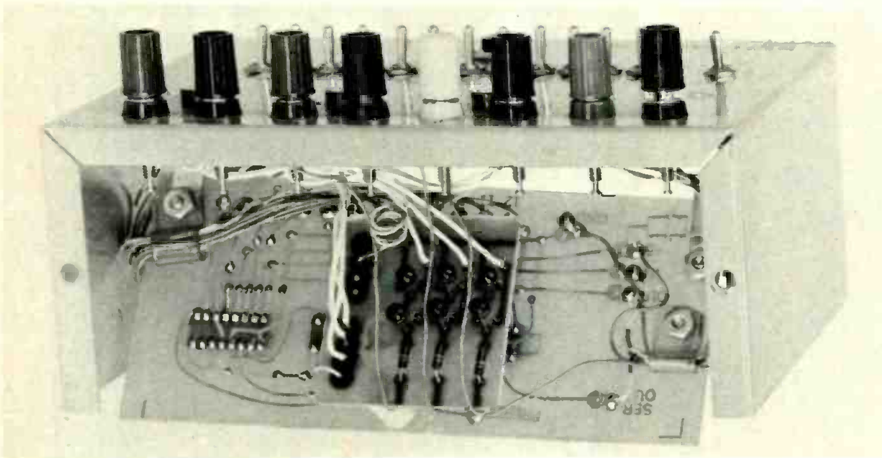
In play-only machines, used generally for stereophonic cassette playback, only a single head is needed. It's a complex head though, with dual gaps. Fidelity in both kinds of machine depends on head alignment and positioning but becomes critical in stereo players. Keeping heads clean is important too, if you want response at its best.

Question: What three factors most seriously affect fidelity of music played back on a stereo cassette machine?

- ☐ The colors of the car in which the cassette machine rides. If you think this is the answer, take a fast look at **frame 19.**
- ☐ The speed of the tape over the pressure roller, the height of the heads above the platform, and type of base upon which the oxide is deposited. You will know if you are right or wrong after you read **frame 11.**
- ☐ Tape speed past the heads, size of magnetic gap in the heads, and the kind of oxide used on the tape. If you think this is right, turn back to **frame 4.**

30 **Right you are.** Since you have that down pat, just roll right along to the next information frame, which is **frame 25.**

Build R-E's Digi-Mod-N Frequency Divider



Divide any frequency by anything from 2 to 4095. Digital switch panel sets up any "divide by" in seconds

by JACK CAZES

THE "DIGI-MOD-N" IS A FREQUENCY divider that can divide by any integer from 2 to 4095. The unit is designed around three National DM-8520 integrated circuits. Each IC contains the functional equivalent of about 55 logic gates. Included in each IC are:

a) the internal logic gating that performs EXCLUSIVE-OR logic operations needed to produce a shift register that has a maximum number of stable states (the maximum possible for the number of flip-flops present in the register)

b) a known-state detector that permits only one output pulse per cycle of the register, and

c) provision for data input to short-cycle the register to any cycle length between 2 and 4095 bits

Using the Digi-Mod-N

The Digi-Mod-N can fill many jobs, depending upon the nature of the input and output devices. For example, it can replace mechanical pulse counters in many applications and provide greater reliability.

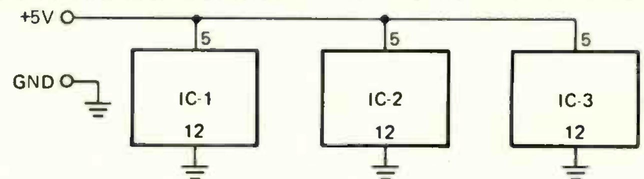
1. The Digi-Mod-N fills many applications on the digital circuit experimenter/designer's workbench, as a general-purpose frequency divider-scaler, not limited to powers of ten as most scalers are! In this application it provides the accuracy and repeatability of true digital division.

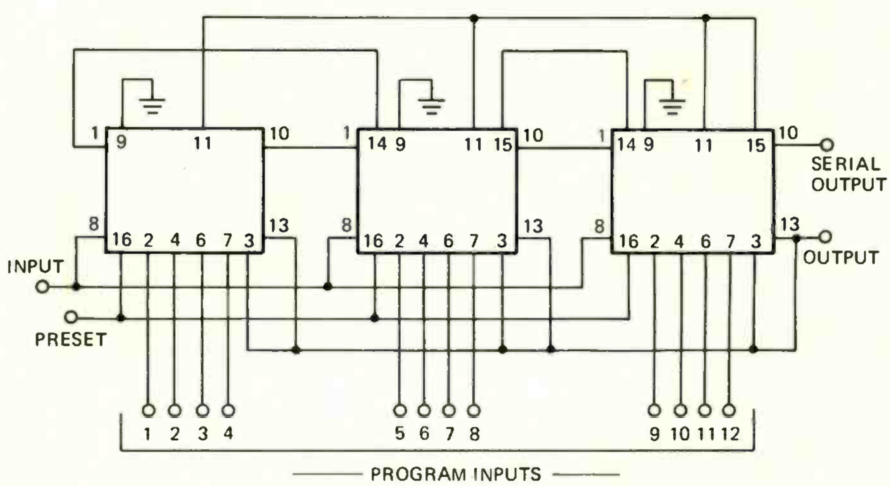
2. It can be used as a variable frequency time-base/oscillator by using a

PARTS LIST

R1, R2, R3—22,000 ohms, ¼-watt
IC1, IC2, IC3—National DM-8520
Q1, Q2, Q3, Q4, Q5, Q6—2N5129
LM1, LM2, LM3—Lamp assembly, miniature, 5V 50 mA
J1 through J8—Binding posts (H. H. Smith 1517 or equal)
S1 through S13—spdt miniature toggle (Alco MST-105 or equal)
S14—spdt momentary contact pushbutton
Miscellaneous parts: Case, 7"L x 5"W x 3"H): PC boards: wire: solder: etc.
Complete set of transistors and IC's (#DMN-1) are available from Electronetics Co., P.O. Box 278, Cranbury, N. J. 08512. $14.50 including postage and insurance.

Frequency-divider board (*$2.55*) and lampdriver board with lamps and lenses (*$2.20*) are available from Southwest Technical Products, 219 W. Rhapsody, San Antonio, Texas 78216.





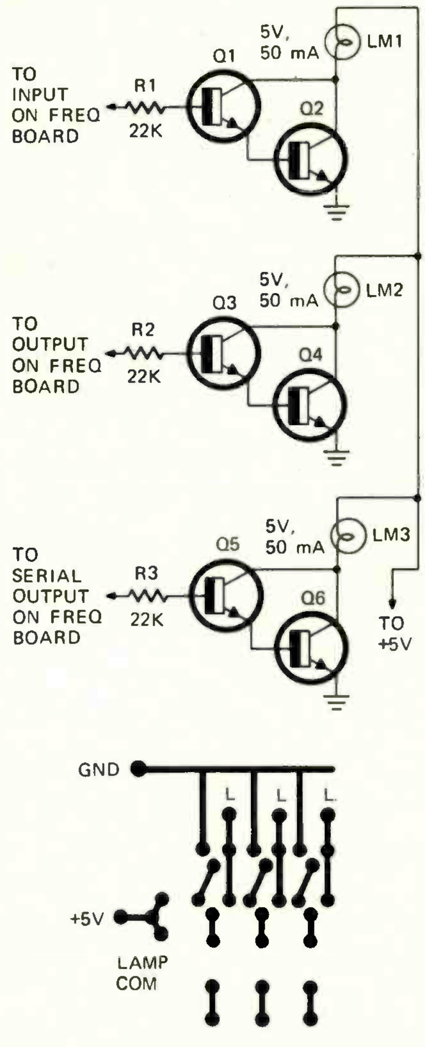
IC INTERCONNECTIONS are shown here. This diagram connects into circuit on facing page.

simple fixed-frequency oscillator as its input. Adding shaping circuits results in a variable-frequency wave synthesizer.

3. The Digi-Mod-N can serve as an automatically recycling events counter, programmed to produce an output every time a given number of events have occured. Such applications include counting moving items such as people entering an area, packages moving along a conveyor, etc. The input could be a photocell circuit or a Microswitch while the output might be a solenoid-operated register, a relay, or an alarm. Moving articles could be counted by some convenient unit such as tens, hundreds, dozens, etc. A packaging plant could use a photocell to count items going into a carton and the output pulse, set to occur when the carton is full, would trigger a mechanism that removes the full box and moves an empty one into position. A chemist might use the divider to count operations in an automatic analyzer. Here again, remember that the end use depends upon the ingenuity of the user.

4. To make a precise motor-speed control, use an oscillator on the input and a phase-shifting circuit feeding a stepping motor on the output. This would provide variable speeds at precisely controlled, reproducible increments.

5. The serial output could serve as a recycling pseudo-random bit generator, the length of the cycle ranging from 2 to 4095 bits, depending upon the program switch settings.



LAMP DRIVER CIRCUITS (top) are built on lamp driver board. Pattern shown above.

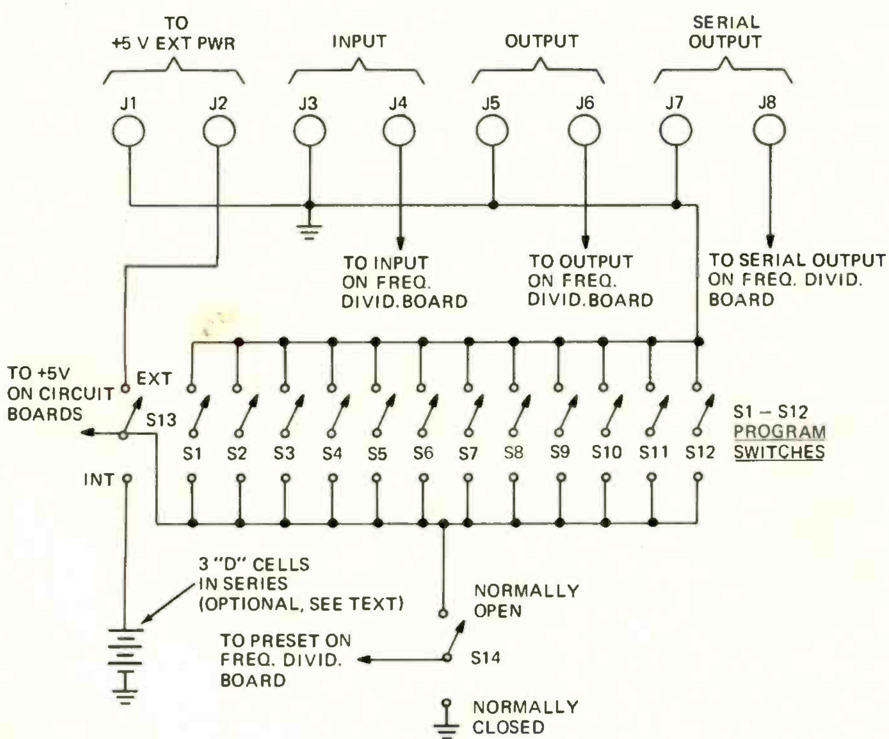
How it works

When the outputs of two or more flip-flops in a shift register are fed back to its input via an EXCLUSIVE-OR gate, a unique progression of stable states results. Proper selection of outputs yields a shift register with a maximum number of stable states. This is often called a *Maximal Sequence Generator.* The three DM-8520's in the Digi-Mod-N are wired so flip-flop outputs 12, 9, 8, and 5 are used to produce a maximal sequence generator. It is called a 12-9-8-5-0 shift register. The maximum number of stable states that can be obtained with such a register is 2^n-1 where 'n' is the total number of flip-flops present in the system. In this case, this is 2^{12}-1 or 4095.

The all-ones-state (where all flip-flops are in their logical '1' state) occurs only once during each cycle. A logic AND function is used to detect this state when it occurs and to provide a logical '1' output at that time. This is the divider output.

The Digi-Mod-N is programmed to divide by numbers smaller than 4095 by entering and presetting the register to the bit pattern that would exist at the flip-flop outputs when the register is in the state that would normally have been reached after 4096–m input pulses, where 'm' is the desired divisor. Thus, we make the register "skip" from its initial all ones state to the (4096–m) state by entering that bit pattern via the program switches and depressing the PRESET button.

For example, to divide by 1000, the bit pattern that would normally be present at the flip-flop outputs at the 3096 state, (4096–1000) pulses after the all-ones-state, is set with the program switches and entered into the register by depressing the PRESET button. The Digi-Mod-N "skips" over to the 3096 stable state and can then progress 1000 steps back to its original all-ones state.



PROGRAM SWITCH WIRING. Arm of switches connect to IC circuit at left.

Build your unit

The case should be punched first, then painted, and lettering applied. Mount the switches, binding posts, and lamp assemblies next. I used dry-transfer lettering to make all front-panel markings.

Make two circuit boards next, using the foil patterns shown. Solder the integrated circuits directly to the frequency-divider board, being careful not to overheat the ICs. Use L-shaped brackets to mount the board to the inside of the front panel, in a vertical position. Mount the lamp driver components next. The transistors are also heat sensitive; so use a heat sink, such as long-nose pliers, between the board and the transistor while soldering each lead. Mount the lamp-driver board onto the frequency divider board with spacers.

Finally, wire the switches and binding posts and complete all wiring

PROGRAMMING CHART

SWITCH SETTINGS

÷By	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12
2	1	1	1	1	1	1	1	1	1	1	1	0
14	0	0	1	0	0	1	0	1	0	1	0	1
26	0	1	1	1	0	1	1	0	0	0	0	1
38	1	0	0	1	1	1	1	1	0	0	1	1
50	0	0	1	0	1	1	1	0	0	1	0	0
62	0	0	1	0	0	0	0	0	0	0	0	0
74	0	0	1	0	0	1	1	0	1	1	1	1
86	1	1	1	1	1	0	0	1	1	0	1	0
98	0	0	1	0	1	0	1	0	0	0	0	1
110	0	1	0	1	0	1	1	1	0	0	1	0
122	1	1	0	0	0	1	1	0	0	0	0	0
134	0	0	0	0	0	1	1	0	1	0	1	1
146	0	0	0	0	0	0	0	0	1	0	1	0
158	1	1	1	0	0	1	1	1	1	1	1	0
170	0	0	1	1	1	1	1	1	1	0	0	1
182	0	1	1	1	0	1	0	0	1	0	1	0
194	0	0	0	0	0	0	0	0	1	0	1	1
206	1	1	0	1	0	0	0	0	0	0	0	1
218	1	1	1	1	0	0	1	0	1	0	0	0
230	0	0	1	0	0	1	0	0	0	0	0	0
242	1	0	1	1	1	0	0	1	1	1	0	1
254	1	1	1	0	0	0	0	0	0	0	0	1
266	1	1	0	0	0	1	1	1	0	0	0	0
278	0	0	1	0	0	0	0	1	0	1	1	1
290	1	0	0	0	0	1	1	0	1	1	0	0
302	0	0	0	1	1	1	0	0	1	0	1	0
314	0	1	1	0	0	0	1	0	0	0	0	0
326	0	0	1	0	0	1	0	0	1	0	0	1
338	0	0	0	0	0	1	1	0	0	0	1	1
350	1	0	0	0	1	0	0	0	1	0	1	1
362	0	1	0	0	0	0	1	0	0	1	0	1
374	1	1	1	0	1	0	1	0	0	1	1	0
386	0	0	0	0	0	1	1	0	1	1	0	1
398	1	0	1	1	0	0	0	0	1	0	1	0
410	0	1	0	0	1	0	0	1	1	0	0	1
422	1	1	0	1	1	1	0	0	0	1	1	0
434	1	1	1	0	0	0	1	1	1	1	1	0
446	1	0	1	0	0	0	0	0	1	0	1	1
458	0	1	1	0	1	1	0	1	0	0	0	1
470	1	1	1	0	1	1	0	1	1	0	1	0
482	1	0	1	0	0	1	1	0	0	1	0	0
494	1	0	1	1	0	0	1	0	0	1	0	0
506	0	0	1	1	1	1	1	0	0	0	0	1
518	1	1	0	1	1	0	1	1	0	1	1	1
530	0	0	1	0	0	0	1	1	0	1	1	0
542	1	1	1	1	1	1	1	0	1	0	1	0
554	1	1	0	1	1	1	0	1	0	1	1	0
566	1	1	0	0	0	1	0	0	0	0	1	0
578	0	0	1	0	0	1	1	0	1	1	0	1
590	1	0	0	1	0	1	1	0	0	1	0	1
602	1	0	1	1	0	0	0	0	0	0	1	1
614	1	1	1	1	0	1	1	0	0	1	1	1
626	1	0	1	1	0	1	0	0	1	1	0	0
638	0	1	1	0	0	1	1	0	1	0	1	1
650	0	1	1	0	1	0	1	1	1	0	1	0
662	1	1	1	0	1	1	0	1	0	0	0	0
674	0	1	0	0	0	0	0	1	1	0	1	0
686	1	0	0	0	1	1	0	1	1	1	0	1
698	0	1	0	0	1	0	1	0	1	0	1	1
710	1	1	0	1	1	0	1	1	1	1	0	0
722	1	1	1	1	0	0	1	1	0	1	1	1
734	0	0	0	0	1	1	0	0	0	0	1	0
746	1	1	1	1	1	0	0	1	0	1	1	0
758	0	1	1	1	1	1	0	1	1	1	1	1
770	1	1	0	0	0	1	1	0	1	1	0	0
782	0	1	0	1	0	0	1	0	1	0	0	1
794	1	0	0	1	0	0	0	1	0	1	1	0
806	0	1	1	1	0	0	0	0	1	0	1	1
818	1	0	1	0	1	0	0	0	1	1	1	0
830	0	0	0	0	0	1	0	0	1	0	1	1
842	0	1	0	0	1	1	1	1	0	0	1	1
854	1	1	1	0	1	0	1	1	0	0	1	1
866	1	1	0	0	1	0	0	1	0	0	0	1
878	1	1	0	0	1	1	1	1	1	0	0	1
890	1	0	1	0	0	0	0	0	1	0	0	1
902	1	1	0	1	1	1	0	1	0	0	0	1
914	0	1	0	0	0	0	1	1	1	1	0	1
926	0	1	0	0	1	0	1	0	1	0	1	1
938	0	0	1	0	0	1	0	1	0	0	0	0
950	1	0	0	1	1	1	1	0	0	0	0	1
962	0	1	1	0	0	1	1	0	0	1	1	1
974	0	0	1	1	1	1	0	0	0	1	0	0
986	0	1	1	1	1	1	0	0	1	1	1	0
998	1	1	0	1	0	1	1	0	1	1	1	1
1010	0	0	0	1	1	0	1	0	0	0	1	0
1022	0	0	1	1	1	0	1	0	1	0	1	0
1034	1	0	0	1	0	1	0	0	0	1	0	0
1046	1	1	0	0	1	0	0	0	0	0	0	1
1058	0	0	1	1	0	1	1	1	1	0	1	1
1070	0	0	0	1	0	0	1	0	1	1	1	0
1082	0	1	1	0	0	1	0	0	1	1	1	1
1094	1	1	1	1	1	0	1	1	1	1	0	0
1106	1	1	0	1	0	1	0	1	1	0	0	0
1118	1	1	1	1	0	1	0	1	1	0	0	0
1130	1	1	0	1	0	1	1	0	1	1	1	1
1142	0	0	1	0	1	0	1	0	1	1	0	1
1154	0	0	0	0	0	0	0	0	1	1	0	0
1166	0	1	0	1	0	1	1	1	1	1	1	0
1178	1	0	0	1	0	0	0	1	1	1	1	0
1190	1	0	0	1	0	1	1	1	0	1	0	1
1202	1	0	0	1	0	1	1	1	1	1	1	1
1214	0	1	1	1	0	0	0	0	0	0	0	1
1226	0	1	0	0	1	1	1	1	0	0	0	0
1238	0	0	1	1	1	1	1	1	0	1	0	0
1250	0	0	1	1	1	0	1	1	0	0	0	1
1262	1	1	1	0	1	0	1	1	1	1	1	1
1274	0	0	0	1	1	0	0	1	0	0	0	0
1286	0	0	1	1	1	1	0	0	0	0	0	0
1298	1	0	0	0	0	1	0	0	1	0	1	0
1310	0	1	1	0	0	1	0	0	1	1	0	0
1322	1	0	1	0	0	0	1	1	1	1	0	0
1334	1	0	0	0	0	0	1	0	1	0	1	1
1346	0	0	0	0	0	1	0	0	0	1	1	1
1358	0	0	0	1	1	0	0	0	1	1	0	1
1370	0	1	1	1	1	0	1	0	1	0	1	1
1382	0	1	0	1	1	1	1	0	1	0	1	0
1394	0	1	0	1	0	0	0	0	0	1	1	1
1406	1	1	0	1	0	0	0	0	1	1	0	0
1418	1	0	0	1	0	0	1	0	1	0	0	1
1430	0	1	1	1	1	0	0	0	1	1	1	1

SWITCH SETTINGS

÷By	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12
1442	0	1	1	1	1	1	1	0	0	0	1	0
1454	1	1	0	0	1	1	1	0	1	0	0	1
1466	1	0	0	0	0	1	1	1	0	0	0	1
1478	0	1	0	1	1	0	1	1	0	1	1	1
1490	1	0	1	1	1	0	0	0	1	0	0	1
1502	0	0	0	1	1	0	0	0	0	0	1	0
1514	0	1	1	1	0	1	0	1	0	0	1	1
1526	1	0	0	1	1	0	0	0	1	0	0	1
1538	0	0	1	1	1	1	1	0	1	1	0	1
1550	1	0	0	0	1	1	0	0	1	0	0	1
1562	1	0	1	1	0	0	1	0	1	0	0	0
1574	0	1	1	0	1	0	0	1	1	1	1	1
1586	1	0	0	1	0	1	0	1	0	1	0	1
1598	1	0	1	1	0	1	0	0	0	0	1	1
1610	0	1	1	0	1	0	0	1	0	1	0	1
1622	1	0	1	0	1	1	0	1	0	1	0	1
1634	1	0	0	0	1	0	1	1	1	0	1	0
1646	0	0	0	1	1	1	0	1	1	1	1	1
1658	1	0	1	0	1	1	0	1	1	1	0	0
1670	0	1	0	1	1	0	1	1	1	0	1	1
1682	1	1	1	0	1	1	1	1	0	1	1	1
1694	1	0	0	0	1	0	0	1	1	1	0	0
1706	1	1	1	0	0	1	0	0	1	0	1	0
1718	0	0	0	0	1	1	1	1	0	1	1	0
1730	0	1	1	0	1	1	1	0	1	1	0	0
1742	1	1	0	0	0	1	1	1	0	0	0	1
1754	1	0	0	0	1	0	0	1	1	0	1	0
1766	0	1	0	1	0	0	1	0	0	1	1	0
1778	1	0	1	0	0	0	0	1	0	0	0	1
1790	1	0	1	0	1	1	0	1	0	0	1	1
1802	0	1	0	1	0	1	0	0	0	1	0	1
1814	0	0	1	0	1	0	0	1	1	0	1	0
1826	1	1	1	0	1	1	1	1	0	1	1	0
1838	1	0	1	1	1	1	1	0	0	0	1	1
1850	0	0	1	0	1	1	1	1	0	1	1	1
1862	0	1	0	1	1	1	1	1	1	1	0	0
1874	1	1	1	1	0	1	1	1	1	0	1	0
1886	1	1	1	0	1	0	1	1	0	0	0	1
1898	1	0	1	1	1	1	0	0	1	0	1	0
1910	0	1	0	1	0	1	1	1	0	0	0	1
1922	1	0	0	1	1	1	1	0	0	0	0	0
1934	0	1	0	1	0	0	0	1	1	0	0	0
1946	1	1	1	1	0	0	0	1	0	1	0	1
1958	0	0	1	0	1	1	0	0	0	1	0	0
1970	0	1	1	0	1	0	1	1	1	0	0	1
1982	0	1	1	1	0	1	0	0	0	0	1	0
1994	0	0	0	0	1	1	1	1	0	0	1	0
2006	1	0	0	1	0	0	0	1	0	0	1	1
2018	1	1	1	0	1	1	1	1	0	1	0	0
2030	1	1	0	0	1	0	1	1	0	0	0	0
2042	1	0	1	1	0	1	1	1	1	1	1	0
2054	0	1	1	0	0	0	0	1	0	0	0	1
2066	0	1	1	1	0	1	0	1	0	0	1	1
2078	0	1	0	0	0	0	0	1	1	0	0	1
2090	1	1	0	1	0	1	0	1	1	0	0	1
2102	0	0	0	1	1	1	0	1	1	1	0	0
2114	0	0	1	0	1	0	1	0	0	0	1	1
2126	0	0	1	1	1	0	0	0	1	0	1	1
2138	0	1	0	1	1	1	0	0	0	0	1	0
2150	1	0	1	0	0	1	1	1	1	1	1	0
2162	0	1	1	1	0	0	1	0	0	1	1	0
2174	1	0	0	0	0	1	1	1	1	0	0	0
2186	0	1	0	1	0	1	0	0	1	0	0	1
2198	0	1	1	1	1	1	1	0	0	1	0	0
2210	0	1	1	1	1	1	1	1	0	0	0	0
2222	0	1	0	0	1	0	0	1	0	1	0	0
2234	1	0	1	1	0	1	0	0	1	0	0	0
2246	1	0	0	1	1	1	0	1	1	1	1	1
2258	1	0	1	1	1	1	0	0	0	1	1	0
2270	1	0	1	0	1	1	0	0	0	0	1	1
2282	1	0	0	0	0	1	1	1	1	0	0	1
2294	1	0	1	1	1	1	0	0	1	0	0	1
2306	1	0	0	1	0	1	1	1	0	0	0	0
2318	0	1	1	0	1	1	0	1	0	1	0	0
2330	0	1	1	0	1	0	1	1	0	0	0	0
2342	0	1	1	0	0	1	0	1	1	0	0	0
2354	1	1	0	0	1	1	0	0	1	0	1	0
2366	1	0	1	0	1	0	0	0	0	0	1	1
2378	0	0	0	0	1	0	1	1	0	1	0	1
2390	0	1	0	0	1	0	1	1	1	1	1	0
2402	1	0	0	0	1	1	0	1	1	0	0	0
2414	1	1	1	0	1	0	0	1	0	1	0	0
2426	1	1	1	0	1	1	1	1	1	0	1	1
2438	1	0	1	1	0	0	1	1	1	1	0	1
2450	1	1	1	0	0	0	0	1	1	0	0	0
2462	0	1	1	0	1	0	1	0	0	1	1	0
2474	1	0	1	0	0	1	1	1	1	1	1	1
2486	1	1	0	0	1	1	0	1	1	0	0	1
2498	1	0	1	1	1	0	1	1	0	0	1	0
2510	0	1	1	0	0	1	0	1	1	0	1	1
2522	1	1	1	0	0	1	0	0	1	0	0	1
2534	1	0	1	1	1	1	1	1	1	1	0	1
2546	0	0	0	0	1	0	1	1	0	1	1	0
2558	0	0	1	1	0	0	1	1	1	1	0	1
2570	0	1	1	0	1	1	0	0	0	1	1	0
2582	1	0	1	0	0	1	0	1	1	1	1	1
2594	1	0	0	0	1	0	0	0	0	0	1	0
2606	1	0	0	0	0	0	0	0	1	1	0	0
2618	1	1	1	0	0	0	1	0	0	0	1	0
2630	1	0	0	1	1	0	1	1	1	0	1	1
2642	1	1	0	1	0	0	0	0	1	0	1	1
2654	0	1	1	0	1	0	1	0	1	0	1	0
2666	1	0	0	0	1	1	0	1	1	1	0	1
2678	1	0	1	0	0	0	0	0	1	1	1	0
2690	0	0	1	0	0	0	1	0	1	1	0	0
2702	0	0	1	1	0	1	1	1	0	0	1	0
2714	1	0	1	1	1	1	0	1	1	1	1	1
2726	1	1	0	0	0	0	0	1	0	1	0	0
2738	0	0	1	0	1	1	1	1	0	0	1	0
2750	1	0	1	0	1	0	0	1	1	0	1	1
2762	0	1	0	0	0	0	1	0	1	0	0	1
2774	0	1	1	0	0	0	0	1	1	1	1	0
2786	0	0	0	0	0	0	1	1	0	0	0	1
2798	1	0	0	0	1	1	0	1	0	0	1	1
2810	1	0	0	1	1	0	1	1	0	0	1	0
2822	0	0	0	1	1	1	0	1	1	1	1	0
2834	1	0	1	0	1	1	1	0	1	1	1	1
2846	0	0	0	1	0	1	0	1	1	1	0	0
2858	1	0	0	0	0	1	0	1	1	1	0	1
2870	0	1	1	0	1	1	0	1	0	0	1	1

SWITCH SETTINGS

÷By	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12
2882	1	0	0	0	0	0	1	0	0	1	0	1
2894	0	0	1	1	1	1	0	0	0	1	1	0
2906	0	0	0	1	0	0	1	1	0	0	0	1
2918	0	1	0	0	1	1	0	0	1	1	0	1
2930	1	0	1	1	1	0	1	1	0	1	1	1
2942	0	1	0	0	1	0	0	0	0	1	1	0
2954	1	1	1	1	0	1	0	0	0	1	0	0
2966	1	0	1	0	0	0	1	1	0	1	0	1
2978	0	0	1	1	1	1	0	1	0	1	0	1
2990	0	1	1	0	1	1	0	0	1	1	0	1
3002	1	0	0	1	1	1	0	1	1	0	0	0
3014	1	0	1	1	0	0	0	1	1	1	0	0
3026	1	1	0	1	1	1	1	0	0	1	0	1
3038	1	1	1	1	0	1	0	0	0	1	1	1
3050	1	1	1	1	1	0	1	1	0	1	0	1
3062	0	1	1	0	1	0	1	0	0	1	1	0
3074	1	0	0	1	1	1	0	1	0	0	1	0
3086	0	1	0	1	0	1	1	0	0	0	1	0
3098	1	1	1	0	0	0	0	1	1	1	0	0
3110	1	0	0	0	0	0	0	0	1	1	0	1
3122	1	1	1	1	1	0	1	1	1	1	1	0
3134	1	0	1	1	1	0	1	0	0	1	1	1
3146	0	1	1	0	1	1	1	1	1	0	1	0
3158	0	1	1	1	0	0	1	0	0	0	1	0
3170	0	1	0	1	1	0	0	0	0	0	0	1
3182	0	1	1	0	0	0	0	0	1	1	0	0
3194	0	0	1	1	1	1	0	0	1	1	1	0
3206	1	0	0	1	1	0	1	1	0	0	0	0
3218	1	1	1	0	1	0	0	1	0	1	1	0
3230	0	1	1	0	1	1	1	0	1	0	0	0
3242	0	0	1	1	1	0	1	0	0	0	0	1
3254	0	1	0	0	0	1	0	0	0	1	0	1
3266	0	0	1	1	1	0	1	0	1	1	0	1
3278	0	0	0	1	0	0	1	1	1	0	1	1
3290	1	0	1	0	1	0	1	1	0	0	1	1
3302	1	0	0	0	0	1	0	0	1	1	1	0
3314	0	0	1	1	1	1	0	0	1	1	0	0
3326	1	1	1	1	0	1	0	0	1	1	1	1
3338	0	1	1	1	0	0	1	1	0	1	0	0
3350	1	1	0	0	1	1	1	1	1	1	0	1
3362	0	1	0	0	1	0	0	0	1	1	0	1
3374	0	0	1	0	0	1	0	0	0	1	0	1
3386	0	1	0	1	0	0	0	1	1	1	0	1
3398	0	0	0	1	1	0	0	1	0	1	0	1
3410	1	1	0	1	0	1	0	1	0	0	0	0
3422	0	1	1	1	1	1	0	1	1	0	0	0
3434	0	1	1	1	0	1	1	0	1	1	0	0
3446	1	1	1	1	1	1	1	1	0	0	1	0
3458	0	1	1	1	0	0	1	0	1	0	1	1
3470	1	1	1	0	0	1	1	1	1	1	1	1
3482	0	0	0	0	1	0	0	0	0	1	1	0
3494	1	0	1	1	1	0	0	1	1	0	1	1
3506	0	1	0	1	0	0	0	0	0	0	0	1
3518	0	1	1	0	1	0	0	1	0	1	1	1
3530	1	1	0	0	0	0	1	0	1	0	0	0
3542	0	0	0	1	0	0	0	1	1	0	0	0
3554	1	0	1	1	1	1	0	0	1	0	1	0
3566	1	1	0	1	1	1	1	1	0	0	0	0
3578	0	0	1	1	1	0	1	1	1	0	1	1
3590	1	0	0	0	0	1	0	0	0	1	1	1
3602	1	0	0	0	0	0	1	1	0	0	1	0
3614	1	0	0	1	1	1	0	0	0	1	0	1
3626	1	1	1	1	0	1	1	0	0	0	0	1
3638	0	0	0	0	0	1	0	0	1	1	0	0
3650	1	1	0	0	1	0	0	0	1	1	0	0
3662	1	0	0	0	1	0	0	0	0	1	0	1
3674	0	1	1	1	1	0	1	0	0	1	0	0
3686	1	1	1	0	0	0	0	1	1	0	1	0
3698	0	0	1	1	0	0	0	0	1	1	0	1
3710	0	1	0	1	0	1	0	1	1	0	0	1
3722	0	1	0	1	1	0	0	1	1	0	0	0
3734	1	1	1	1	1	0	0	0	1	1	1	0
3746	1	1	0	1	0	0	1	0	0	0	1	0
3758	1	1	1	0	0	1	0	1	0	0	0	1
3770	0	1	1	1	1	1	1	1	1	1	1	0
3782	1	0	1	1	1	1	1	0	1	0	1	0
3794	1	0	0	1	0	0	0	0	1	0	0	1
3806	0	0	1	1	0	1	1	1	0	1	1	0
3818	0	1	1	1	0	0	1	0	1	1	1	1
3830	0	0	1	1	1	0	0	0	0	0	0	0
3842	0	0	1	1	1	1	0	0	0	0	1	1
3854	1	1	1	1	1	0	1	1	0	0	0	1
3866	1	0	1	1	0	1	0	1	1	0	0	1
3878	1	0	1	0	1	0	0	1	0	1	1	1
3890	0	0	0	1	0	1	0	0	1	0	0	0
3902	0	0	0	0	0	1	0	0	0	1	0	0
3914	0	1	0	0	0	0	0	0	1	1	0	1
3926	0	0	1	0	1	1	0	1	1	1	1	0
3938	1	0	1	0	1	1	1	1	1	0	1	1
3950	1	0	0	1	0	0	1	1	1	1	0	1
3962	1	0	0	0	0	0	0	0	1	1	0	0
3974	1	1	0	0	1	1	0	0	0	0	0	1
3986	0	1	1	1	0	1	1	1	0	1	1	0
3998	0	0	1	1	1	1	1	1	0	0	0	0
4010	1	1	0	0	1	0	1	1	0	1	0	0
4022	0	1	1	0	1	0	0	0	0	0	0	1
4034	0	1	0	1	0	1	0	1	0	1	0	0
4046	0	0	1	1	1	0	0	1	1	0	0	1
4058	1	0	1	0	0	1	0	0	0	0	0	1
4070	0	0	0	1	0	1	0	1	1	1	0	1
4082	1	1	0	0	1	0	1	1	1	0	0	0
4094	0	0	1	1	1	1	1	1	1	1	1	1

interconnecting them to the boards. If an internal battery is to be used, install a suitable battery holder, dimensions chosen to fit the space available in the case. Connect it to any ground (negative) and switch S13 (positive).

NOTE: The lamp-driver combination is useful only for the visual observation of input and outputs that proceed at slow rates (i.e., only a few Hertz). If the end use involves only very fast signals or if you are not interested in visually observing these signals, omit the lamps and the lamp driver board.

Lead dress is not critical from an operational point of view, but neatly placed wiring simplifies trouble-shooting and results in a more esthetically pleasing product.

Programming the Digi-Mod-N

Programming is done by setting the proper program bit pattern selected from the programming chart for the divisor desired. Note that the chart gives the required settings for every twelfth divisor. Since the Digi-Mod-N contains twelve flip-flops wired as a shift register with twelve programming inputs, the entire bit sequence for the register is accounted for by listing every twelfth shift, i.e., the program input for every twelfth divisor. Inputs for divisors between those shown in the chart are obtained by interpolation.

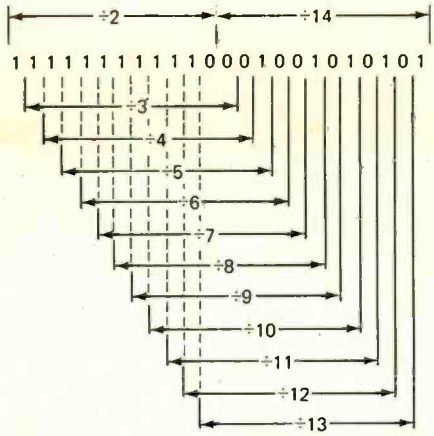


Fig. 1—HOW TO CALCULATE divider switch settings for numbers not listed in the programming chart.

As an example, suppose we want to divide by 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, or 13. We would note that the desired divisor lies between 2 and 14 in the table and would write the bit patterns for 2 and 14 next to each other and interpolate for the other divisors (Fig. 1).

Thus, we can divide by 8 by setting S1 thru S12:

1 1 1 1 1 0 0 0 1
0 0 1

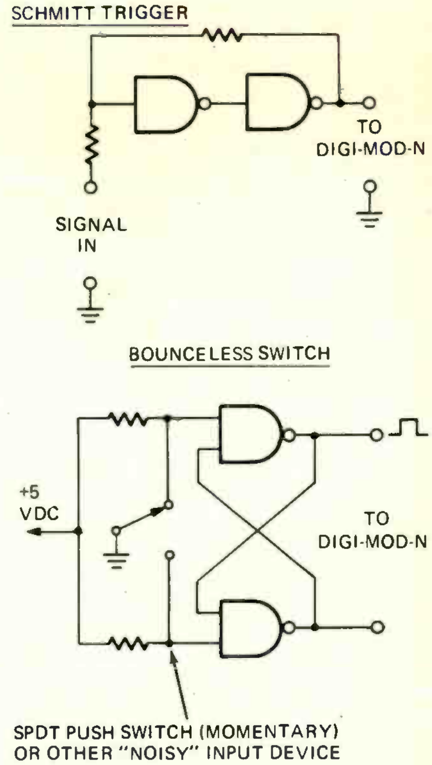


FIG. 2—OPTIONAL CIRCUITS for use with the frequency divider include a Schmitt trigger and bounceless switch.

Similarly, switch settings for dividing by any number not given in the table (within the range of the Digi-Mod-N, of course) would be obtained by interpolating between two numbers in the table.

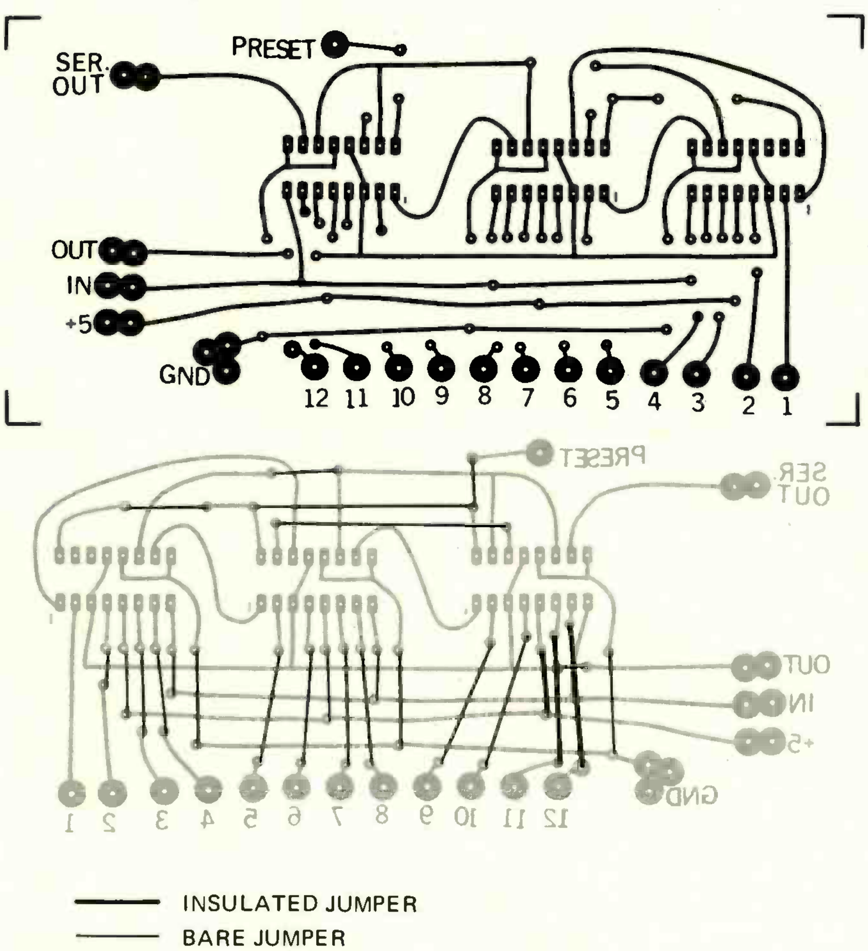
Testing and operation

Connect a regulated 5-volt source to J1 and J2 and set S13 to EXT. (**NOTE:** If internal batteries are used, install them in their holder and set S13 to INT.). Connect a square wave or pulse generator to the INPUT (J3 and J4) and set it to a low frequency with an output height of 5 volts. Set the PROGRAM switches for a given divisor and check to see that the output pulse rate equals the input rate divided by the programmed divisor. The panel lamps may be used as indicators if the input is slow enough to count. If not, use a scope to monitor the input and output.

Depressing and holding the PRESET button should stop the division and reset the register to its all-ones starting state. In this condition, the input lamp should still indicate the entering input pulses, but the output lamp should remain on. Releasing the PRESET button should permit division to begin again.

The SERIAL OUTPUT lamp should flash on and off to indicate the individual "1" and "0" bits as they pass through and out of the shift register. The relative sequence of bits at this output should be identical to the sequence in the programming chart. The SERIAL OUTPUT can be thought of as being a

(continued on page 82)



PROGRAMMING CHART on facing page lists all switch setting for dividing by numbers between 2 and 4094.

FREQUENCY DIVIDER board pattern is shown top above. It measures 5 inches in width. Jumper wiring is shown in lower diagram.

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THE RADIO-ELECTRONIC'S DIGITAL PRINTing Computer (DPC) is a specialized timer for the photo buff who does his own black and white or color printing. It has several brand new circuit features not found on *any* commercially available device, even those costing many times its price. Unlike any ordinary photo timer, the Digital Printing Computer works directly in quarter stop increments of time. This means it thinks in exactly the same manner that photo paper does. There's now no more guesswork or fancy math involved any more—the computer does it for you. If your prints turn out a half a stop too light, just advance the computer two quarter stop clicks for a perfect print. If you decide to retard your enlarger a stop or two, just click the exposure computer just as much the opposite way, and you're right back where you started—with no guesswork and no math.

The instrument uses all integrated circuits and a very simple switching system that gives permanent calibration and unbeatable long-term accuracy. Both these features are picked up by counting cycles of the stable 60-hertz power-line instead of relying on traditional resistor-capacitor timing schemes that have to be calibrated and drift with age.

You get a range of 29 quarter-stop increments, ranging from 0.5 to 64 seconds, set and read by two overlapping, easy-to-read, red backlit dials. In addition to its "by stops" unique operation, you get all the other features normally found on high-quality timers, including a safety isolated remote control for foot switches, three-wire inputs, outputs and safety ground, dual-complementary ENLARGER-SAFELIGHT outputs, focus override and an emergency stop panic button.

About stops

Photographic papers work on a logarithmic rather than on a linear basis. This means you *double* the light every time you want to go one stop darker. Thus, going from 1 second to 2 seconds exposure time will make a one stop darker exposure. But, going from 31 seconds to 32 seconds will have practically no effect. It's not the time difference that counts, but how much time or light you add as a percentage of what you already have. If a 1 *f*-stop difference is a 2:1 time or light ratio, a one-half stop difference would be a 1.41 time or light ratio, and a quarter stop difference would be only a 1.2 time or light ratio. Incidentally, a quarter-stop is cutting things pretty fine—few photo experts could spot a quarter stop change even in critical color work. Table I shows the actual time values you get for each quarter-stop increment.

The DPC is a real digital computer that you program as a frequency synthesizer. It generates the needed times to very high accuracy and in the required log scale quarter-stop increments. Figure 1 shows the block diagram.

The 60-Hz power-line frequency is divided down by six to get a train of 0.1-second reference pulses. These are counted by two cascaded counters, called the F-STOP counter and the BASELINE counter. The *f*-stop counter divides the 0.1-second reference pulses to switch selectable basic output times of 0.5, 0.6, 0.7, 0.8, 1, 1.2, 1.4, 1.6, and 2.0 seconds, giving either an exact or extremely accurate approximation to a –1 stop, –3/4 stop, –1/2 stop, –1/4 stop,

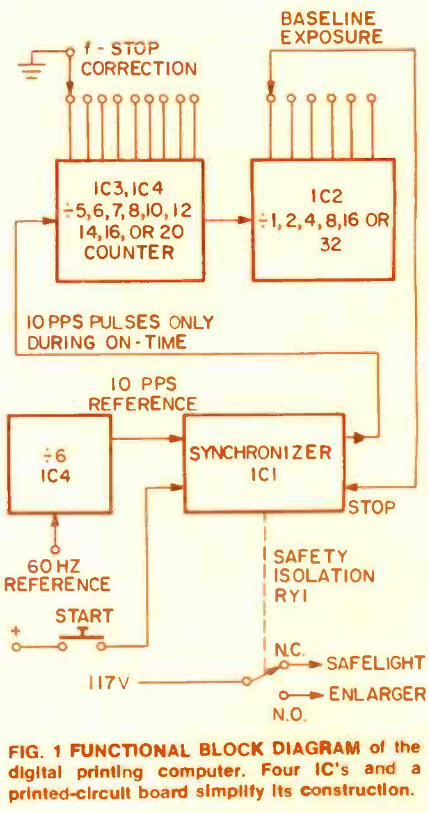
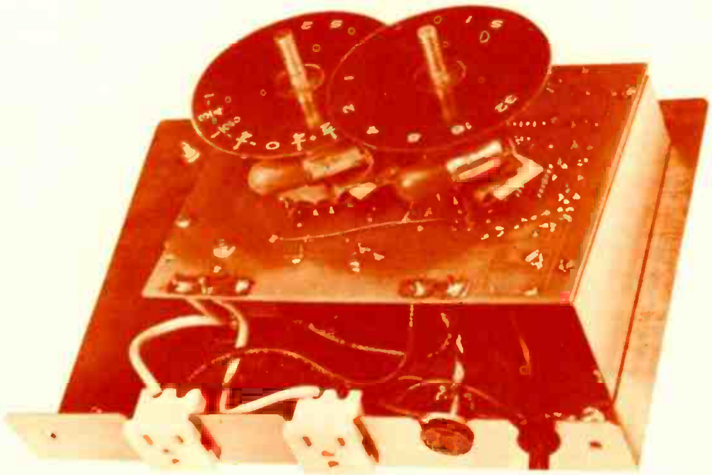


FIG. 1 FUNCTIONAL BLOCK DIAGRAM of the digital printing computer. Four IC's and a printed-circuit board simplify its construction.



baseline exposure, +1/4 stop, +1/2 stop, +3 +4 stop, or +1 stop exposure value. The baseline counter extends the *f*-stop counter's range to 1, 2, 4, 8, 16, or 32 seconds. Together the two give you a continuous range of 0.5 to 64 seconds in quarter-stop increments. Considerable overlap is provided by the two counters for ease of operation.

The computer acts independently each time as a one-shot counter. Every time the START switch is depressed, a special synchronizer locks the counter to the power-line, loads the proper division ratio into the *f*-stop counter, resets the baseline counter, and starts the count process. When the count is finished the synchronizer goes back to its initial or WAIT state. During the counting time, a signal is routed to a safety isolating relay that turns the safelight off and the enlarger on for the timing duration.

The remaining switching is omitted in Fig. 1 for simplicity. The other circuitry lets you bypass the timer for focus-

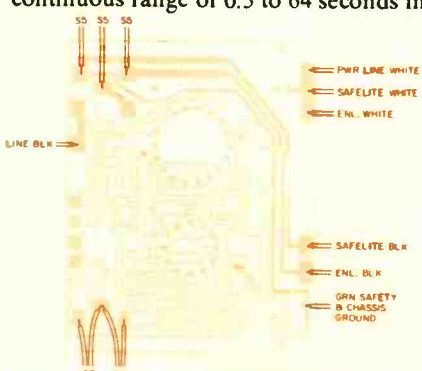
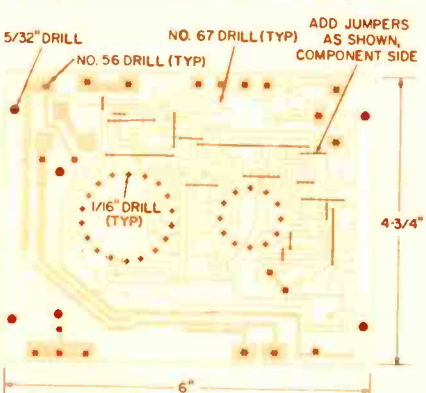


FIG. 2—EXTERNAL COMPONENTS connect to the circuit board as shown in this diagram.



1 REQ'D 1/16" G-10 PC MAT'L

FIG. 3—PC BOARD MECHANICAL DETAILS. Drill as indicated then install the jumpers.

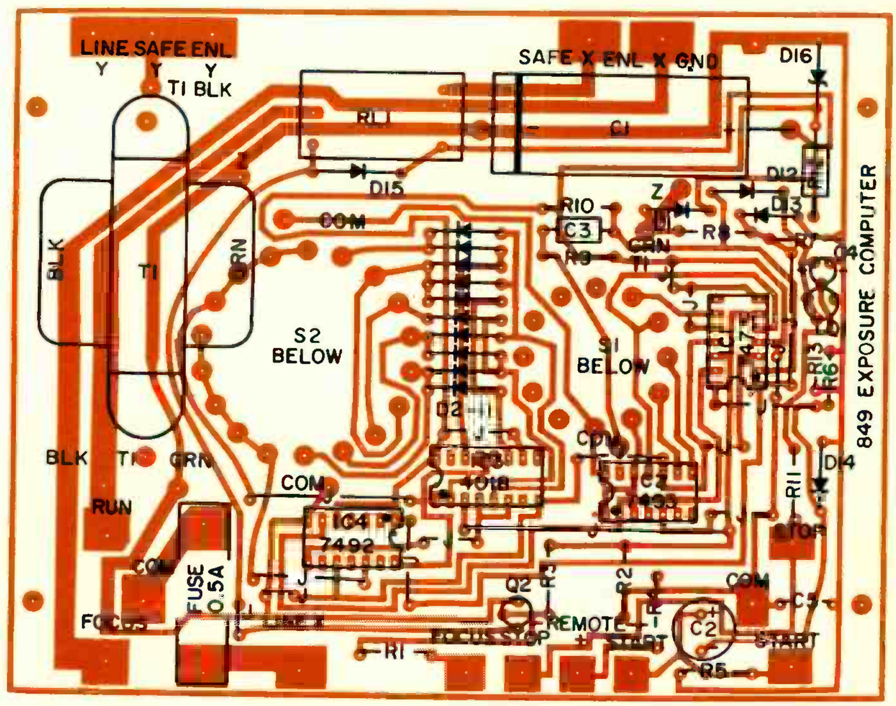


FIG. 4—COMPONENT SIDE OF THE BOARD showing the external connections and the location of major components. Be sure to observe polarity of the diodes and electrolytics.

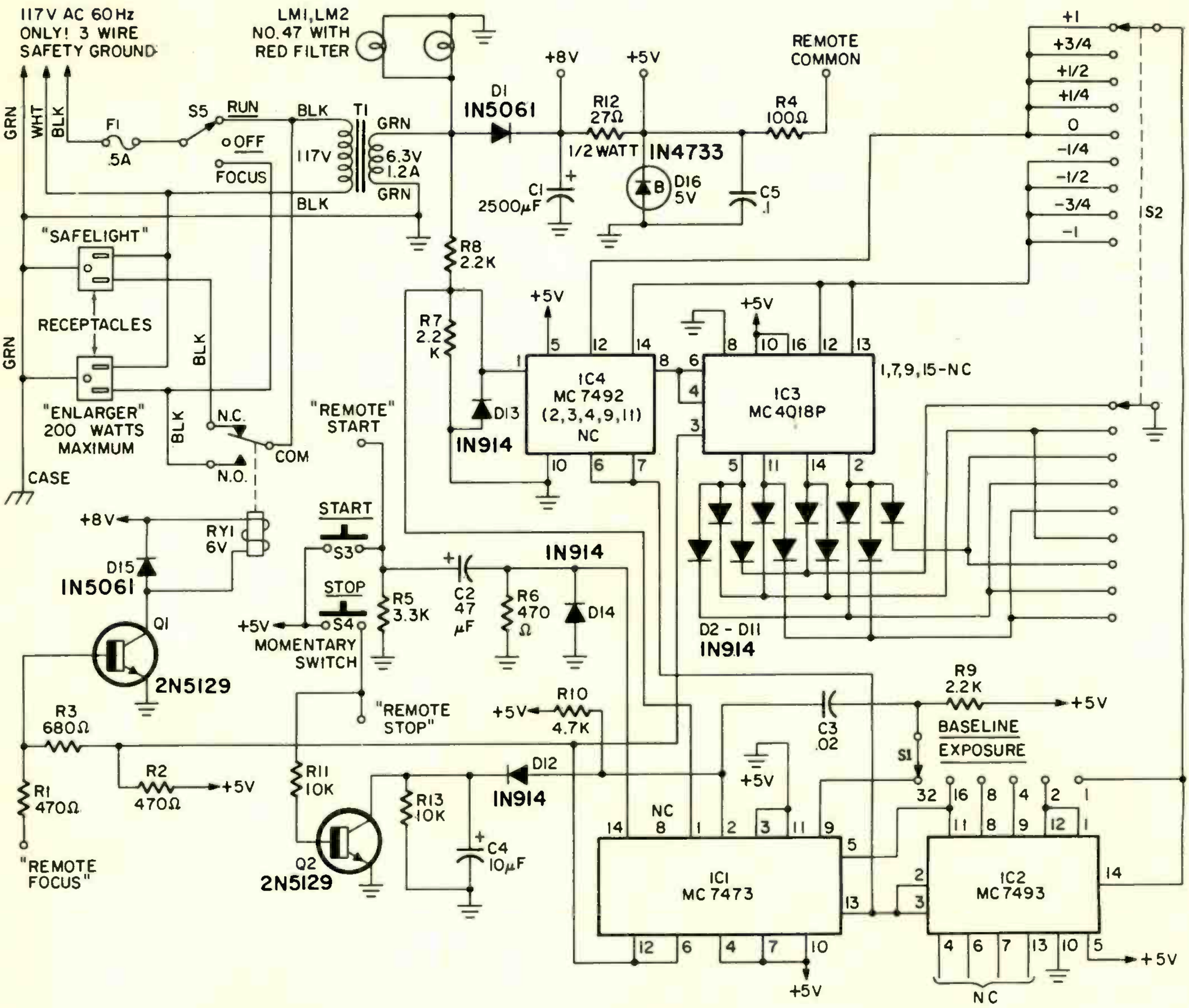


FIG. 5—SCHEMATIC OF THE DPC. The selector switches are mounted directly on the PC board to minimize point-to-point wiring. The IC frequency dividers are clocked by the powerline.

PARTS LIST

Resistors

R1, R2, R6—470-ohm, ¼-watt carbon
R3—680-ohm, ¼-watt carbon
R4—100-ohm, ¼-watt carbon
R5—3300-ohm, ¼-watt carbon
R7-9—2200-ohm, ¼-watt carbon
R10—4700-ohm, ¼-watt carbon
R11, 13—10,000-ohm, ¼-watt carbon
R12—27-ohm, ½-watt carbon

Capacitors

C1—2500 μF, 10-volt electrolytic
C2—47 or 50 μF, 15-volt electrolytic
C3—0.02 μF, 50-volt Mylar
C4—10 μF, 15-volt electrolytic
C5—0.1 μF, 10-volt disc ceramic

Semiconductors

D1, 15—1-amp, 50 piV silicon power diode, 1N5061 or equiv.
D2-14—Silicon computer diode, 1N914 or equivalent
D16—5.1-volt, 1-watt Zener diode, 1N4733 or equiv.

IC1—MC7473P or SN7473N TTL dual flip-flop
IC2—MC7493P or SN7493N TTL divide-by-sixteen counter
IC3—MC4018P programmable binary divider, TTL
IC4—MC7492P or SN7492N TTL divide-by-twelve counter
Q1, Q2—2N5129 transistor

Miscellaneous

RY1—6-volt spdt relay, 300-ohm coil, 2-amp contacts
S1—1-pole, 6-position non-shorting selector switch
Mallory 3226J. **Do not substitute.**
S2—2-pole, 9-position non-shorting selector switch
Mallory 3229J. **Do not substitute.**
S3, S4—spst momentary pushbutton
S5—1-pole, 3-position, rotary selector switch, 2-amp 110 V contacts, non-shorting
T1—6.3-volt, 1.2-ampere filament transformer, Triad F-14X, Stancor P6134, or equal
F1—0.5 amp, 3AG fuse and PC mounting clips

LM1, LM2—No. 47 pilot lamp, 6.3 volts, 150 mA.

MISC: 4¾" x 6" PC board (See text and Fig. 3, 4 and 5), case, bottom plate, end brackets (2); switch hardware; 1⅛" push-on knobs; dial assemblies including ¾" knob (2), (See Fig. 6 and 7); mounting bracket and red filter (APM 1813-27-R5) and socket for pilot lamps (2); 3 prong ac safety outlets (2); PC board mounting brackets (2); Line cord and strain relief; feet (4); 6-32 hardware; jumpers, sleeving, wire, solder, ground lug, remote control plug and socket, etc. . . .

Note: The following are available from Southwest Technical Products, 217 West Rhapsody, San Antonio, Texas, 78216: PC Board, etched and drilled #ET-1 $6.25. Complete kit of all parts, except case. ETC-1, $34.25. Any and all individual parts also available.

TABLE 1 AVAILABLE QUARTER STOP TIME INCREMENTS										
		F-STOP CORRECTION FACTOR SETTING (S2)								
		-1	-3/4	-1/2	-1/4	0	+1/4	+1/2	+3/4	+1
	1	0.5	0.6	0.7	0.8	1.0	1.2	1.4	1.6	2.0
BASELINE	2	1.0	1.2	1.4	1.6	2.0	2.4	2.8	3.2	4.0
EXPOSURE	4	2.0	2.4	2.8	3.2	4.0	4.8	5.6	6.4	8.0
SETTING	8	4.0	4.8	5.6	6.4	8.0	9.6	11.2	12.8	16.0
(S1)	16	8.0	9.6	11.2	12.8	16.0	19.2	22.4	25.6	32.0
	32	16.0	19.2	22.4	25.6	32.0	38.4	44.8	51.2	64.0

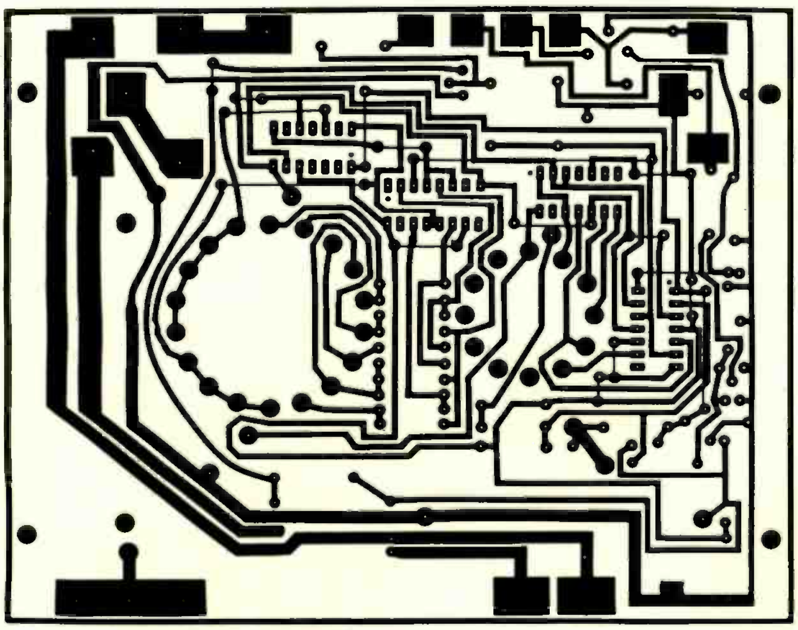


FIG. 6—PATTERN FOR THE PC BOARD. It is 6 inches wide and 4¾ inches high overall. Use it to make photographic copy for your board.

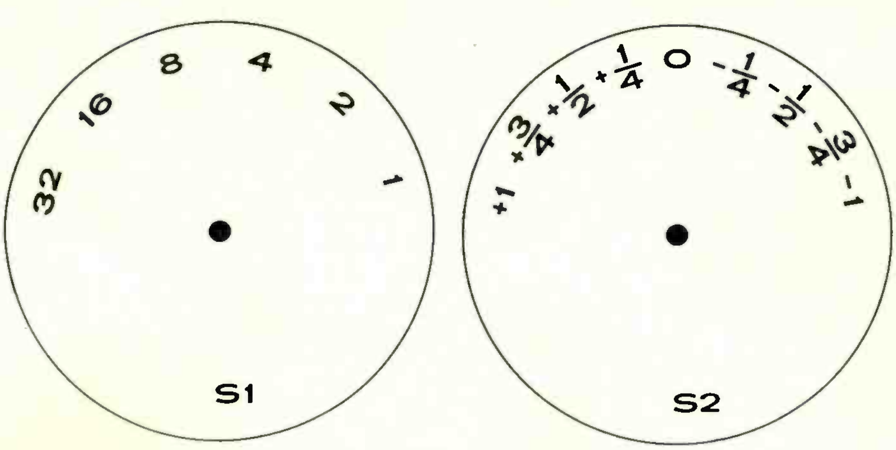


FIG. 7—PATTERNS FOR THE SELECTOR DIALS. The 3-inch circles—as photo negatives—can be mounted on or laminated to thicker plastic.

ing, stop in the middle of a time cycle if you make a mistake, or remotely control any of the functions with a foot switch or two.

The complete schematic and parts list appear in Fig. 5. Note that the two single deck rotary switches do all the time switching. These mount directly on the PC board for very low cost and minimum external wiring.

Construction

A printed-circuit board is a must for this project and may be obtained commercially or the pattern in Fig. 6 may be used. Drilling and layout details are given in Figs. 2 and 3. Fig. 4 shows component and wiring locations.

PC assembly is begun with the sixteen jumpers. These are mounted on the component side exactly where shown. Sleeving should be used on the two longest jumpers. The IC's are mounted next, noting carefully the alignment dot and notch. IC numbering is counterclockwise from the notch when viewed from the **top**, starting with pin 1. Use a small iron and fine solder for the IC's, and follow up with a close inspection with a magnifying glass.

The remainder of the components are then mounted on the component side *except* for the large switches. Note particularly the type and orientation of the diodes, as well as the + and - terminals on the capacitors. Start with the smaller components and finish up with the transformer, large electrolytic, and relay.

The board may then be flipped over and the switches may be mounted. Half of each switch terminal is cut away so the switch terminals may be freely passed through the holes in the PC board. The switches mount on the *foil side*. The common terminal is wired to a small jumper and then terminated on its foil pad. Be sure the common switch terminal goes "straight through" the other terminals to reach its common pad; otherwise the switch will be jumped one position and the unit will

(continued on page 73)

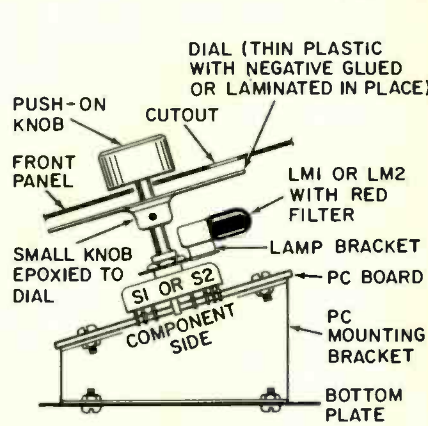


FIG. 8—CONSTRUCTION AND MOUNTING DETAILS for selector switches, dials and PC board.

8-Track Car Tape Player Repairs

Six case histories of automotive-type tape-cartridge player repairs

by JOSEPH J. CARR

THE EIGHT-TRACK TAPE PLAYER has, for many people, replaced the auto radio as the primary automotive entertainment. The radio's lack of program choice and annoying commercials have pushed it into a back seat, as far as many listeners are concerned. Because of the tape player's immense popularity it will become increasingly difficult to find a service shop that can gracefully refuse to repair units owned by old and valued customers. Let us take a close look at some of the most common tape-player ailments, their causes and remedies.

Automotive electronics has grown to be such a big business that the jargon makers have even given the field it's own special name: Autotronics. Now that Autotronics has matured into a specialized field it may be wise to consider offering this service to your customers. Very little extra equipment will be required for the average TV technician. A tape repair bench takes up very little space. An audio frequency generator and a signal tracer will be needed. A vtvm is also a must, preferably one with 0.5, 1.5, 5, and 15-volt scales. Since most eight-track players are automotive units it will be necessary to invest in a decent 12-volt battery eliminator. Tape players normally use a solenoid to change programs. It can draw—for a second or so—up to 10 amperes. The supply, therefore, must be able to supply a 10-amp intermittent load without dragging down the output voltage. Most of the battery eliminators available will handle these requirements nicely. A do-it-yourself kit can help keep costs down.

Also handy on a tape-player repair bench will be various tape cartridges used for test purposes. There are several that have recorded segments for checking speed, azimuth, crosstalk, wow, and flutter. Motorola, Delco, GC, and RCA offer such tapes. All are handy, because none of them are best in all tests. Also keep an empty cartridge around. This is used when the customer's complaint is "breaking tapes" or when the machine must be operated upside-down. The reason for this is that many tape cartridges develop enough drag when turned over to snap the tape. Since nobody seems to offer empty tape cartridges it is necessary to make your own. Merely strip the tape out of a defective cartridge or, if none are available, out of a low-cost "cleaning" cartridge.

Case of the three complaints

The first case is a Delco T-400 series tape player. These are the slim-line players used in many late model General Motors cars. This machine uses a heavy-duty transistor-regulated motor to drive a flywheel-capstan assembly via a rubber drive belt. Track, and therefore, program changing is accomplished by a solenoid-cam assembly. An arm on the solenoid plunger pushes the cam. It, in turn, sets the head height. A small screw on the head carriage allows for minor corrections in head height so that crosstalk can be eliminated. A spring supplies the tension that holds both the cam and the head in position.

In past models of the T-400 that solenoid was fired by an SCR. The manual and automatic track change switches supplied a signal to the SCR gate terminal. This initiated the change cycle by turning on the SCR. The solenoid winding was in series with the SCR anode. It would, therefore, energize whenever the SCR was conducting. The SCR was turned off by a little glass-enclosed thermal circuit breaker in series with the solenoid winding. It would open circuit (hopefully) every time the solenoid was fired. Later models of the T-400 use a simpler method of energizing the solenoid.

This particular tape player came in with three separate complaints . . . all of them common in T-400 series machines. This player often failed to change tracks, would also occasionally run slow or wow excessively, and had the habit of producing a rattle every time the car hit a bump.

Complaint No. 1

This particular T-400, being out of a 1970 Buick, used the simpler solenoid (Fig. 1) and switch track changing system. When the manual programming switch was depressed the ammeter on the power supply would leap up several amps. The solenoid could be heard at these times (it has a very loud "thunking" sound). This sound generally means that the solenoid itself is in good shape. Lifting the tension spring (see Fig. 1) just a little bit allows us to move

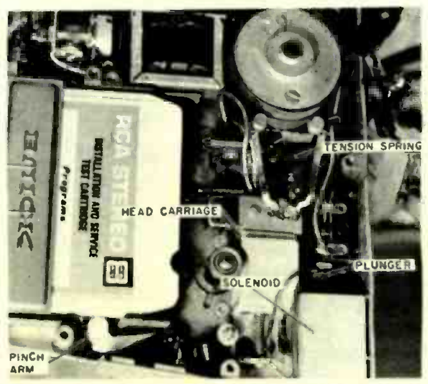


FIG. 1—DELCO EIGHT-TRACK T-400, shows track change and carriage head assemblies

the head carriage assembly by hand. It was not binding and would move freely through its entire travel. On the T-400 player this usually means that the head carriage isn't under enough tension. The condition is corrected merely by lifting that part of the tension spring that rests on the head carriage and bending it back slightly. Not much rebending is necessary—don't go overboard!

Complaint No. 2

There are several main causes of slow speed and wow in all tape players. One is the motor. These motors have an internal centrifugal speed governor. The motor can be "rough checked" by removing the drive belt and observing the motor shaft. It should speed up considerably when the load is removed. Grip the motor pully firmly between your fingertips. The motor should exhibit a fair degree of torque and should resume its normal speed rapidly upon being released. Another cause of speed problems is dirt or tape oxide in the capstan assembly. Clean this dirt out every time the player is repaired or, in any event, at least once a year. A stretched or worn drive belt is also frequently the cause of speed problems.

In this particular case, the problem was the pinch arm not seating properly in the locking slot on the side of the tape cartridge. The post the pinch arm is mounted on is made of soft metal that bends easily. If—as in this case—the post is bent, the pinch arm cannot reach the slot. This keeps the pinch roller inside the cartridge from pressing against the capstan shaft.

Complaint No. 3

"Rattles when going over bumps" has been a common T-400 complaint for the past couple of years. The cause is usually traced to a sloppy fit between the solenoid plunger and its guide. This assembly can be seen in Figs. 1 and 2. The cure is to slide a piece of insulated tubing over each of the wings on the guide as shown in Fig. 2. Some trim-

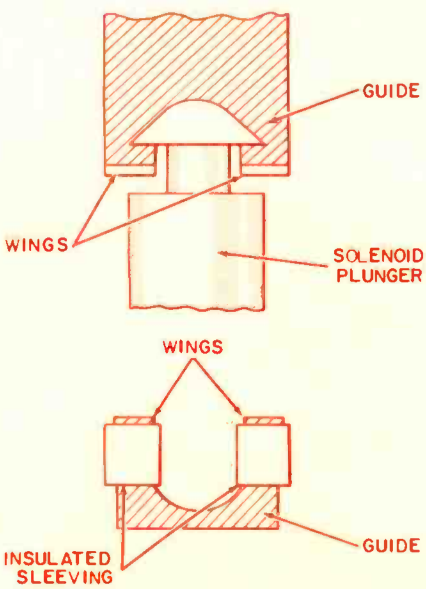


FIG. 2—SOLENOID PLUNGER causes rattle when loose. Insulated sleeving cures the rattle.

ming may be necessary lest the plunger be unable to pull all the way in.

Complaint No. 4

This complaint also involves a Delco tape player. This type unit is the older and bulkier T-200 series. The owner's complaint was that the player would lose its right channel whenever the car was jarred or hit a bump. Signal tracing (see circuit, Fig. 3) turned up the fact that the volume control was at fault. Fig. 4 shows the control with its front section damaged. This is rather common on underdash-mounted tape players. It seems that passengers' legs want to occupy the same space as the equipment.

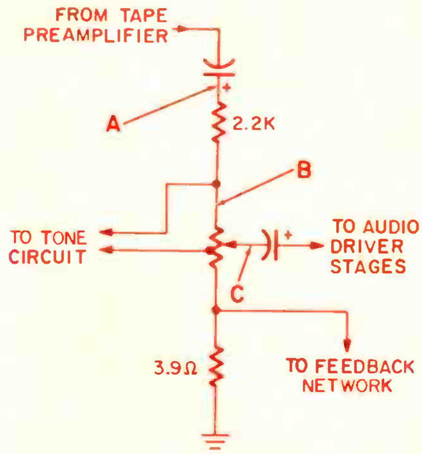


FIG. 3—A SIMPLE ONE—voltage at B but not at C pinpointed an open volume control.

FIG. 4—KICKED BY A RIDER, this unit still worked—with one intermittent channel.

Complaint No. 5

This case involved a Craig model 3121 eight-track tape player. The owner said that it kept blowing fuses even when a fuse twice the rated size was used. This model uses a solenoid to hold in the pinch arm. An eject switch de-energizes the solenoid and kicks the cartridge out of the machine. The circuit, shown in Fig. 5, is rather odd. Both switches must be operated together or the low-resistance winding of the solenoid is shunted to ground. This causes the heavy current that pops the fuse. The switch actuating arms can be adjusted by bending, to restore the Craig to normal operation. Determine which of the two arms is failing to hit properly, then make the adjustments.

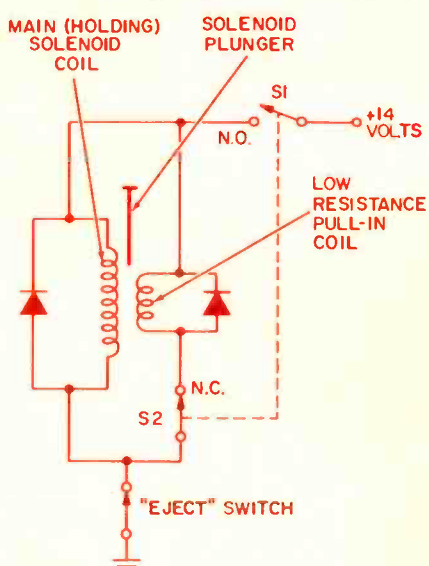


FIG. 5—CRAIG 3121. The two switches must operate simultaneously or the fuses blow.

Complaint No. 6

Another Craig tape player was in the dock in this case. The complaint was weak and distorted output. A bench check showed that one channel was normal. The audio output stage of this set uses a pair of 6-watt pnp transistors in a stacked totem-pole circuit. The difference between this circuit and the quasi-complimentary circuit is that phase is inverted by a split-secondary interstage transformer rather than through complementary transistors.

The voltage readings in Fig. 6 explain why this circuit is considered relatively easy to troubleshoot. The supply voltage is split between the two transistors. At point B in Fig. 6 we measure the full supply voltage. At point A we find approximately one half that

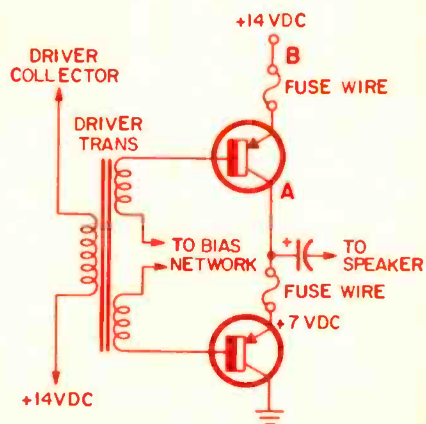


FIG. 6—AUDIO OUTPUT STAGE found in the Craig and many other imported tape players

amount. In this set the voltage at point A was around 1 to 1½ volts, indicating that the lower transistor was leaky. New transistors fixed the player. (Output transistors are usually matched so use matched pairs as replacements.)

In this type of set the wires to the emitters of the power transistors are really stretched-out fuse resistors. They may well be charred and may require replacement. Also, be careful when using universal replacement transistors. These are 6-watt units. Some replacement substitution guides list transistors that are considerably lower powered than the originals. In one case where the author was involved the guide called for a 150-milliwatt transistor to replace a 6-watt Japanese number . . . it blew immediately. **R-E**

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how to design your own solid-state audio amplifier

For long and reliable life, a transistor must operate within several fairly rigid limits. Let's look at these boundaries and see how to use them to our advantage.

by MANNIE HOROWITZ*

TRANSISTOR DATA SHEETS SUPPLIED by the various manufacturers can roughly be divided into two sections. One defines the electrical, mechanical and thermal characteristics of the device. The second section indicates the maximum ratings beyond which operation is hazardous to the transistor. Many of the characteristics of the transistor and methods of applying these characteristics, have been discussed in previous articles. Here, the discussion will center on information contained in the second group of data defining the various limits of the device.

Bipolar transistors

In the article on diodes, the definitions of Zener and avalanche breakdowns were discussed. Breakdown characteristics were applied to the device when it was reverse-biased—its anode negative with respect to the cathode. We saw that above a specific applied voltage peculiar to the individual diode, it would break down and start conducting large amounts of current. The diode was considered to be in avalanche condition if the breakdown voltage was above about 6 and in a Zener breakdown condition if the voltage was below 5, with a combination of the two characteristics evident for breakdown between 5 and 6 volts.

The collector-base junction of a transistor is reverse-biased in normal audio amplifier circuit applications. The junction will break down above a voltage referred to as $V_{(BR)CBO} = BV_{CBO}$. (In the following discussion, the first symbol shown is the preferred JEDEC notation for a limiting value. Subsequent symbols, also frequently used in the literature, indicate the same characteristic.) No voltages applied to any pair of terminals or leads of a transistor, should ever exceed the $V_{(BR)CBO}$ rating.

A tighter limit imposed on the transistor is the breakdown voltage between the collector and emitter. The voltage is at its maximum when a reverse bias is applied between the base and emitter terminals. Here, the symbols for the breakdown voltage are $V_{(BR)CEV} = BV_{CEV}$. Starting with $V_{(BR)CEV}$, the highest collector to emitter breakdown voltage, other collector to emitter breakdown voltage in descending order of magnitude are:

- $V_{(BR)CES} = BV_{CES}$, when the base-emitter junction is short-circuited,
- $V_{(BR)CER} = BV_{CER}$, when a resistor, R is connected between the base and emitter, and
- $V_{(BR)CEO} = BV_{CEO}$, when the base-emitter junction is open circuited.

It is obvious that the smaller the resistor placed across the base-emitter junction, the higher the breakdown voltage will be. The voltage may even be specified for the presence of a particular circuit that may be placed between the base and emitter. In this case, the symbol is $V_{(BR)CEX} = BV_{CEX}$.

The various breakdown voltages occur at *low* collector currents. At high current, the breakdown voltage is reduced and is referred to as a sustaining voltage. It is simply noted by placing the symbol "(sus)" after the particular breakdown voltage notation. Sustaining voltage should be specified at the specific current used in a circuit. A hypothetical collector characteristic curve showing $V_{(BR)CEO}$ and $V_{(BR)CEO(sus)}$ is in Fig. 1.

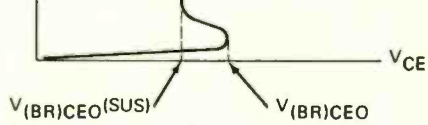


FIG. 1—COLLECTOR CHARACTERISTICS showing breakdown and sustaining voltages when the base circuit is open.

The base-emitter junction forms a diode subject to Zener or avalanche breakdown when reverse biased. This voltage, $V_{(BR)EBO} = BV_{EBO}$, should not be exceeded at any time. Special precautions must be taken when operating in a push-pull Class AB or Class B mode, for a reverse signal is applied to this junction for a portion of the cycle.

Other maximum ratings which must not be exceeded are the collector and base current limits, power dissipation at specific operating temperatures, and the specific maximum temperatures when storing, operating and soldering a device into the circuit.

Junction field-effect transistor

Similar to bipolar devices, the JFET's are encumbered by limiting factors. The obvious limiting voltages are:

- $V_{(BR)GSS} = BV_{GSS}$, the gate-to-source breakdown voltage with the drain connected to the source,
- $V_{(BR)DGS} = BV_{DGS}$, the drain-to-gate voltage with the source connected to the drain,
- $V_{(BR)DSS} = BV_{DSS}$, the drain-to-source voltage with the gate connected to the source and
- $V_{(BR)DSX} = BV_{DSX}$, the drain-to-source voltage with the gate at a specified voltage with respect to the source.

All these voltages are specified on transistor data sheets, as being identical in value.

The maximum allowable drain power dissipation, drain current and the various temperatures are normally stated on data sheets and should, of

*Chief Project Engineer, EICO Electronic Instrument Co.

course, not be exceeded in any design.

Secondary breakdown

JFET's and small-signal bipolar transistors should *not* be forced to operate outside the limits set by the maximum-power-dissipation hyperbola discussed in the article on power amplifiers. More stringent restrictions are placed on medium- and high-power bipolar devices by a phenomenon known as *second breakdown.*

A transistor is subject to second breakdown when there is a substantial amount of collector current while the collector-emitter voltage, although within all ratings, is relatively high. This phenomenon may occur even if the transistor is operating well within its maximum-power-dissipation rating. At one specific combination of I_O and V_{CE}, the collector-emitter voltage drops suddenly and the collector current rises rapidly. A curve illustrating this is in Fig. 2, where at $V_{(BR)}$(sus) and I_{SEC}, the transistor goes into a second-breakdown state. The voltage across the device in this state is V_{SEC}.

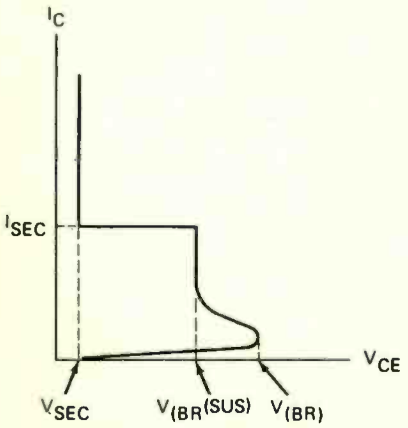


FIG. 2—SECOND BREAKDOWN is indicated when, at some value of I_C and V_{CE}, the collector-emitter voltage drops and I_C soars.

Second breakdown is usually explained by stating: "large amounts of current flow through a tiny area of semiconductor material causing local overheating producing breakdown." Once a device is in second breakdown, the transistor is usually destroyed.

Several precautions should be taken to minimize the chances of second breakdown.

1. Keep the collector-emitter voltage to the minimum consistent with the design requirements.

2. Use single diffused rather than double or triple diffused devices, if this restriction is at all compatible with the circuit.

3. Check the frequency requirements of the circuit carefully. Use the transistor with the lowest high-frequency cutoff specification that will satisfy a design. (The frequency characteristics of a transistor will be discussed in a future article.)

4. Watch out for inductive loads! When a transistor is reverse-biased during a portion of a cycle, it will theoretically not conduct current. However, when the voltage across the transistor is high, an inductive load will discharge current through the device. Current through a small area of the semiconductor flows while V_{CE} is large—the perfect situation to initiate second breakdown. In this case, the proper precaution is to keep the reverse base-emitter voltage as small as practical so that $V_{(BR)CEV}$ is minimized while the resistor in that circuit is large.

Once transistors have been designed into an audio output circuit, it can be checked against safe-operating-area curves, to ascertain if the transistors are operating within the boundaries necessary to avoid second breakdown. These safe operating curves are provided by the manufacturer of the device. Curves of this type for the 2N3055 transistor are shown in Fig. 3.

A circuit should be established and tests performed to ascertain if the load line for a transistor is within the limits set by the curves. Thus if there is a 100-msec pulse through the transistor, the load line for the transistor should be below the curve marked 100 msec. Similarly, if there is a 100-μsec pulse in the collector circuit, the load line for the transistor should fall below the curve marked 100 μsec. As the pulses get longer, the limiting curves get more severe. For intermediate size pulses not shown on the curves, the limits can be determined by interpolation. It is obvious that for a pulse of any duration, a safe load line will fall below the curve marked *dc operation.* However, this severe limit is not required for the load line should shorter pulses be reproduced.

The question may arise as to how the load line may vary with the duration time of the pulse. In a previous article, we drew the dc and ac load lines and disregard their dependendency on frequency. It should be obvious that an inductive load line, such as due to a transformer or speaker load, is frequency sensitive, and will vary in shape and size with the duration of the pulses.

In testing a circuit, sinewaves rather than pulses may be used. Here, operation can be considered safe if the load falls below the pulse limit curve of f/2 seconds, where f is the frequency of the sinewave.

The circuit may also be tested by using the actual haphazard signal, such as music or speech, normally present at the output of an audio amplifier. In this case, the load lines, continuously varying, should fall below the *dc operation* curve in Fig. 3. This is a severe test and more indicative of transistor safety in operation than a test performed with any other type of signal.

To perform the test, the transistor in the output circuit can be connected to a calibrated scope in the arrangement shown in Fig. 4.

The collector current flows through R_E. The voltage across R_E is then proportional to collector current I_C. This voltage is plotted on the vertical axis of the scope, in terms of collector current. At the same time, the collector-emitter voltage is applied to the horizontal input of the calibrated scope. The V_{CE}-I_C plot on the scope is the load line of the transistor. Vary the frequency fed to the amplifier or change the type of load,

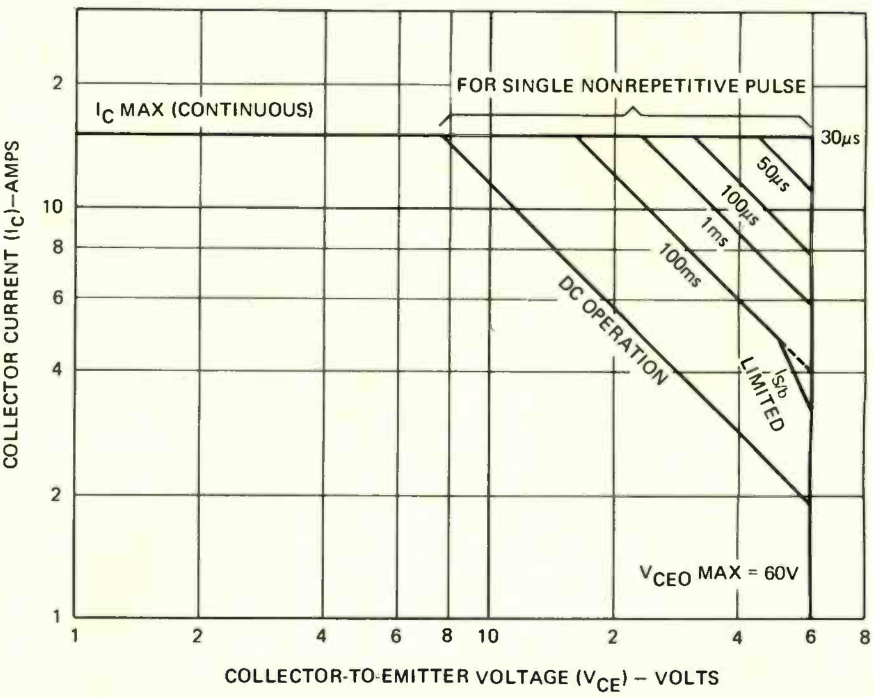


FIG. 3—SAFE-OPERATING CURVES for the 2N3055 transistor. Its circuit should be designed so load line falls below the curves related to the type of operation.

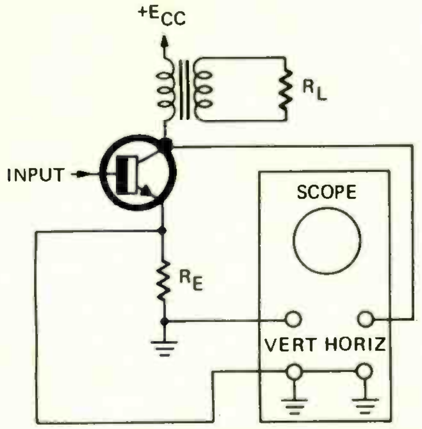


FIG. 4—TEST SET-UP used to determine whether the transistor is operating within limits set by its safe-operating curves.

and the load line plot on the scope will be altered. To attain a safe operating condition, no point on the load line is to be above the limits set by the curve in Fig. 3 at any frequency of operation, for any load, and at any power output level. Identical test arrangements can be made for transistors in push-pull and output-transformerless circuits, measuring I_C and V_{CE} across one output device at a time.

Thermal circuits and limits

The primary source of heat in the bipolar transistor is the power dissipated at the collector junction. The contribution of heat generated at the base-emitter junction to the final temperature of the device, is relatively negligible. The maximum operating junction temperature for silicon transistors is usually specified at 200°C while for germanium devices, it is limited to 100°C.

The heat generated within the transistor must be removed from the junction as it is being generated, if the transistor is not to become too hot and break down. There is a thermal resistance, θ, (units are in degrees Celsius per watt) which resists the flow of heat from the junction. The thermal resistance between the junction and the case of the transistor is θ_{JC}. The case is cooled by the surrounding air which is normally at a lower temperature than is the case. There is a thermal resistance between the case and the air, assigned the symbol θ_{CA}.

Because the surface area of the case is small, very little air can flow over it within a specified period of time, to remove the heat. The case is usually mounted on a large metal surface or sink. It has a large area exposed to the ambient temperature. There is, however, a thermal resistance between the case and the sink, θ_{CS}, and between the sink and the air, θ_{SA}. It is obvious that $\theta_{CA} = \theta_{CS} + \theta_{SA}$, but it should be noted that θ_{CA} is smaller when a heat sink is present than when only the case is exposed to the air. The thermal resistance between the case and sink, θ_{CS}, can be relatively large, but may be reduced if silicone grease is used between the case and sink to assure good conduction between the surfaces.

Electronic circuits frequently require that the case (usually connected to the transistor collector be insulated from the grounded heat sink. A mica insulator is usually placed between the case and sink. The thermal resistance between the case and sink is increased when the mica is used, but this is unavoidable. Once again, the situation can be minimized by applying silicone grease to both sides of the washer. Typically, when a plain mica washer is used, θ_{CS} is about 0.8°C/W. The addition of silicone grease reduces θ_{CS} to approximately 0.4°C/W. Compare this with the thermal resistance when no washer is used. Here, θ_{CS} can be 0.2°C/W without the silicone grease and 0.1°C/W with the use of the grease between the contacting surfaces.

Thermal resistance can be put into a thermal equivalent circuit and treated as an ordinary resistor is treated in an electric circuit. The equivalent to the electric current is the power, P_{diss}, dissipated by the semiconductor. P_{diss} flows through the thermal circuit as current flows through an electric circuit.

When current flows through an electric circuit, a voltage is developed across a resistor in the circuit. Heat, measured in °C, is developed across a thermal resistor. We can thus write an equation relating thermal resistance, power and temperature.

$$P_{diss} = \frac{T_J - T_A}{\theta_{JA}} = \frac{T_J - T_A}{\theta_{JC} + \theta_{CS} + \theta_{SA}} \quad (1)$$

where T_J is the temperature at the junction and T_A is the ambient temperature. This is an important equation to remember. A diagram presenting the information described by the equation is shown in Fig. 5. T_{JA}, T_{CA} and T_{SA} are

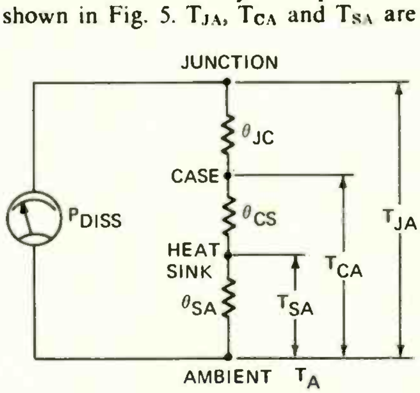


FIG. 5—TRANSISTOR THERMAL EQUIVALENT circuit resembles a voltage divider with temperatures referenced to ambient (ground).

the differences between the ambient temperature and the temperatures at the junction, case and sink respectively. Each temperature is developed across a thermal resistor shown in the drawing. They represent the temperature rise above the ambient, which is treated as if it were the circuit ground.

Using equation 1, the temperature at the heat sink is $T_S = \theta_{SA}P_{diss} + T_A$. Similarly, if the case temperature, $T_{CA} + T_A$, is known, the junction temperature, $T_{JA} + T_A = T_{CA} + T_A + \theta_{JC}P_{diss}$. It is evident that the junction temperature is directly related to the case temperature. It is further evident that if the junction temperature is limited to some maximum such as, 200°C, the maximum allowable case temperature will decrease as the power dissipated by the semiconductor rises. For example, if θ_{JC} is 1.5°C/W, as it is for the 2N3055, and there are 50 watts dissipated by the transistor, the maximum allowable case temperature is 200°C − (1.5°C/W) (50 watts) = 125°C.

A curve can be drawn relating the maximum allowable power dissipation by the device to the temperature of the case. Since the maximum rated dissipation of the transistor is 115 watts, the curve for the 2N3055 (from RCA data) is as shown in Fig. 6. Note that at 125°C, the maximum allowable dissipation as noted on the curve is 50 watts, substantiating our calculation from the data.

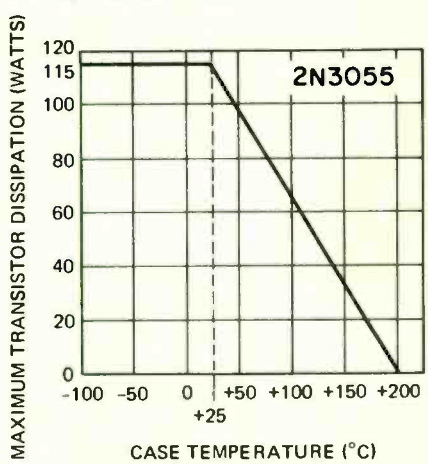


FIG. 6—POWER DISSIPATION derating curve. Note that the power that can be dissipated safely drops as temperature rises. It becomes obvious that adequate heat-sinking is a vital consideration if the transistor is to be operated at high power levels. Use the data from the derating curve and Fig. 7 to select a heat sink with sufficient radiating surface.

If the transistor temperature rises faster than its ability to dispose of the excess heat, the device will obviously overheat. Current flow will increase primarily due to a rise in temperature and a subsequent increase of I_{CBO}, the collector-base leakage current. This will in turn produce more heat. The cycle will repeat itself, building up until the transistor is destroyed. This is known as thermal runaway. To avoid thermal runaway, the following inequality must be satisfied.

(continued on page 94)

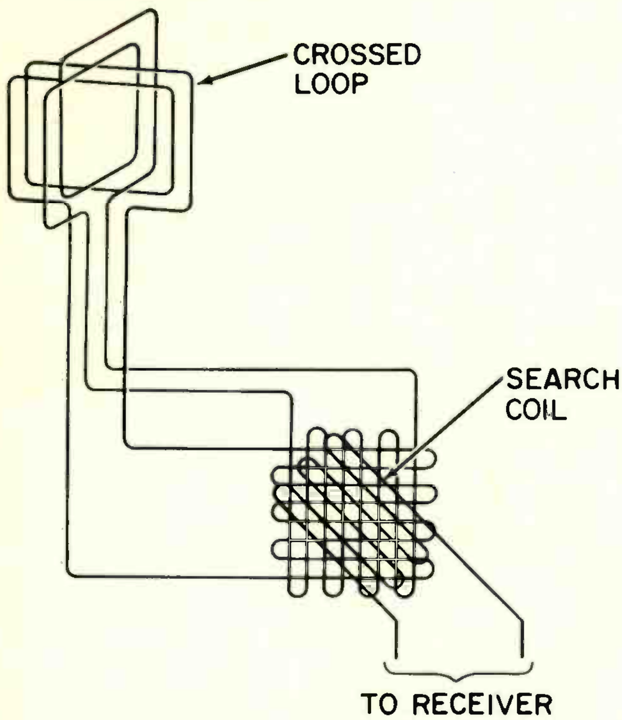


Fig. 1—BELLINI-TOSI GONIOMETER uses phasing methods to locate radiobeacons.

OMNISONICS—

A new kind of sound reproduction system

We are pleased to present the first news of a new development that may have a more profound effect on sound reproducing techniques than did the introduction of stereo

by S. H. MANN, IRE*

STUNNED BY THE MORE SPECTACULAR developments in various electronic fields, we sometimes fail to realize that possibly the greatest advances in electronics over the past few decades have been in the field of sound. Less than 30 years ago we lived in a monophonic world in which the manufacturer of some of our best speakers published a brochure that proved convincingly, among other things, that reproduction above 5000 Hz (pardon, cycles!) was unnecessary and useless. Now the value of even the ultrasonic components of sound is universally recognized, and we already see stereo sound giving way to quadrasonics.

For—make no mistake about it—the intelligent and sensitive sound enthusiast will no more be content with "stereo" after having been exposed to the best four-channel sound than he was content with mono after hearing the first real stereo records. It is likely that he will be less satisfied with his present stereo—because now he sees the way to the greatest enjoyment of sound—the possibility of listening to an authentic simulation of the original sound as he hears it in real life. Indeed, it is more than possible that he will realize that quadrasonic—like stereo—is really only another and closer approximation to the real thing, and will look further.

Omnisonics, the accurate positioning of sound from *any* direction—not just four or eight—is already on the way. It is realizable with present equipment. To check the possibilities and capabilities of such a system, we set up an experimental assembly based on a technique well known in other branches of electronics but not—as far as I know—used heretofore in sound reproduction. That technique is *phase reproduction*. As color is transmitted by assigning a given phase of an ac signal to red, another to green, etc, or as an "electronically scanned" antenna may be made to rotate its direction of greatest power output by varying the phases of the current put into it, so can a sound source be pinpointed by varying the phase relations of a battery of microphones.

A classic example of electronic phase-location of a signal source is the Bellini-Tosi radio compass. It uses two crossed loops, as shown in Fig. 1, usually set up in a North-South and East-West direction. These are connected to two coils wound round a small enclosure or box to simulate the N-S, E-W orientation of the antenna. A *search coil* is mounted inside the enclosure. It can rotate so that it lines up with one of the coils at each 90° of travel or take any position between the two. A radiobeacon directly north or south of the station produces a strong current in the N-S antenna and a strong field around the N-S coil. The search coil, when aligned with the N-S coil, picks up a strong signal, which is fed to a radio receiver and amplified to produce an audible or visible output that increases in strength as the search coil is manually positioned in the strongest field.

If the radio beacon is in a northwest position, fields of equal strength are induced in both sets of coils, and the search coil produces the strongest signal at a point midway between them, thus pointing out the direction of the station. (Another bit of phasing—the conventional "sense" antenna—shows whether the signal is coming from NW or -NW, that is, southeast.)

The sound pickup

For the first experiments, four microphones were deemed sufficient. These were mounted in N, S, W, E (or if you prefer: L, R, F, B) position, and powered with *two* ultrasonic frequencies in the order of 75 kHz. The "mittel-seite" technique (two crossed bidirectional microphones) was also tried, and would probably have worked well if microphones with more pronounced directional patterns had been available. Strain-gage microphones were used, but any non-generating microphone should work, since the system depends on the application of phased outside power. The two frequencies were not synchronized—there is just enough difference between them to cause the vector representing their strongest direction of pickup to rotate through the full 360° in a suitable time interval. The action is something like that of the television rainbow generator.

A sound source near the N microphone would create a strong signal in that microphone, and a weaker signal in the -N or South microphone. Due to the phasing, there would be little output from E or W. A sound source positioned in the NW quadrant would produce signals in the N and W mikes.

*Institute of Reproductive Engineers

These signals are recorded on tape, with a control strip indicating the phase of the signal, to control the playback amplifier. No experiments have been made with phonograph recording, but it would seem comparatively simple to put the phase and control signals on a groove. The system is, in effect, time-sequential multiplexing, now being used so effectively in data transmission.

Reproduction

So much for the pickup and transmission. How about the playback? Here again the problem is simple. By *synchronous distribution* we can portion out each element of signal to a speaker roughly in the same direction from the listener's position as the original sound was from the microphone. This is analogous to the *synchronous detection* of the color TV receiver, which allots the correct signal to each of the color tubes (or shares it among them) as a function of the phase of the subcarrier.

Gating each speaker on and off might seem to require cumbersome equipment and a multiple cable of many conductors. Not so! A recent discovery makes it possible to switch positively and without on and off pulses that would disturb the program. The discovery is the *charge-coupled* scanner announced recently by Bell Laboratories. This device makes it possible to do all the switching with three wires, one of which also carries the signal.

As you remember, the charge-coupled scanner is a series of capacitors along which a charge may be made to move by changing the voltage on the capacitor plates. If plates A and C of Fig. 2 have a negative voltage and B a positive voltage, electrons will be attracted to the area of strip D that is under plate B. Now if the positive voltage is suddenly shifted to plate C and plate B allowed to go negative, the charge moves to the area under plate C. Thus a signal can be made to step-by-step down a line of such plates and—in the original device—be read off at the output as a scanned line.

One of these charge-coupled devices is installed at each speaker in the listening area. It is, of course, desirable that there be the same number of speakers as microphones, and that their placement be analogous. In actual practise, four speakers were omitted in a 12-microphone hookup without noticeable deterioration of the sound.

The charge-coupled units are all connected in parallel; thus the whole series of signals is stepped down each unit. But each speaker is connected to only one of the charge plates. The control signal on the tape steps the charge-coupling plates so that each speaker unit is excited in exact synchronism with its corresponding microphone. Speaker No. 1 reproducing the sound from microphone No. 1, etc. Thus as the signal sweeps through the 360° of its cycle, each speaker reproduces the sound that reached the analogous microphone.

If each speaker is to be actuated by a single charge plate, obviously the portion of the strip under the plate will have to be isolated. The method is shown in Fig. 3. The "active" portion of the strip for each speaker is connected with resistors and capacitors so that the action along the whole strip is much the same as if the strip were continuous, yet the section is practically isolated throughout the audio spectrum. The isolated portion of the strip is connected to a small IC amplifier that operates the speaker.

To simplify matters in the experimental model, the audio signal was applied to the B wire only. The speaker amplifiers were then "clamped" to the average positive level of the B conductor. Its voltage then looks like dc to the equipment, though it might be oscillating in voltage at a rapid rate if compared to earth or other reference. All the amplifiers see is the increase and decrease at an audio rate as the signal adds to or subtracts from the voltage on the B conductor.

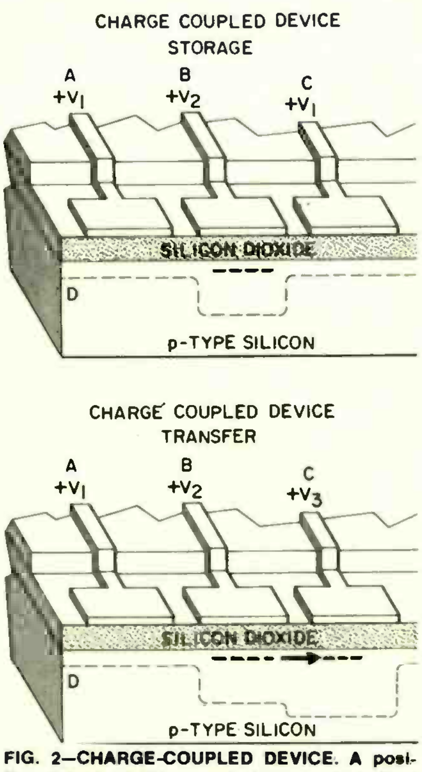


FIG. 2—CHARGE-COUPLED DEVICE. A positive charge on V2 causes electrons to collect under it. Reducing the voltage on V2 and increasing it on V3 moves the charge.

But won't this jumping from one signal to another, switching rapidly between amplifiers, create an unholy mess? Not at all—the action is continuous as far as the audio is concerned. The pickup vector swings around the circle at a 75-kHz rate, five times the frequency of the highest audio signal. Thus it requires five pulses on the charge plate to reproduce a single cycle of the highest frequency notes.

This is analogous to the phase detection in television, where a large number of cycles of the 3.58-MHz subcarrier is required to produce a small colored spot on the screen. The cycling frequency can in fact be much lower—down to just above the hearing range—with the only noticeable difference a certain glissando between certain notes.

Conclusion

Much work remains to be done on the prototype. The best microphone technique has not yet been worked out, and the final version of the reproducing equipment will have signal applied to all three series of plates, with a consequent reduction in switching frequency and its associated problems. It is confidently expected, however, that a commercial version will be available in the spring of 1972, and a tentative date for the introduction of the new system has been set for **APRIL 1.** **R-E**

This new proposed audio system is based on the charge-coupled switching concept developed at Bell Labs and announced on page 6 of our June 1971 issue.

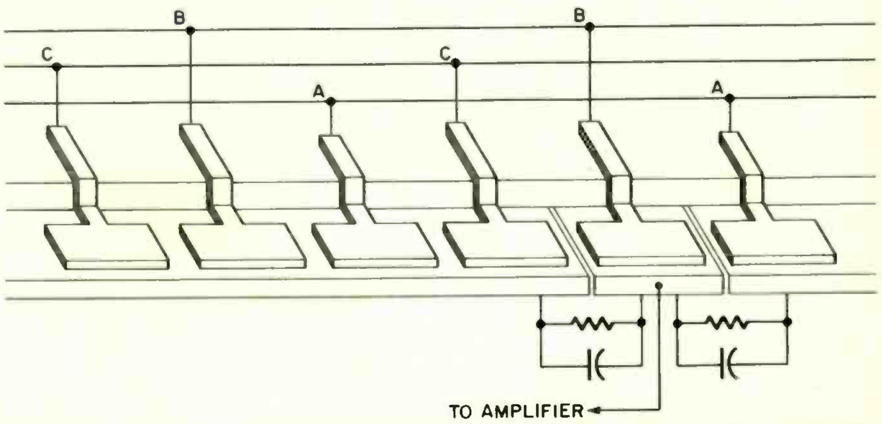


FIG. 3—HOW THE ACTIVE AREA can be isolated for the audio signal, while remaining part of the strip at dc and higher frequencies.

R-E's Service Clinic

dynamic convergence-- amp and tilt controls

Get the amp and tilt controls straight and those lines will follow suit

JACK DARR
SERVICE EDITOR

WE'VE BEEN SEEING AND USING, CONtrols on convergence boards for a good while now, and there seems to be just a wee bit of confusion as to exactly *what* some of the controls are, and what they do. The two most often confused seem to be AMPLITUDE and TILT controls. Thank goodness, the newer sets use names like "Red-Green Horizontal, Lines At The Bottom Of The Screen", and so on. Much less confoozin'.

However, these are the same controls we had all the time. You'll find AMP and TILT on older sets. So let's find out what the names mean and what they do. Makes it a lot easier when you know what to expect.

We use parabolic waveforms in the convergence yoke, to get the results we must have; that is, good convergence all the way across (and up and down, too, of course) the screen. These change the convergence-point of the three beams while they're moving. After all that's all that "dynamic convergence" means; convergence while in motion. To get exact compensation, we can't use a parabola that is exactly symmetrical. We might need more convergence at one place than at another. So, we use controls on the waveforms.

One regulates the amplitude, just like a volume control, so this is the AMP control; meaning, how much of this waveform do we need. The other regulates the phase of the thing so that we can make one end or the other lift or drop; in other words, we can TILT the *waveform.* Now what will this do, on the screen? Let's see.

We're trying to get a red line (F'rinstance) to scoot in behind the blue and green that are already nicely overlapped. (Use any color; all the same.) We see something that looks like Fig. 1. The dashed line represent the color that's "showing" too much.

Two of them are nice and straight. The other hangs out on one side at the top and the other side at the bottom! Now move the RED TILT control, and you'll see the line go further out of convergence, going one way, and get closer to "right", going the other. Note that it stays almost stationary in the center! This is the TILT control. If we adjust it properly, we'll see this line straighten out and hide behind the others. Also, we may see an opposite reaction: this line may bow in the middle, touching the others at the top and bottom! This is also a tilt-control reaction. For correct adjustment, we set the control so that the one we're adjusting is as near to *parallel* with the rest as we can.

Now what about the amplitude? Well, we may find that we have to deliberately introduce a bowing in this line to make it overlap the rest properly. So we set up our bow with the tilt control; perhaps it will be of just the right *shape,* but not cover the other lines, as in Fig. 2. To make it cover them, we add more amplitude, by turning up the

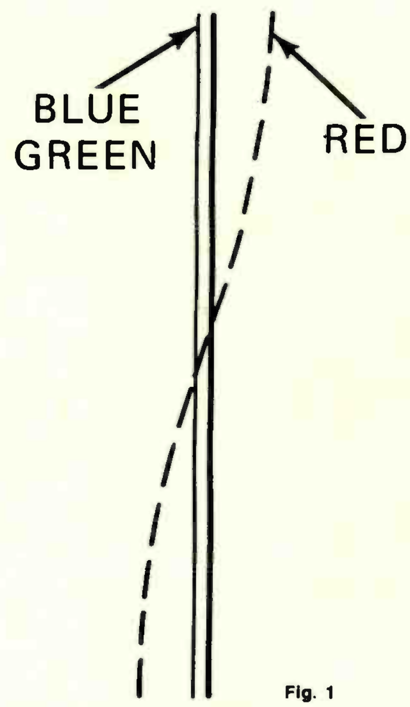


Fig. 1

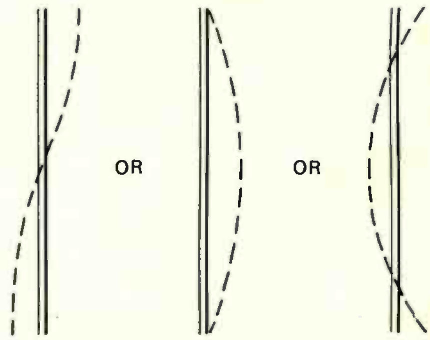
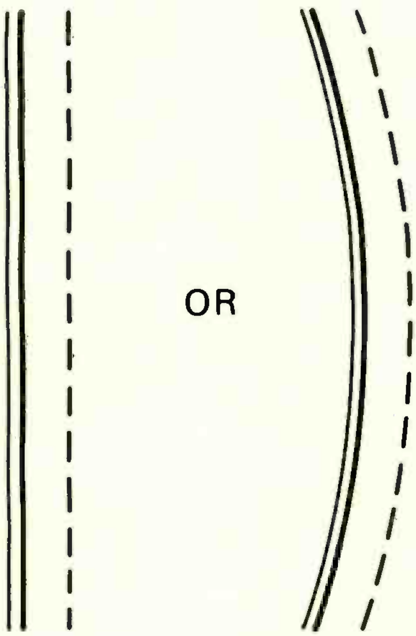


Fig. 2

This column is for your service problems—TV, radio, audio or general and industrial electronics. We answer all questions individually by mail, free of charge, and the more interesting ones will be printed here.

If you're really stuck, write us. We'll do our best to help you. Don't forget to enclose a stamped, self-addressed envelope. Write: Service Editor, Radio-Electronics, 200 Park Ave. South, New York 10003.

AMP control. Once we get the line set up so that it is obviously the right *shape* (That is, parallel to the others) we have the Tilt set, and all we need to do is adjust the *amplitude* until it moves in behind the rest and we get the white line we've been looking for all this time (Fig. 3).



a Fig. 3 *b*

There are your clues; if a line is not of the right *shape*, adjust the tilt control; if it's the right shape but there's 'not enough of it': set the amplitude control, and away we go!

Reader Questions

BAD TRANSISTORS, ORPHAN TAPE PLAYER

I'm trying to fix a KRACO Stereo tape player. Do you have a schematic for this, or know where I can get one? It has two blown 2SB487 transistors (power outputs) and I can't find them listed either! Could be "2SB481"; not sure. What is a replacement for this?—T.K., Wellington, Ohio.

Sorry; nothing at all in my files on "KRACO". You have an orphan. However, I did eventually locate a listing on a 2SB481 transistor, which is the same as the 2SB487. HEP-642 Motorola, RCA SK-3052, GE-30, or Sylvania ECG-131. Be sure to check the little emitter resistors, which will probably be about 1.0 ohm each. If the original transistors shorted, these probably burnt up.

VTVM PROBLEM

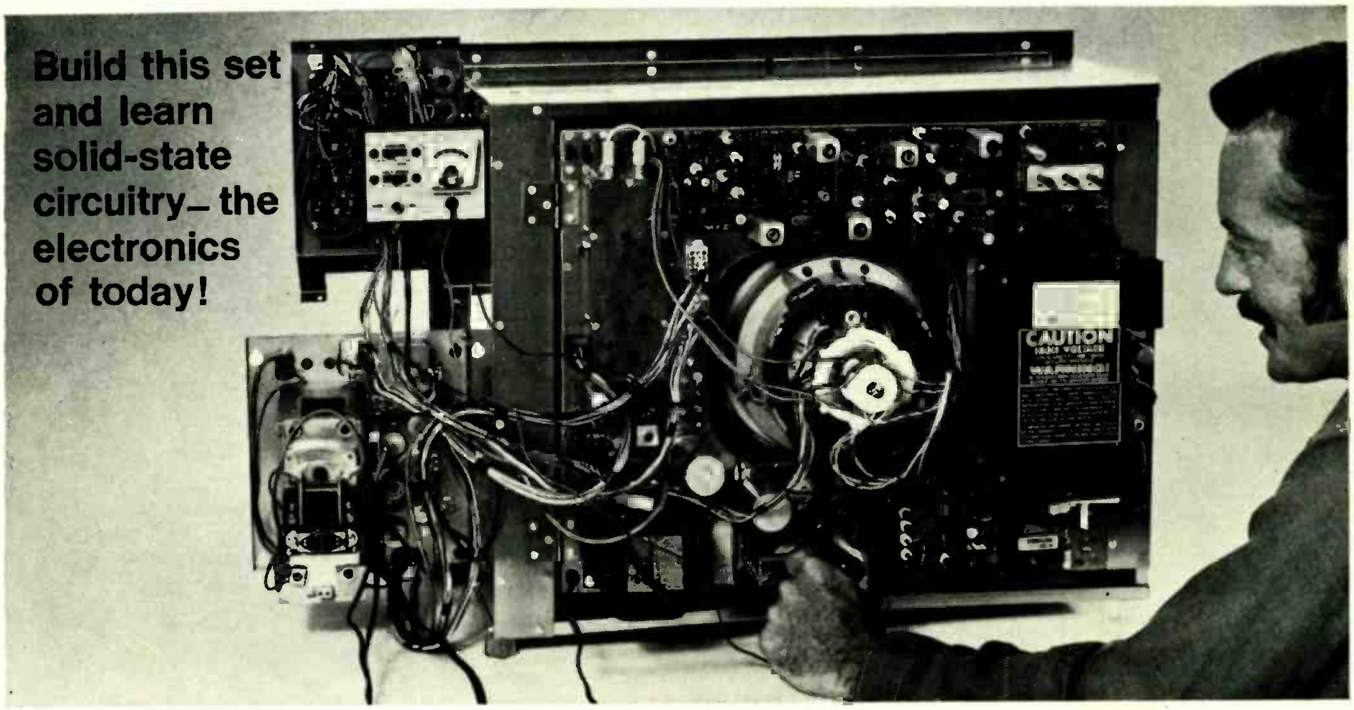
I've got a weird intermittent in my vtvm! On the Ohms ranges, it can be zeroed, but if I switch to a different scale, the needle jumps around, and may come to rest off-zero. Same on dc voltages. Sometimes I read the correct voltages, then get only 1 or 2 volts! I noticed that once, when I pulled on the test leads, it changed. What's going on here?—W.T., Illinois.

Offhand, one of *two things. You may have* an intermittent contact inside one of your test leads (which happened to me once, and caused problems!) or your grounding, inside the meter may be poor! At times, the "circuit board", internal framework, etc. may develop a poor ground connection to the front panel! This can really cause some problems. Take the meter apart and loosen the front panel. Clean the mating surfaces, and tighten the bolts firmly. (Reader later confirmed this. It was a bad ground connection.)

FLOATING BARS IN COLOR

In an almost-new solid-state RCA CTC44B chassis, we have good color, but slowly rising "bars" (horizontal) of red, green, and blue, about 2 in. wide, through the picture. There's also a pretty bad hum at high volume, which is reduced when you turn the treble control full-up. Once in

(continued on page 68)



train on solid-state

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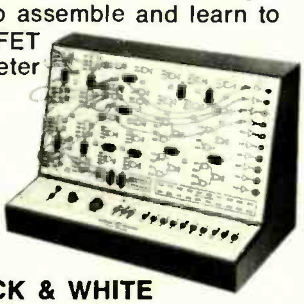

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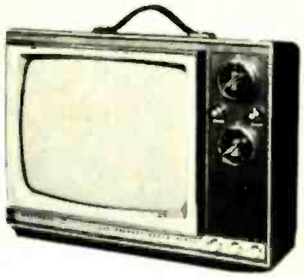

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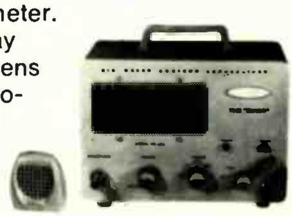

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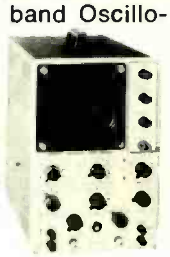

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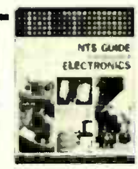

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READER QUESTIONS
(continued from page 63)

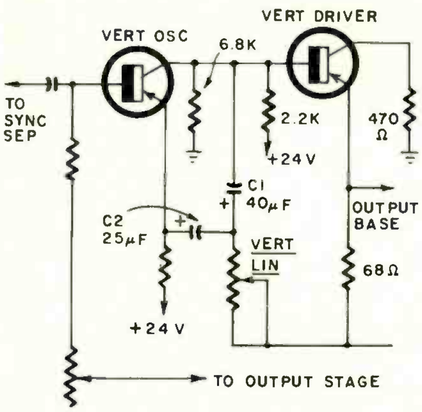
a while, the channel-change function of the remote control acts up, too.—F.D., New York.

With so many different things going on at once, it must have a common cause! Look for something like an open filter capacitor. (This was the original answer, cut down: the reader came back at us later. He found an open 200-μF electrolytic capacitor, C1109, in the remote control receiver!)

NO VERTICAL SWEEP

I've got no vertical sweep on this little transistor portable, an Emerson 120771 chassis. All of the transistors check good with my in-circuit tester. I get no sawtooth waveforms at any point in the vertical circuit. I do see "spikes" which are at the vertical frequency, and can be controlled by the vertical hold! What's going on here?—L.S., New York.

If you have "spikes" (which are probably the *amplified* vertical sync pulses going through the circuit), but no "saws", then the trouble is most apt to be in the "saw-forming" circuit. In this type of multivibrator circuit, the sawtooth waveform needed for operation is developed by the slow charging and rapid discharging of a "capacitor"; in quotes because this is actually two separate capacitors, the 25- and 40-μF units between the collector and base of the "vertical oscillator" transistor. The two capacitors are used, with the vertical linearity control connected to the junction, to make the sweep linear. The diagram shows a partial circuit.



So; on the face of the evidence, if you have spikes, this means that the amplifier function of the circuit is ok. If you are not developing sawteeth, one of these capacitors is probably leaky or open. Your dc voltages will probably be very close to normal.

By the way, do not use ordinary aluminum electrolytic capacitors to replace these! Your tolerance will not be tight enough. The originals are the tiny tantalum types: in this "timing circuit", you must get very close to the proper values, or the circuit will not work.

REPEATED BURNOUT HORIZONTAL DRIVER TRANSISTOR

I have a Philco Q1054BK solid-state TV. Came in with the horizontal driver transistor (Q10, Sams 896) burnt up. I replaced it, and the new one promptly blew too.—J.G., New Jersey.

A few! One would be to check the driver transformer, T6. If it is bad, it probably caused the original transistor to blow, and will blow the new ones.

To be safe on things like this, use a Variac in the ac line input. Connect current meters into the collector (or supply) circuit of any suspected transistors, and then bring the line voltage up very slowly. If you see more than normal current being drawn, but the line voltage is only up to about 50-60 volts, look out! This will save a lot of transistors!

NO COLOR SYNC

I've got no color sync in a Magnavox 933 chassis. When I ground the grid of the reactance tube, and adjust the reactance

coil, I get a weird effect! I can get rainbows, then tune the coil slowly toward the point where the color ought to lock in, but instead, at that point, it drops out entirely! This does the same thing on either side of what ought to be the resonant point! What is this?—R.T., Arkansas.

Check your dc voltages on the acc and killer diodes. I expect you'll find them *unbalanced.* You should get exactly the same voltage, with opposite polarities, on the two diodes in the acc. If they won't balance, replace them with a matched pair. Same thing for the killer diodes. Acc diodes should read about 13 volts; + on one and – on the other, but they must be able to balance, for the color-oscillator works with exactly zero volts on the control tube grid; + going one way, – the other. (Discriminator action!)

SCANNING LINES SQUEEZED

I've got an odd problem. In a Zenith 14Y33 chassis, the raster is squeezed up, about 2 inches from the bottom. (Covers full screen.) This makes a bright line across the picture, and distorts it badly. The middle is stretched quite a bit. I've checked all of the parts in the feedback loop, since the vertical sync isn't too good. They are all ok; tubes replaced.

I suspect the vertical output transformer. What do you think?—L.C., Hatfield, Ark.

The first time I saw this, I suspected the transformer, too. However, when I replaced it and it didn't help at all, I began to doubt the validity of this diagnosis! (hi!). This type of vertical problem is almost always due to trouble in the vertical yoke. This has been verified in at least three recent cases.

This will not cause the familiar keystone effect of a heavy short; it is apparently due to a short in the vertical yoke, but not as bad as if it did keystone. On one of these, I checked the resistance of each half, and found one half reading 8 ohms, the other 12. (Normal total, 24 ohms, so each half should have read 12 ohms) The actual resistance is not so important as the fact that the two halves balance. Should read exactly the same.

Incidentally, vertical-output transformer shorts will tend to make the raster either squeeze or stretch at the top of the picture.

SWEEP GENERATOR OUTPUT LOW?

My sweep generator works very well on i.f. alignment, but I can't get enough scope pattern height on tuner alignment, especially on the high channels. What can I do about this?—E. N., Winnipeg, Man.

This is pretty much "normal." Most sweep generators use fundamentals on i.f.'s and even the low TV channels, but go to harmonics for the very high bands. When you double the frequency of an rf signal, you also *halve* the amplitude! Since we have a good-sized loss in our pickup probes, too, this often leaves us with not a heck of a lot of "curve" on tuner alignment.

You might do two things: One, go on through the first i.f. stage and hook the scope to the second i.f. grid. Shunt the tuned circuit in the first i.f. plate with about a 10,000-ohm resistor, to flatten it and keep it from affecting the curve. Makes the first stage act as a "preamp" for the scope.

The other thing you might do—add a wide-band rf amplifier between the sweep generator and tuner input. A good all-band TV antenna booster might work very well for this, since many of these have overall gains of up to 20-25 dB. Some boosters have 75-ohm coax input and output, or 75 in and 300 out, which would make them very useful. **R-E**

NEXT MONTH
Amplified automobile antennas can improve FM stereo reception. But it takes more than just amplification to do the job. See how it's done.

new products

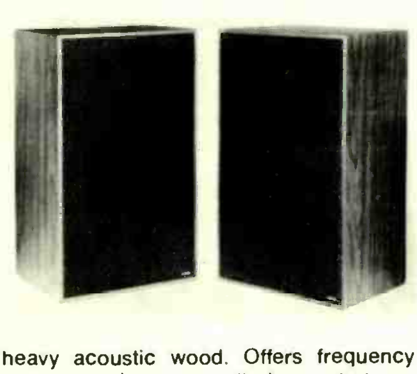
More information on new products is available from the manufacturers of items identified by a Reader Service number. Use the Reader Service Card on page 103 and circle the numbers of the new products on which you would like further information. Detach and mail the postage-paid card.

CASSETTE RECORDER, *models GXC-40 and GXC-40D (deck).* Both deck and amplified recorder have special bias switch to pick up broader frequency response (with higher signal-to-noise ratio) of the chromium dioxide tapes. An over-level switch activates low-noise circuit that cuts distortion to 1.5%. Features crystal ferrite

head. *GXC-40* units have piano key controls, pause button for editing tape, left and right volume slide pot controls, tone control, three-digit counter and two VU meters. Hysteresis synchronous outer-rotor motor *GXC-40D* is \$190.00; *GXC-40* is \$240.00.—**AKAI America, Ltd.,** 2139 E. Del Amo Blvd., Compton, Calif. 90220.

Circle 31 on reader service card

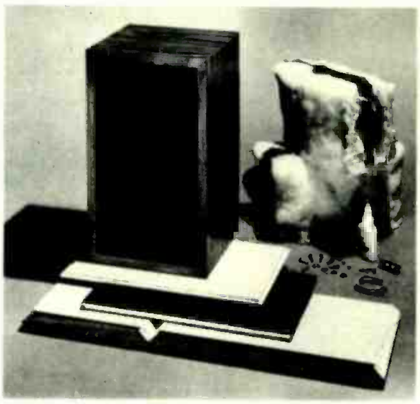
SPEAKER SYSTEM, *BR-12-SP.* Walnut-finished cabinets use 12-inch high-compliance woofer, large horn midrange speaker, and a 3½ inch closed-back tweeter, as well as a crossover network; all enclosed in air-tight enclosure made of



heavy acoustic wood. Offers frequency range from lower to well above what can be heard by human ear. This 3-way speaker system has 8-ohm impedance. Two pairs of matched speakers are now available with new adapter for 4-channel sound use. Single speaker, \$49.50; matched pair, \$95.00.—**Carlu Mfg. Co.,** 18002 South Hobart, Gardena, Calif. 90248.

Circle 32 on reader service card

SPEAKER ENCLOSURES, *Kab Kits.* Easy-to-assemble enclosures in kit form are offered to audio enthusiasts. 8-⅞ x 8 x 15 in. assemblies for economical speakers (up to 8-inch round or 6 x 9 inch oval). Walnut-



finish vinyl exteriors, complete with all hardware, acoustic lining material, and full assembly instructions. Just add the speaker. \$16.95.—**Kab Kits, Unilarm,** P.O. Box 76, Ann Arbor, Mich. 48107.

Circle 33 on reader service card

AMPLIFIER KIT, *AA-2004.* This 200-watt 4-channel amplifier operates in any of four modes: mono, stereo, discrete 4-channel, or matrixed 4-channel with its own built-in decoder. Provides four conservatively

rated and fully protected amplifiers driven by single power supply. Dynamic power is 260 watts into 4 ohms, 200 watts into 8 ohms, and 120 watts into 16 ohms. The amplifiers are controlled in pairs with one complete stereo system for left and right front speakers, and another for left and right rear. Twenty input level controls provided, enough for five quadraphonic program sources. Can be used to power two separate and distinct stereo speaker systems, or two 4-channel speaker systems. Power bandwidth on all channels from less than 5 Hz to more than 30 kHz for .25% total harmonic distortion. IM distortion less than 0.2%. Kit, \$349.95. Optional walnut cabinet, *AAA-2004-1*, \$24.95.—**Heath Company,** Benton Harbor, Mich. 49022.

Circle 100 on reader service card

DIGITAL CALCULATOR KIT, *IC-2008.* An 8-digit desk-top calculator performs addition, subtraction, multiplication and division electronically, and shows up to 8-figure totals on ½ inch seven-segment display tubes. Simplified keyboard provides 10 numerical keys (0–9), decimal, plus, minus, multiply, divide, and +/− for performing algebraic calculations with positive and negative numbers. Performs

constant or chain operations. The K (constant) key allows multiplication or division of series of figures by one preselected number, or of the constant itself for squaring or taking to a power. Embodies latest digital technology, making it an easy kit to build. All logic functions, keyboard encoder, 3 registers, decoder driver and matrixing circuitry in one IC (LSI). Kit, \$129.95—**Heath Company,** Benton Harbor, Mich. 49022.

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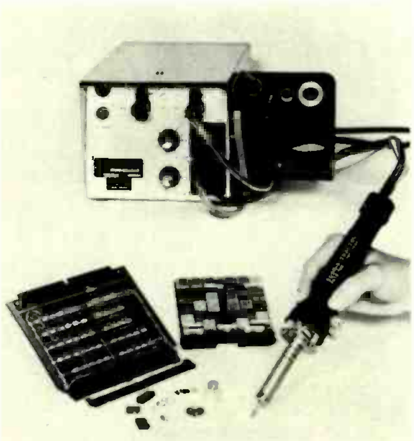
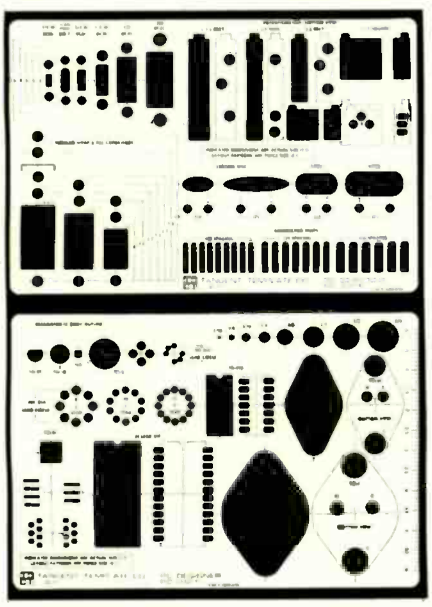
SOLDER JOINT REMOVAL SYSTEM, *Sodr-x-tractor SX300.* Portable, self-contained, bench-top unit removes solder from all known solder joint configurations including those found in the latest designs of micro-electronic equipment. Pressure, vacuum and hot air jet modes of operation are supplied by controlled air flow and heating levels to suit the range of work from the most delicate micro-miniaturized applications to the larger component assemblies. Requires 117 Vac; 50/60 cycle, 1 phase. Standard equipment includes



one set of tips, cleaning brushes, air line, and connect.—**Pace Inc.**, 9329 Fraser St., Silver Spring, Md. 20910.

Circle 34 on reader service card

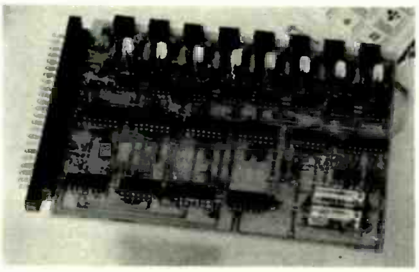
DESIGN TEMPLATE SET, *pc-2 (2:1).* Comprehensive template set for printed-circuit layouts and assembly drawings. Component body outlines, layout patterns and pad diameters conform to guidelines established by MIL-STD 275C and The Institute of Printed Circuits bulletin IPC CM-770. All component mounting patterns are on grid centers and are compatible with



automatic insertion equipment. Patterns for resistors, capacitors, potentiometers, and the most common semiconductor packages are included on the templates. Available separately at $7.50 each, the PC-2 (2:1) is a two template set for $12.00.—**Tangent Template Co.,** P.O. Box 15206, San Diego, Calif. 92115.

Circle 35 on reader service card

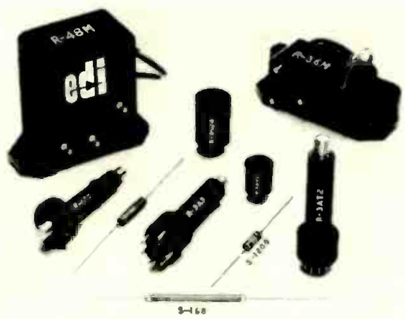
DECODER BOARD, *Multone*, used in data communications terminals, modem interface, traffic control systems, security systems, mobile recall. Features include decoding 12 functions (3 x 4 pad) with *Hi-True* TTL outputs in decimal form, with * and #; *Hi-True* outputs also in 4-line BCD, 0-9 only; decoding 7 tones from standard pad—100 mA. *Low-True* sink drive for bulbs and relays; separate high and low group "hit" out for single tone detection; two-tone "parity" out for simultaneous tone detection. Operates from +



Vdc power supply. Mil-grade G-10 glass-epoxy board; plated-through holes; quality components; metal film resistors; cermet trimmers; tantalum and polycarbonate capacitors. $169.95.—**Lee-Com Associates,** P.O. Box 43204, Cleveland, Ohio 44143.

Circle 36 on reader service card

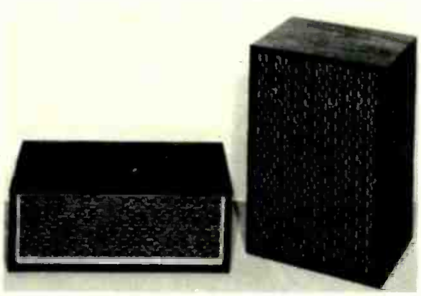
REPLACEMENT PARTS. *Solid Tubes.* Broad line of four solid-state tube replacements and six renewal parts for color TV. Cool operation, instant starting, longer and more consistent voltage life, prevention of circuit and socket damage and elimination of one potential X-ray source are benefits offered. The Solid-Tubes in-



clude *R-3A3* high-voltage rectifier, and *R-DW4* damper diode. The renewal parts include *R-36M* solid-state tripler, *R-158* silicon focus-rectifier cartridge, and *S-168* selenium focus rectifier. Replacement guide on tubes and parts available free.—**Electronic Devices, Inc.** 21 Gray Oaks Ave., Yonkers, N.Y. 10710.

Circle 37 on reader service card

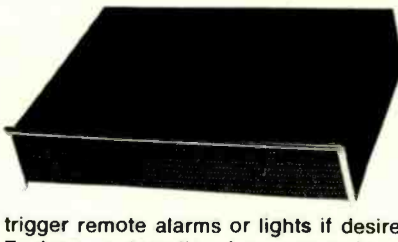
ALARM SYSTEM, *Gardlarm*, provides fail-safe intrusion protection with connections for fire detection, for home and business.



It is sensitive to movement in pre-determined areas, but insensitive to activation by noise, high-frequency signals, movement of air or small animals. If cable from transcator to receiver unit is disconnected or cut, additional security circuitry instantly triggers an alarm. Transcator-detectors are housed in 6 x 7 x 11 in. wood-grain cabinets resembling hi-fi speakers. One transcator protects an area up to 2,000 sq. ft. They contain a security barrel ignition key switch for remote mounting and relay unit to turn on lights, activate sirens or other devices, etc., when desired.—**PRI Electronics Div., Perceptual Remediation Inc.,** 127 S. Long St., Buffalo, N.Y. 14221.

Circle 38 on reader service card

ALARM, *Mod-Guard*. Ultrasonic intruder alarm detects motion in a 200 to 300 square-foot area at a range of up to 20 feet. High intensity built-in horn emits shrill blasts when activated, or unit can



trigger remote alarms or lights if desired. Features automatic change-over to external batteries if power fails.—**MOD Electronics Inc.,** Box 141, 7275 Croswell Road, Croswell, Mich. 48422. **R-E**

Circle 39 on reader service card

DIGITAL PRINTING COMPUTER

(continued from page 53)

not work. Also be sure the common terminal and its jumper do not short any foil on the board or other switch terminals. After the switch commons are wired and soldered and the switch is seated, the terminals may be clinched on the component side. Finally, the remaining terminals may be soldered in place.

Dial replicas appear in Fig. 7. Figure 8 shows how these + ¾ mounted to the switch shafts. Pilot lamps and red filters are bracket mounted between the PC board and the dials.

Final assembly

An antique brass and walnut-finished case assembly was used on the prototype, although any suitable enclosure should do the job. It has to be large enough to hold the PC board, the three-wire outlets, and has to have a front panel with two cutouts for the dial display. The additional START, STOP, and SELECT switches are mounted on the front panel, while the line cord, output sockets, and the remote control jack mount on the rear panel. The green safety ground from the three-wire line cord goes both to the case and the two output sockets.

The PC board mounts to the bottom of the units via two brackets. Be very careful to align these brackets so the dials, knobs, pilot lamps, and front panel holes line up. When properly aligned, you should see a red numeral on a black background, properly centered and corresponding to the right switch settings. Push-on knobs complete the front assembly.

The unit may be initially tested with 15-watt red and white lamps in the safelight and enlarger sockets. Use an oscilloscope, a kitchen clock, or a stopwatch to verify that each switch setting is correct. As there are no adjustments or calibration needed, this should be all the checkout required. If you are going to use an enlarger lamp greater than 200 watts, add a suitable high-current relay or triac to the output.

Normally, you start off with a nominal baseline exposure, say eight seconds for a normal black and white print to be dodged and burned on a single pass. You also set the CORRECTION FACTOR dial to ZERO, and run a test strip or a test exposure. If you want a small correction after running these tests, advance or retard the correction factor dial as needed. If you ever get to +1 or −1 on the correction factor dial, simply snap to one higher or one lower baseline exposure position and reset the correction factor dial to zero. This way you get a continuous exposure range. **R-E**

ADD-ON ELECTRONICS FOR YOUR CAR

(continued from page 36)

fires on the high end. ARE claims they have solved this problem electronically with their dwell stretcher.

The dwell stretcher also shunts the points with a thyristor. It increases the point dwell in the following manner: When the points open (Fig. 8) the dwell stretcher is triggered. Three hundred microseconds later the thyristor turns on to "quench" the spark, electrically. ARE's theory is that once combustion is begun, within the 300 microseconds, further arc current is not only unnecessary but shortens spark-plug life. Thus, by shortening the time during which the ignition coil is allowed to discharge, the dwell is effectively increased. On an eight-cylinder engine operating at 5000 rpm, the dwell stretcher increases the dwell angle to 41 degrees out of a possible 45 degrees, regardless of the point dwell angle setting.

The dwell angle will, however, change with the rpm of the engine, since the dwell stretcher serves to increase the dwell by shortening the firing pulse to a fixed 300 microseconds. For example, at 10,000 rpm the dwell angle will have decreased to 36 degrees. Nevertheless, it should serve to significantly increase the performance of the engine during high speed operation. Also, like the Revgard, the dwell stretcher helps to eliminate the effects of point bounce.

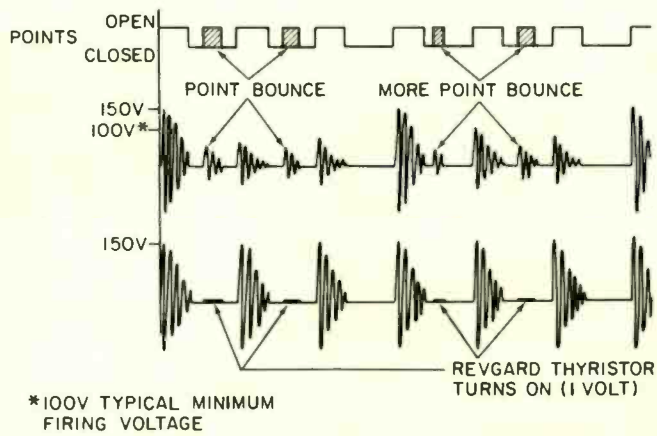


FIG. 7—HOW THE REVGARD helps cure point bounce by squelching the bounce pulses.

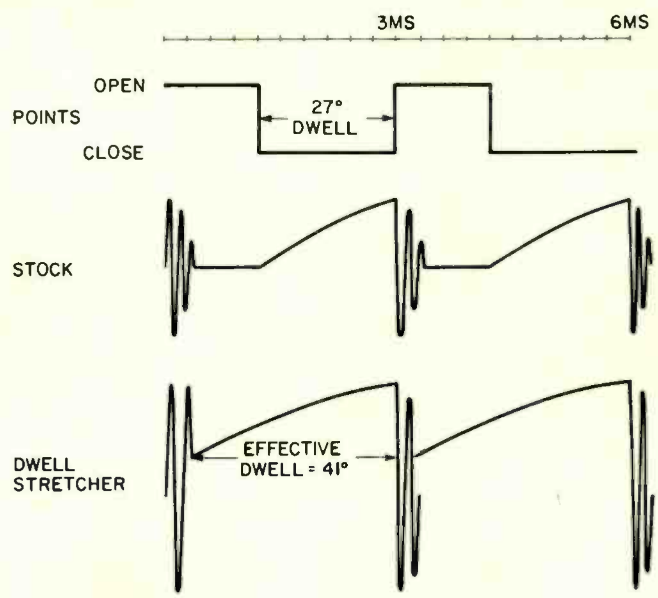


FIG. 8—DWELL STRETCHER increases dwell by reducing time the coil carries current.

This unit is available in combination with the RPM limiter or as a separate unit.

Tachometer

The electronic tachometer has been around for several years and is produced by a number of manufacturers. Units are available that can be triggered by the car's ignition points, from the current flowing in a spark plug wire, or from the alternator. Normally, the alternator-driven units are used on diesel engines while the spark-triggered units are used on automobiles. The circuit configurations may vary widely; however, each circuit is designed to provide an rpm-dependent current to position an ammeter. Two circuits demonstrate the variety of configurations they may take. First, let's look at the Heathkit Tachometer Model MI-18.

Fig. 9 shows the Heathkit tachometer circuit. This is basically a monostable (one-shot) multivibrator triggered by a spark pulse from the engine. The triggering pulse biases transistor Q1 into cutoff, causing transistor Q2 to conduct. The length of time during which Q2 conducts is determined by the value of capacitor C1. (C1 has different values for 8-, 6-, and 4-cylinder engines.) When C1 has discharged through R7, Q1 will again conduct and turn off Q2. The meter in the collector circuit of Q2 is calibrated to read the average collector current in engine rpm. The me-

(continued on page 83)

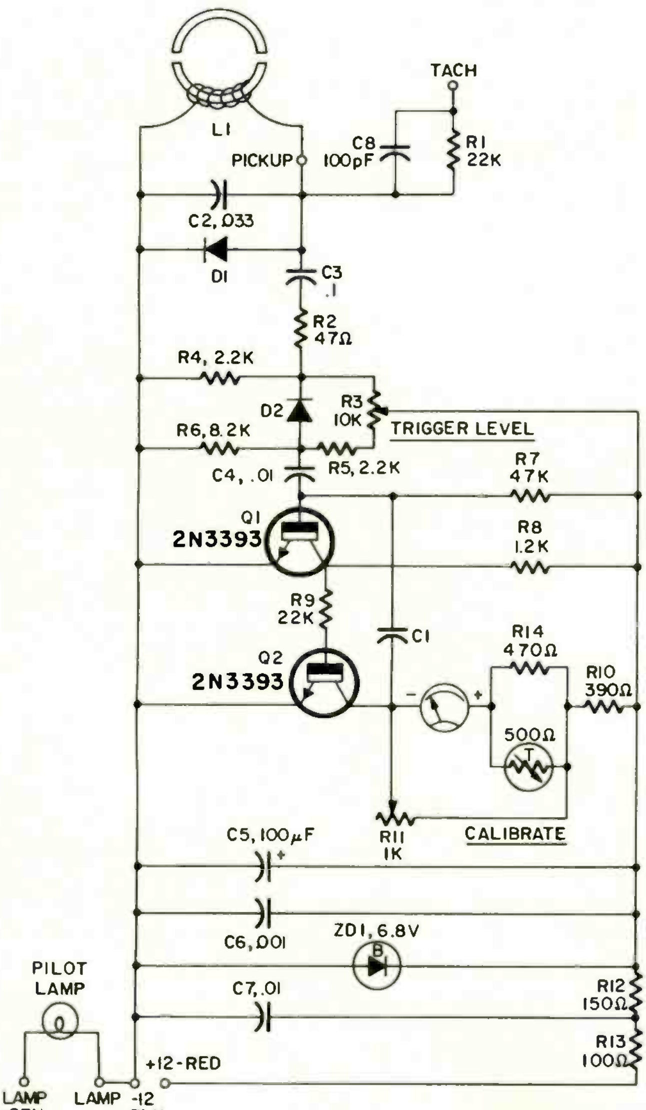


FIG. 9—HEATHKIT M-1 TACHOMETER uses a one-shot multivibrator to count pulses.

APPLIANCE CLINIC
(continued from page 22)

temperature will not exceed 60°C (about 132°F). The vinyls and polyethylenes are rated in the same area. If we must go above this, to about 90°C, we'll need neoprene insulation. In fact, UL allows the use of a jacketed neoprene wire up to 105°C. Above that, a silicone-insulated, fiberglass-jacketed wire is needed. A new Dupont plastic, "Hypalon" (chlorosulfonated polyethylene for short) is now coming into use for temperatures up to 130°C.

The old standby for hot wires—asbestos—is still with us. You'll find it used in flexible cords for electric irons, and other high-current appliances. Asbestos covered wire is fine, but it, too, has limitations. In a lot of cases, it will be simply "laid" wrapped around the wire. This needs a stout braid jacket, mainly to keep the asbestos in place! Don't use asbestos-wire with laid insulation in places where it must flex, or where it can touch the metal case of the unit. This insulation can be pulled off the wire with your fingers!

Another thing we must beware of is "crush". In many appliances, especially smaller, hand-held types, the wiring runs in slots or grooves inside two-piece metal handles, cases, and so on. Unless we are very careful putting the thing back together, the wires can be caught between two sharp metal edges. When the bolts are tightened, these can crush the insulation. This could cause a short to the case. Even if the insulation is not crushed when the case is first tightened, it could be softened by heat later on as the unit is used, and then short!

Installation

When we install new wires, they must be handled and worked with the correct methods. This is especially important in some of the things using very small wires. The little wires can be hard to work with, unless you know "the lick it's done with".

In the past, most of us grabbed the end of the wire between the jaws of our diagonals and yanked, pulling the insulation off.

Modern plastics are pretty tough. If the wire inside is very small, you can break it before you pull the insulation off! And, of course, the break will be somewhere inside an apparently undamaged part of the insulation.

There's a very easy way. Just touch the tip of a soldering iron to each side of the insulation, where you want it pulled off. Fig. 1 shows how. Melt a tiny nick in each side, then pull the in-

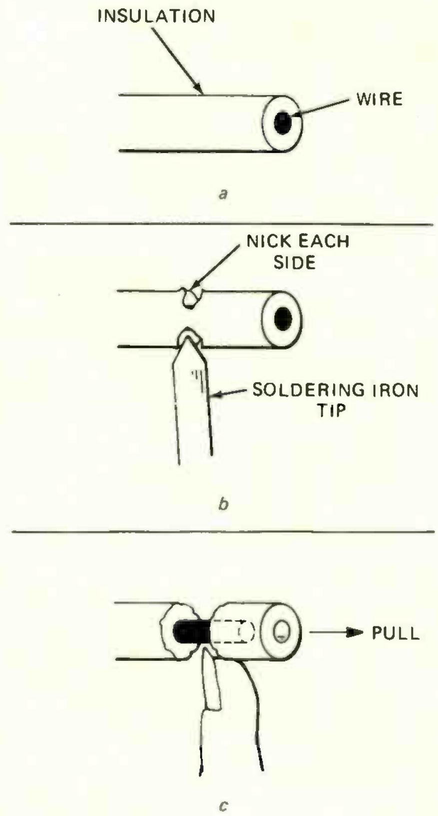


FIG. 1

(continued on page 92)

next month

MAY 1972

- **Installing Burglar Alarms—MATV—PA—Intercoms**
  Wiring a system calls for going through walls and ceilings of an existing house. It's a difficult job at best. This article shows how to handle this "impossible" task.

- **Build R-E's IC Tester**
  Digital IC's are plentiful and inexpensive. Here's a test instrument that makes it easy to check the dynamic operating characteristics of the IC.

- **Solid-State Pocket Calculator**
  It adds, subtracts, multiplies and divides. It carries a constant, is battery powered, and fits in your pocket. Complete construction details

- **Active Car Antennas**
  It takes much more than just a high-gain transistor amplifier to make this kind of antenna perform well.

- **IC Logic Demonstrator**
  See how digital logic elements work. Use this simple dynamic demonstrator to set up working logic functions and explain how they work.

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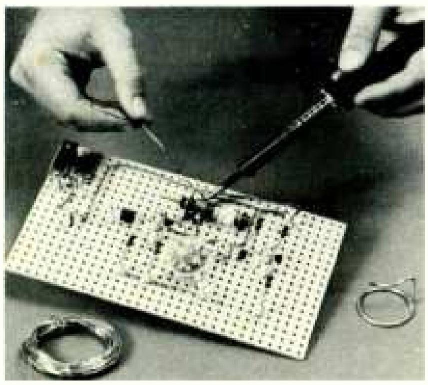
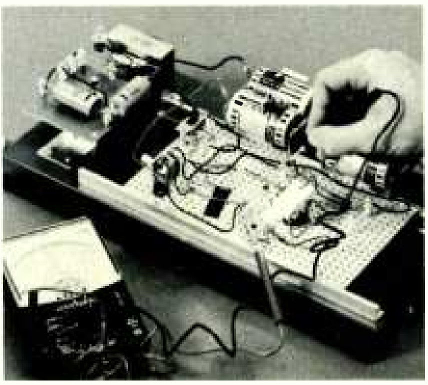
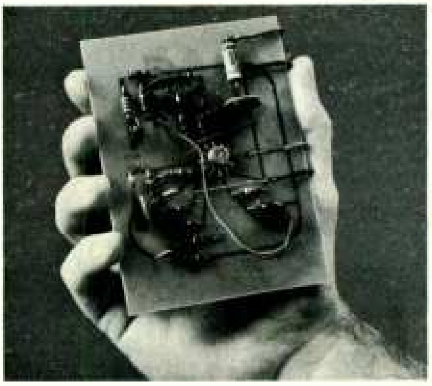


You learn how to construct circuits and connect them with a soldering iron, which is part of your CIE laboratory equipment. This "hands on" experience is extremely valuable in applying what you learn.



Testing and troubleshooting are an important part of your learning experience. Included in your laboratory is a precision "multimeter" to diagnose electrical and electronic troubles quickly and accurately.



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Circle 83 on reader service card

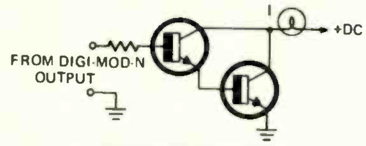
DIGI-MOD-N FREQUENCY DIVIDER

(continued from page 45)

pseudo-random bit generator and can be used as such where a truly random sequence is not required.

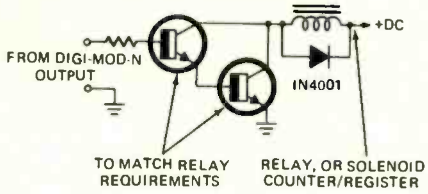
The Digi-Mod-N should be able to operate at input rates up to at least 10 MHz.

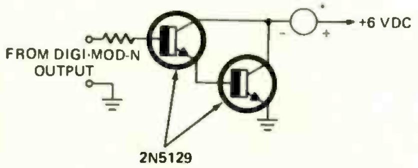
The circuitry requires a relatively noise-free input approximating a 5-volt square wave for proper operation. For many applications, you must use an input signal conditioning circuit between



TYPICAL COMPONENTS

Q	LM	+DC
2N5129	5V, 50 mA LAMP	+5V
MPS6554	6.3V #47 LAMP	+6.3V
2N4410	NE-2H NEON LAMP WITH 47K SERIES RES.	+100V
MJE-340	10W, 117V BULB	+110V





*MALLORY SONALERT

FIG. 3—DRIVER CIRCUITS for visual, mechanical and audible indications at points remote from the Digi-Mod-N.

INTERIOR VIEW OF DIGI-MOD-N showing how the PC boards are installed.

the input device and the Digi-Mod-N. Some pulse-shaping circuits that can be used are in Fig. 2.

There are lamp indicators at the input and at both outputs. Slow pulse trains can be observed visually on the front panel. For applications where it is desirable to have remote indicators such as lamps, alarms, relays, etc. some of the driver circuits shown in Fig. 3 can be used. **R-E**

(continued from page 75)

ter circuit is temperature stabilized by thermistor T and voltage stabilized by Zener diode ZD1. ZD1 provides a constant 6.8 Vdc to the tachometer even though the battery voltage may vary from 10.5 to 17.5 Vdc.

The second circuit is the Knight-Kit model KG-340 electronic engine tachometer shown in Fig. 10. The input circuit is a pulse-shaping and voltage-limiting circuit. It converts the pulse developed across the coil primary, when the points open, to positive and negative spikes of fixed amplitude and shape. These voltage spikes are rectified by the full-wave bridge rectifier and used to drive the meter. The current flowing through the meter is proportional to the rpm of the engine.

Both the Heathkit and Knight circuits are calibrated with a special meter calibration cord using 60-Hz house current.

Entertainment

Several interesting accessories have been developed for use with AM/FM radios and stereo tape players. For example, AM/FM and FM Stereo Cartridge Tuners are available which plug directly into your 4 or 8-track tape player unit, adding radio reception to your stereo tape player. Also, 8-track to cassette adapter cartridges are available to enable your 8-track stereo tape unit to play cassette tapes. A number of these units are available through J. C. Whitney & Co. (auto accessories, 1917-19 Archer Ave., Chicago, 60616.) Another unit, the Switch-O-Matic, available from GC Electronics, 400 S. Wyman Street, Rockford, Illinois, is an electronic, solid-state switch that permits your car radio to be played through your tape system stereo speakers. When the tape system is being used, Switch-O-Matic automatically cuts itself out of the circuit.

Safety devices

A wide range of safety devices are now available as optional items on new cars. For example, anti-skid brakes, sequential turn signals, and time-delayed windshield wipers. Anti-skid brakes aren't available as an add-on accessory yet, but sequential turn signals are available from J. C. Whitney & Co. and a time-delayed windshield wiper kit is available from Knight Kit.

A new item introduced by TIS Corporation, 505 E.

(continued on page 84)

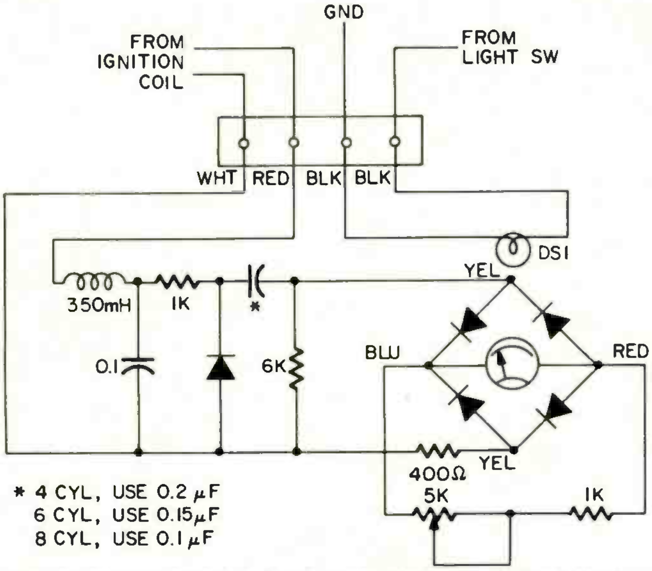


FIG. 10—KNIGHT-KIT KG-340 tachometer with an input circuit that has combined functions of pulse-shaping and voltage limiting.

ADD-ON ELECTRONICS FOR YOUR CAR

(continued from page 83)

Eisenhower Drive, Loveland, Colorado, should help us to stay awake on those long night drives we often make during vacation time. This unit, named Lifetimer, mounts on top of your dash and flashes a light every 20 seconds. If you happen to be dozing and fail to press a floorboard contact strip with your foot, a buzzer will sound. If that doesn't wake you up, the Lifetimer shuts off your ignition, flashes your lights, and honks the horn to signal other drivers of trouble. The Lifetimer may not keep you awake, but it'll slow up your trip if you go to sleep. It might even save your life!

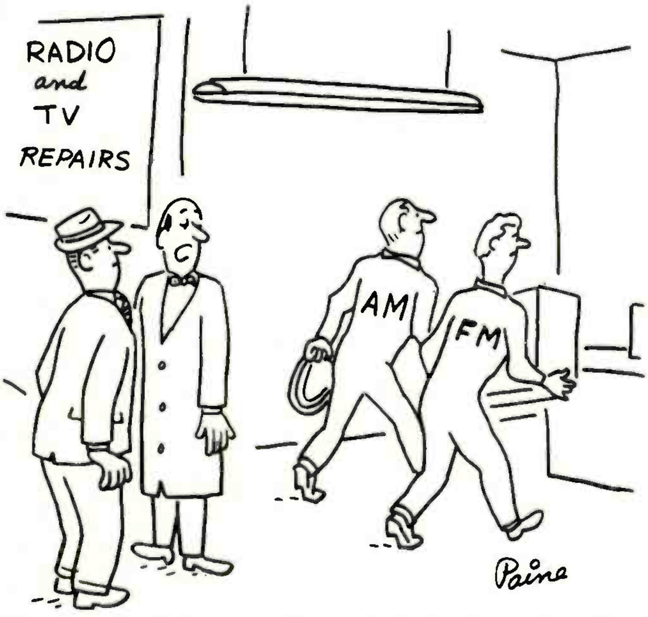
Burglar alarms

The past few years have seen a flood of new electrical/electronic devices to help protect car owners against thieves. A number of these units are available from J. C. Whitney & Co. In a recent catalog they list eight burglar alarms.

These units are generally actuated in one of two ways: a circuit senses a sudden drop in battery voltage (even a few millivolts) as would happen when the dome light comes on when the door is opened, or switches installed in doors, hood, and trunk are used to turn on the unit. Some models use the car's horn as a sounding device. Others have their own horn or siren. In most cases, the unit puts out a pulsating sound to draw attention to the car. For example, one unit available from James Electronics Inc., 4050 N. Rockwell St., Chicago, Ill. sounds the car's horn 60 times per minute for up to eight minutes and then resets. It's then ready for another burglar.

Time-delay anti-theft devices

These units are not burglar alarms, but serve as a deterrent to thieves. One unit listed by J. C. Whitney & Co. stops the ignition by burning out a time-delay element when the car is started without disabling the unit; the element must be replaced before the car can be started. A second unit, available from Automark Ind., 641 S. Vermont Street, Palatin, Ill., shuts off the gas flow to the carburetor when the unit is actuated. The car will start, but runs only as far as the fuel in the carburetor lasts. **R-E**



No. Actually it's their initials . . . they're brothers, Al and Fred Murray.

facts and electronic

Electronic ignition systems can Here's what they can

by JOE SHANE

PROPONENTS OF ELECTRONIC IGNITION SYSTEMS WILL be happy to get the chance to tell you just how much such a system can do for you. Much of what they will tell you is true and part is false; and the reasons behind true or false are rarely explained.

Recently, I considered purchasing an electronic ignition system for a 4-year-old 8-cylinder Chevrolet. But before I ran out and bought a system, I decided to look into what they had to offer.

The first point I found myself confronted with was: "All electronic ignition systems are the same."

Well you can just label that statement "False". There are considerable differences between systems. They vary from one-transistor switching circuits to multi-transistor capacitive-discharge arrangements. Some have a magnetic or photo-electric circuit that eliminates the needs for the points in the distributor.

Generally, the capacitive-discharge type of ignition circuit is recognized as the most desirable system for today's cars. Some ignition systems require a special coil to replace the one now in your car. Others use the existing coil. Those that use the existing coil sometimes provide a simple switch that enables the car owner to disconnect the electronic system and reconnect the standard ignition system that was in the car. This is not only great should something go wrong with the electronic system while you are on the road, it permits the owner to easily compare performance with and without the electronic system.

Improved gasoline mileage

The most obvious improvement you can find in any device that helps your car run more efficiently is improved gas mileage—more miles per gallon. "An electronic ignition system will deliver more miles per gallon." Label that one "Fact".

A properly installed and operating electronic ignition can improve the gas mileage of your car from 1 to 5 miles per gallon. The reason for the improved gas mileage is that with the electronic system installed, the car is, in effect, always in perfect tune and so is always operating at peak efficiency.

Without the electronic system, the only time the car is perfectly tuned is immediately after it leaves the shop. From that time on till it is next tuned up, performance slowly degrades and as it degrades so does your gas mileage.

Longer life for points and plugs

In normal use the plugs and points in your car should be changed about every 10,000 miles. For in this length of time the plugs wear enough for the gap width to become excessive and point contacts erode enough to require replacement. An electronic system increases the voltage but decreases the current, and in turn the plugs and points last longer, much longer. In some instances as much as ten times longer.

There are, however, two new problems to watch for once you have installed the electronic system. First you must be sure that the system passes enough current through the points to keep them clean. This means that the system should be

fallacies of ignition

improve your car's performance. and can't do for you

passing about 0.5 ampere through the points. This is enough current to prevent oxidation from forming on the points.

Second the points should be checked periodically to look for wear in the point lifter. If this wears excessively the points will never open. Also it is wise to change the points after about 40,000 miles of use to prevent the breaker spring from snapping because of metal fatigue.

Higher top speed

The possibility of getting a higher maximum speed with an electronic ignition system is both a fact and a fallacy. The way conventional ignition restricts maximum speed is by misfiring at high speeds because the points are opening and closing so rapidly that the coil doesn't get enough time to build up a voltage level high enough to jump the gap in the spark plugs. But this only becomes a problem around 5,000 to 6,000 rpm.

Fortunately, cars with automatic transmissions rarely reach this rpm range—2500 to 3000 rpm is a typical maximum. So for this kind of car higher speed is a fallacy. But a car with a standard shift and a high-performance engine will easily turn up 5000 to 6000 rpm. So for this kind of car, the electronic ignition system can boost top speed. **R-E**

APPLIANCE CLINIC

(continued from page 76)

sulation off with a thumbnail. Using this method, you won't run the chance of cutting or breaking several of the tiny strands of the wire! Better still use the proper wire stripper.

Watch it when making solder joints with this type of wire! Whenever possible, do *not* solder a thermoplastic insulated wire, if it is leaving the terminal in a sharp *bend*, as in Fig. 2-a. The wire carries the heat very nicely, softens the insulation, which promptly "straightens out", leaving you with about an inch of nice bare wire (Fig. 2-b).

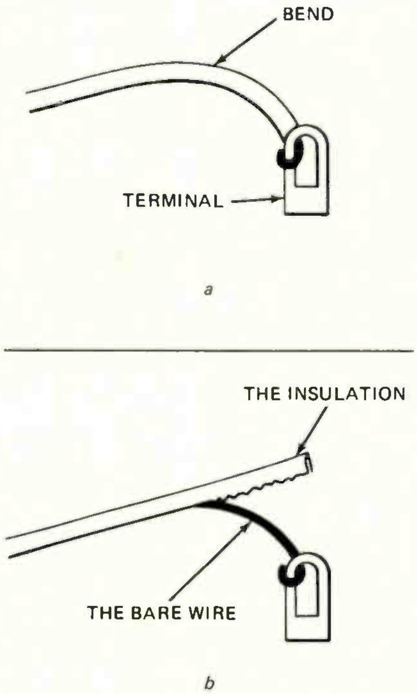


FIG. 2

To avoid this, be sure the wire is straight. A better way is to heat-sink it. Grab the wire between the tips of a pair of long-nose pliers, as close to the solder-joint as you can get. It will also help to tin the stranded wires before starting. Hold the wire between the tips of the long-noses, and quickly tin it, with fresh solder. Now, you won't have to stay on the joint so long to get a good scald on it. Heat-sink it with the pliers anyhow; it couldn't hurt.

For a final word, study the characteristics of each type of wire. If you know what it can do, and, much more important, what it *can't* do, you will find things a lot easier! Use the right wire in the right place. **R-E**

BUILD R-E's IC TESTER. It's an interesting piece of test equipment that tells you if a digital IC is working properly. It's in May.

IMPOSSIBLE? BARGAINS IN SURPLUS ELECTRONICS AND OPTICS

THIS MONTH'S SUPER SPECIAL!

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First announced in our January advertisements, the response to B & F's calculator kit can only be described as fantastic! We supply complete kit of everything (except a case) to build a professional calculator, for under $100.00. Includes extra large scale integration MOS Chips for calculator functions, complete professional keyboard, all parts for clock and drivers, all printed circuit boards, eight, seven segment readouts, power supply and complete step-by-step instructions.

Keyboard Functions: The input is organized to accept the following inputs: Numerals 0-9 plus decimal point – Constant Multiplier/Divisor Set – Decimal point Set – Clear – Clear Entry – Multiply – Divide – Sum and Execute – Subtract and Execute – Alternate Display – Equals.

Display Functions: The output is designed to produce the following output functions: Eight digit numerical display, in BCD code – Negative Sign Indication – Overflow Indication – Zero Suppression - all nonsignificant zeroes are suppressed.

Operational Description: The following descriptions apply for the designated calculator operations:

Figure Entry: Up to 16 digits – Up to seven decimal fraction digits – Entry of positive quantities only – Entry may be cleared without destroying intermediate results in accumulator – Decimal point.

Addition: Addition results accurate up to 16 digits – Overflow of 16th digit detected – Signed results possible during chained operations.

Subtraction: Subtraction results accurate up to 16 digits – Overflow of 16th digit detected – Signed results possible.

Multiplication: Product up to 16 digits with the eight most significant digits available for display. The least significant eight digits can be displayed on command of the Alternate Display key – Signed results possible in chained operations – Round off is not implemented (results truncated if necessary) – Solution time is 80 ms maximum at 200 KHz.

Division: Quotient up to 16 digits with eight most significant digits available for display. The least significant eight digits can be displayed on command of the Alternate Display key – Signed results possible in chained operations – Solution time is 120 ms maximum at 200 KHz.

General: Continued (chained) operation · capability is provided for continued multiplication, division, addition, and subtraction – Clear · all storage registers and display are cleared by command of the Clear Key. Decimal point position is not modified – Storage · the machine storage registers are cynamic shift registers – Overflow · overflow is indicated but overflow information is not saved. Further operation of keys (except "clear" or "clear entry") is inhibited – Electronic interlocking · electronic interlocking is provided which prevents erroneous operation due to simultaneous depression of two or more keys – Clear Entry · enables correction of a figure input error (and clears figure entry overflow condition).

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Discounts on technical books are rare, since the publisher discounts are low, but B and F is happy to give you a 10% discount and postpaid delivery in the U.S. on what we feel are some of the best books in the electrical engineering field. They are:

☐ Alley and Atwood, *Semiconductor Devices and Circuits*, Wiley, 1971. Without relying on calculus, this book describes basic semiconductor devices and explains their use in electronic circuits. The operations and uses of linear and digital integrated circuits are given considerable coverage. List Price $11.95, B & F Price $10.75.

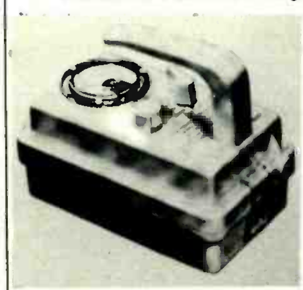
☐ Paul Siegal, *Understanding Digital Computers*, 2nd Edition, Wiley, 1971. A great introductory text for logic and computer design. We supply it as part of our logic experimenters kit. List $12.95, B & F Price $11.75 . . . . $11.75

☐ Eimbinders, *Semiconductor Memories*, Wiley, 1971. List $11.95 . . . . $10.75

☐ Eimbinder, *Designing with Linear Integrated Circuits*, Wiley, 1969. List $10.95 . . . . $9.85

☐ Barna, *Operational Amplifiers*, Wiley, 1971. List $9.95 $8.95

RADIATION METER ("Geiger Counter")



You can buy a complete radiation meter, complete with original instruction books, at less than the price of the meter movement alone. Range is 0.02 to 50 Roentgens/hour. This is not sensitive enough for prospecting, but useful for other radiation measuring and monitoring purposes. If not used for its original function, then the case, meter and battery holder alone are worth our asking price as a basis for building a metal locator, etc. Uses standard D cell and 22.5 volt Battery.

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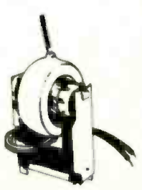

We have thousands of flyback transformers for TV sets, and have worked out an interesting modification of them so that using a pair of power transistors and a few resistors you can build a 12 volt D.C. powered oscillator converter providing an output of 18,000 volts. With this high voltage output you can perform many interesting experiments and demonstrations, such as a jacobs ladder . . . or lighting a florescent tube by just holding it near the supply. We supply the flyback transformer, two power transistors, resistors, instructions and an experiment manual. Use our 12 volt supply advertised on this page as a supply for this if you don't already have one.

☐ Flyback "Tesla Coil" Kit $4.75
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☐ 25 Watt RMS Amplifier $14.75
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☐ Complete kit for 100 watt rms stereo amplifier (200 watt music) including two 50 watt Sanken hybrids, all parts, instructions, and nice 1/16" thick black anodized and punched chassis $88.00

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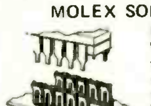
☐ Same for 20 watt rms stereo, includes two 10 watt Sankens, etc. $30.00

MOLEX SOLDERCON CONNECTIONS



Molex soldercon connections for I.C.'s. With these you can build low cost I.C. sockets by just cutting off the number of connections required, i.e., two strips of seven for 14 pin socket.

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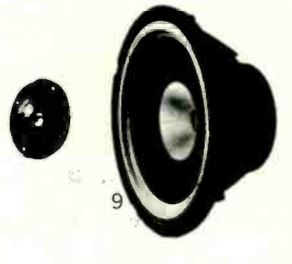
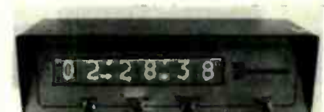


A local manufacturer went out of the speaker enclosure business, and we were lucky enough to buy his inventory of Jensen high-compliance (acoustic suspension) speaker systems. These systems consist of a 12" extended range woofer, a hemispheric dome tweeter, plus crossover. The dome tweeter response extends into the supersonic. The dome shape provides an ideal polar pattern response. The system is ideal for use with our Sanken Amplifier Systems, or any system capable of putting out at least 20 watts rms per channel. Full instructions for cabinet construction are included.

Single System (One Woofer, Tweeter and Crossover) . . $29.00
Shipping weight 10 lbs.
Stereo System (Two of Above) $55.00
Hi Compliance Woofer Only (8 lbs.) $22.00
Dome Tweeter only (3 lbs.) $5.75

DIGITAL CLOCK KIT WITH NIXIE DISPLAY



We have well over 20,000 surplus nixies in stock, and because of this bargain purchase we can sell a complete digital clock kit for less than the usual cost of the display tubes only. We provide a complete etched and thru-plated circuit board, all integrated circuits, complete power supply, display tubes, I.C. sockets and a nice front panel with polaroid visor. We have never seen anyone offer this kit for less than $100.00 before. Includes BCD outputs for use as with timer option. May be wired for 12 or 24 hour display. Indicates hours, minutes, seconds.

☐ Clock Kit, complete less outside cover $57.50
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☐ 0.5 Ampere hour cell . . $1.00 each, 2 for $1.50, 10 for $5.00

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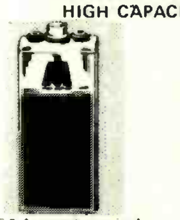

The advantage of the vented nicad is in fast recharge. These 1.35 volt 5 ampere hour cells can be recharged in 1/2 hour if necessary, by charging at 12 amperes. Supplied with electrolyte and partially charged. Five cells grouped together provide a 6 volt "nominal" systems. Work well even in sub-zero weather, perfect for radio control, etc.

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☐ Group of five, banded together 9.75
☐ LIMITED QUANTITY of 30 ampere hour cells . . . 6.75 ea.

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STEREO AMPLIFIER DESIGN

(continued from page 59)

$$\theta_{JA} = \frac{T_{JA}}{[I_C + SI_{CBO}'] \, [E_{CC} - I_C (R_C + R_E)]}$$

where

T_{JA} is the junction temperature less the ambient temperature

I_C is the idling collector current

S is the stability factor discussed in a previous article, and equal to $\Delta I_C/\Delta I_{CBO}$

I_{CBO}' is the maximum leakage current (collector to base with the emitter open) for the maximum temperature at which the semiconductor device can be used. As you recall, it approximately doubles for every 6°C rise in the junction temperature of silicon devices and for every 10°C rise in the junction temperature of germanium transistors.

E_{CC} is the collector supply voltage

R_C is the dc resistance in the collector circuit

R_E is the dc resistance in the emitter circuit

The heat sinks used to help maintain safe temperatures are rated by their thermal resistance. They are best used vertically with all surfaces exposed to the air in a type of chimney effect. Once θ_{SA} has been calculated, the size of a non-standard heat sink may be estimated from Fig. 7.

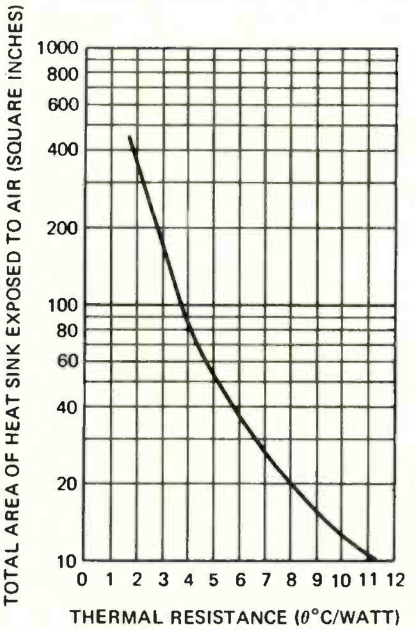

FIG. 7—HEAT-SINK DESIGN CURVE relates surface area exposed to thermal resistance. The curve is for ⅛-inch bright aluminum.

Thermal fatigue

It is well known that if a piece of sheet metal is bent back and forth along one line, it will eventually break. Some types of metal can be flexed more often than other types before cracking.

So it is with transistors. They can be brought up to a specific high temperature and then cooled. This can be repeated only for a specific number of times before they break down. The graph (from RCA) in Fig. 8 shows the number of these heating and cooling cycles that a 2N6099 transistor can endure before breaking down. This *Thermal-Cycling Rating* is related to both the power dissipated by the transistor and to the change of the case tempera-

(continued on page 96)

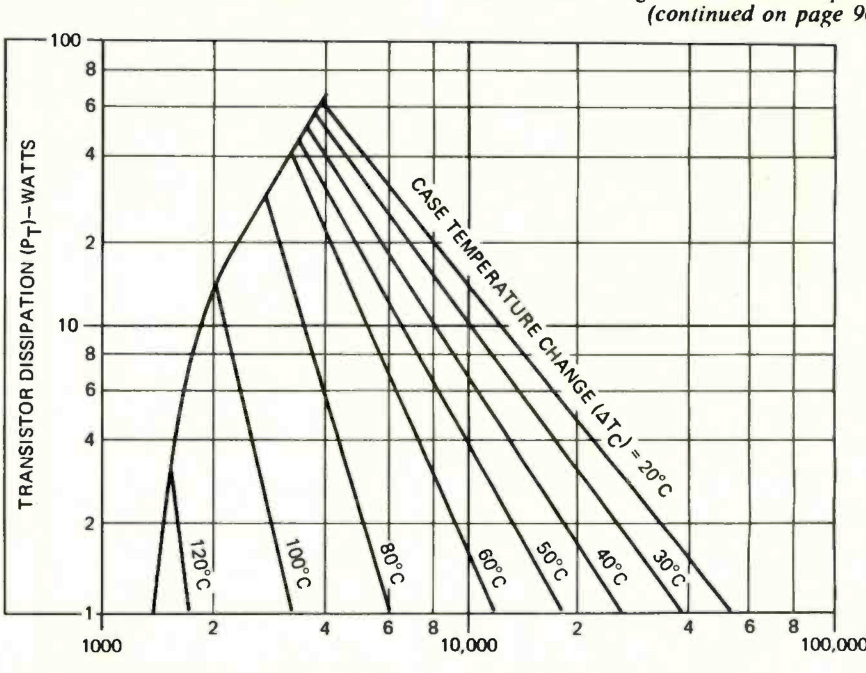

FIG. 8—THERMAL-CYCLING CURVE for RCA 2N6099. Circuit must be designed so transistor does not breakdown prematurely due to a combination of high P_T or ΔT_C.

STEREO AMPLIFIER DESIGN

(continued from page 94)

ture during each thermal cycle.

At an average, audio amplifiers can be assumed to go through 1000 of these thermal cycles each year. If you expect the equipment to last five years (another average figure), the transistors must last for at least 5000 cycles. Equipment designed and built by the hobbyist can be made to last through many more cycles, if desired.

In the practical situation, the 2N6099 may be asked to dissipate 20 watts. If the minimum number of thermal cycles should be 5000, the case temperature should not change by more than 50°C. This can be determined from the curves in Fig. 7. Used at an ambient temperature of 20°C, the heat sink should limit the case temperature to 70°C when power is applied to the amplifier.

A Class AB amplifier dissipates different amounts of power when operating at different volume levels. Assume, as an example, that one transistor of a push-pull pair dissipates 4 watts when operating at low volume levels and that it dissipates 20 watts when producing loud music. Furthermore, assume that it is anticipated that the transistor in the amplifier will be dissipating 4 watts for 10,000 cycles, and that the case temperature will increase 30°C. At the 20-watt level, the case temperature may change by 80°C, but it is required to go through only 2000 cycles. The problem is to determine if the device is being used within its thermal-cycling rating.

At the 4-watt level, the number of cycles permitted with a temperature change of 30°C is 17,500, as determined from the curves. Since only 10,000 cycles are required, 10,000/17,500 or 0.57 of the maximum permissible number of cycles are used here.

Similarly, when operating at the 20-watt level with a temperature change of 80°C, 3000 cycles are permitted. Only 2000/3000 or 0.67 of the permissible number of cycles for this temperature change, is used here.

The sum of 0.57 and 0.67 is 1.24. The transistor is used within its thermal-cycling rating if the sum of the two decimals is equal to or less than "1". Obviously, operation is beyond the rating of the device.

If the number of cycles at the 4-watt level is fixed so that the decimal is 0.57, at the 20-watt level the number should not exceed $1 - 0.57 = 0.43$. Since 3,000 cycles are permitted when used exclusively at $\Delta T_C = 80°C$, the number of actual permitted cycles at the 20-watt level, for the combination of conditions, N, can be calculated from $N/3000 = 0.43$. Hence $N = 1290$ cycles. **R-E**

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ADVERTISING INDEX

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READER SERVICE CARD NO.		PAGE
11	Allied Radio Shack	32
89	Allied Radio Shack	94
87	B.F. Enterprises	93
90	B.F. Enterprises	95
12	B & K, Division of Dynascan Corp.	63
	Bell & Howell Schools	88-91
81	Brooks Radio & TV Corp.	84-85
97	Castle TV Tuner Service, Inc.	Cover IV
82	Center For Technical Development, Inc., The	87
83	Cleveland Institute of Electronics	78-81
61	Cook's Institute of Electronics Engineering	71
	CREI, Division of the McGraw-Hill Continuing Education Co.	46-49
6	Crown International	13
91	Delta Electronics, Co.	96
5	Delta Products, Inc.	7
14	Edlie Electronics, Inc.	69
95	Edmund Scientific Co.	102
75	Electronic Chemical Corp.	82
76	Electronic Distributors, Inc.	82
80	EICO, Electronic Instrument Co.	84, 85, 86
	EMC, Electronic Measurement Corp.	86
88	Enterprise Development Corp.	94
71	Environmental Products	75
70	GC Electronics	74
	Grantham School of Engineering	18-21
	GTE Sylvania Electronic Components	14-15, 56
100	Heath Co.	26-27
67	Indiana Home Study Institute	73
13	International Crystal Mfg. Co.	68
77	Jensen Tools & Alloys	82
85	E. F. Johnson	92
94	Judson Research & Mfg. Co.	87
79	Lectrotech, Inc.	83
4	Mallory Distributor Products Co.	5
68	National Camera Co.	73
	National Radio Institute	8-11
	National Technical Schools	64-67
64	Nelson-Hershfield Electronics	72
86	Newport Organs	92
92	Olson Electronics	96
8	PTS Electronics, Inc.	16
69	Radio Shack	73
	RCA Institutes	28-31
10	RCA Parts & Accessories	22
96	RCA Test Equipment	Cover III
72	Rye Industries, Inc.	83
2	Sams & Co., Howard W.	1
63	Schober Organ	71
78	Sescom, Inc.	82
9	Solitron Devices, Inc.	17
73	Sonar Radio	76
3	Sony Corp. of America	2
1	Sprague	Cover II
84	Techni-Tools	92
66	Tri-Star Corp.	72
93	Universal Securities	96
65	Weltron Co., Inc.	72
74	John Wiley & Sons, Inc.	77
62	Workman Electronic Prods., Inc.	71

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109	Babylon Electronics
108	Circuit Specialists
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105	Kimberly Research
	Lakeside Industries
104	John Meshna Jr. Electronics
106	Park Electronic Products
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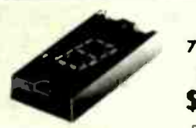

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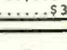

100 for	$1.00	200 for	$1.80
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Each additional 1000 pins...$7.50

TTL DIGITAL IC'S

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7401	29¢	7451	29¢	74151	$1.40
7402	29¢	7453	29¢	74153	$2.15
7403	29¢	7454	29¢	74154	$2.50
7404	30¢	7460	29¢	74155	$1.75
7405	30¢	7470	65¢	74156	$1.75
7406	70¢	7472	60¢	74157	$1.95
7407	70¢	7473	60¢	74158	$1.95
7408	30¢	7474	60¢	74160	$2.00
7409	30¢	7475	$1.20	74161	$2.00
7410	29¢	7476	65¢	74162	$2.00
7411	30¢	7480	90¢	74163	$2.00
7413	75¢	7483	$1.55	74164	$1.85
7416	60¢	7484	$2.25	74165	$1.85
7417	60¢	7485	$3.25	74166	$1.85
7420	29¢	7486	80¢	74167	$3.50
7421	30¢	7489	$6.00	74176	$1.35
7423	75¢	7490	$1.20	74177	$1.35
7426	50¢	7491	$1.35	74180	$1.50
7430	29¢	7492	$1.20	74181	$6.00
7432	99¢	7493	$1.20	74182	$1.70
7437	70¢	7494	$1.45	74190	$3.50
7438	70¢	7495	$1.45	74192	$2.20
7440	29¢	7496	$1.40	74193	$2.20
7441	$1.35	7497	$4.00	74196	$1.75
7442	$1.30	74100	$1.95	74197	$1.75
7443	$1.35	74107	85¢	74198	$2.75
7444	$1.35	74121	80¢	74199	$2.75
7445	$1.75	74122	90¢		
7446	$1.65	74123	$1.40	1N270	15¢
7447	$1.65	74141	$1.50	1N751A	30¢
7448	$1.55	74145	$1.50	1N4002	15¢

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NE526	$2.75
NE531	$3.50
NE533	$3.50
NE536	$6.50
NE540	$2.75
SE540	$4.00
NE550	$1.35
NE560	$4.75
NE561	$4.75
NE562	$4.75
NE565	$4.75
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N5556	$2.00
N5558	$1.50
N5595	$3.50
N5596	$2.00
709	50¢
710	60¢
711	70¢
723	$1.20
741	65¢
748	75¢
SN7511	$2.25
SN75107	2.45
1N4154	15¢
2N3860	25¢
1N914	10¢

All IC's are supplied in 8-, 14-, 16-, or 24-pin plastic DIP (Dual-in-Line) package, except for NE536, NE537, NE540, and SE540 which come in TO-5 package.

We give free data sheets upon request, so ask for those data sheets that you NEED, even for those IC's that you are not buying! On orders over $50.00, we'll send you a new 250-page COMPLETE TTL IC data book FREE. Or you may obtain a new 200-page LINEAR data & application book instead. Orders over $100.00 receive both books. Orders over $150.00 will receive a complete LIBRARY of 7 DIGITAL & LINEAR data & application books totaling 1000 pages FREE. PLEASE NOTE: Data books will be shipped separate from your order. Allow three weeks for delivery.

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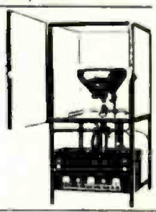

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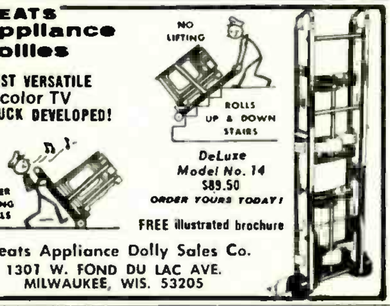

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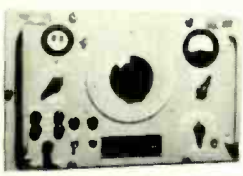

Frequency range 20 to 200,000 CPS in four bands, output imp. 1000 ohms, amplitudes continuous variable .0-10 volts; Freq. response 20 CPS to 150,000 CPS; approx. ±1 DB; Freq. accuracy ±6%, stability ±2%; Hum 60 DB below rated output; attenuator accuracy 3% except 10 Micro. V +2 or —3 Microvolts. Power input 115 V. 50-1600 cyc. Output 100 MW. With nine tubes, calibrated tuning dial, freq. range switch, output level cont. output level attenuator, signal input and ouput jack, output level meter, vibrating reed-type meter used as accuracy check of the osc. calibration. Size: 18¾ x 10 x 12¾". Shpg. Wt.: 75 lbs.

Prices: Used, serviceable: $75.00 Checked: $85.00

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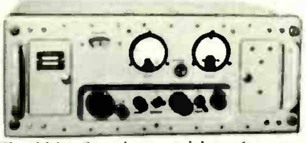

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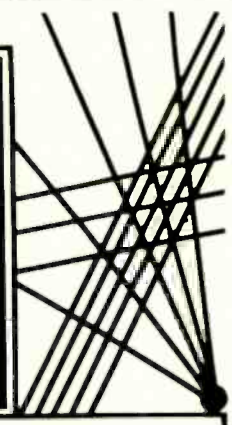

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Op-amp package 10-741's, data sheet and application notes only $7.00

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74193	up/down binary counter	2.00
74195	univ. 4 bit SR	1.40
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8281	preset binary counter	1.40
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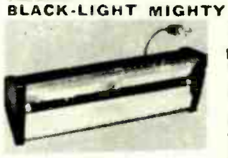

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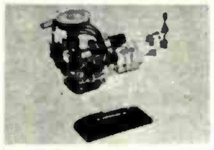

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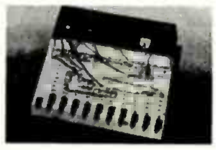

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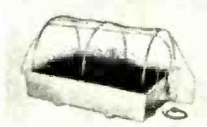

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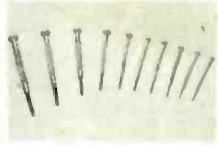
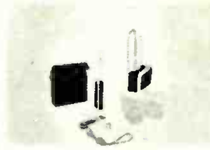
TREMENDOUS WAR SURPLUS VALUE in excellent condition. Mark 57, Mod 0, 1-meter Erect Image Coincidence Rangefinder—ranges from 100-10,000 yds., accurate to 12-arc seconds. Optics & mount alone worth more than price. Fabulous precision optical instrument, 51" x 7" dia. Yellow, dark neutral, polarizing & clear ray glass filters. Non-magnetic constr.; 2 bearing mounting surfaces (1⅛ x 5¾" O.D. & 1⅛ x 5½" O.D.). Storage box instrs.
No. 85,208EH (Shppg. WT.-200-lbs.) .. $450.00 F.O.B.
$1,250 HAND HELD 50 CM MODEL
No. 85,213EH (Shppg. Wt.-11-lbs.) ... $600.00 F.O.B.

PRECISION MICRO SCREWDRIVERS



Set of 10 top quality professional screwdrivers with blade widths ranging from 0.6 to 3.8mm! For fine precision work, intricate assembly. Invaluable for hobbyists, camera, instrument and electronics repairs, tool and watchmakers, jewelers. Handy swivel tops, non-slip knurled shafts, tempered steel blades. Width of blade clearly marked on each screwdriver. Convenient see-through plastic pouch.
Stock No. 41,671EH .... $4.00 Ppd.

ELECTRONIC REMOTE CONTROL



Trigger still or movie cameras, start/stop tape recorder, alarm, houselights . . . up to 400 ft. away. Ideal unit for selfportraits, candids, dangerous action shots, or when 2 cameras are used. No wires. Just attach transmitter to camera, screw in cable release and shoot! (Not for elec.-eye cameras but operates on manual setting). Receiver, transmitter, cable release; POLAROID ADAPTER, elec. adapter cord & instrs. Req. 1 9v trans. 4 AA batt (not incl.).
Stock No. 1620EH .... $51.50 Ppd.

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