60c ■ DEC. 1968

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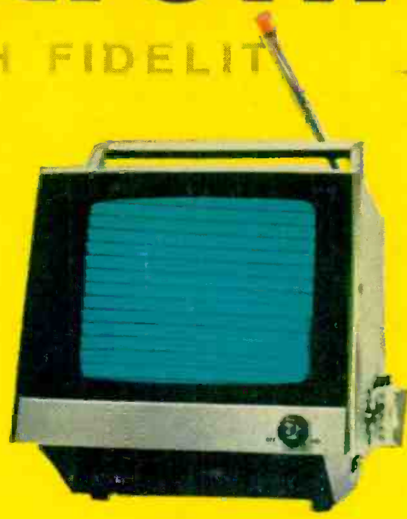
It's easy to fix Solid-State TV

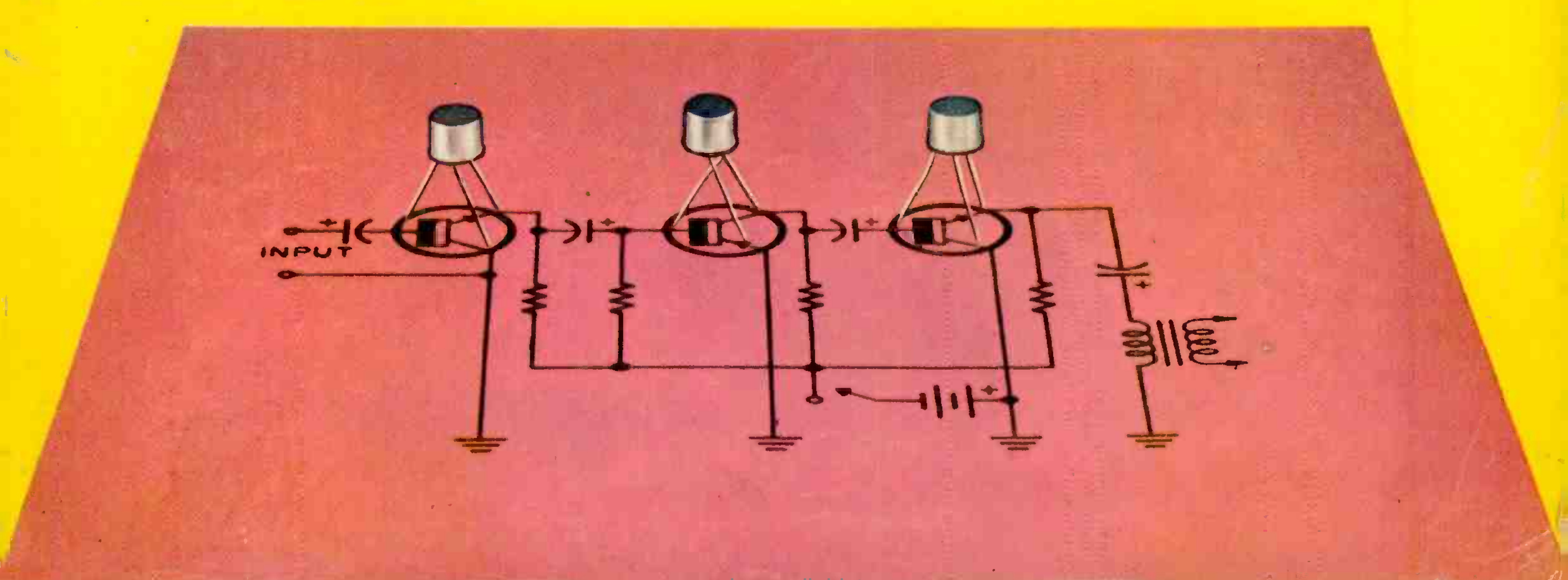


BUILD:

Stereo headset

Control center

ABC's of Transistors



LOOKING AHEAD

By DAVID LACHENBRUCH
CONTRIBUTING EDITOR

Mike with ears

The gadget in the photo may look a bit eerie, but it's described by its developers as the next step after stereo. Called Environ-Ears, it's basically a two-microphone assembly with an "integrated acoustical labyrinth that duplicates the localization and noise-reducing functions of the human ear." Developed by Listening, Inc., Arlington, Mass., and used in Navy-backed research, Environ-Ears resembles two human ears mounted at opposite ends of a rod.

It is claimed to be ideally suited for recreating the actual sounds at the original recording session—for everything from business conferences to symphonies—since it simulates in playback the actual physical positions of the sounds recorded. Used with a conventional stereo recorder, its developers say it permits the listener to differentiate between sounds from below, in front of, or behind the microphone, and eliminates reverberation and extraneous environmental noises, much as human ears do. It's currently priced at a rather steep $950, but lower-priced versions could be forthcoming.

FM on the rise

There's no let up in sight for the groundswell in the popularity of FM radio. In the first half of this year, 44 percent of the table, portable and clock radios purchased in the US contained FM, as compared with only 35 percent one year earlier. It now seems entirely possible that the majority of radios sold in the coming year will contain FM tuners.

Interestingly, the overwhelming majority of FM radios sold here—more than 86 percent in the first six months of 1968—were imported, mostly from Japan. Even FM radios carrying the trademarks of American radio manufacturers have a better than 50-50 chance of coming from abroad.

In the automotive market, FM is moving more slowly. For January through June 1968, a little less than 10 percent of all car radios sold as original equipment or after-market "hang-ons" could tune the FM band. This represents a small increase over FM's 8.4 percent penetration of the car radio field in the first half of 1967.

Cassettes—how hi the fi?

Can a high-fidelity enthusiast find happiness with a tape that moves at 1⅞ inches per second? Apparently some of the major component audio equipment manufacturers think he can and will, in the latest chapter of the amazing saga of the tiny, Dutch-born two-reel cassette. Although its original acceptance came in a battery-operated, voice-recorder format, such audiophile manufacturers as Ampex, Fisher, Harman-Kardon and H. H. Scott have now embraced the cassette recorder.

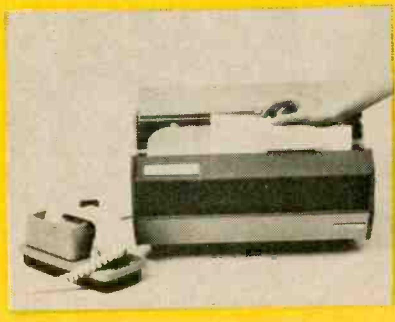
Unquestionably, there's a trade off between fidelity and convenience in the use of the cassette, whose response is around 20-12,000 Hz. But many manufacturers feel this won't always be the case. The very success of the cassette is spurring an all out effort to extend its characteristics into the high fidelity range, while improving on its convenience as a music playback medium. Cassettes using high-density tape, such as DuPont's Crolyn, will soon be available. High-quality precision recorder mechanisms have already been developed to reduce flutter by maintaining very constant speed. One manufacturer, TEAC of Japan, soon will offer a two-speed cassette recorder, which will include a double-fast 3¾ ips for high-fidelity recording.

For greater convenience in music playback, several manufacturers are developing automatic-reverse cassette recorders and players. And there's a race on for an endless-loop cassette that never has to be rewound. Philips of Holland and Sony and TDK of Japan are among the leading entries in this effort.

Mail by phone

The increasing availability of low-cost facsimile systems which can send graphic material over regular telephone lines without the need for special treated paper or other supplies is giving birth to a new public "mail-by-phone" industry.

At least four "networks" of public facsimile stations are now in operation, under the names of Docu-Trans, Insta-Fax, Transceiver Corporation and Tele-Trans. They have set up shop in major US cities to offer long-distance document transmission facilities to the general public. Charges generally are around $2.50 to $3.00 per standard 8½-by-11-inch page—plus the regular long-distance telephone charge for the 6 minutes required to send a page of copy.



All of the networks currently use a facsimile system developed by the Magnavox Company (photo), which is available on lease from the Xerox Corporation under the name of Xerox Telecopier or from Magnavox under the Magnafax name. A single machine is used for both transmission and reception. For transmission, the material to be sent is affixed to a revolving drum and the telephone handset placed in a special cradle. A photocell scanner converts the light and dark material on the page into audible signals. At the receiving end, a standard carbon-paper set (a sheet of carbon attached to a piece of manifold paper) is placed on the drum, and a stylus recreates the original copy. **R-E**

Radio-Electronics

December 1968 • Over 60 Years of Electronics Publishing

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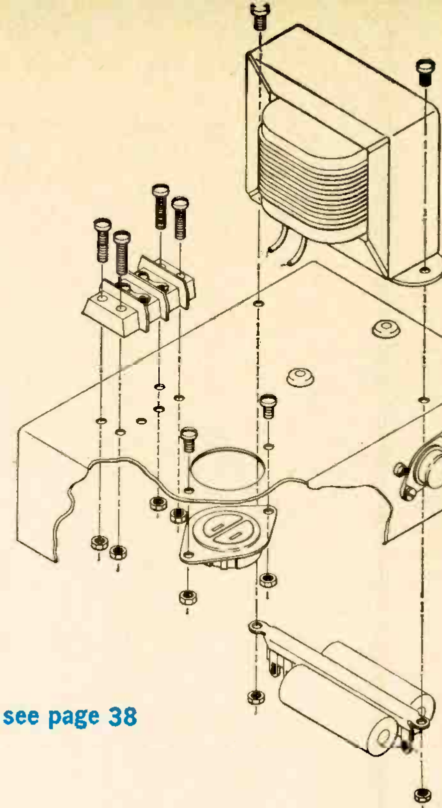
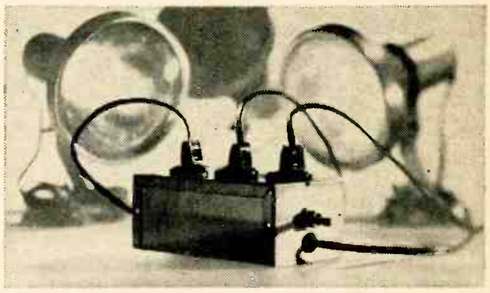
DEPARTMENTS

INDEX p. 68



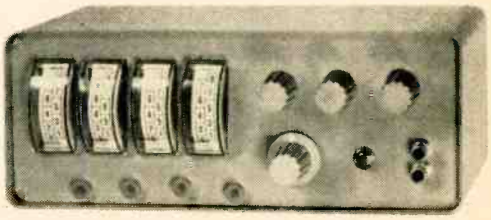
see page 38

Portable ac outlet delivers up to 50 watts. Just hook it up to a 12-volt battery. Simplified exploded diagrams make it easy to build.



Dancing lights this Christmas? It's a cinch with this tricky SCR circuit to automatically vary the intensity of outdoor lighting.

see page 50



You can make 9 digital instruments. A large assortment of equipment and the necessary building techniques are shown.

see page 57

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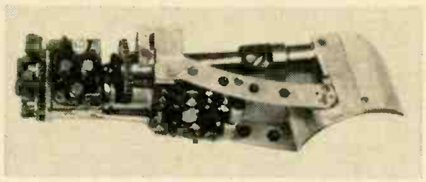
NEWS BRIEFS

NEW ARM WORKS WITH THOUGHT SIGNALS

Artificial arm is willed into operation, producing natural arm-like movements.

A new electronically controlled artificial arm that promises greatly increased dexterity for amputees has been developed. The system uses a solid-state, sensor–amplifier package and a unique feedback circuit that enables operators to sense how much weight they are supporting.

Amputees, by willing a non-existent arm into action, contract



Amplifier circuits and the drive motor.

stump muscles that generate millivolt-level signals. Sensors in the system detect and amplify these signals, and the operator can apply varying degrees of force by "thinking" the amount of effort needed.

Developers believe that with a little experience amputees can use the new arm with no more conscious thought than is needed for a normal one. Similar systems under consideration may aid some 7000 Thalidomide children with above-elbow stumps.

The 2-lb arm is powered by a battery that can be worn around the waist. Although it is not available for general use, the arm could be mass-produced for less than $1000 each. The mechanism was developed in a joint project by MIT, Harvard, Massachusetts General Hospital and Liberty Mutual Insurance.

DIM LIGHT TV CAMERAS

Two highly sensitive TV-camera tubes have been developed independently by Bell Telephone Labs and Westinghouse. The new devices have potential applications for see-in-the-dark surveillance TV and Picturephones that permit people to see each other as they talk. The Westinghouse system is an offshoot of similar devices used in military and space applications ("Starlight Scope Sees in the Dark," August 1968). The camera tube uses the principle of secondary electron conduction, which "amplifies" light by accelerating electrons from a photocathode onto a sensitive target. The camera system shown here weighs only 12 lbs, draws 17 watts and can provide clear TV pictures under moonlight conditions.

Bell revealed a camera tube they plan to use in their Picturephone. A

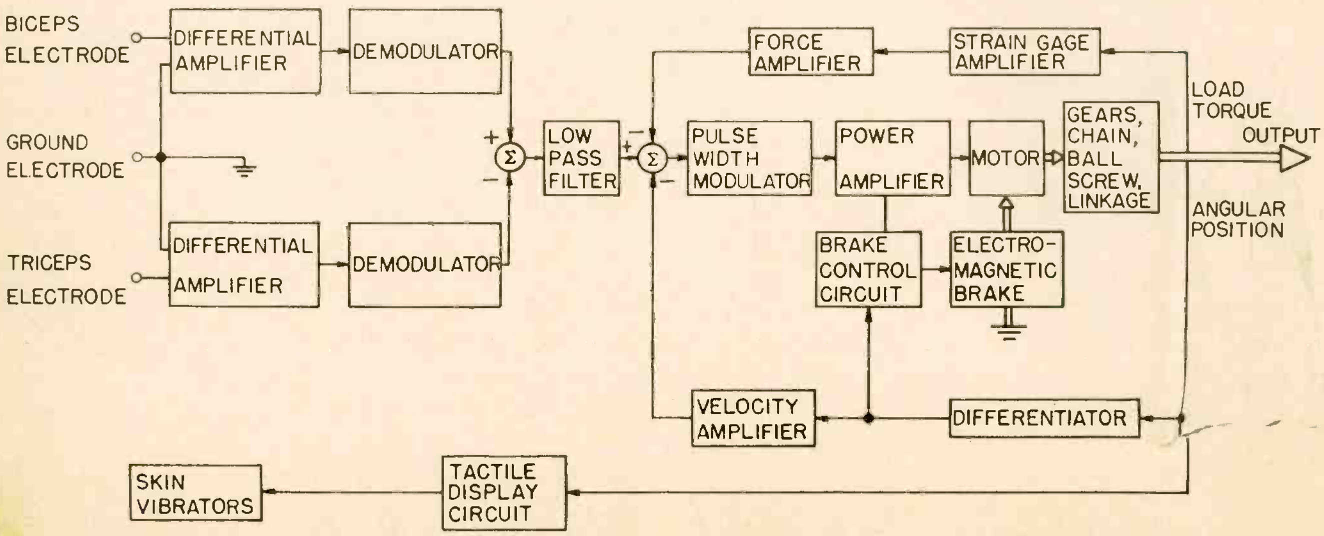


Diagram shows how signals are detected by sensors and amplified to operate motors.

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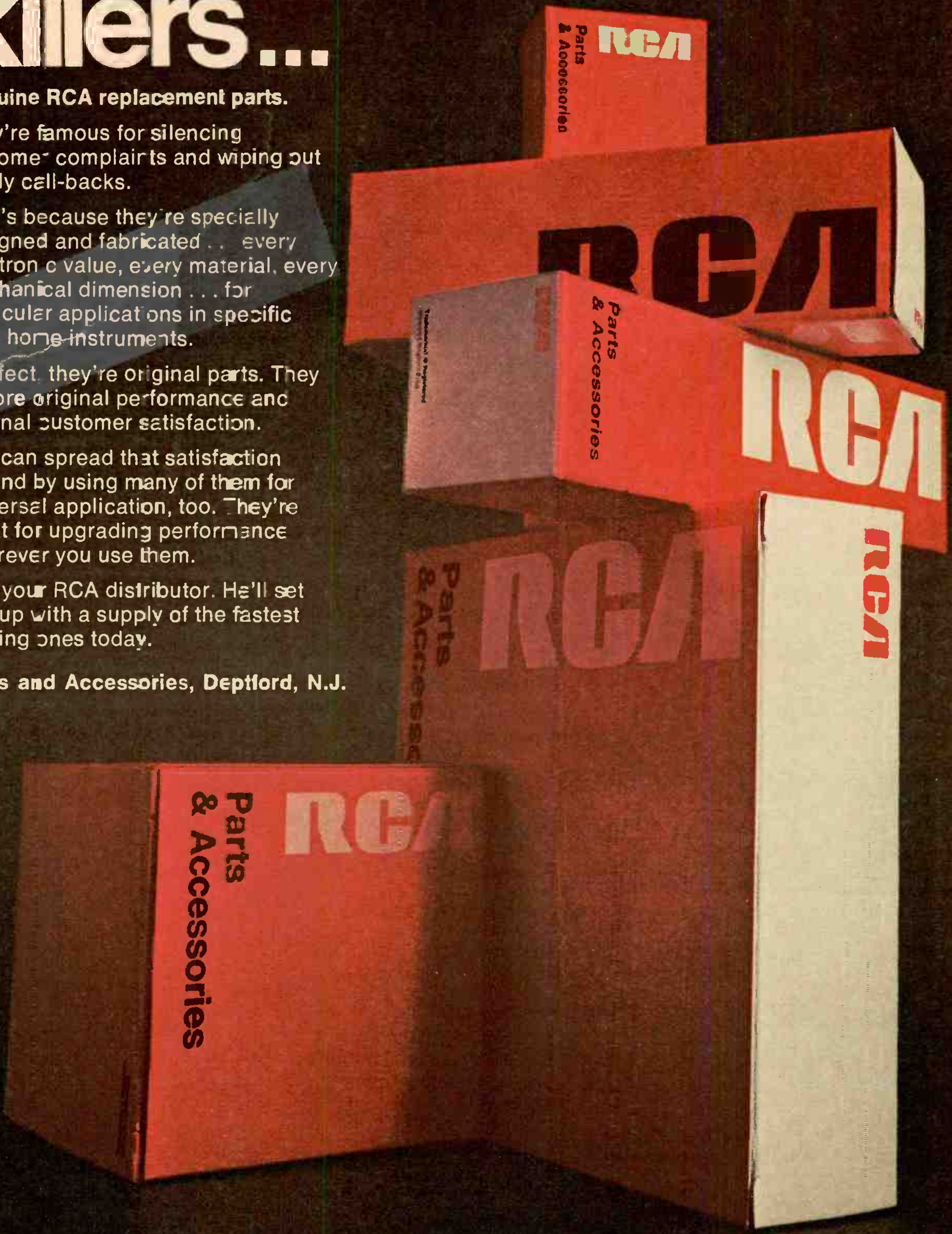

penny-size, silicon-water target enables the tube to produce images without illuminating the subject with floodlights. Light energy is converted into electrical energy by some 500,000 photodiodes on one side of the wafer. The new tube is the same size as standard vidicon tubes (1" in diameter, 7" long), but Bell predicts a lifetime of 20 years compared to the vidicon's few thousand hours.

MIXING 'MEMORY' CRYSTALS

Two different types of liquid crystal material are combined by an RCA scientist to form a quasi-emulsion that can "memorize" its reflective "on" condition after power is removed. The clear solution becomes

reflectively opaque when subjected to an electric field. ("Liquid Crystal Displays," News Briefs, August 1968). A storage cell in the "on" state is in the foreground. The novel mixture, when placed between transparent flat "windows", is expected to be useful for graphic displays that are changed only periodically.

SPACE GUN READIED

Earth will be "zapped" with a gun from outer space this year if all goes according to plan. The "attack." however, will be friendly and planned *(continued on page 12)*

Radio-Electronics

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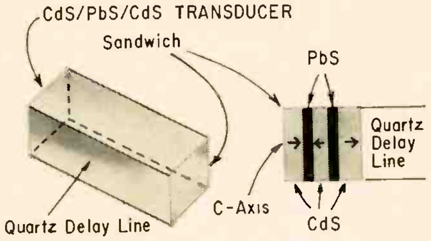
NEWS BRIEFS

(continued from page 6)

by NASA scientists to determine if man can create artificial aurora light formations in the atmosphere. This electron accelerator system will be carried 120–180 miles into space by an Aerobee rocket to fire a stream of charged particles toward the atmosphere. The gun's reed-switching mechanism, which fits an 8"-deep gun platform assembly, is in the foreground. Device was built by Ion Physics Corp.

'FLIPPED' CRYSTAL DELAY LINE

A technique of "flipping" alternate layers of thin-film piezoelectric transducers makes possible acoustic delay lines with four times the power range and twice the frequency range of earlier transducer crystals. The devices convert electrical signals into

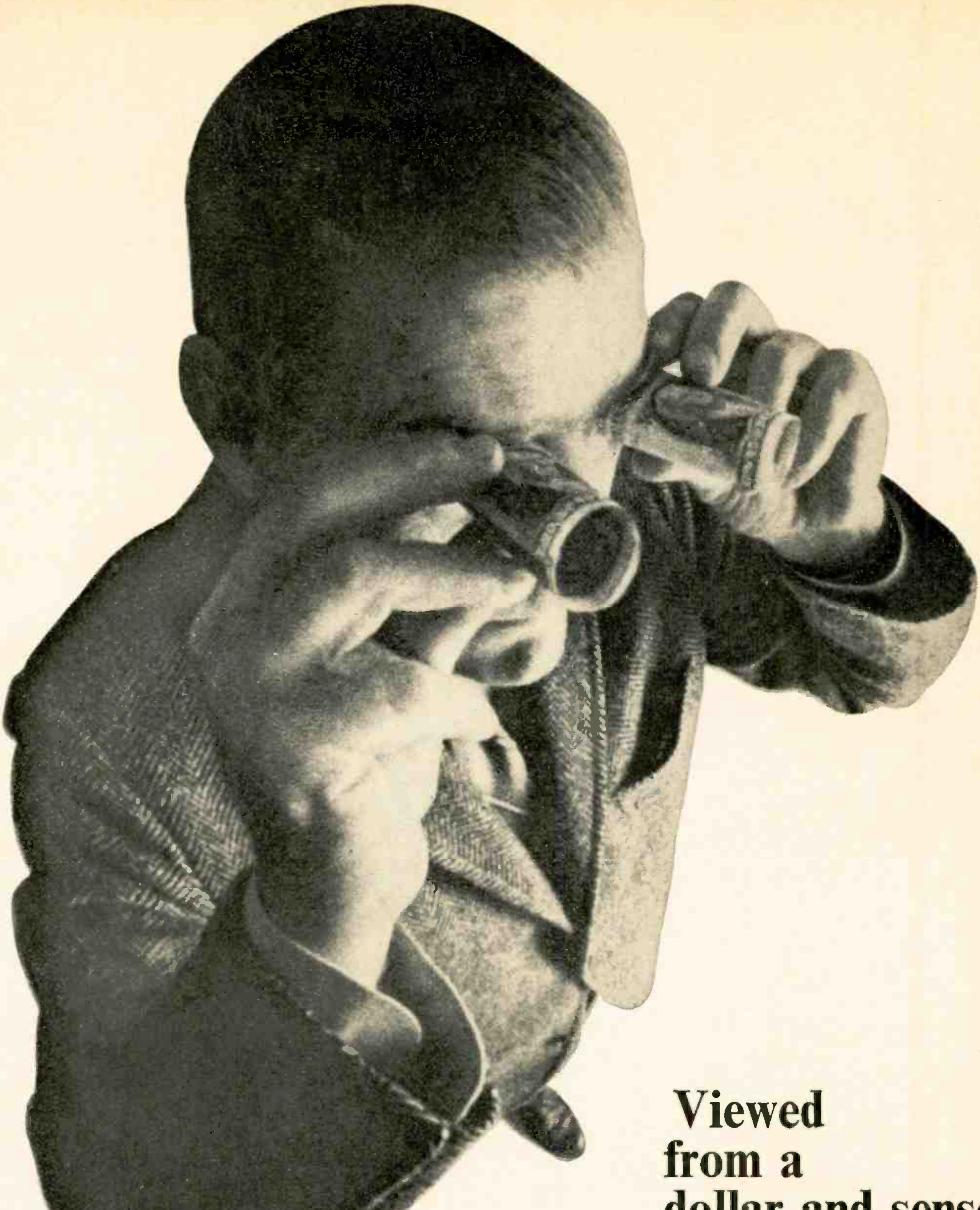


CdS = Cadmium Sulfide, PbS = Lead Sulfide.

sound waves for an interval, then convert the signal back into electricity. The transducer sandwiches consist of up to five layers of crystalline piezoelectric cadmium sulfide separated by extremely thin crystalline layers of lead sulphide. The PbS layers, Westinghouse scientist Dr. John de Klerk discovered, reverse the transduction direction of successive CdS layers. When an electric field is applied across the crystal, the reversed layers assure correct acoustical phasing.

TELEVISION FROM SPACE

India is planning a pilot project for 1971 in which TV broadcasts from a satellite will be received directly by 10,000 community receivers and rebroadcast to three times as many sets by vhf stations. Plans call for eventually broadcasting directly to all of the country's villages and cities. NASA is cooperating with the Indian Government, and will provide communication channels for Indian use aboard a synchronous satellite to be orbited above the Indian Ocean in 1971. **R-E**



Viewed from a dollar and sense standpoint

You can't get a better buy for your new hi-fi system than a Shure cartridge, whether it's the renowned "Super Track" V-15 Type II at $67.50 or the *new* M91E Easy-Mount "Hi-Track" at $49.95, made in the tradition of all fine Shure cartridges. If you're new to hi-fi, benefit from the published opinions of experts the world over: the **Shure V-15 Type II** Super Track makes a decidedly hearable difference. If you want to spend less, the M91E is right for you. You can always "trade-up" to a V-15 Type II at a later date. Shure Brothers, Inc., 222 Hartrey Avenue, Evanston, Illinois 60204.

NEW! M91E Hi-Track Elliptical Cartridge with optimized design parameters for trackability second only to the incomparable V-15 Type II. Bi-radial .0002" x .0007" diamond stylus. 20-20,000 Hz. Channel Separation: more than 25 db @ 1 KHz. Tracking force range ¾ to 1½ grams. Trackability specifications @ 1 gram: 20 cm/sec @ 400 Hz.; 28 cm/sec @ 1 KHz.; 25 cm/sec @ 5 KHz.; 18 cm/sec @ 10 KHz. $49.95.

Circle 15 on reader's service card

Correspondence

I WANT AN INDEX

Just looked at the December 1967 index and from what I saw, I would very much like you to continue with your annual indexes.

In earlier indexes (1950's) the big problem was that you had to look under almost all the headings to find what you were after and even then you might only get part of what was covered in that year since the Correspondence, Noteworthy Circuits, and Try This One columns usually weren't listed.

One idea which I would like to see you incorporate is to publish the yearly index and also an index covering a period of five or ten years.

KEITH MUDDLE
Stratford, Ont., Canada

We'll compromise. There will be an index in the December 1968 issue. But it will be shortened somewhat. It will list all articles and monthly columns. However, it will not break down each department in detail. The space we save will be used to present you with an extra article.

NEW RESISTANCE BRIDGE

Recently the United States Patent Office granted me a patent on a new resistance measuring bridge.

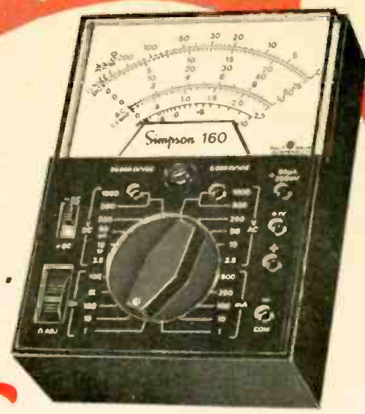
To measure the resistance of an ordinary carbon resistor, we normally use an ohmmeter. But an ohmmeter is unreliable when measuring the resistance of a ½% wirewound resistor. To measure the resistance of such precision wirewound resistors we use a Wheatstone bridge.

But resistance can be measured to a remarkable degree of perfection. Many instruments have been made that depend on resistance change to measure temperature, chemical composition, strain, etc. To measure the temperature from the planet Mars requires something more accurate than a Wheatstone bridge. The Bucher bridge, my invention will do it.

The Bucher bridge will measure as accurately one mile from the unknown resistor as it will three inches for her...

2 FREE PAIRS
of famous
KAYSER®
gloves!

for him...



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Wouldn't you like your wife to give you a 160 VOM this Christmas?

Right now at participating Simpson distributors . . . the 160 Christmas package. Your wife buys the 160 Handi-VOM® for you—and receives a bonus for herself. Two *free* pairs of famous Kayser gloves!

Kayser, as your wife knows, is the quality fashion glove sold in fine stores. She'll receive a black and a white pair, in stretch nylon, free with the Simpson 160.

And you will get the one hand-size VOM with full-size VOM accuracy and sensitivity. Its virtually friction-free Taut Band movement is protected by a varistor from even 200,000% overloads. The five resistance ranges, combined with low millivolt and microvolt ranges, are just what's needed for work on today's solid-state circuits.

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Fig. I

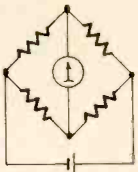
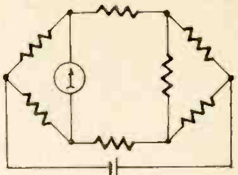


Fig. 2



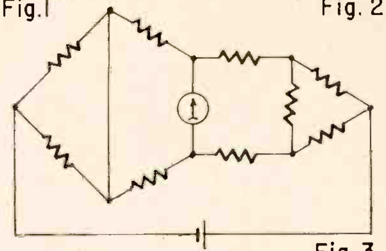


Fig. 3

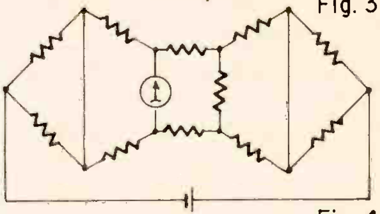


Fig. 4

from the same unknown resistor.

Fig. 1 shows a conventional Wheatstone bridge. Figs. 2, 3 and 4 are forms of the Bucher bridge. Fig. 2 is the hexagon bridge. Fig. 3 is the octagon bridge. Fig. 4 is the decagon bridge.

DR. J. F. BUCHER
2980 River Road
Eugene, Ore.

Hate to say it, Doctor, but you're a tease. You've got to tell us more. How does the bridge work? What's your patent number? How do you make those long-distance measurements? Put it all together and you may end up with an article R-E readers would find fascinating.

EAVESDROPPING DROPOUT

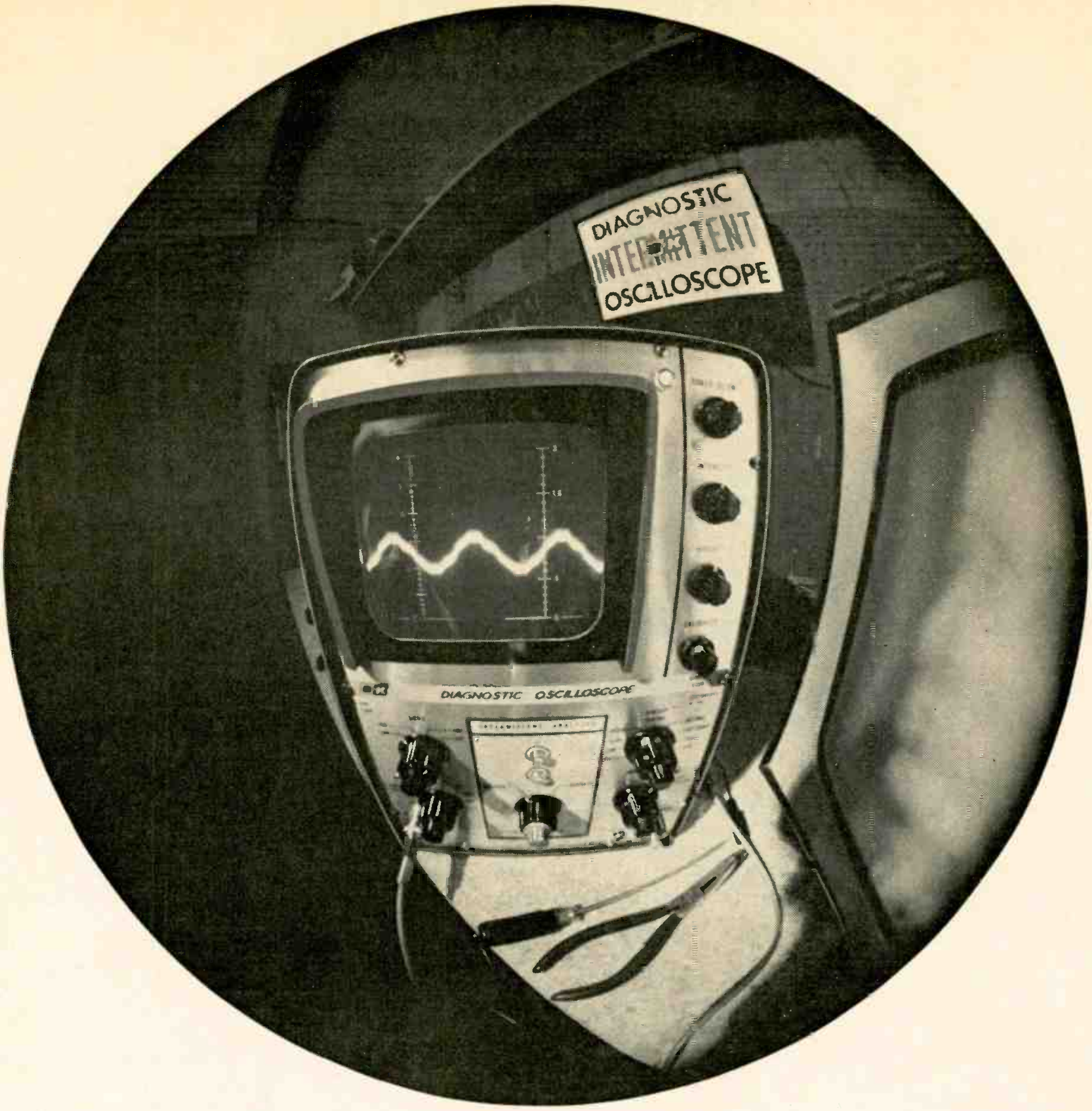
Len Buckwalter's article, "Eavesdrop on Aircraft, Fire & Police" was interesting (August 1968). But like all other articles on the subject, he neglected the 450–470-MHz band.

In Fig. 1 the band is listed and that's about it. Not a word is mentioned about converters or receivers.

A few converters are available for the uhf band. They are not easy to locate, but do exist. The Ameco model CUT is probably the best on the market. Olsen sells one called the Clark 450. And the Electra Corp. makes two units called the Little Tiger and the Eavesdropper Jr.

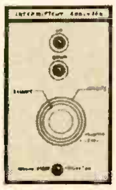
KEN GREENBERG
Chicago, Ill.

Ok, Ken, you've filled that gap yourself. Thanks for the comments. But until 450–470-MHz gear is readily available at reasonable prices, many readers cannot get it. **R-E**



Another benchwarmer?

Not this one. Our new B&K Diagnostic Oscilloscope is more than re-engineering of an old model to keep pace with TV technology. It is instead a basic departure from all other oscilloscopes. A departure that has simplified a complex instrument to make it easier for you to use. But there's something else.



What this oscilloscope has is exclusive. An Intermittent Analyzer with electronic memory—and optional remote Audio/Visual Alarm.

With it, the elusive intermittent conditions that make so many TV sets tough dogs can now be detected and identified in your absence. Preset one control. When the faulty stage is detected, you'll know about it as soon as you come back from service calls. Then run the scope overnight to check another set for an intermittent condition.

All this adds up to greater shop efficiency, more time for profit-making service calls and a lot more mileage out of a very fine diagnostic oscilloscope.

An oscilloscope that shows vector patterns exactly as specified by color TV manufacturers. (All vectorscope inputs and controls are conveniently located on the front panel.) Also allows you to read peak-to-peak voltages in all ranges on a double-scale calibrated screen—just by turning a switch. (As the range is selected, the appropriate scale lights automatically.)

Automatic synchronization locks in all patterns at any signal level or frequency. There are also fewer controls and these are positioned for easier operation.

Give our Diagnostic Oscilloscope some thought. It's worth it not to be sidelined with a benchwarmer. See your B&K Distributor or drop us a note for detailed literature on Model 1450 and our full-line test equipment catalog, AP-24.

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Circle 19 on reader's service card

Two more examples of how RCA Institutes provides up-to-the-minute Home Training in all phases of electronics:

NEW CATV LESSONS

The demand is heavy for technicians in the booming field of CATV (Community Antenna Television Systems).

CATV was initially used to make it possible for large numbers of television receiver users to get good reception in remote areas through the use of a common antenna. It now brings to more people more programs than are available from local stations. It also improves reception where multipath signal transmission exists.

RCA Institutes includes two comprehensive lessons, covering the practical phases of CATV systems and servicing in Television Servicing and Communications courses and programs at no additional total tuition cost. Get in on the ground floor of this rewarding and expanding field. Send for full information today!

&

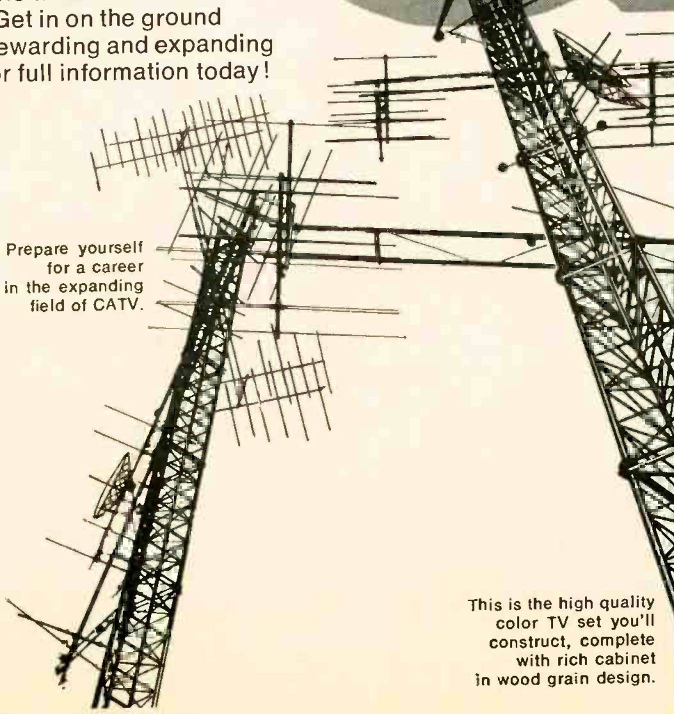
NEW COLOR TV KIT

To make courses even more practical and to better prepare you for a more rewarding future, RCA Institutes now includes an exciting Color TV Kit in both the beginner's program and the advanced course in color TV servicing. The cost of the kit is included in the tuition—nothing extra to pay. You also get five construction/experiment manuals plus a comprehensive service manual.

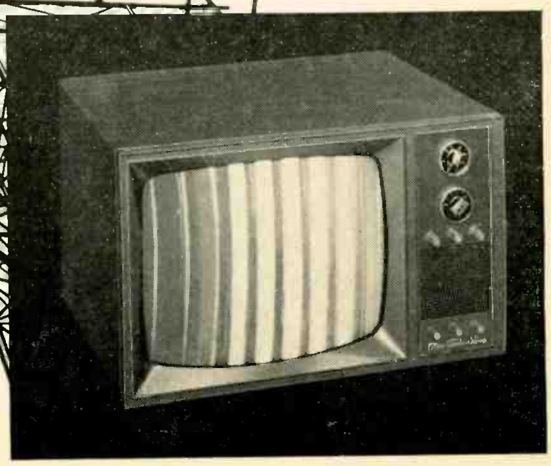
You'll receive all the materials and components to perform over 50 information-packed experiments. When you finish you'll have constructed an 18" (measured diagonally) high quality, color TV set, complete with rich cabinet in wood grain design.

Get all the details on RCA Institutes' valuable new Color TV Kit!

SEND THE ATTACHED CARD TODAY!



Prepare yourself for a career in the expanding field of CATV.



This is the high quality color TV set you'll construct, complete with rich cabinet in wood grain design.

Learn electronics at home faster, easier, almost automatically—with RCA AUTOTEXT

Are you just a beginner with an interest in the exciting field of electronics? Or, are you already earning a living in electronics and want to brush-up or expand your knowledge in a more rewarding field of electronics? In either case, AUTOTEXT, RCA Institutes' own method of Home Training will help you learn electronics more quickly and with less effort, even if you've had trouble with conventional learning methods in the past.

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In the Shop . . . With Jack

By **JACK DARR**
SERVICE EDITOR

SIGNAL TRACING COLOR TV

THERE ARE A COUPLE OF COLOR TV circuits that we ought to get straightened out. It'll make things easier, when you run into color trouble—all colors or any one color that isn't what it ought to be.

Check the picture tube first, of course, and try new tubes in the demodulators and bandpass amplifiers. After that, if you've still got the same trouble, try signal tracing.

The signal to check comes from the bandpass amplifier and goes through the three demodulators to the picture-tube grids. Put a color-bar signal into the set and follow it with—you guessed it—a scope. Incidentally, a wide-band scope is not absolutely essential for this, though it's nice. You can use a narrow-band scope, but a low-capacitance probe *is* necessary. What you follow is practically an *audio* waveform. The 10 color bars are basically a waveform with a fundamental of about 160 kHz. (Each "bar" is a pulse at 157.5 kHz.)

Take the red signal, for instance. Look at it on the grid of the red (R–Y) amplifier (Fig. 1). This odd-looking pattern means that the red gun *conducts* whenever the peaks of the "bar" signal drop *below* the imaginary center line of the waveform. Each pip is one bar. On that basis, the third bar from the left should be the brightest—pure red. If you kill the blue and green guns, that's what you'd see.

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.

You're on the grid, so the *negative* signal peaks make the tube's plate current drop and the plate voltage rise. You get a *positive* voltage peak on the plate. Since this is dc-coupled to the red CRT grid, it makes that gun conduct more, causing a *brighter* red bar.

The plate waveform should look exactly like the grid waveform but inverted (Fig. 2). Gain? Easy to check. First read the p-p amplitude of the *grid* signal. Then read the plate waveform the same way. The normal p-p amplitudes are usually on the schematic, but even if they aren't, you can tell from the *ratio* between the two.

In a Motorola 908 chassis, for instance, there's about 13 volts p-p on

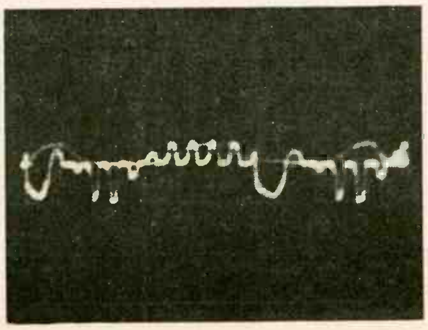

Fig. 1—Color-bar signal on R—Y grid. Each pip is one color generator bar.

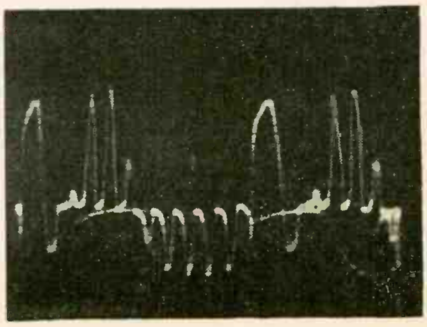

Fig. 2—Inverted plate waveform. Check gain by comparing with the grid signal.

Scott's new LR-88 receiver takes the !#@*☆ out of kit building

Building a kit used to be something you couldn't do with ladies and children present, but Scott's new LR-88 AM/FM stereo receiver kit has changed all that. First, there's the instruction manual. In clear and simple language, it leads you, step-by-step, through every stage of the assembly process. And each stage is illustrated . . . full-size, full-color. Next, there's Scott's ingenious new Kit-Pak®. The parts for each assembly stage are in individual compartments, keyed to the instructions. All wires are color-coded, and pre-cut and pre-stripped to the proper sizes. Difficult or critical sections are pre-wired, pre-aligned, pre-tested, and factory-mounted on printed circuit boards. Is soldering your bugaboo? Scott has provided push-on solderless connectors for the hard-to-get-at spots.

About thirty painless hours after you've started, you've completed one great receiver. The LR-88 is the 100-Watt kit brother to Scott's finest factory-wired beauties. It includes the famous Scott silverplated Field Effect Transistor front end, Integrated Circuit IF strip, all-silicon output circuitry . . . in fact, all the goodies that would cost you over a hundred dollars more if Scott did all the assembling. Performance? Just check the specs below . . . and you'll be amazed at how great a receiver sounds after you've built it yourself. Treat yourself to a weekend of fun and years of enjoyment . . . see the Scott LR-88 at your dealer's today.

LR-88 Control Features: Dual Bass and Treble; Loudness; Balance; Volume compensation; Tape monitor; Mono/stereo control; Noise filter; Interstation muting; Dual speaker switches; Stereo microphone inputs; Front panel headphone output; Input selector; Signal strength meter; Zero-center meter; Stereo threshold control; Remote speaker mono/stereo control; Tuning control; Stereo indicator light.

LR-88 Specifications: Music Power rating (IHF), 100 Watts @ 4 Ohms; Usable sensitivity, 2.0 μV; Harmonic distortion, 0.6%; Frequency response, 15-25,000 Hz $\pm$ 1.5 dB; Cross modulation rejection, 80 dB; Selectivity, 45 dB; Capture ratio, 2.5 dB; Signal/noise ratio, 65 dB; Price, $334.95.

Circle 100 on reader's service card

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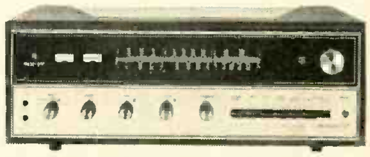

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generate

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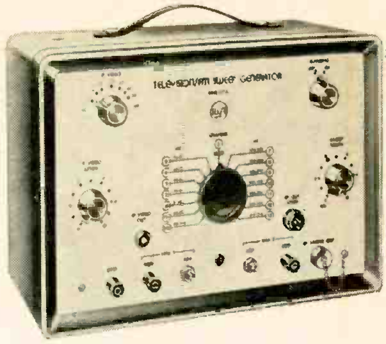

The RCA WR-69A Television/FM Sweep Generator is designed for lab, service, and production applications for sweep-frequency alignment of color and black and white TV receivers and broadcast FM receivers. It's also used to align VHF tuners, picture-and-sound IF amplifiers, video amplifiers and chrominance circuitry in color TV receivers. AND IT'S ONLY $295.00.*

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LOOK TO RCA FOR INSTRUMENTS TO TEST/MEASURE/VIEW/MONITOR/GENERATE

RCA

Circle 23 on reader's service card

the grid and 130 volts p-p on the plate, for a gain of 10. In a RCA CTC19, 10 volts grid, 100 volts plate, p-p, and so on.

The blue will show about the same gain as the red. The green, however, will show the lowest p-p voltages of them all—usually *about* half the voltage of the other two. The relationship between grid and plate waveforms are the same.

What does this tell you? Well, if you think one color is weak, check the p-p amplitude of the bar signals in and out of the amplifier stage for that color. In circuits which do not use the separate red-, green-, blue-amplifier tubes, check the demodulator stages.

Phasing of color and burst signals is supposed to be very difficult. Why? If the "high bar" isn't in the right place for any given plate, *then* the phasing *is* off. If the No. 3 bar on the red plate is not "on top" or the No. 7 bar is high, this shows you the trouble.

You can correct it by retuning the reactance coil or making whatever adjustment is recommended in the service data for the particular circuit, while watching the waveform on the plate. The PHASING control makes the high bar "walk" along the waveform. So does the TINT control.

Here's a handy tint control test. Set the control in the center of its rotation, and check any of the plates for proper positioning of the high bar. If it's off, retune the phasing just a wee bit until it's right. Then check to see that the tint control will walk the high bar back and forth along the waveform. Normal movement ought to be at least one bar on either side of the correct position.

The COLOR control will vary the amplitude of the bars. Make sure that it is set at the specified position before making any p-p voltage readings in this circuit. You can also tell whether the color control is working as it should—just move it and watch bar height.

There you have it. If you use the right equipment in the right way, and interpret your results correctly, it's just as easy to follow the signal through these stages as it is in an audio amplifier. More on other circuits in this section next month. **R-E**

COMING NEXT MONTH

In January, Service Editor Jack Darr looks at some peculiar problems caused by faulty bandpass amplifier and burst circuits. What happens to scope patterns and color bars with weak burst or sync? How do you check interaction between the horizontal hold control and color sync?

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Computer Lingo—Today's

By MATTHEW MANDL
CONTRIBUTING EDITOR

DIGITAL COMPUTERS ARE BEING USED IN EVER-INCREASING numbers in business data processing, in industrial control and in scientific laboratories. They are vital to the military as well as for the guidance systems of space explorations. With this sharp upward trend in computer use, the demand for computer programers is at an all-time high. Estimates state that over 500,000 people are already engaged in some form of computer programing or operation, and another 250,000 will be needed within the next few years. And this is only in the United States.

A programer tells the computer of the particular problem or data to be processed, indicates the methods to be used and debugs faulty programs. He communicates with the computer by using the "language" the computer understands or a mathematically oriented or business-type "language," which is translated into the computer's basic language.

The binary code

Digital computer circuits operate in only two states: the diodes or transistors are either on or off. This assures accuracy and reliability because changes in transistor characteristics or other solid-state devices do not affect the two states unless the component shorts or opens. The two states represent digits 1 and 0—hence *digital* computer.

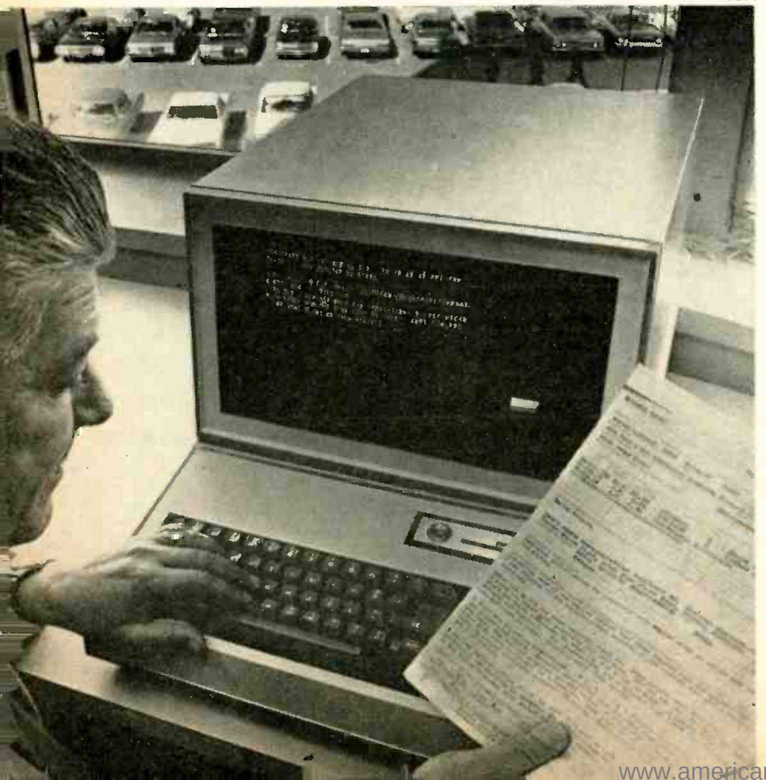
The use of only 0 and 1 requires a binary-type math with a base 2 instead of base 10, as in our ordinary numbering system. This binary code is the basic language of all digital computers. The following table shows binary numbers ranging in value up to 19:

Base 10 Value	Binary Representation	Base 10 Value	Binary Representation
0	00000	10	01010
1	00001	11	01011
2	00010	12	01100
3	00011	13	01101
4	00100	14	01110
5	00101	15	01111
6	00110	16	10000
7	00111	17	10001
8	01000	18	10010
9	01001	19	10011

Note the pattern of the binary sequence. In the right-hand column (first place) the 0's and 1's alternate; in the second column from the right the 0's and 1's are paired, while in the third column from the right the sequence down the column is four 0's, four 1's, etc. Subsequent columns follow the same pattern related to the squence 1, 2, 4, 8, 16, 32, 64, etc. Thus the fifth column from the right would have 16 0's, followed by 16 1's, etc. Knowing this principle enables you to expand the table easily.

The computer uses this binary code to identify storage locations, to identify instructions from the programer regarding how to process data and to make computations directly. Programs consist of a sequence of instructions, each accompanied by a storage address or explanatory number. Thus, the binary numbers 000100 and 000101 might mean, "add to the accumulator the number in storage location 5." The first binary number, 000100, is the "add" instruction and the second number the address of the number to be added. Another set, such as 101010 and 001000 may indicate a shift command. Thus, the binary 101010 instructs the computer to shift a number right, while the binary 001000 indicates an 8-place number shift.

Communicating with the computer via a Video Data Terminal, a Dodge claims supervisor in Philadelphia updates 50,000-mile warranty information in Chrysler's Detroit computer.
RCA



Octal code

Since the early days of digital computers, design engineers have strived to simplify the programing processes. Binary code becomes cumbersome when large numbers are involved, such as 101101 = 45, and 1000110 = 70. Thus, if 70 meant "subtract" we would have to convert it to its binary form. While there are various methods (including conversion tables) to find binary equivalents, much time is wasted. A simpler method is to group the binary digits into sets of three to form what is known as the *octal* code, as shown in the following examples:

101 101 = octal 55 (true value = 45)
001 110 = octal 16 (true value = 14)
101 001 011 = octal 513 (true value = 331)

Thus, all instructions and storage addresses can be in octal coding to expedite entries. Often the pushbuttons on the computer console are in groups of three to facilitate punching in numbers. If the computer binary address value of 331 is needed, you would be given octal 513 instead. By entering a binary 5, followed by a 1, and a 3, we have 101 001 011. The computer senses this as 101001011, which has the true value of 331.

New Machine Languages

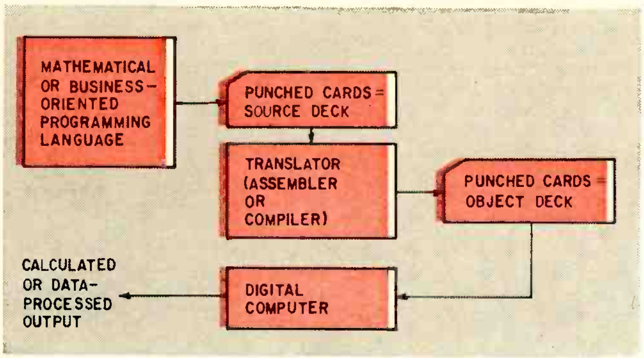


Fig. 1—Step sequence for translating mnemonic and SPS programs into binary language. Initial program is punched on cards or tape, which are read by compiler. The Computer then reads the object deck generated by the compiler.

Binary and octal codes permit us to enter programs at the computer console and examine numerical binary displays for checking the status of a program or process. It would be much more convenient, however, if we could do without the binary or octal numbers for the programing instructions.

Mnemonic or SPS language

We could save programing time if we could use the actual words *add, multiply and divide,* or abbreviations of them in our instructions to the computer. To do this we must use some sort of translating system to tell the computer that *add* means binary 100, and *shift* means binary 101010, etc. This is done by using capitalized abbreviations such as MPY for multiply, DIV for divide, etc. We could also use just A for add, S for subtract, M for multiply or D for divide. Such coding is also known as mnemonic (aid-to-memory) or SPS (symbolic program system). Thus, a simple program for adding of 5 + 3 would be:

```
LDA 50   (Put the 5 into accumulator)
ADD 51   (Add 3 to accumulator contents)
STP 00   (Stop computation)
```

In this example, the 5 would have had to be placed into storage location 50 and the 3 into 51. Also, the entire program would have been stored within the computer's memory earlier. Once the data and program are loaded, the program initiating button is depressed and the program run. Thus, the addresses in which the program itself is stored must also be indicated, as shown in the following example, where a print-out instruction is also included:

Program Address	Instruction	Data Address	Data	
00	LDA	50	5	(Load 5)
01	ADD	51	3	(Add 3)
02	PRT			(Print answer)
03	STP			(Stop computation)

The translating of mnemonic and SPS programs into machine (binary) language is done by assembler programs, which also select storage locations automatically. The program is punched on cards or paper tape and fed into the assembler. Another deck of cards is automatically punched containing the binary-language equivalent, and these cards are read by the computer. The initial stack of cards which contains the mnemonic program is called the *source deck,* and the resultant cards from the assembler program are called the *object deck.* These terms are also used for other language procedures, as shown in Fig. 1.

FORTRAN language

The word FORTRAN is an *acronym* formed by using the letters from the phrase: FORmula TRANslator. It is a mathematically oriented computer language that permits us to make math statements almost in the same form as the original equation. A special translator (called a *compiler*) selects appropriate storage locations and converts the FORTRAN into machine language to be processed by the computer.

Though programing math with FORTRAN is easier than with the mnemonic coding method (particularly for complex math equations), a number of rules must be observed. Among them are that all capital letters must be used, and that multiplication is expressed by an asterisk (*). Divide is shown by using the slash (/) and exponents are identified by a double asterisk (**). Thus, if we wanted to indicate the equation $(a - b)c^2$ it would appear as:

(A – B) * C ** 2

Similarly, the FORTRAN expression for the equation $y = \frac{(a + b)}{c}$ would be written as:

Y = (A + B)/C

Such statements are not, however, the complete program—but only the mathematical portion. The computer must be told what values (a, b, etc.) to read, in what manner, and what is to be printed out. The complete program would have the following:

```
   READ 1, A, B, C
   Y = (A+B)/C
   PRINT 2, Y
   STOP
1  FORMAT (3F10.4)
2  FORMAT (F12.4)
   END
```

The READ statement tells the computer to read three variables (from cards or tape) designed as A, B and C, in the manner designed by a later FORMAT statement identified by the 1 preceding it. Thus, if we check with the FORMAT statement identified by the "1" we find that three variables are involved (the "3" in 3F10.4) and that the field width (F) is 10 characters, with four characters pointed off. The PRINT statement indicates the answer (Y) is to be printed out as identified by FORMAT 2. The latter states that 12 total characters are to be allocated, with four decimal places.

A compiler is used to translate, and the program (on the source deck) is translated into machine language on the object deck. As with the assembler, the object deck is fed into a card or tape reader and then into the computer for processing. In the FORTRAN program, STOP tells the computer when to stop computation, and END tells the compiler the program is finished.

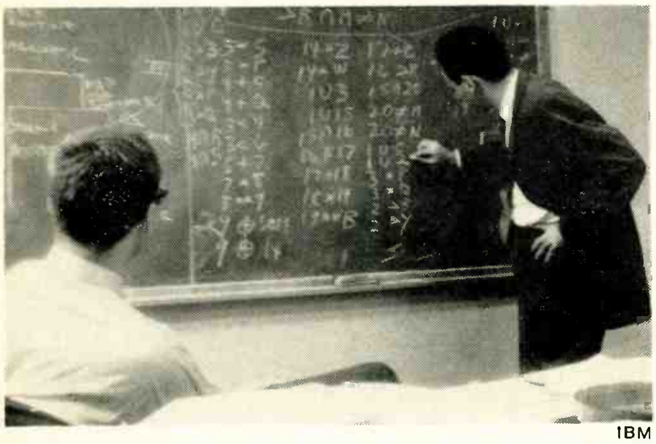
Other statements are used in FORTRAN to permit the computer to undertake "decision" type operations, modify the program as required and perform other manipulations. Program errors are sensed by the compiler and clues printed out so that the programer can locate the errors or note the use of incorrect statements.

COBOL language

As with FORTRAN, the word COBOL is an acronym made up of the initial letters of the phrase: Common Business Oriented Language. Like FORTRAN, COBOL can be used with any computer if the proper compiler is used for translating it into machine language.

COBOL uses the English language directly and is made up of selected words to express the series of operations which the computer is to execute in business data processing. Hence, COBOL uses letters, numbers and punctuation marks to form descriptive or instructional sentences. However, COBOL must be written by following certain rules, just as our English language uses rules of grammer. Curiously, when a written COBOL program is examined by a nonprogramer he can understand most of the commands and data descriptions, but could not write such a program without knowing the rules.

Verbs are used for instructional commands, and nouns for denoting the nature of the data to be processed. Capital letters are used, such as READ, WRITE, OPEN, CLOSE, DISPLAY, etc. for verbs. Nouns would include FILE, PAYROLL, INVENTORY, etc. The verbs ADD, SUBTRACT, MULTIPLY and DIVIDE can also be used, or as in FORTRAN,



IBM

Programs are constantly being developed to solve new problems.

signs such as "+", "−", "*", and "/" are valid.

COBOL programing consists of an identification division which describes the nature of the program—a configuration section, describing computer equipment to be used; a data division which identifies data sources, and a procedure division which spells out to the computer what processes are to be performed. A typical program section for the latter would appear as:

```
PROCEDURE DIVISION.
START.  OPEN OUTPUT PAYROLL-FILE.
READ-IN.  READ PAYROLL-FILE RECORD.
COMPUTE WITHHOLDING-TAX.
```

Hyphens and periods must be used according to COBOL rules and can't be changed arbitrarily.

Program language

The newer PL/I language was introduced early in 1966 by IBM and is intended to be a universal-type computer language. It retains some of the basic features of both FORTRAN and COBOL and can handle either mathematical or data-processing programs. A compiler, suitable for PL/I must, of course, be used for translating this language into machine language.

In PL/I statements are written on a single line as in FORTRAN, and parenthesis are used (not brackets). Thus, $Y = a+b/a-b$ becomes:

Y = (A + B)/(A − B);

Note that a semicolon is used to indicate statement end instead of the period. As with COBOL, verbs and nouns are used to indicate instructions or descriptions. For example:

```
DECLARE (COST, PRICE, DISCOUNT);
COST = PRICE − DISCOUNT;
```

These two statements tell the computer that we are "declaring" that the program concerns cost, price and discount rates. Then we tell the computer that it determines cost by subtracting the discount from the price. Actually you could declare any name you wish and the computer will reserve a storage area for it and act accordingly when the same word is used again later in the program. Thus, you could even declare PHILODENDRON or OSHKOSH and the computer will accept them on your say-so and process them as you wish!

Also, in PL/I the programer may insert any comments he wishes into a program and can specify that such comments are not to be acted on by the computer, but are just for the programers information. He does this by using the symbols "/*" before the comment and ending it with "*/". Thus, anything stated within these "/*" and "*/" signs are ignored by the computer.

Other languages

The most widely used computer programing languages today are FORTRAN and COBOL. PL/I is making some inroads, but is still too new to be universally accepted or used. In certain specialized areas, however, other programing languages are used. ALGOL (algebraic-oriented language) has been popular in Europe and also used to some extent in America. FORTRAN IV, however, incorporates some aspects of ALGOL and is, of course, also a mathematically oriented computer language. Others are MAD (Michigan Algorithm Decoder) and JOVIAL (Jule's Own Version of International Algebraic Language). All have specific rules and the written program must follow them to be valid.

A mathematical programer does not have to solve an equation (the computer does this) but he should know how to set it up in the *algorithm* (format) most suitable to computer processing. Similarly, a data-processing programer doesn't have to know accounting, but a fundamental knowledge of business operations and basic bookkeeping is certainly helpful.

Where can you learn programing? At trade schools (advertised in this magazine): at technical schools, community colleges, business colleges, and many other institutions of learning. Leading computer companies also offer courses and often give aptitude tests in logic to determine your ability and leanings toward this interesting and lucrative profession.

Numerous textbooks are available from various publishers on all aspects of programing. Many such books are of the "programed" type, which are intended for self-instruction. (Actual exposure to the operating principles of a computer is, of course, extremely helpful.) If you like checkers or chess as well as other games of logic, you might be a natural! **R-E**

See page 89 for a list of schools offering courses in computer technology and programing.

Stereo Headset Control Center

Easy-to-build battery-powered transistor circuit costs about $10. Just feed in a 0.1-volt stereo signal

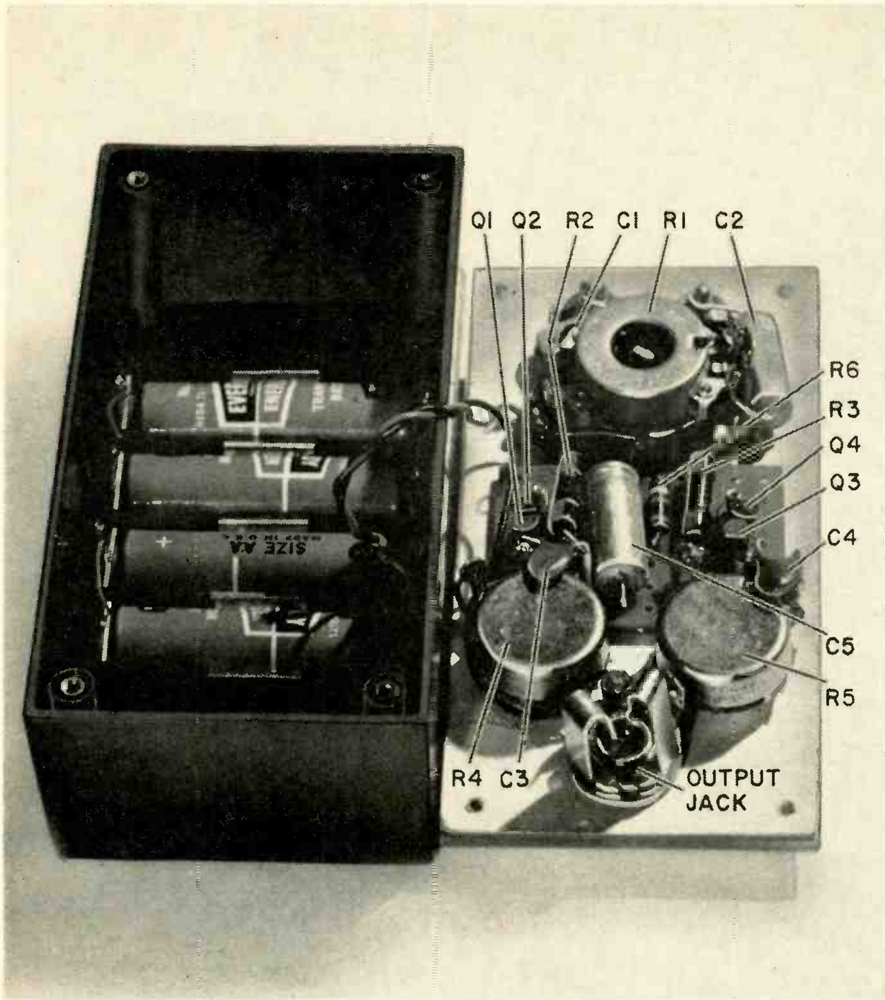
By WAYNE LEMONS

EVER TRY TO FIND A SIMPLE, INEXPENSIVE, HIGH-fidelity, stereo headphone amplifier circuit? It isn't easy. Stabilizing diodes, specially matched transistors, unusual parts and exotic feedback circuits may be nice to have, but they aren't always needed.

It was with economy (around $10) and simplicity in mind that this circuit was evolved. It uses no unnecessary parts (unless you think tone and volume controls are unnecessary). The transistors are inexpensive (about 40¢ each), and there are no transformers.

It works with either low- or high-impedance phones about equally well. The frequency response is slightly better with low-impedance phones, but your ears will have to be pure gold to tell the difference.

Current drain is low, and lower still if the vol-



Front panel of the headphone amplifier was made from 1/8"-thick colored plastic. Lettering was placed on white cardboard, which is beneath the plastic. Flat sides of transistors face each other for one channel, away for the other as shown in Fig. 2.

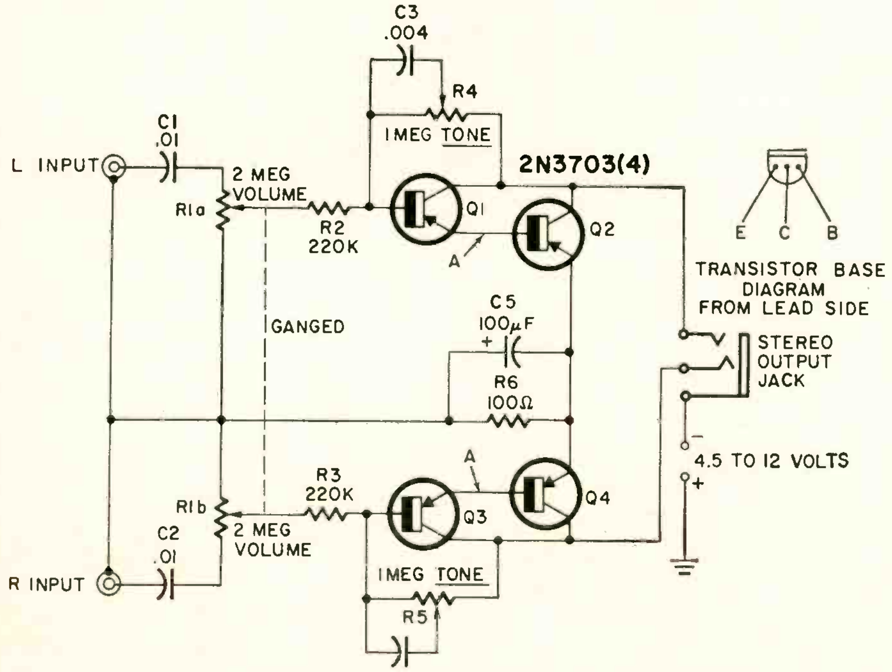


Fig. 1—Emitters of input transistors Q1 and Q3 are direct-coupled to the output transistors. Collector voltage is fed through the earphones. The setting of the tone controls determines both the amount and frequency of inverse corrective feedback.

ume control is not turned up full. Even at full volume a set of penlight cells will last 200 hours or more.

There's no on–off switch because unplugging the phones automatically disconnects the battery. Ganged volume controls are used, but they could have been separate. Individual tone controls are used, but they could have been ganged.

A 0.1-volt input produces ample headphone volume. Input may be up to about 0.5 volt at full volume before noticeable distortion occurs. For higher input voltages, turn down the volume control to remove any overload distortion in the circuit.

The 220,000-ohm base resistors prevent the bias from going to zero when the volume is turned all the way down. Depending on its position, the volume control varies the bias. This permits the circuit to draw less current at low volume and still operate with very good fidelity.

A single resistor (R6) bypassed by a 100-μf capacitor (C5) provides protective bias for all four transistors.

PARTS LIST

C1, C2—0.01-μF, 400V capacitor

C3, C4—0.004-μF, 50V capacitor

C5—100-μF electrolytic capacitor, 3V or more

R1a, R1b—ganged 2-meg-ohm linear potentiometer

R2, R3—220,000-ohm, 1/4-watt resistor

R4, R5—1-megohm linear potentiometer

Q1, Q2, Q3, Q4—2N3703 silicon transistor or equivalent

MISC—2½" x 5" x 1½" Bakelite utility box and cover, jacks, knobs, perforated board

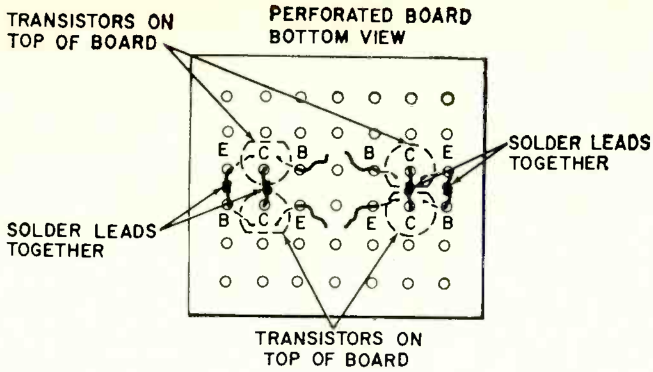


Fig. 2—Transistors are mounted directly on perforated board and the leads soldered together. Parts layout is not critical. The board used is 1⅜" x 2". A PC board can be made even smaller.

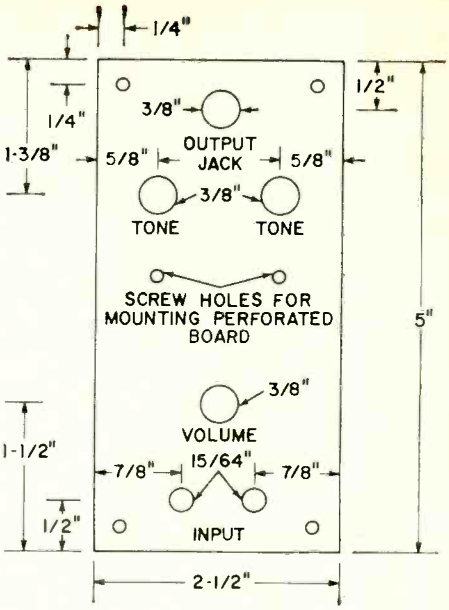


Fig. 3—Panel layout of amplifier. An ac/dc power supply can be installed.

Amplifier gain is ample for all cartridges except low-output phono types. It is an ideal amplifier for turntables with ceramic cartridges or for use with a stereo FM tuner.

Incidentally, you can use npn silicon transistors by simply reversing the battery connections. Germanium transistors will not work without modifying the circuit. Many germanium transistors will work if you will add a 1000-ohm resistor from point A in the schematic to ground.

How it works

The two amplifiers are identical, so consider only the operation of the left channel in Fig. 1. Signal is coupled into the base circuit through C1, the 0.01-μf isolation capacitor. A 2-megohm volume control adjusts the input level to the 220,000-ohm base resistor. Transistors connected this way have a fairly high input impedance, so large input resistances can be used.

Transistor Q1's emitter is direct-coupled to the base of transistor Q2. Collectors of both transistors are tied together. Bias for the circuit is supplied through the 1-megohm tone control. The 220,000-ohm base resistor and the lower part of the volume control act as a bleeder on the bias voltage.

When the volume control is turned all the way down, R2 is grounded and bias is reduced. As the volume control is turned up, bias on Q1 increases, causing it and transistor Q2 to draw more current.

Collector voltage is fed through the earphones from the battery. The connection of the bias resistor to the collector also results in some inverse feedback. The amount of feedback and its frequency is dependent on the tone control setting.

With the tone control adjusted so that C3 is at the collector end, there is maximum feedback of high frequencies. This in turn, because of the inverse feedback, reduces the amplifier gain at high frequencies and appears to improve bass response.

When the tone control is adjusted with C3 at the base end, feedback is essentially the same for all frequencies. The inverse feedback tends to provide a "leveling" action on higher-frequency signals, which are enhanced by earphone inductance so that response is essentially flat when C3 is at the base end of the control.

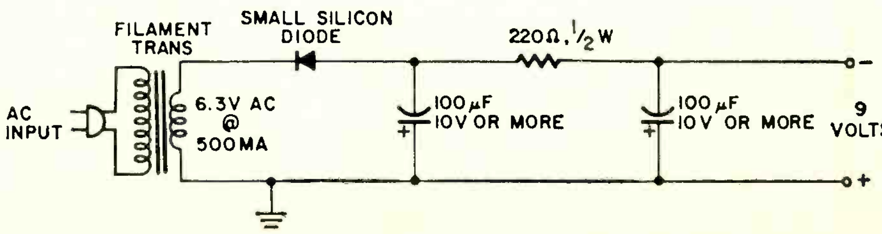
Construction hints

A perforated board can be used to mount the transistors (see Fig. 2). Other parts are also mounted on the board except those that can be mounted elsewhere more conveniently. Figure 3 shows dimensions of the front panel. Layout is not critical and a different arrangement can be chosen if desired. For example, by using a printed circuit and miniature controls, this amplifier could be built into a very small area.

If you want to go "electric," use any filtered 6–10-volt dc power supply with an output current of 12 mA or more. Figure 4 shows a simple supply you can build yourself, but any of the small power supplies designed for transistor radios will work. By rearranging parts you could install the power supply in the amplifier box.

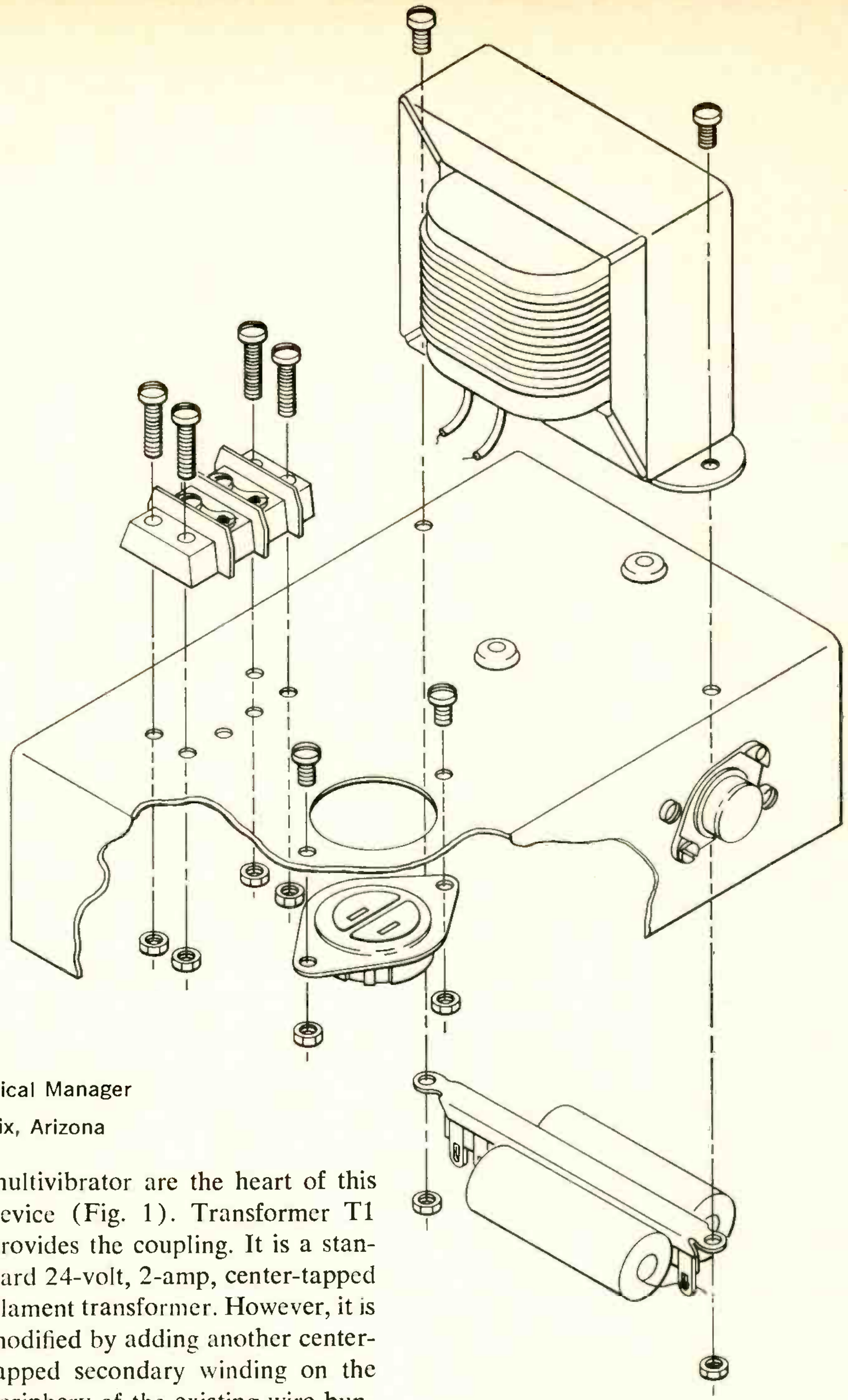
Any way you do it, you'll be pleased with the performance and stability of this unpresumptuous little amplifier. **R-E**

Fig. 4—A power supply can be used with the amplifier. Batteries last about 200 hrs.



BUILD FOR YOUR CAR

50-Watt Portable AC Outlet



By Jack Jaques Technical Manager
HEP Motorola Inc., Phoenix, Arizona

HERE'S AN INEXPENSIVE, EFFICIENT, convenient, compact source of 115-Vac, 60-Hz power from your car, camper or motorboat 12-Vdc battery. It offers an opportunity to eliminate the inconvenience of battery, propane and gasoline lights in boat, camp or camper. The 50-watt rating is ample to operate the HEP Guitar Amplifier (see RADIO ELECTRONICS, November 1968, p. 37) and other utilities such as a small TV set, portable hi-fi, soldering iron, electric shaver, lights, radio, etc. For example a 25-watt light, a 14-watt fan and a 3-watt radio can be used simultaneously without exceeding the 50-watt rating. Thus, by using this inverter and the battery in your vehicle, "boondock" or beach-party singouts are a lot more fun.

A pair of power transistors operated as a magnetically coupled multivibrator are the heart of this device (Fig. 1). Transformer T1 provides the coupling. It is a standard 24-volt, 2-amp, center-tapped filament transformer. However, it is modified by adding another center-tapped secondary winding on the periphery of the existing wire bundle. The new winding consists of 12 turns of No. 22 plastic-covered hookup wire. The space between the frame and the existing wire bundle of the transformer permits installing the new winding (Fig. 2).

The added winding forms the base circuit of transistors Q1 and Q2. The 12-Vdc input from the auto or boat electrical system is applied via TS1 to the secondary center taps of the transformer. The original secondary winding forms the collector circuit of Q1 and Q2. Its center tap provides the negative or return circuit to TS1, and the dc supply. Resistor R1 establishes the turn-on bias voltage for Q1 and Q2. The value of R1 (180 ohms) assures that the transistors will begin oscillating (alternately turning on and off) under all conditions. R2 and C1–C2 set the frequency of oscillation, approximately 60 Hz. Diode D1 prevents unwanted voltage spikes from appearing at the bases of Q1 and Q2.

When voltage is applied to T1's new 12-turn secondary, Q1 and Q2 turn on and off (oscillate) in an alternate sequence. As each

PARTS LIST

- C1, C2—1000 µF, 15 V, electrolytic
- D1—1 amp, 1000 piV, silicon diode, HEP-160 (Motorola)
- J1—Chassis mounting ac receptacle
- Q1, Q2—HEP-230 (Motorola)
- R1—180 ohms, ½-W, 5%
- R2—3300 ohms, ½-W, 5%
- T1—Filament transformer; pri 115 vac; sec 25.2 V ct, 2 A (Triad F-41X)
- TS1—Terminal strip, barrier type, 2-terminal
- Chassis—5" x 7" x 2"
- Cigarette lighter cable (optional)
- Power transistor mounting kit (2) HEP-450 (Motorola)
- Terminal strip, 10 lugs
- Misc. wire, hardware

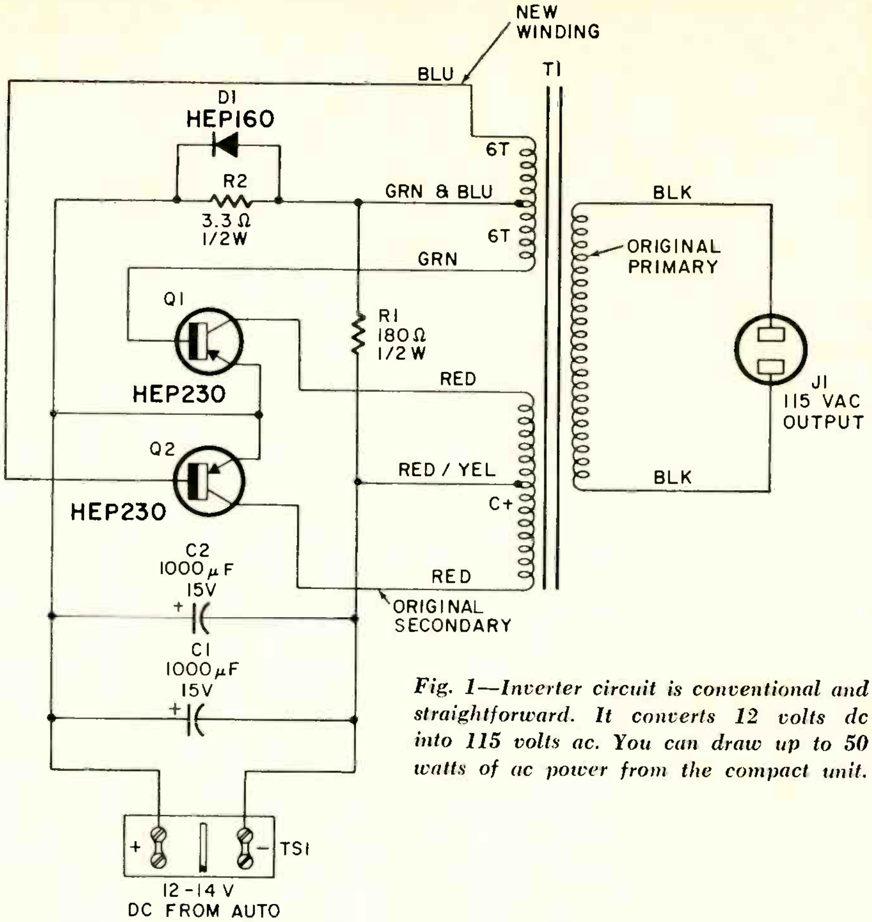
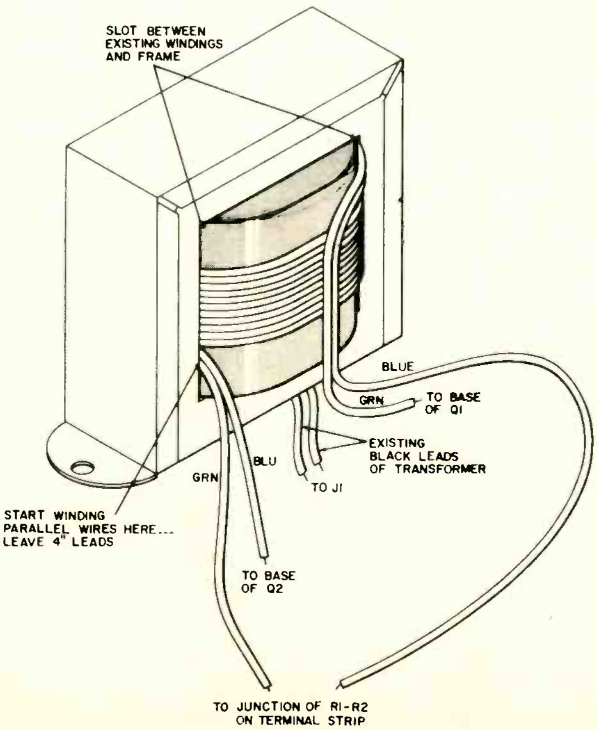


Fig. 1—Inverter circuit is conventional and straightforward. It converts 12 volts dc into 115 volts ac. You can draw up to 50 watts of ac power from the compact unit.

MODIFYING T1

Fig. 2—How to add a winding to the inverter transformer.



1. Stretch two 6' lengths of No. 22 insulated wire side by side (use two colors, say blue and green). Place the blue wire above green wire.
2. Refer to Fig. 2. Position T1 so the side with two black leads faces you. This side will be considered the front in these instructions.
3. Leave 4" of leads and pull the remainder of both wires toward the back through the left slot between the frame and wire bundle. Start near the bottom.
4. Bring the wire around the back of wire bundle and through the slot between it and the frame on right side toward you.
5. Continue to wind wires in this manner until 12 turns are wound on the back side (6 blue, 6 green). Keep the blue wire on top in each pair of turns. Keep turns parallel, uncrossed and snug to the wire bundle.
6. Pull turns 11 and 12 through the slot at the top of the wire bundle on right side. Ample length should remain for leads.
7. Label leads per Fig. 2, using small pieces of masking tape.
8. Apply liberal amount of coil dope or cement to hold winding in place.

transistor conducts, current flows alternately between the extremes and the center tap of the original T1 secondary, first in one half, then in the other. This conduction causes a magnetic field to build up in the alternate halves of the winding, which collapses when the current flow ceases due to transistor turnoff. This alternating buildup and collapse of the magnetic field in the secondary causes an alternating

voltage to be induced across T1's original primary. The ratio of the number of turns in the two windings is chosen so that the transferred output is stepped up to 115 volts. The 115 volts, which is still at the same frequency as the oscillating input circuit (60 Hz), is delivered to output connector J1, where it is available for operation of the amplifier, lights or other low-wattage appliances as desired.

Using the inverter

Operating the inverter is extremely simple. There are no controls. Just connect TS-1 to a source of 12-volt dc. Then plug the 115-Vac appliance into J1.

CAUTION

Correct polarity of the 12-Vdc input must be maintained. The inverter cannot be used in a car with the positive post of the battery connected to the body (ground). Check foreign cars in particular if the cigarette lighter adapter is used.

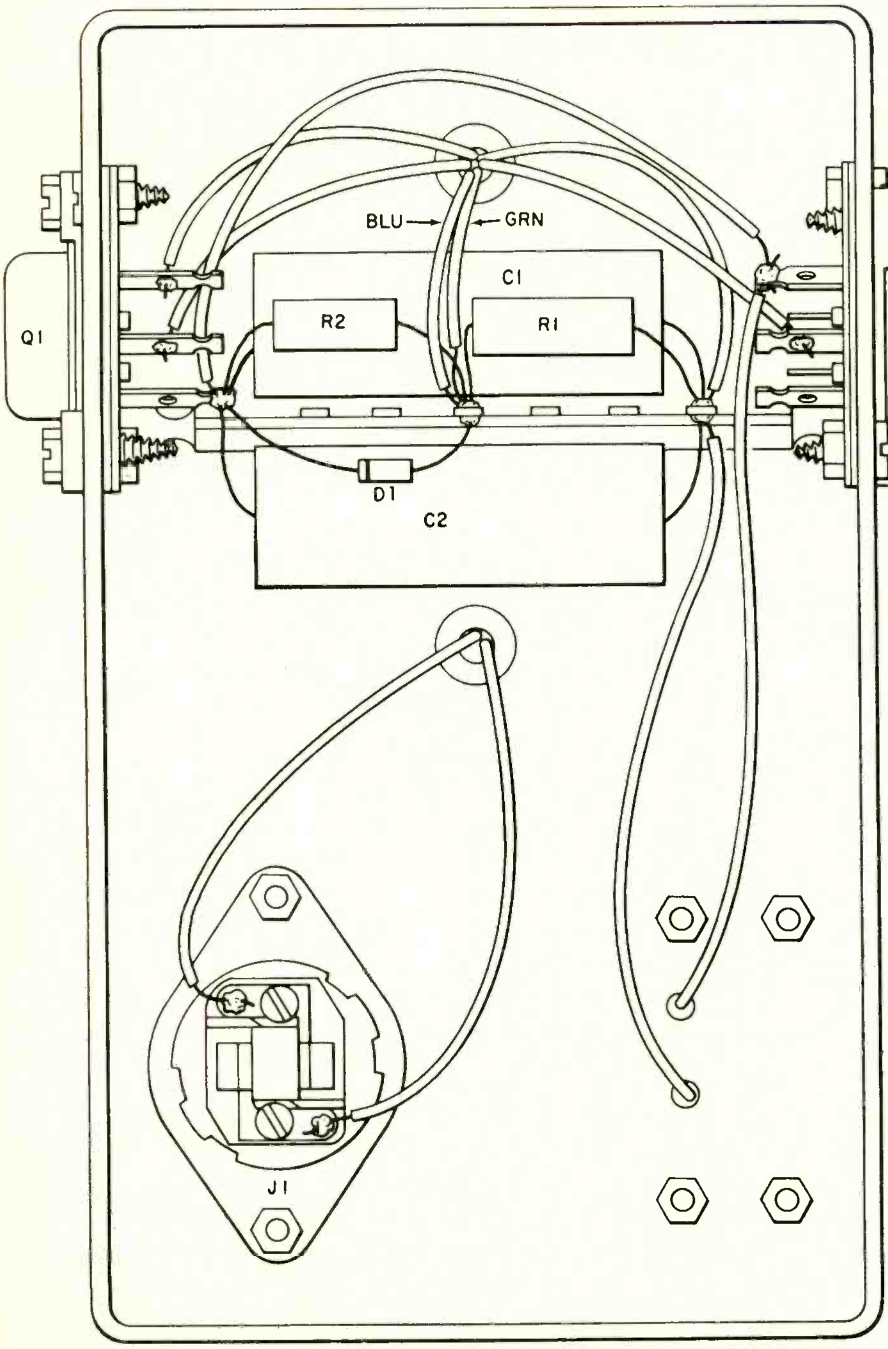


Fig. 3—Pictorial diagram shows what's going on under the chassis. Note details of parts placement and connecting lead layout. Follow this arrangement as closely as possible and you should have no difficulty in building this unit.

A cable with a plug that mates with the cigarette lighter receptacle is available and is recommended as one convenient way to connect the unit to the dc source. Be sure the auto battery is in good condition. Do not overload the inverter with appliances requiring more than 50 watts of power. Do not use excessively long power cords since this added resistance will reduce the power available for operating appliances. **R-E**

CAUTION

Do not attach the inverter directly to the auto body. For rigid mounting to the auto, use insulating sleeves and isolate the inverter chassis with a mat of foam rubber 3/16" thick.

It's Easy To Fix Solid-State TV

The circuits may be different but they do tend to be simpler

By MATTHEW MANDL
CONTRIBUTING EDITOR

TRANSISTOR TVs ARE NOT FAILURE-proof. They operate at lower voltages than tube types, but component ratings are correspondingly lower, and failures do occur. We still run into sweep faults, mistuned circuitry and an occasional transistor failure.

Often, when low-gain transistors are used, extra stages are needed to get maximum performance. As a result, additional trouble possibilities exist. So we still have average run-of-the-mill faults, some troublesome intermittents and even the occasional multiple-trouble conditions of tube TV. Basic circuit knowledge always expedites servicing, as the following case histories emphatically indicate.

Fig. 1—Five faults show up in this TV picture. They include corner shadow, ghosts, dark vertical bars, adjacent-channel interference and poor focus. A sixth problem, blooming, became apparent when the brightness was turned up. A simple repair?

An even half-dozen

A good example of visual multiple troubles is shown in Fig. 1. Here, five faults are easily recognized. At the upper right we have corner shadow, at the center screen we have ghosts, at the left we have dark vertical bars, throughout the screen we have adjacent-channel interference (changing diagonal line segments) and poor focus. When the brightness control was turned up, the picture bloomed, making a total of a half-dozen faults at once.

Even though six faults are in evidence, circuit knowledge would indicate only two defective areas are contributing to the symptoms. The ghosts and dark vertical bars could be antenna troubles, as could the adjacent-channel interference lines. The blooming, focus and corner shadows could be caused by troubles in the high-voltage system.

A high-voltage check showed only 15 kV at the second anode of the pix tube, instead of the 20 kV specified for this Zenith 1Y21B55 receiver. Using a scope and working back toward the horizontal oscillator we tried to localize the bad stage.

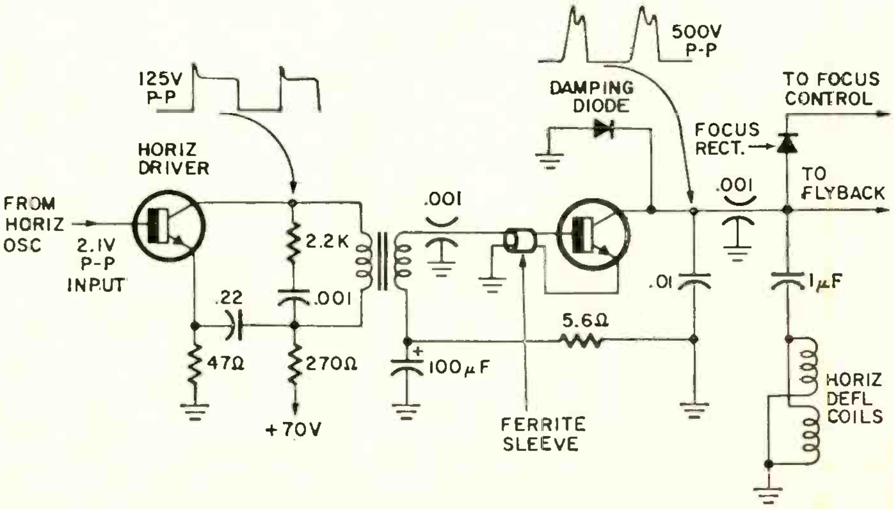


Fig. 2—Horizontal sweep system used in the Zenith 1Y21B55 chassis. A new transistor restored normal high voltage and focus voltage, eliminating the blooming and corner shadow. Interference lines, bars and ghosts remained; their cause not yet known.

The horizontal sweep system for this set is shown in Fig. 2. Note how much simpler these transistor circuits

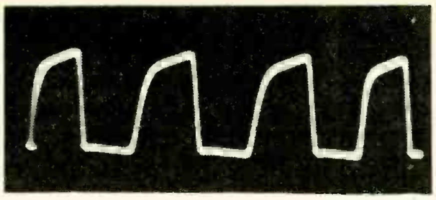


Fig. 3—A distorted horizontal-driver scope trace pinpointed the bad stage.

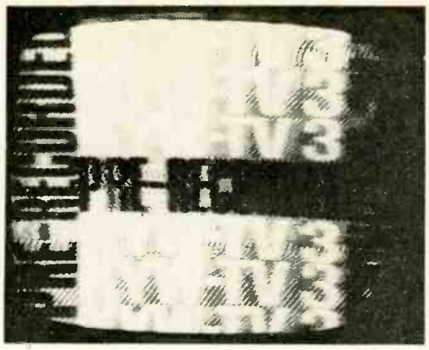


Fig. 4—Agc and focus troubles in an Admiral 2H5 resulted in distorted picture.

are than tube types. Because of the output transistor's low output impedance no transformer is needed between it and the deflection coils. Both the damping and focus rectifier diodes connect directly to the output transistor's collector.

To develop enough drive, however, a horizontal driver stage follows the horizontal oscillator. Note the ferrite sleeve around both the base and emitter leads of the output transistor. It is an inductive-type shield for stabilizing sweep function.

The scope pattern at the collector of the output transistor was some 100 V below normal. While this might indicate a defective transistor, before changing it, the scope was attached to the collector of the driver transistor. Here, the waveform was not only low in amplitude but differed from the normal waveshape. Distortion appeared at the flat-top section (see Fig. 3). A check at the horizontal driver input base, however, showed normal drive signals (2.1 V peak-to-peak). Thus, the trouble was localized to the driver stage.

Resistors and capacitors were checked and found good, but an in-circuit check of the transistor showed poor emitter–collector conduction and reduced gain. A new transistor returned normal high voltage and focus voltage and eliminated the blooming and corner shadow. The interference lines, left vertical bars and ghosts were still there.

A check of the antenna system revealed that the antenna did not turn when the antenna-rotator control-box bar was depressed. The trouble was a defective 80-μF ac type capacitor in the control box. (Always check this item first before deciding that the rotator motor is defective.)

Now, with the antenna free to rotate, the ghosts and vertical left bars disappeared. Remaining, however, were the wiggling adjacent-channel interference lines, though only on channel 10. A slight readjustment of the lower adjacent-channel trap (47.25 MHz) eliminated this interference.

An Admiral 2H5 receiver had the symptoms shown in Fig. 4. While the general appearance is similar to Fig. 1, the trouble indications are not all the same. Again, some interference lines are present as is some defocusing. The overly dark areas indicate video signal overload, possibly agc troubles. If so, this could also contribute to the poor focus.

Adjusting the agc control had no effect. Voltage readings were taken at the agc gate circuit shown in Fig. 5 next. Base and collector voltages were ok, but the emitter voltage was several volts above normal. A component check in the emitter circuit showed, not only an open 0.47-μF bypass capacitor, but a increased-value resistor. Instead of 220 ohms, it read several thousand ohms. Such a large change in resistance in a low-voltage, low-current circuit is not common. It is more likely for a resistor worked near its wattage rating continuously to develop such a change.

New components in the agc circuit cleared up most of the trouble. In this receiver there are three terminal settings for focus—A, B and C. Changing from B to C improved focus. With normal agc function and no video overload, the faint interfering lines also disappeared.

In the early production runs for this receiver, some parasitic oscillations would occur on occasion when component values in the third video i.f. amplifier were off far enough to affect critical circuit operation. Later production receivers incorporated a 100-pF capacitor across the 1000-ohm base resistor shown in Fig. 6. When servicing such sets, this capacitor should be added, even though no symptoms of picture instability or cutoff appear.

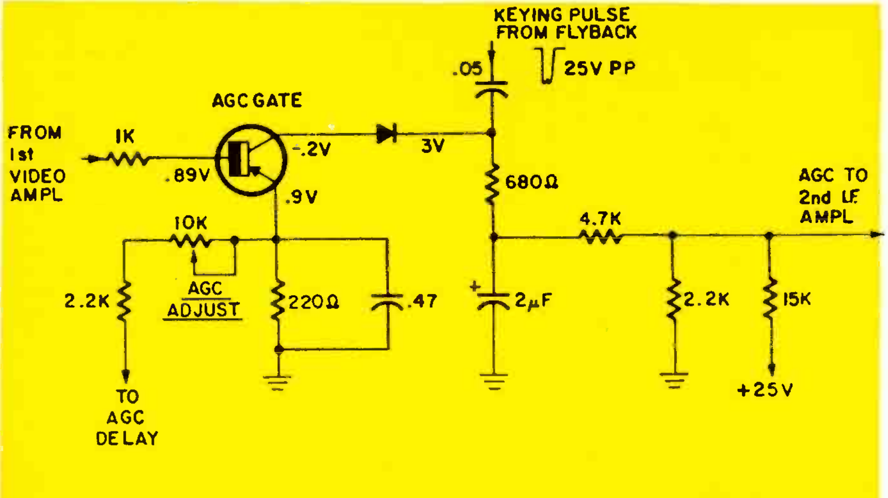


Fig. 5—Open bypass capacitor plus a higher-than-normal value resistor had to be replaced for normal circuit operation.

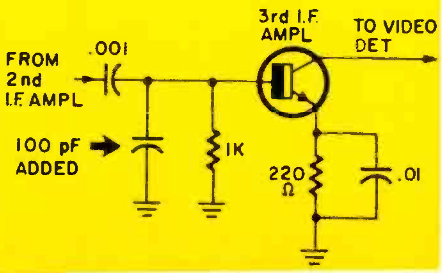


Fig. 6—Early models of the Admiral 2H5 did not include the 100-pF capacitor. If you service one of these sets, add one.

Intermittent sound and sync

In a Magnavox T921 9" portable, both sound and sync were intermittent. The sound would fade for a few seconds, then return for several minutes. Both vertical and horizontal sync would be lost for several minutes, then return to normal for a half-hour or more.

In this receiver a sync amplifier and phase splitter npn transistor follows the sync separator, as shown in Fig. 7. The sync amplifier feeds the horizontal phase detector diodes (connected across emitter and collector). The vertical oscillator is fed from the collector. All voltages and components checked ok in both the sync separator and the amplifier, as did the transistors with an in-circuit tester.

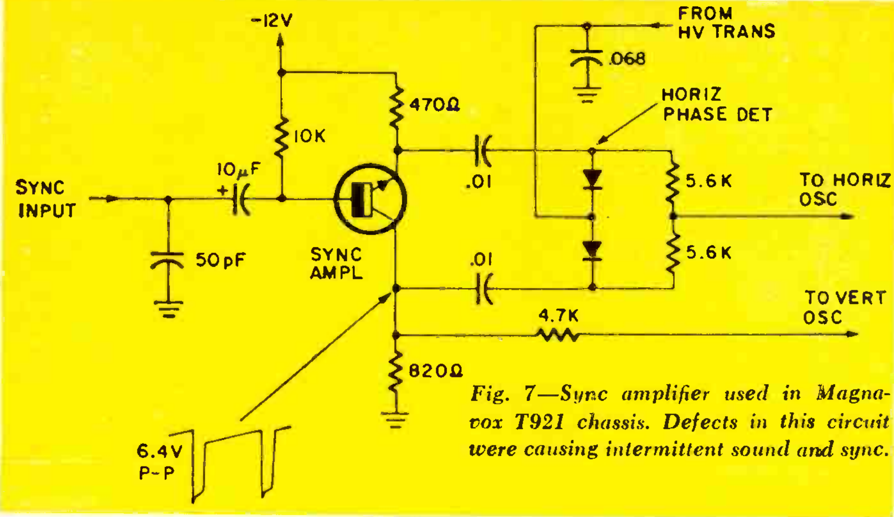


Fig. 7—Sync amplifier used in Magnavox T921 chassis. Defects in this circuit were causing intermittent sound and sync.

the base (−0.2 V). When base voltage drops to zero the forward bias is lost. In some transistors cutoff occurs for zero forward bias (or reverse bias where the emitter is negative with respect to the base).

Since collector voltage (−11.2 V) was not affected, it appeared obvious that the 47,000-ohm dropping resistor was causing the trouble. While we expect intermittents to occur in transistors, capacitors and diodes, it is unusual for resistors to act intermittently, particularly in low-voltage circuitry. A new resistor, however, cured this trouble. **R-E**

A scope was attached to the collector of the sync amplifier to observe the waveform (see Fig. 7). We wanted to note any change when the intermittent occurred. Any intermittent in the sync separator would also be noted here, and since both horizontal and vertical sync were affected, the trouble had to be ahead of the sweep oscillators.

After a while the intermittent recurred and the scope pattern changed to that shown in Fig. 8. A transient signal appeared along the positive base line of the sync pulses. This oscillatory condition in the sync amplifier was most likely caused by a change in characteristics of the transistor rather than of circuit resistors and capacitors. Thus, even though a checker indicated no faults in the transistor (intermittents rarely show up under normal testing) the transistor was replaced and the sync problem was eliminated.

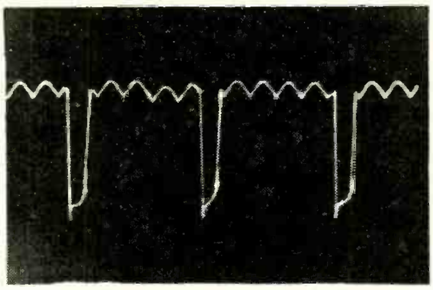


Fig. 8—Scope pattern revealed a transient along the base line of the sync pulses. A defective transistor was the problem.

As suspected, the intermittent sound was unrelated to the intermittent sync, and it was still fading in and out.

The intermittent sound happened every few minutes, so a quick check was made by placing earphones across the volume control. Here, however, the sound stayed normal. Next, we checked voltages in the audio amplifier circuit (Fig. 9), but all appeared normal. For a sustained check, a vtvm was placed between the collector and ground to read −11.2 V, but little difference was noted during the intermittent.

Next, the vtvm was placed between base and ground. Now, when the intermittent occurred, we lost the −1 V at the base. This is a pnp transistor and forward bias requires that the base be negative with respect to the emitter. Normally the −1 V at the base and the −0.8 V at the emitter provide a negative voltage at

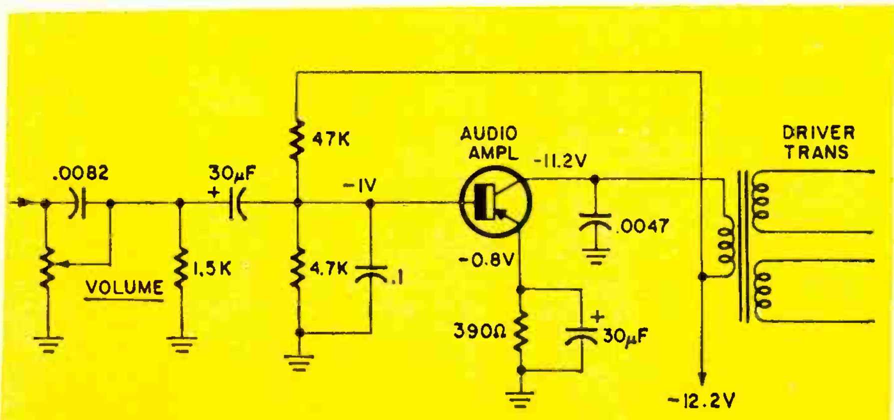


Fig. 9—Intermittent sound was the problem, but the circuit appeared normal. Careful monitoring with a vtvm revealed that the 47K voltage-dropping resistor was bad.

STATEMENT OF OWNERSHIP. MANAGEMENT AND CIRCULATION. Act of October 23, 1962, Section 4369, Title 39, United States Code.)

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

(Signed) M. Harvey Gernsback
Publisher

ABC's of Transistors

Here's how they work

TRANSISTORS HAVE PUZZLED TECHNICIANS FOR NEARLY A decade and there appears to be no sign of easing the strain. Each year more transistorized equipment is introduced in both television and hi-fi equipment. To keep up to date we must learn efficient transistor servicing procedures.

Many articles have been devoted to transistor troubleshooting and all of them have leaned heavily on theory. But many successful technicians working on vacuum-tube circuits do not have a solid foundation in vacuum-tube theory, so perhaps the solid-state troubleshooter does not necessarily need theory. Let's look at transistors from a troubleshooter's standpoint and minimize the theory.

For those of you with experience with tubes here is a comparison of transistors and tubes: A transistor is somewhat like a tube: Corresponding elements are:
ponding elements are:

Tube—Transistor
Cathode—Emitter
Grid—Base
Plate—Collector

There are two important differences:

1. The tube is a voltage amplifier.
2. The transistor is a current amplifier.

The grid of a tube usually has an opposite potential to the cathode and plate of a tube, but the transistor base potential is between the emitter and collector potentials.

Just two diodes

Transistors are further complicated as there are two types which operate with opposite bias and supply voltage polarities. Yet it is easy to determine proper polarities for bias and supply voltages and what voltages we can expect in standard circuit configurations for each type.

The two basic types are, of course, pnp and npn. Physical and electrical characteristics of pnp and npn transistors are shown in Fig. 1. Both transistors are shown electrically as two diodes wired back to back. In the pnp type the cathodes are tied together; in the npn type the anodes are connected. The junction represents the base connection with the emitter or collector at either end.

Two common symbols for both pnp and npn transistors are in Fig. 2. Note that the arrows in both the diodes and the transistor symbol point in the same direction. Remember this and you cannot go wrong.

Normal circuit parameters

In conventional circuits a small forward bias, normally 0.2 to 0.7 volt, is applied to the emitter junction. An easy way to remember which polarity is required to forward-bias a junction is to note that, when a negative voltage is applied to an n-element and a positive voltage to a p-element of a pn junction, it is forward-biased. This is shown in Fig. 3. The letters tell you the crystal type in each element. That is, pnp stands for p-type (crystal) emitter, n-type base and p-type collector. Npn stands for n-type emitter, p-type base and n-type collector.

In other words, for a forward-biased emitter junction, a pnp transistor requires a negative voltage on the base with respect to the emitter. To forward-bias an npn transistor emitter junction a positive voltage on the base, with respect to the emitter, is required.

The collector circuit, on the other hand, requires a back-bias or reverse bias. So in a pnp transistor, a negative voltage

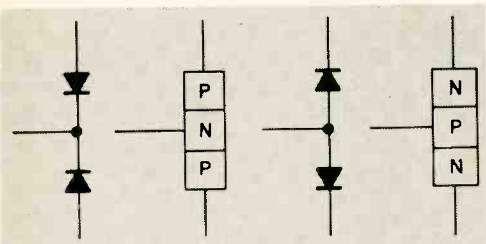


FIG. I


FIG.2

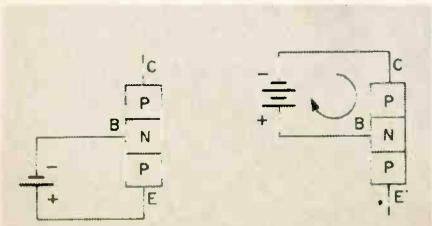


FIG.3

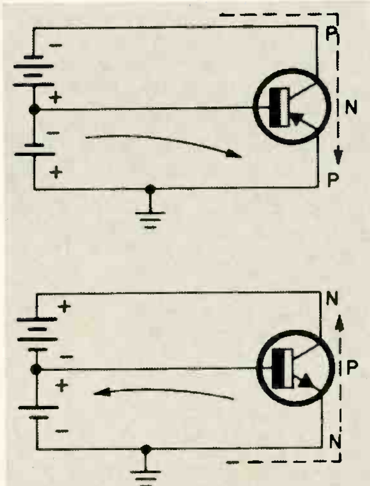


FIG. 4

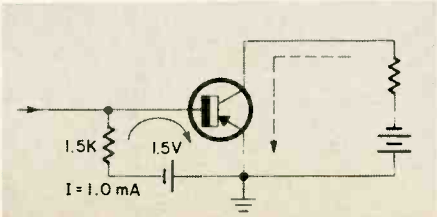


FIG. 5

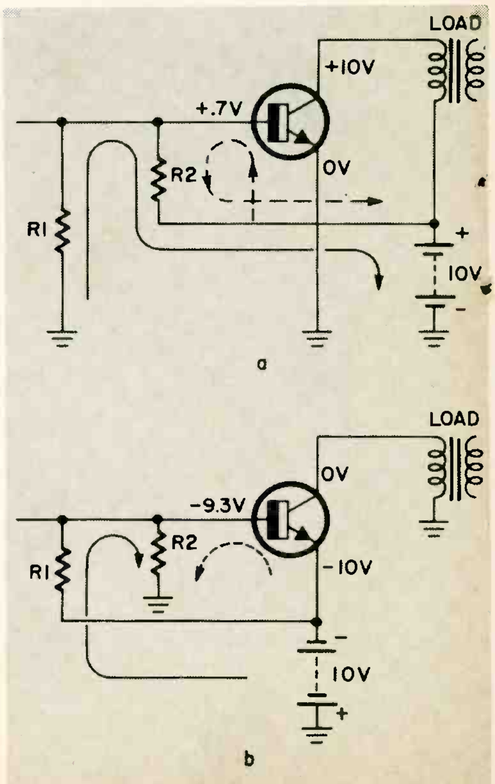


Fig. 6

is required on the collector with respect to the base and the opposite for an npn transistor. Circuits with these typical configurations are shown in Fig. 4. Note that the bias batteries are connected so they aid one another.

The need for biasing

Biasing is used in transistor circuits for the same reason that it is used in tube circuits—to set up a static operating point. Without proper bias, what was intended to be a class-A amplifier might operate class-B.

The simplest bias is accomplished with a single-resistor network. A common-emitter amplifier with a single bias resistor is shown in Fig. 5. Since the emitter-junction resistance is quite low, the base bias current can be calculated by dividing the bias voltage by base bias resistor. The base resistance is ignored because it is very small compared to the base bias resistor.

In Fig. 6-a, the negative terminal of the power supply is grounded. In Fig. 6-b, the positive terminal of the power supply is grounded. Each circuit's operation is identical. The resistors form a voltage divider network and selection of various values can result in any voltage between the supply and zero volts to appear at the base of the transistor. If there is a 0.7-volt difference between base and emitter, the transistor is turned on and emitter/collector current flows. If this voltage difference is reduced, less collector/emitter current flows. Conversely if this voltage difference is increased, collector/emitter current increases.

In Fig. 6-a, if a 10-volt supply is used, R2 will be approximately 9 times as large as R1 and +0.7-volt appears at the base. In Fig. 6-b, the values of R1 and R2 stay the same, but their relative positions are reversed to effect a +9.3-volt potential on the base. Either way, the base is +0.7-volt with respect to the emitter. The voltages shown are typical for a silicon transistor. Note that the base voltage is closest to the emitter voltage and between collector–emitter voltage.

An important consideration is the polarity and magnitude of voltage that must be applied to the base/emitter junction to turn the transistor "on" and cause electron flow between emitter and collector. While a tube requires bias voltage to reduce electron flow, the transistor requires bias current to cause electrons to flow. A tube with zero bias between grid and cathode generally has heavy current flow while a transistor with zero bias between base and emitter is shut off and no current flows between collector and emitter.

To forward-bias or "turn on" a transistor, a small voltage is applied between the base and emitter elements. When measured from the emitter, the polarity of this bias voltage is the same as the collector voltage but its value is much lower.

Remember, as the voltage on the base element changes in the direction of the collector potential, the emitter/collector current increases. If the voltage on the base element moves in the direction of the emitter potential, the emitter/collector current decreases. This is true regardless of whether the transistor is silicon or germanium and npn or pnp.

In Fig. 7, resistor R3 is in series with the emitter. It stabilizes collector current and is referred to as a stabilizing resistor. As collector current flows through emitter resistor R3, a voltage is developed which opposes the forward-bias voltage. The effect of R3 is to oppose any change in current flow since the voltage across it is in series with the forward-bias voltage. For example, if collector current increases, the voltage drop across R3 increases and reduces the effective forward bias which, in turn, reduces collector current.

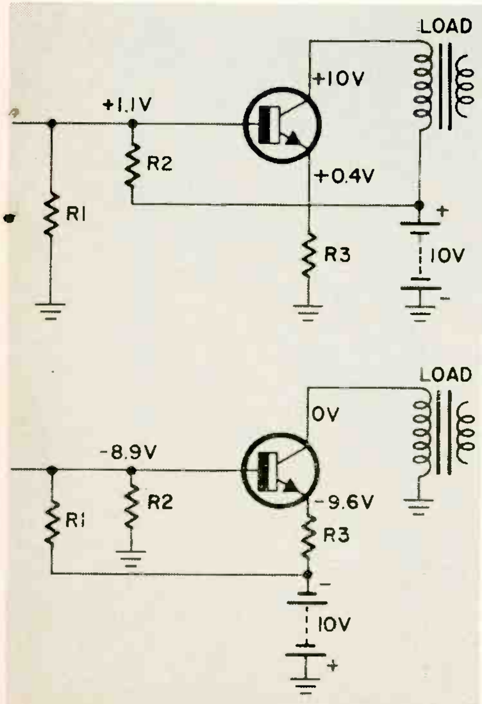


FIG. 7

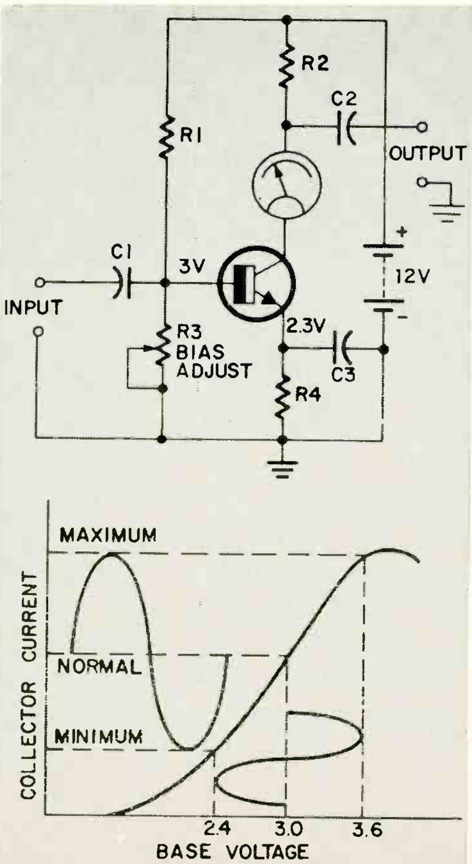


FIG. 8

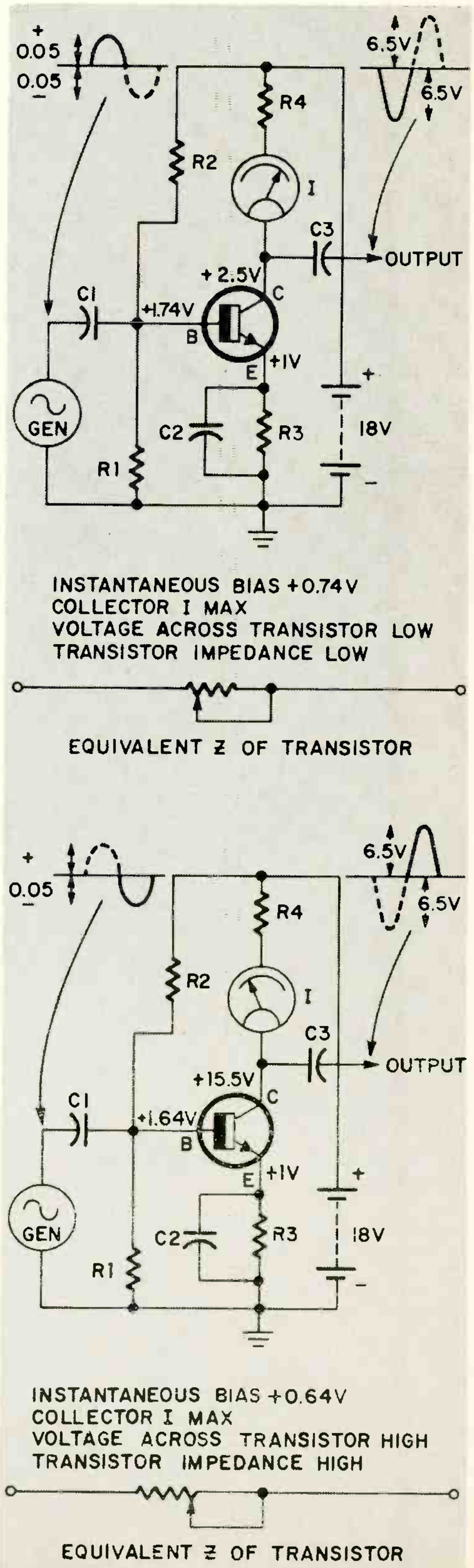


FIG. 9

Conversely, if collector current decreases, less voltage is developed across R3 and the effective forward bias increases. This, in turn, increases collector current. Adding an emitter resistor stabilizes a transistor with respect to collector-current variations which occur for a variety of reasons. The most common cause is an increase in collector current as a result of temperature increase.

When troubleshooting, the voltage drop across the emitter resistor is an important test point for checking circuit operation. A higher than normal emitter voltage generally indicates excessive collector current. This can be caused by a shorted transistor or a bias defect. A lower than normal emitter resistor voltage would indicate an open transistor or bias defect.

Class-A amplifier

A transistor stage set up for class-A or linear operation is shown in Fig. 8. In this stage, bias resistor R3 is shown as an adjustable unit, so some desired collector current will flow. This control can be used to show how the transistor amplifies the input signal.

The base voltage–collector current curve in Fig. 8 shows the collector current for several bias voltages. The horizontal line shows bias voltages developed across bias resistor R3. The vertical line shows values of collector current for each value of bias and we will neglect the effect of emitter resistor R4.

Note the mark on the bottom line indicating 2.4 V. This actually means 0.1 V between the base and emitter since the emitter is at +2.3 V. This mark corresponds with a line on the vertical column marked "minimum" as indicated by the dotted lines. This means that, with 0.1 V forward bias, only a small amount of collector current will flow.

If R3 is adjusted to make the base voltage become 3 V (0.7 V between base and emitter), the collector current increases. Referring again to the curve, we see that the collector current has increased to the mark on the vertical column marked "normal".

If R3 is adjusted to make the base voltage become +3.6 V (1.3 between base and emitter), there will be an increase in collector current. The collector current has increased to the "maximum" level.

From this we can see that by varying the base voltage, we can produce any desired value of collector current. In practice, the emitter voltage would not remain constant with different values of collector current. This action is similar to cathode-voltage variation in a tube.

An ac signal fed to the base element can also cause collector-current changes. Referring again to Fig. 8, we adjust R3 to make the base voltage become +3 V. This causes a collector current that corresponds to "normal" on the curve. The collector current through R2 causes a voltage drop so about half the supply voltage appears at the collector. These are the necessary conditions for a linear stage (amplification without distortion).

An ac generator supplies a signal between the base of the transistor and chassis ground in Fig. 9. This signal at any instant will add or subtract from the dc bias supplied by bias resistors R1 and R2. Capacitor C2 provides an ac bypass across R3 at the signal frequency.

In Fig. 9-a the generator is passing through its maximum positive excursion and is producing a peak +0.05 V. This voltage will add to the +1.69 Vdc bias voltage and cause a total instantaneous voltage between base and ground of +1.74 V. From the curve in Fig. 8, we see that this corresponds to maximum current through the transistor. This is indicated by the current meter connected in series with the collector of the transistor.

The increased current through R4 causes a larger voltage drop, so that for an instant the collector voltage drops to approximately 2.5.

The result of the negative half-cycle of the generator is shown in Fig. 9-b. This negative 0.05-V excursion subtracts from the 1.69-V bias, so that for an instant the voltage between base and ground is 1.64 V. The curve in Fig. 8 shows that this corresponds to minimum collector current. The reduced current causes a smaller voltage drop across R4 and allows the collector voltage to rise to approximately +15.5.

From this we can see that an input signal of 0.1 V peak-to-peak can cause a collector or output signal of 13 V peak-to-peak. Also, phase inversion occurs. The dc and ac voltage excursions shown demonstrate amplification of the transistor. Capacitor C2 is large enough to bypass R3, so that no ac signal is lost across this resistor. The voltage at the emitter will reflect any average current change through the transistor. Emitter voltage is a good indicator of transistor conduction. If this voltage is too high, the transistor current is too high. If it is low, the current is too low.

Diode stabilization

Some amplifiers require a different type of bias stabilization since their primary purpose is to increase power. The circuits discussed are designed to maintain constant current. This would defeat the purpose of the push-pull amplifier, so another method is used.

The most common stabilization method used for these amplifiers is to use bias elements which are temperature-sensitive. One method, shown in Fig. 10, is to use a diode made from the same material as the transistor.

The diode is fed with a constant current through R1. The voltage drop across the diode biases the transistor and is inversely proportional to its temperature. In other words, as the temperature of the transistor and diode increases, the resistance of the diode decreases and the voltage drop across the diode decreases lowering the bias voltage the necessary amount.

Push-pull stabilization

Thermistors are frequently used to stabilize push-pull output stages. Thermistors have a negative temperature coefficient of resistance. A circuit using a thermistor for bias stabilization is shown in Fig. 11. The current through the thermistor is held relatively constant by the high series resistance. The voltage drop across the thermistor supplies the actual transistor bias. Since the compensation in this circuit is often greater than desired, a parallel resistor is sometimes added to the circuit to decrease its sensitivity.

Note that the purpose of the temperature sensing element is, not to compensate for ambient temperature, but to compensate for the junction temperature of the transistor. Consequently, whether the sensing element is a diode or a thermistor it should be located intimately with the transistor or transistors that it controls. **R-E**

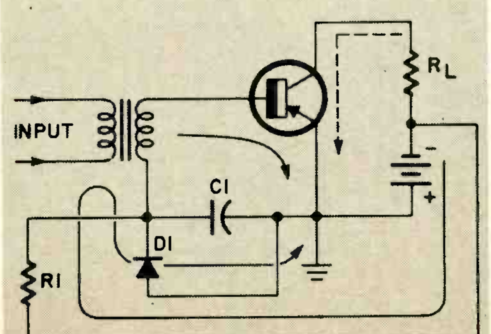


FIG. 10

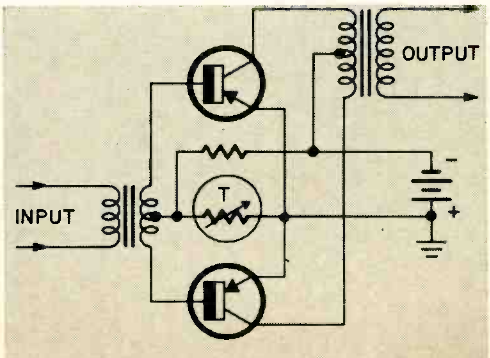


FIG.11

Build–Stereo Tape/Slide Controller

Solid-state control module lets you program stereo slide shows. Inaudible signals change slides automatically

By EARL T. HANSEN

WHY NOT RELAX WHILE YOU'RE showing slides? Let your tape machine provide stereo background music, narrate the show and change the slides.

You can do this by linking your tape playback equipment and automatic slide projector together with this controller.

An inaudible signal on the tape actuates the controller, but does not interfere with recorded audio. Using readily available components—including 5 inexpensive transistors—the controller can be built for about $20. It has a high input impedance and relatively low output impedance.

A low-level 15-kHz signal is added to one channel during initial recording of the tape program. During playback, a notch filter in the controller attenuates this control signal.

Circuit operation

First let's look at the PLAYBACK CONTROL mode selected by switch S1 (Fig. 1). Program and control signals from the tape preamplifier enter the control module at J1.

Low frequencies are passed through R1 to Q1, which has a voltage gain of about 1. High frequencies, including the control signal, pass through R2 and C2 for a higher gain in Q1.

The 15-kHz control signal is routed through C3 and C4 to T1. The control signal *does not* appear at the output (J2) because it is rejected by the parallel-tuned trap, C5 and L1, and low-pass filter R7–C6. The low-pass filter also compensates for pre-emphasis added by R2 and C2.

As a result, this part of the circuit passes the program through unchanged, while amplifying and rerouting the control signal. The control signal is fed through double-tuned transformer T1, which rejects all other frequencies. The T1 secondary feeds emitter follower Q2, which drives sensitivity control R13.

Transistor Q3 amplifies the control signal and drives a peak-to-peak rectifier (C12–D1–D2–C13). When voltage on C13 is great enough to cause base current in the Q4–Q5 Darlington pair, they conduct and energize relay RY1. Resistor R17 discharges C13 when the control signal has stopped. Since C13 is a relatively large capacitor and requires some time to charge, it provides excellent noise immunity and prevents unwanted relay operation from speech consonants or music harmonics. The delay is from 0.1 to 0.5 sec, depending on the setting of sensitivity control R13.

In the RECORD COMMAND mode, Q1 has a flat frequency response from input to output. The high-frequency pre-emphasis network (R2 and C2) is opened and the rejection filter (L1–C5–R7–C6) bypassed. The function of Q2 is changed to a Hartley oscillator, which is inoperative until the emitter current path is completed by pressing S2.

When S2 is pressed the oscillation frequency is determined by the resonance of T1, normally 15 kHz to 17 kHz. Part of this signal is fed from the secondary tap, through S1-c, R6 and R5 to the base of Q1, where it is added to the program material. The signal from Q2 is also fed through the sensitivity adjustment, R13, and the relay amplifier to actuate the relay.

Construction

An aluminum box is used for construction. Mount the large components on the sides and front. Secure T1 with self-tapping screws in the side of the can. Remove the coil assembly before drilling the pilot holes.

A perforated circuit board and push-through terminals were used for mounting most small components. The relay specified needs an insulated mounting and should be put on the perforated board.

Test and adjustment

Adjustment is much easier with an audio oscillator and ac vtvm. A scope and dc vtvm are essential.

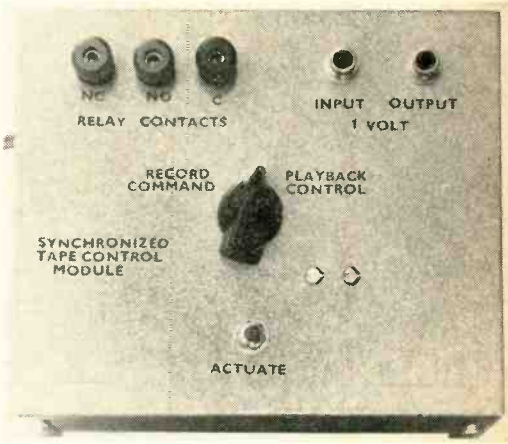
Apply power and check the dc voltages shown on the schematic. Measure them with no signal in and S1 to playback. A 20% variation is acceptable. Collector voltages on Q1 and Q3 can fall between 5 and 12 volts with no loss of performance.

Next, apply a 1-kHk audio signal to the input and check the gain at the output. There should be approximately a gain of 1, which is controlled by the ratio of resistor R1 to R3.

Now select a control-signal frequency. This is nominally 15 kHz, but may be higher if your tape machine has excellent high-frequency response and you want the highest possible point for the playback rejection filter. It should be lower if the tape machine has poor high-frequency response.

Set the audio oscillator to the control frequency and feed approximately 1 volt to the input, J1. With the switch set to playback, connect a scope or ac vtvm to the output and adjust L1 for minimum output. The output should be 10% or less of the input amplitude (20 dB down).

Reduce the input to 50 mV (140 mV p–p), and connect the scope or ac vtvm to the emitter of Q2. Adjust both T1 slugs for maximum indication. This signal should be at least 50% greater than the input signal amplitude. Adjust sensitivity control R13 so the relay just closes.



Controller has 1-volt input and output. Unit will work with monophonic recorder.

Remove the audio oscillator and connect the scope or ac vtvm to the output. Press the ACTUATE button and adjust R6 for an output signal of 100 mV rms (240 mV p-p). This puts the control signal 20 dB below a program signal of 1 volt, as recorded, and the rejection filter gives an additional 20 dB attenuation during playback.

If an audio oscillator is not available, set the adjustment of R6, L1 and T1 about mid-range. Set S1 to the RECORD mode, and connect the output

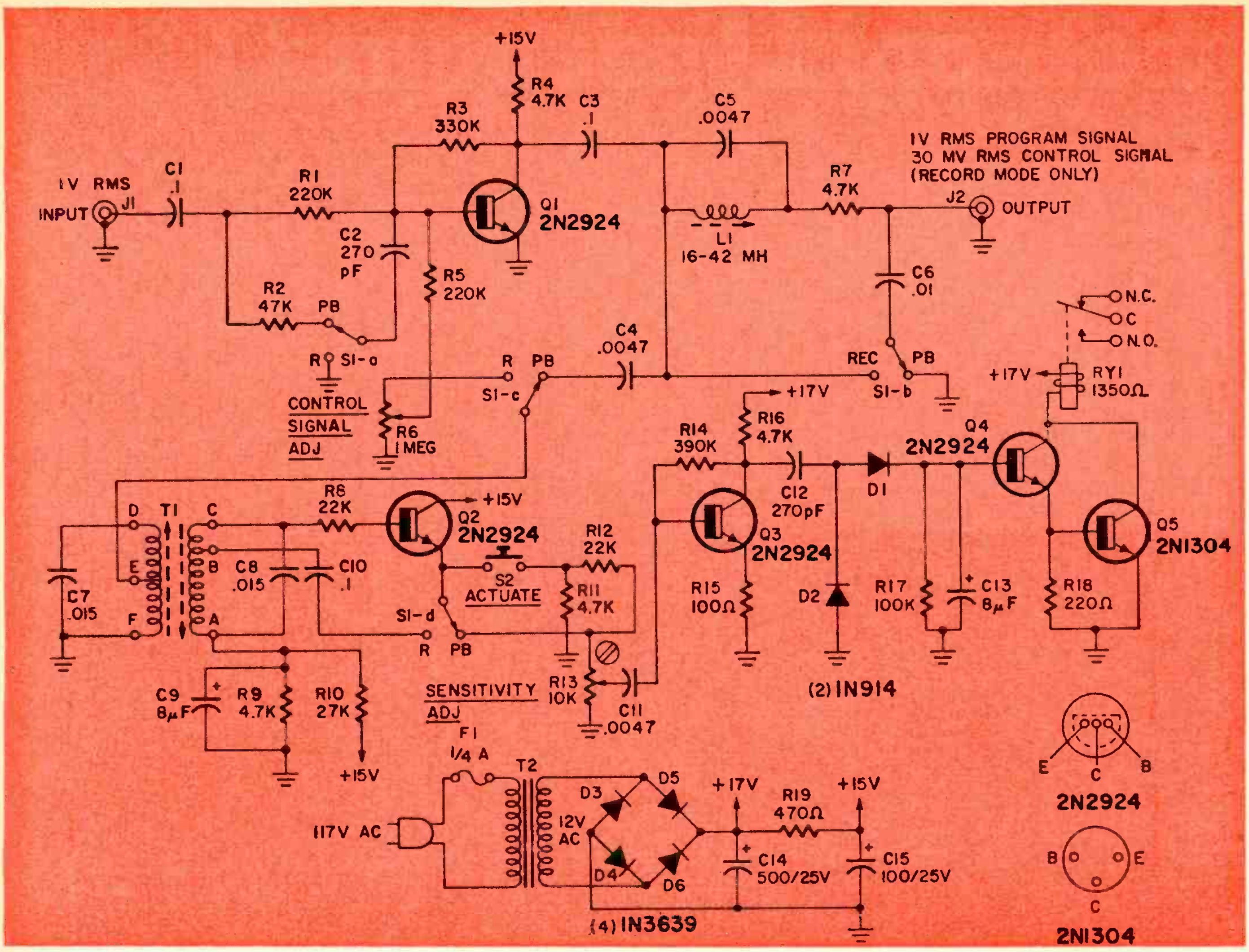


Fig. 1—Control signals are filtered from the output (J2) by parallel-tuned trap C5–L1, but amplified and routed to T1, tuned to the selected control frequency. Voltage on C13 triggers Darlington pair Q4–Q5, which energizes relay RY1 and advances slide changer or, with an extra unit, automatically shuts off the system. Q2 generates the command signal when S1 is in RECORD *mode.*

PARTS LIST

All capacitors 100-V paper unless noted
C1, C3, C10—0.1-μF
C2, C12—270-pF, mica or ceramic
C6—0.01-μF
C7, C8—0.015-μF
C9, C13—8-μF, 6-V electrolytic
C14—500-μF, 25-V electrolytic
C15—100-μF, 25-V electrolytic
All resistors ½-watt 10% unless noted
R1, R5—220,000 ohms
R2—47,000 ohms
R3—330,000 ohms
R4, R7, R9, R11, R16—4700 ohms
R6—1-megohm linear potentiometer (Mallory MTC or equal)
R8, R12—22,000 ohms
R10—27,000 ohms
R13—10,000 ohm linear potentiometer (Mallory MTC or equal)
R14—390,000 ohms
R15—100 ohms
R17—100,000 ohms
R18—220 ohms
R19—470 ohms
Q1, Q2, Q3, Q4—2N2924 transistor
Q5—2N1304 transistor
D1, D2—1N914 silicon diode
D3, D4, D5, D6—1N3639 silicon rectifier
T1—double-tuned 15-kHz transformer (Miller 6194 or equal)
T2—12.6-V, 0.1-amp or more, filament transformer.
L1—16–42-mH adjustable inductor (Miller 6210 or equal)
RY1—spdt, 12–15-V, 1350–2000-ohm relay (Potter Brumfield PB R 55D or equal)
S1—4-pole, 2-position rotary switch (Centralab 1011 or equal)
S2—spst normally open push-button switch
Misc.—4" x 5" x 6" aluminum box. Vector type G board and T-28 terminals. RCA-type audio panel jack, hardware, ac power cord, binding posts, wire.

to your tape recorder.

Press the ACTUATE button and record several minutes of the control signal at a relatively low level. (Most tape machines will not record a 15-kHz signal at the normal record level and, therefore, frequency response runs are usually made at from 15 to 25 dB below the normal record level.)

When this recorded control signal is played back, it will be a control-signal source to make the above adjustments. You may skip the gain check using the 1-kHz signal, if the other tests look good.

Using your controller

The controller is designed for use with a tape playback deck that has a 1-volt output and an external amplifier. For playback control use, the controller is connected between one tape output channel and the amplifier.

It may be left connected at all times even though its control function is not being used. Set the switch to the RECORD COMMAND mode, and frequency response will be flat beyond 100 kHz.

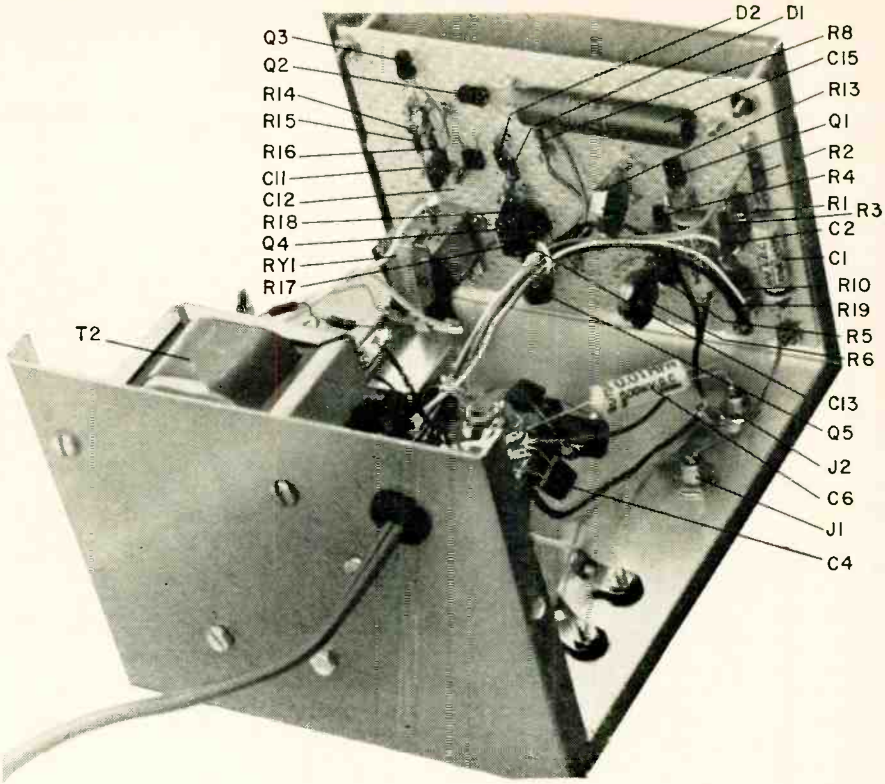
If you do not have a separate tape deck and amplifier, the controller may be connected to your all-in-one tape machine. Connect the controller in the path of the signal feeding the volume control, as shown in Fig. 2. If the same volume control is used for recording and playback, the controller will operate in both modes without changing connections.

In preparing a slide sound program I've found it easiest to record the music and commentary on a master tape, disregarding the controller. Then I borrow a second tape machine and play the master tape through the controller to make a tape copy, adding the slide-change command signal as I go.

In the RECORD COMMAND mode, the relay is operated by the ACTUATE button as the control signal is added to the program. If the projector is connected and loaded with slides it affords a good chance to rehearse the program and keep track of the slide sequence as commands are recorded.

In the PLAYBACK CONTROL mode, it may be necessary to readjust the sensitivity control for your particular equipment. If it is set too high it will operate from "print through" from the adjacent tape. If set too low, operation will be erratic.

When recording the command signal, the recording level indicator should indicate a level about midway or less from the normal record level, even though the signal is about 20 dB down. The relatively high indication is caused by the high-frequency preemphasis in all tape recording equipment.



Transistor circuitry is mounted on perforated board with point-to-point wiring.

Automatic shutoff

When not being used as a slide controller, I have found the unit very useful as an automatic shutoff for all equipment at the end of a tape. This requires an extra box containing a holding relay, outlet and on button (Fig. 3).

Record the command signal at the end of each tape. The normally closed contacts are used for this function. When the signal occurs at the end of the tape, the relay opens and the ac hold relay turns the system off.

To disable the controller, operate it in the RECORD COMMAND mode. It will not affect your tapes or record anything unless your recorder is in the record mode. With a stereo system, either channel may be used for the command signal, but you should be consistent to avoid confusion. The controller can monitor only one channel at a time.

The controller inverts signal polarity 180°. If you feel phasing is critical, reverse the speaker leads on the controller channel.

Although designed for 1-volt input and output, the controller will accept signals up to 4 volts rms without distortion or clipping. Signals as low as 50 mV rms may be used without noticeable internal noise from the controller, which is down 68 dB from the 1-volt level.

When connecting the controller to your projector, locate the two leads to the regular remote pushbutton and extend these to connect to the normally open contacts on the controller.

You'll never cease to amaze people with this "magic" gray box. **R-E**

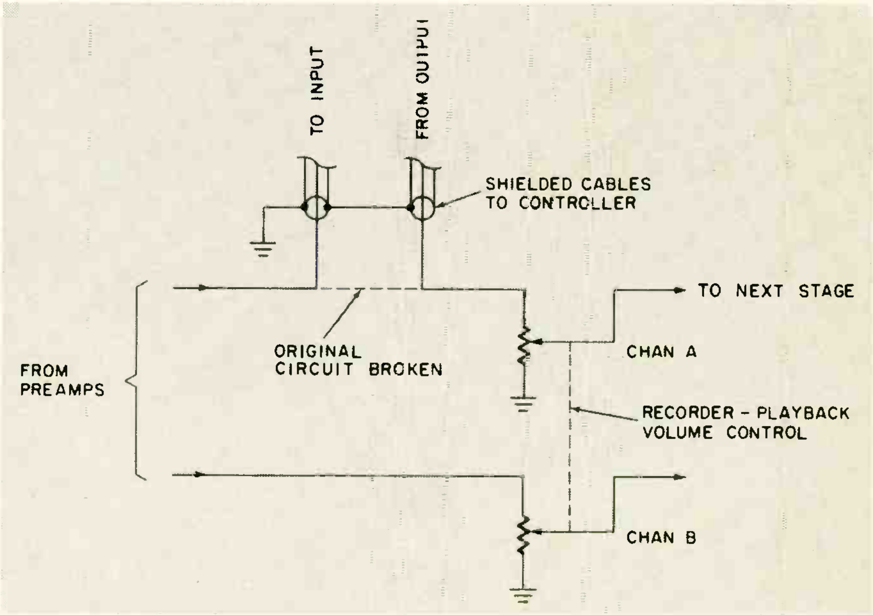
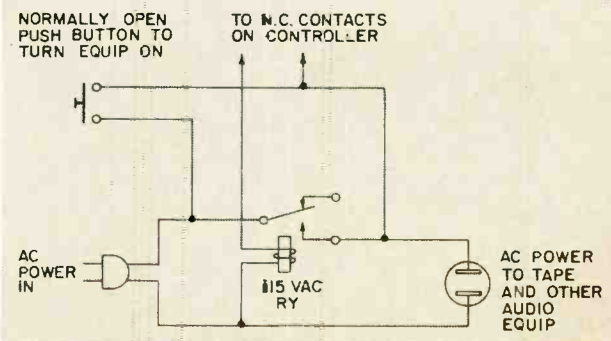


Fig. 2—Controller can be connected to tape recorders (self-contained) by wiring the controller into the signal path from the preamplifiers feeding volume control.

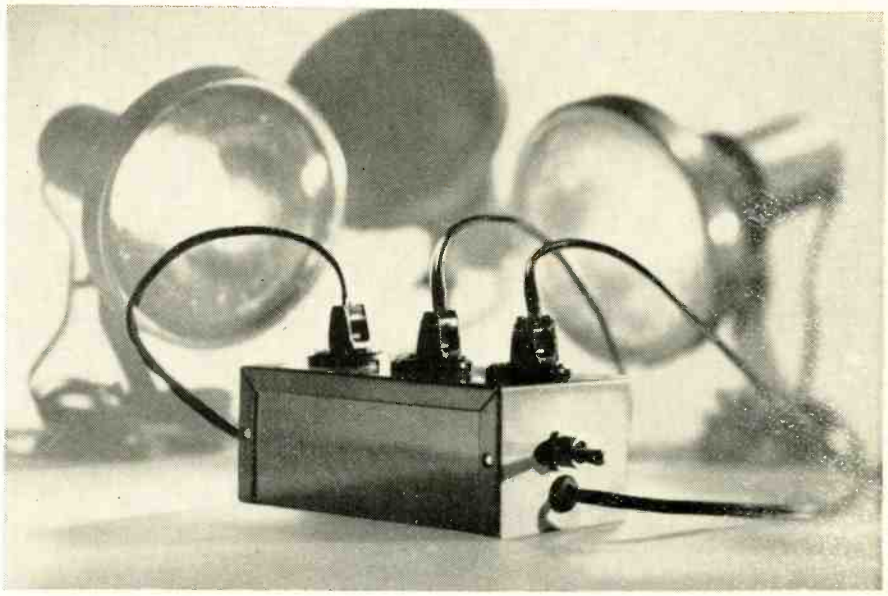
Fig. 3—An additional box with holding relay can be used to turn off your hi-fi system. When a control pulse occurs at end of tape, relay opens and removes power.



Brighten your home this season with rainbow lighting

Dancing Christmas Lights

By R. W. FOX*



REMEMBER THE COLOR WHEEL YOU bought last year, and the blinking lights from the year before? They're obsolete. Here's the color blender, the latest in special lighting for this Christmas season. No more sudden flashes; no more monotonous repetition of red, yellow, green, for hours. This year you can get every color of the rainbow with a cycle time of—well, it still hasn't been measured. All of this in a tiny box, waiting to please both family and friends.

The Color Blender consists of three identical circuits, one for blue, one for red, and one for green. Combinations of these colors will produce every color in the rainbow. Figure 1 shows graphically what is happening and, by the way, the first time you turn it on could very well be a happening! Due to the variation in component tolerances, these circuits will not be identical in performance. One may come on faster than the rest; one may stay off longer. This will give a true randomness to the colors, which is not possible with a color wheel or two, three or even fifty color wheels, since they operate similarly.

Figure 1 shows the output of the three channels as a function of time. At the start the green light is on while the others are off; the red then comes on and the color changes to yellow; then the red and green go off and the blue comes on. As this is happening the color of the display passes through a violet portion and then to pure blue. In this picture the next scene is all the lamps out or dark. Then the red comes on, followed by the green to give yellow, then the blue to give white light since all the channels are at full intensity. At the end the red lamps go out to leave a blue-green scene.

With Christmas just around the corner, the Color Blender would be the perfect addition to your home decorations, inside and out.

Inside, the Color Blender will handle up to 25 miniature lights (6 watt) per outlet on your Christmas tree. If you intermingle three strings, one each of red, blue and green, with balls and tinsel to reflect the light, your tree will seem to come to life. Or, as another way, you could use up to 150 watts per outlet of flood lamps with color filters shining on a metallic tree.

Outside, you could use strings of lights on a tree (be careful not to exceed the load limit on your circuit), or flood lights on the house or on a door covered with wrinkled foil. The wrinkling keeps the colors separated but allows them to blend in some areas to give a multiple color effect.

After Christmas, there is no need to put the Color Blender away. Just build a foil reflector with a large picture frame and shine floodlights on it for a great addition to your game room.

How it works

The G-E type D13T1 Programmable Unijunction Transistor, allows us to build this unique circuit. The D13T1 can be thought of as a complementary SCR. When the gate voltage drops below the anode voltage, current flows from anode to cathode. This circuit uses this feature to phase-fire the C106B1 SCR (see Fig. 2). When the Color Blender is initially turned on, both C1 and C3 have no charge. Capacitor C4 quickly charges to a voltage greater than the D13T1 gate voltage and triggers the D13T1, which in turn triggers the SCR, causing the light to come on brightly. On each succeeding cycle of operation capacitors C1 and C3 have a higher initial charge so that C4 cannot charge to a voltage which would trigger the D13T1 until much later in the cycle. Since C3 charges at a faster rate through R7–R8 than C1 and through R5, R6, R4, the lamp dims slowly. When the lamp goes dark, C1 discharges faster than C3 and the triggering angle of Q1 is advanced and the light brightens again.

The purpose of R1 in the circuit is solely for the protection of the C106B1 SCR. This resistor keeps the peak current through the SCR within its ratings. Although it wastes a considerable amount of power, about 4 watts at full load, it is better than replacing the SCR whenever a lamp burns out.

In addition to adding to the beauty of your Christmas display, the Color Blender also increases lamp life at least 25 times. This increase in life is due to operating the lamp on half wave. An added consequence of half wave operation is lower bulb temperature, decreasing the chance of fire, hence giving greater safety.

With the board mounting, all three circuits can be built at the same time, reducing the chance for mistakes. Since one side of the line is common to many components, a single bus running the entire length of the board may well be a good way to start. To make the circuit compact, R1 should be left off the board and wired directly to the outlet. This also

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Semiconductor Products Department
General Electric Company
Auburn, New York

keeps R1 far enough away from the SCR. Watch the connections of the SCR and Programmable Unijunction Transistor. Reversing the lead order could very well destroy these units. The polarities should also be observed on the electrolytic capacitors and the three diodes.

For safety's sake do not ground the box to the line, for a reversal of the plug could be dangerous. If you have a three wire system, though, by all means use that third wire as a ground for the case.

Figure 3 shows the board as it was constructed with all three circuits so that it would fit in a 5 x 2 x 3 inch box (Bud-CU-2106-A or equal). You will note in Fig. 3 that the leads and tab of the C106B1 are bent. *CAUTION:* The tab should be held by long-nosed pliers between the body and the bend while you are forming the device.

To prepare your box, punch three 1¼ inch diameter holes in the top, one small hole in one end for the line cord, one for the switch and the box is ready. Insert into the box the three outlets and fasten them in place with spring clips. The R1 resistors can be attached on one terminal and their free ends connected to the switch. Use heavy bus wire from the other outlet terminals to the board, and no other supports should be needed to hold the board in place.

Once the circuit board is mounted in the box and the final connections are made, but before you put the Color Blender to use, you may have to adjust the R8 resistors. If an associated light comes on but damps out to a level between full on and off, R8 should be decreased. If the lamp snaps on, R8 should be increased. **R-E**

References For Further Reading

1. SCR Manual, 4th Edition, General Electric Company
2. Hobby Manual, 2nd Edition, General Electric Company

PARTS LIST

Capacitors—50 volts unless noted
C1—33μF, electrolytic
C2—1μF, 25 V, electrolytic
C3—10μF, electrolytic
C4—0.05 μF, paper
D1, D2, D3—1N5059

Resistors—½-watt, 10%, carbon unless noted
R1—5 ohms, 5 watts
R2—1000 ohms
R3—82,000 ohms
R4—22,000 ohms
R5—220,000 ohms
R6, R7, R9—100,000 ohms
R8—50,000 ohms, potentiometer
Q1—D13T1
SCR1—C106B1
Miscellaneous hardware—box, line cord, outlets (Amphenol 61-F1 or equiv.) circuit board, switch (Except for the box and line cord, three sets of parts will be needed to build a three-lamp controller)

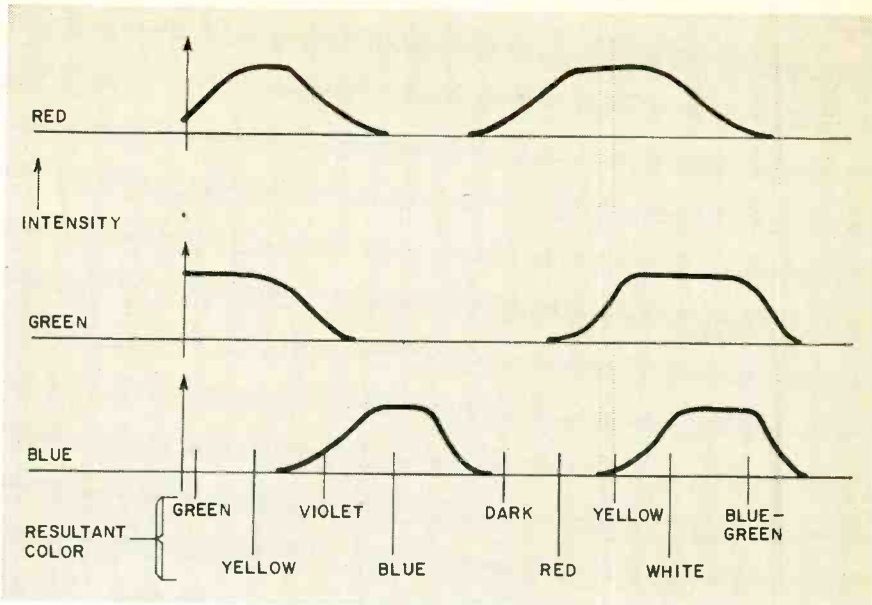


Fig. 1—Output amplitude of three light channels as a function of time. Variation in component values cause each channel to randomly vary lamp pattern and intensity.

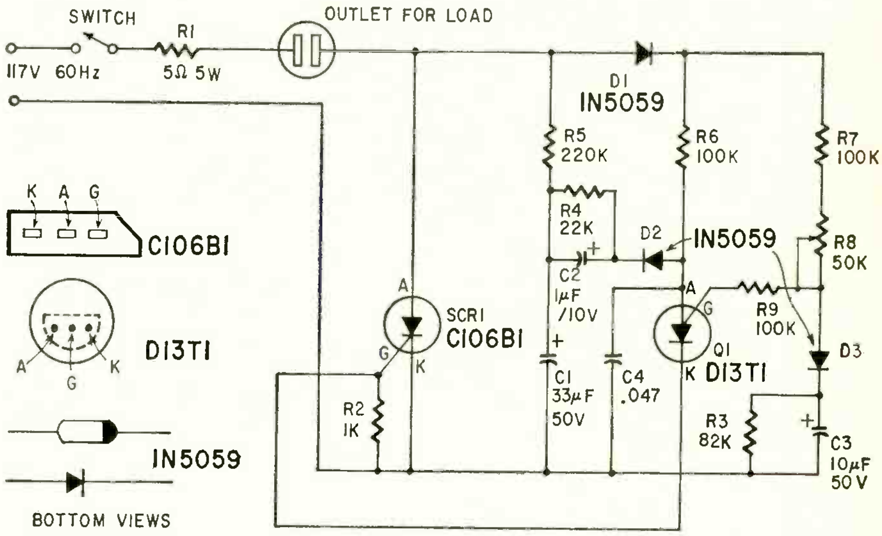


Fig. 2—Unijunction transistor Q1 is used in conjunction with the D13T1 SCR to turn the lamps on and off. The charging relationship between C1, C3 and C4 set the pattern.

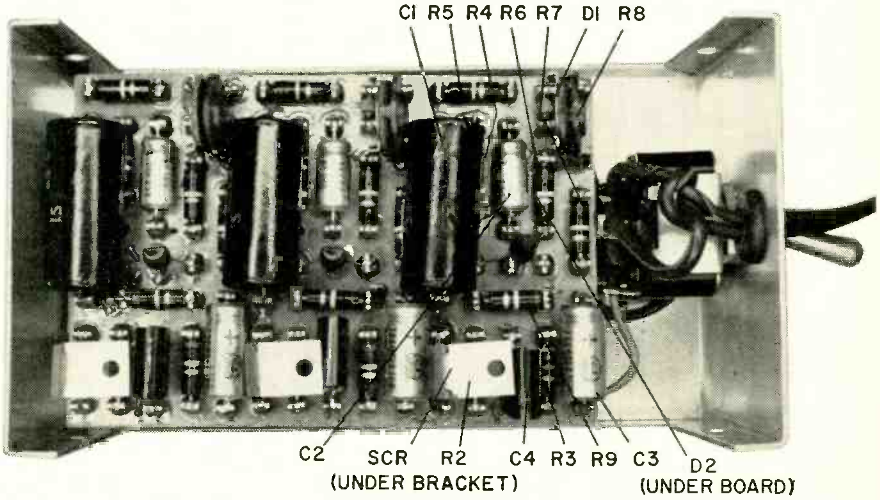
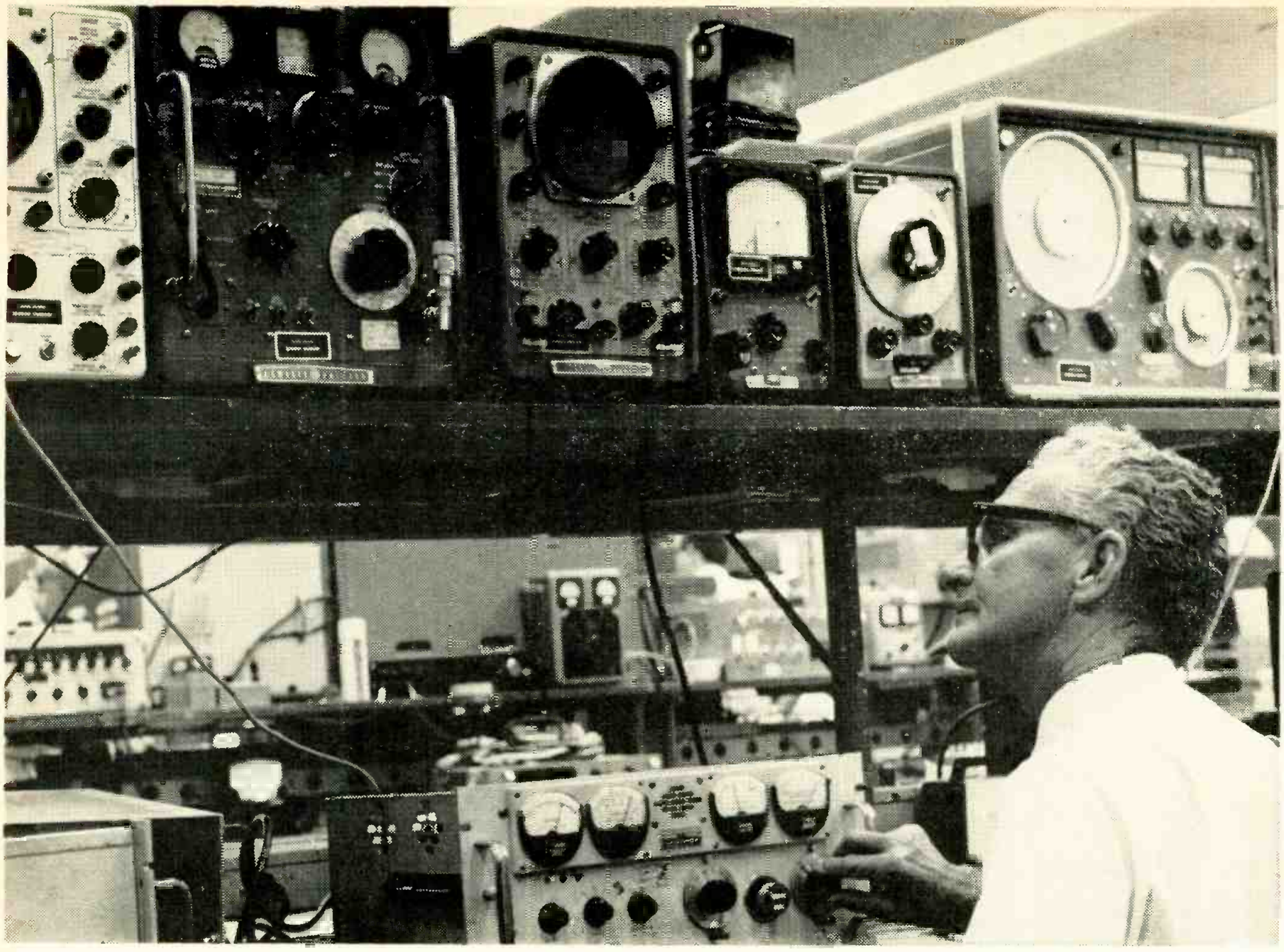


Fig. 3—Component layout for all three identical control channels. Parts are identified on one channel only. Resistor R8 is adjusted to establish proper "on" sequence.



Jobs For Electronic Testers

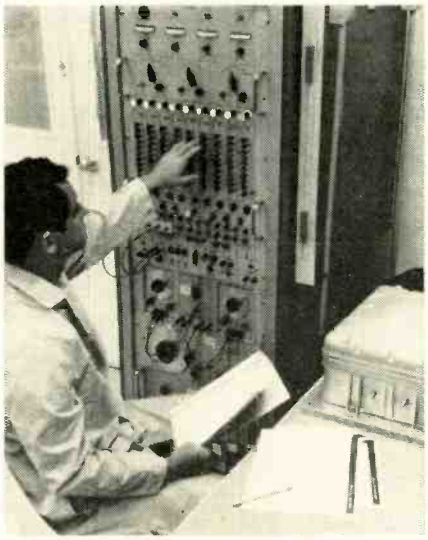
Find out what know-how you need to start a fascinating career

By L. L. FARKAS*

WHAT SHOULD AN ELECTRONIC TESTER know to get a job in industry? The first prerequisite of course, is knowledge of basic electronic theory. This can be obtained through reputable electronic schools.

He should be familiar with the theory of transmission, reception, detection and amplification of radio signals, and with circuits used to handle audio and video frequencies. He should also know something about the different types of power supplies and various antennas.

Moreover, an electronic tester should be capable of calculating voltages and currents. In testing, he may have to find the value of a certain voltage-dropping resistor or determine the amount of current flowing through a circuit. This is particularly true when working with current-sensitive devices whose current must be limited to protect them from burnout.



Testmen must often record data from a completed unit using special equipment. Testing Saturn Control Signal Processor.

The tester should be able to calculate the frequency response and impedance of a circuit, since he may need to match input and output impedances to obtain maximum energy transfer.

With the advent of solid-state technology, the tester must know something about diode and transistor characteristics, as well as the types of circuits in which they are used. In fact, by outside reading, he should bring his knowledge up to the state-of-the-art on all semiconductor devices. This is especially useful in a research and development job where, as a technician, he will have to hook up and check such devices.

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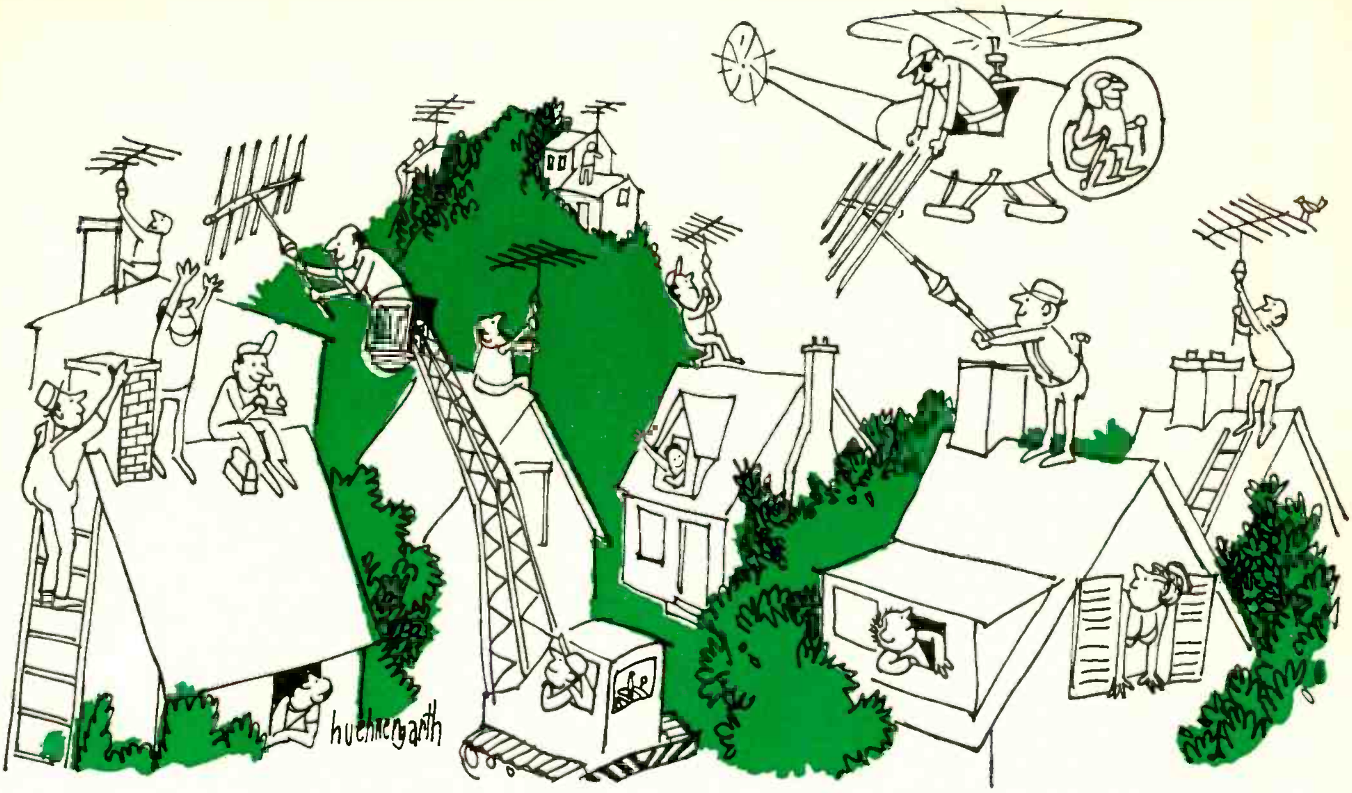

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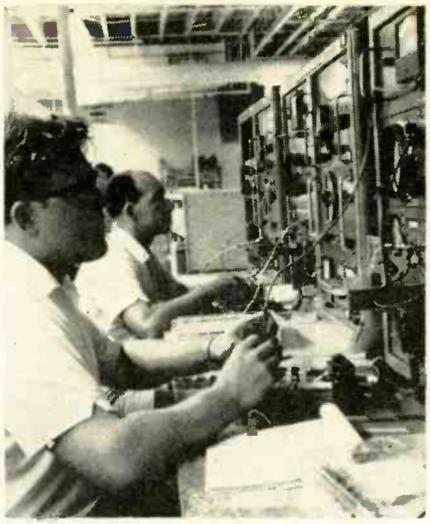
Circle 26 on reader's service card

of-the-art familiarity is the ability to use test equipment. While technical school students get some practice in using test equipment, this function is not always stressed. Furthermore, the number and types of equipment may be limited.

Remember that a tester's or a technician's tools are the meters, bridges, generators and oscilloscopes with which he feeds signals into equipment and checks the output of the equipment.

Where will he use this test equipment? At a component plant, the tester must check the electrical characteris-



Completed missile modules under test.

Troubleshooting a subcarrier oscillator.

Checking transistors on automatic tester.

Recording data on field effect transistors.

tics of resistors, capacitors, diodes, transistors, coils and transformers. He may have to check complete subassemblies such as i.f. or rf strips, power supplies, amplifiers, or chassis of radio or television receivers.

If he is working for a firm that buys such equipment, he may have to test components or equipment to make sure they meet purchase specifications.

On the production line, the tester will again test components, subassemblies, chassis, subsystems or complete systems. Here, not only the basic types of test equipment are used, but often the more complex digital voltmeters, frequency meters, counters, dual-beam oscilloscopes and electronic tools built specially to test hardware parameters.

Other areas where the tester uses equipment include standards and calibration laboratories, anechoic chambers, environmental test areas and various engineering laboratories where electronic equipment is developed.

To use test equipment correctly, the tester must know its characteristics. What are the limits to which it can test hardware, parameters such as voltage, current, frequency? What is its impedance? How accurately will it measure a certain value? What are its usable scale factors?

One quality the tester must acquire is the ability to follow test procedures. On a production line, test procedures are used to insure each component or chassis is tested in the same way. Deviating from procedure might facilitate a test or make it shorter, but there is always the danger an important part of a test may be omitted or equipment may be tested to the wrong parameter. Once test procedures have been established, the tester must learn to follow them implicitly. Then, should test procedures be wrong, it is the tester's duty to point them out to his supervisor so they can be remedied.

Testers must also be able to read and record production test data. This

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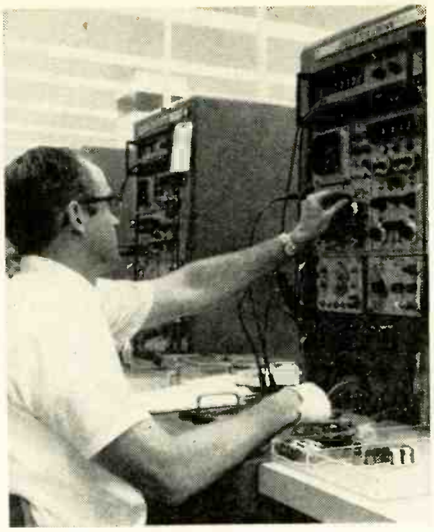


Test station for electronic modules.

Automatically testing a module "card."

may sound simple, and it is, provided the tester pays particular attention to the way he determines the data. Are the meters on the correct scale, the switches on the right setting? Are the data read directly? Are the multipliers taken into consideration? Is the right extrapolation made when the results are between calibration points? These are some of the factors that must be kept in mind when reading data.

In recording the data, the tester must also insure he does not list results erroneously. Here a little extra time checking that data are placed in the right columns, that records are legible, and that decimal points are not misplaced will prove invaluable when the time comes to refer to test results.

It also helps to write down any unusual test conditions, particularly when these affect test readings. The more information a test evaluator has about a specific test, the better he will be able to analyze problems and correctly interpret test results.

A tester must also have experience in troubleshooting hardware. Normally, troubleshooting is a fairly simple function. Faced by malfunction in equipment, the tester first plans the method he will use to isolate the defect. Then he selects the test equipment required to execute his plans.

However, to troubleshoot properly, the tester must have a good idea how the defective hardware should operate. He should know what voltages, currents or types of signal the hardware should produce. He then selects test equipment that will correctly show these characteristics.

Finally, he must determine where to connect this test equipment so it will record the desired data without affecting normal hardware operation.

Of course, troubleshooting complex equipment cannot be done without training in its theory and operation. But the basic methods used for troubleshooting such items as receivers, transmitters, power supplies and displays should be part of every tester's education. As long as he knows basic troubleshooting methods, he will be able to adapt these to solving problems in more complex hardware.

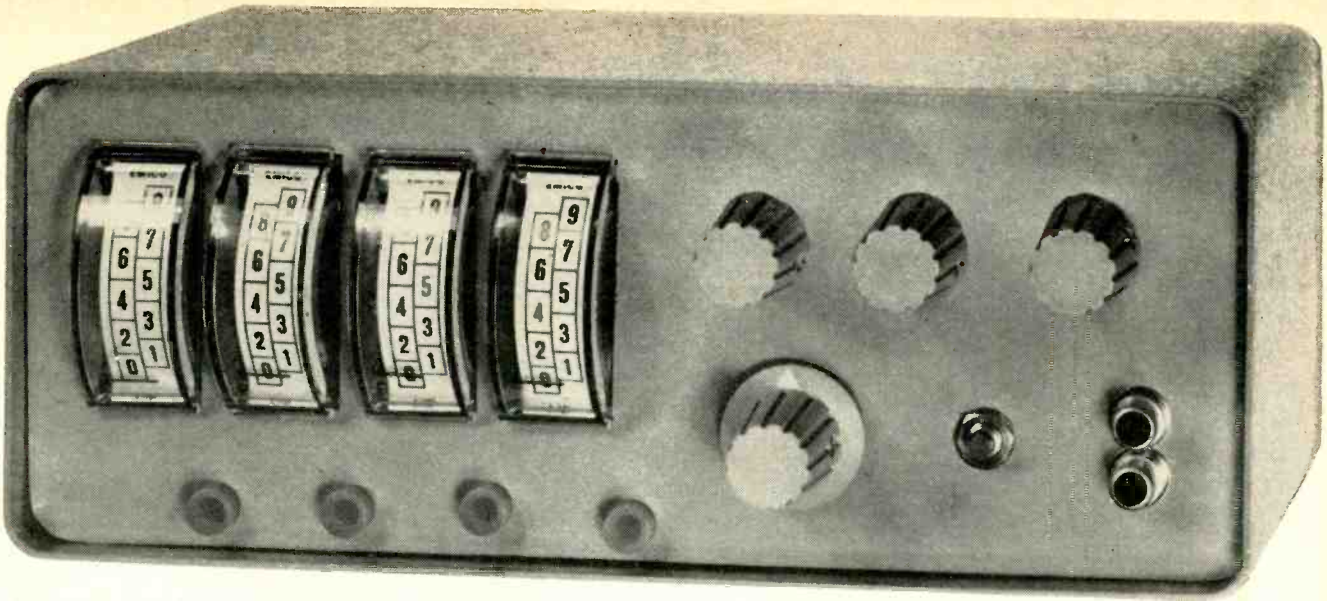
Know your schematics

One basic requirement for troubleshooting is the ability to read schematics and line drawings. Only by being familiar with circuit symbols, drawing methods and print references can the tester hope to trace the operation of the circuits he's investigating.

Once he isolates the defects, he must record his findings. (There is nothing more frustrating to the corrective-action engineer than to find the record of a component replacement without an indication of the problem encountered, or with a description of the defect so garbled that he can't decipher it.)

So it is extremely important that the tester who troubleshoots does a good job of documenting his findings. Only by providing such definite and clearly understandable data can the tester help provide the required corrective action.

Thus, testers must not only know the basic theory of the equipment they are testing, but they should also be thoroughly familiar with the characteristics of their test equipment. They should be capable of following test procedures implicitly, know how to isolate defects and have the ability to record data accurately. With the capabilities, a tester should have no difficulties in obtaining and maintaining a job in industry. **R-E**



FOR THE EXPERIMENTER

9 Digital Readout IC Instruments

Start with digital readout modules, add a power supply, then try these devices.

By RALPH GENTER

WOULD YOU LIKE TO BUILD A FREQUENCY COUNTER, A digital voltmeter, an electronic piano tuner, and half a dozen other typical digital instruments? You can, and rather easily. First though you'll need some digital readout modules—complete instructions on how to build them at $10 each appeared in November's RADIO-ELECTRONICS.

Powering the modules

The first order of business is a power supply. For a 4-digit readout, we'll need a regulated 40 mA at 18 V; around 0.5A at 3.6 V; and possibly a split, low current dual 6-V supply. The circuit is in Fig 1.

It is vital that the meters in the individual modules do not interact or change their readings with time. The Zener/transistor regulator insures a stable reference voltage. Low ripple is the main problem on the 3.6-V supply. We maintain it through brute-force filtering with two large electrolytics. To get by on a stock transformer, we have to drop the input dc voltage on the 3.6-V supply with the forward drops of several silicon diodes. This is better than using resistors as the voltage drop is nearly constant and independent of loading.

The final portion of the supply provides the low current +6- and −6-V supplies that will be needed if a comparator is part of the particular instrument you want to build.

Driving the modules

Now we can connect our four modules in cascade,

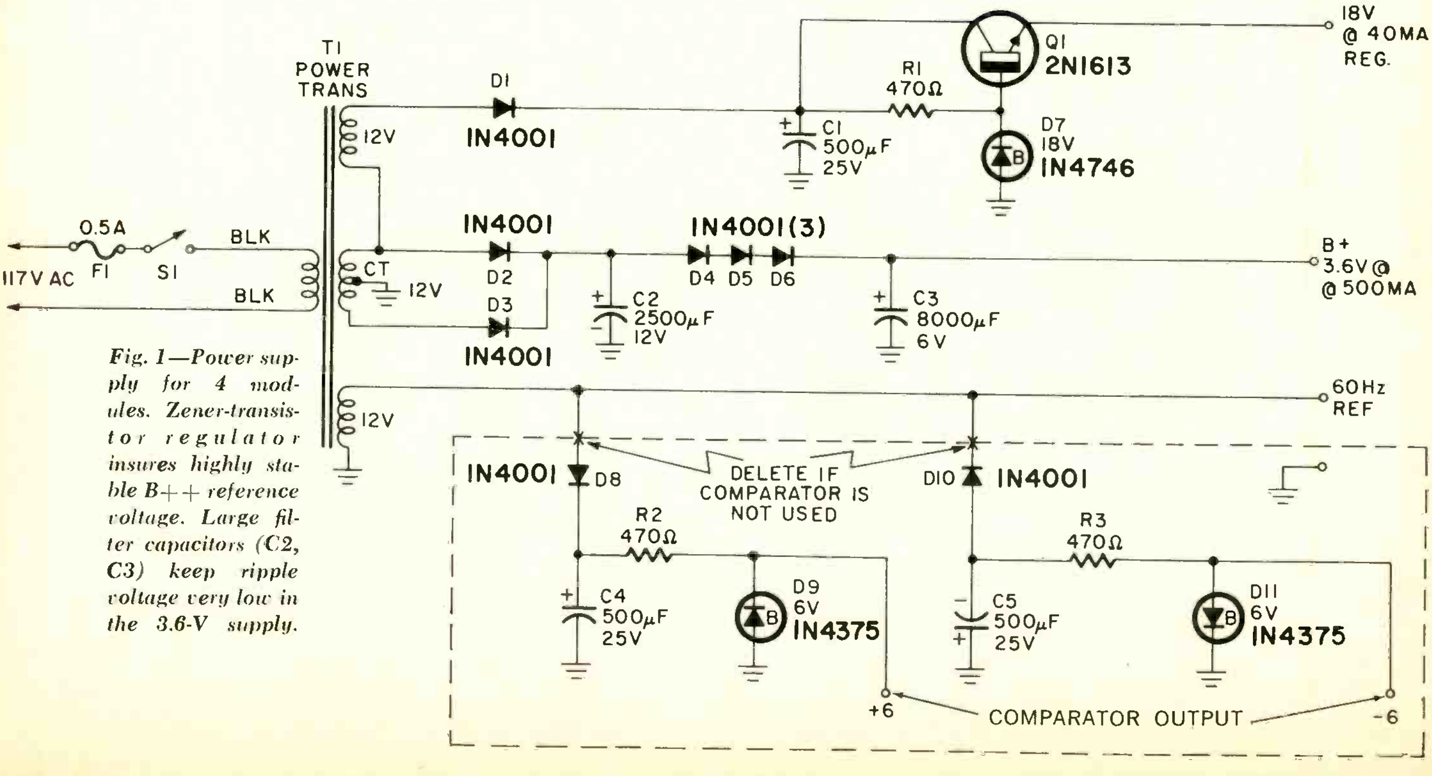


Fig. 1—Power supply for 4 modules. Zener-transistor regulator insures highly stable B++ reference voltage. Large filter capacitors (C2, C3) keep ripple voltage very low in the 3.6-V supply.

powering them off the supply. Each module directly drives the next digit over, simply by connecting the CARRY output of the first to the COUNT input of the next, and so on. As we pointed out last month, the input signal *must* be normally positive by about 2 V or so and must *very abruptly* drop to zero, once and only once, per desired count. Any other form of COUNT input will simply be ignored or will cause very erratic operation.

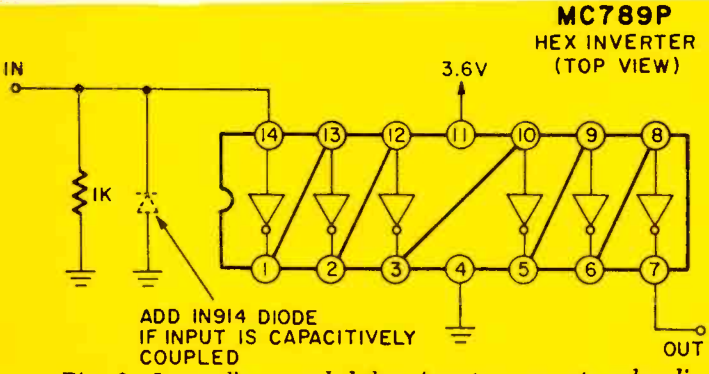


Fig. 2—Internally cascaded hex inverter converts subaudio.

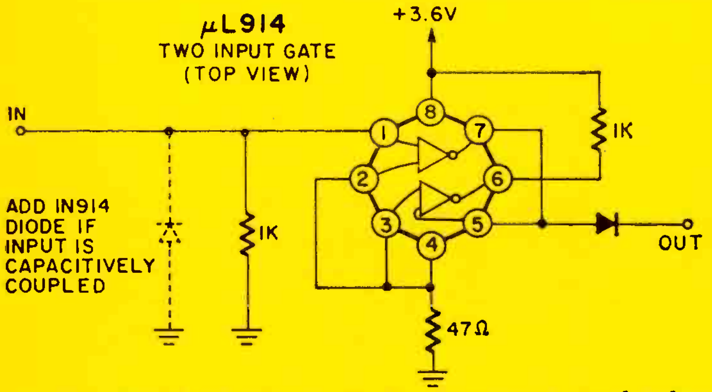


Fig. 3—Schmitt trigger will also shape input signal pulses.

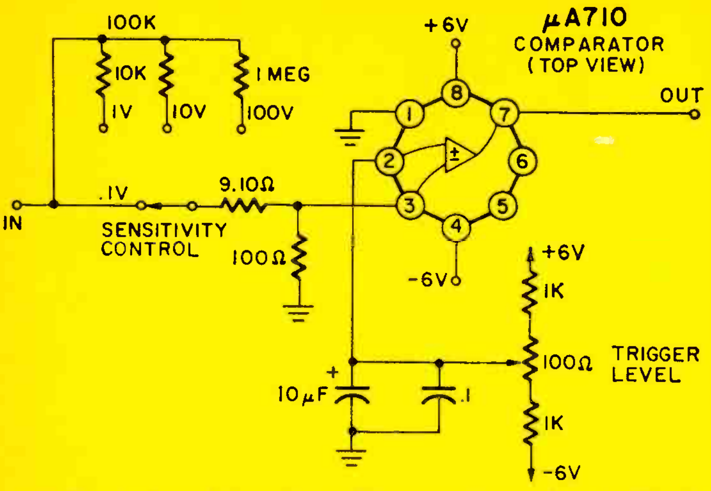


Fig. 4—Best, but costly, an IC comparator works on millivolts.

We can directly drive the COUNT input with a good fast-fall square wave or with pulses that have a good fall time. We can also use sine-waves, if their frequency is above 100 kHz. Any other form of input signal *MUST* be conditioned by one of the circuits described below.

We speak of the process of getting the signals we have into the desired form as conditioning. There are several ways we can condition our inputs. The easiest is to simply amplify and limit our input enough to obtain the necessary fall time. A hex inverter can have all six of its internal gates cascaded together, giving a one-piece, $1.08 limiter that will even handle sub-audio sine-waves (see Fig. 2).

An alternative is a Schmitt trigger (Fig. 3). This one takes two 2-input gates, three resistors, and a diode, and provides a snap action anytime the dc level on its input goes above 1.5 V or drops below 1.2 V. If either of these two circuits is driven by a capacitance-coupled input, you'll have to add a diode dc restorer to the input and have to be sure your capacitor has a low reactance at the *lowest* frequency you'll be concerned with.

If we switch to an integrated-circuit comparator (Fig. 4), we can get much better performance, but not without adding $6.75 worth of IC, and another $5 worth of parts to the circuit. Either of the simpler circuits takes about 4 V peak-to-peak drive. The comparator will operate on a few millivolts. Further, we can pick the highest peak on a lumpy input signal, or establish a threshold level that ignores noise and concentrates on the input signal we are trying to measure. Another big benefit of the comparator is that it works well with a wide range of input signals and voltage levels. You will not need an input sensitivity potentiometer. A simple 0.1, 1, 10, 100 V switched divider will do as well and handle any size signal.

Mechanical contacts

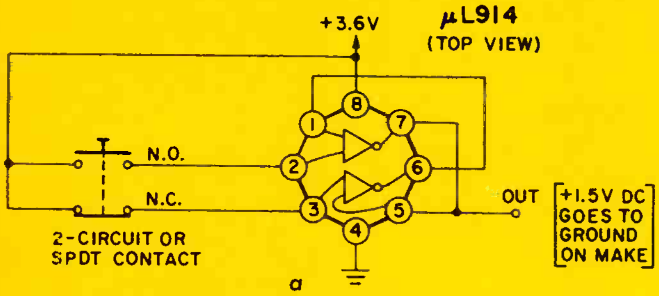
Ordinary pushbuttons have considerable contact bounce and noise. So much, in fact, that if you connected one to the input of a counting module chain, you'd most likely get several hundred counts each time you hit the button. Mechanical contacts of any sort must be made bounceless before they can be used with an electronic counter! Two simple anti-bounce techniques are illustrated in Fig. 5. If you can use a spdt pushbutton, you can connect two gates into a set-reset flip-flop combination that latches in one state the instant the button is pressed and snaps back the moment it is released (Fig. 5-a). One 80¢ integrated circuit is needed.

If you are stuck with a single make contact, you'll have to use a monostable circuit (Fig. 5-b). This takes an additional resistor and capacitor. It produces a constant-width output pulse after the first contact is initially made. Normally a 10-msec pulse width is desirable, but certain applications [slot car track trips, for instance] might require a 1-second pulse width. Just use the larger capacitor and resistor values to get the longer time.

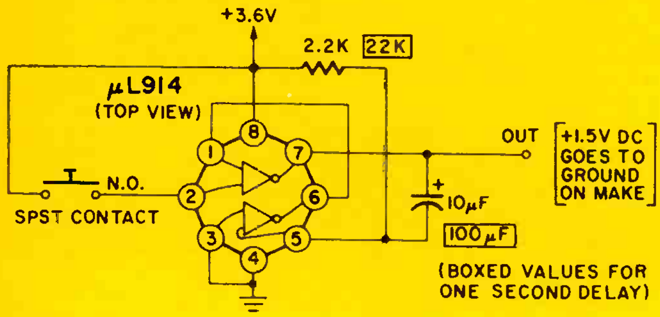
Gating

So far, we have no way to turn the decimal counting modules on and off. This is fine if we are counting events. But for most counter applications, we want to know how many events happened during some known exact period of time [electronic frequency counters, digital voltmeters, etc. . .], or else how many pulses of known frequency occur during the presence of an input event [ballistic velocity meters, piano tuners, etc. . .]. Either method takes an electronic switch called a *gate*, to "start" and "stop" the counter in a predetermined sequence.

An ON-OFF gate is shown in Fig. 6. Here signal **A** is passed only when signal **B** is *grounded*. This takes a dual 2-input gate, or else one 2-input gate and an inverter. All signals must be conditioned properly before they reach this point in the circuit. Another gate form is the START-STOP gate (see Fig. 7). Here input signal **B** starts the gate and allows signal **A** to pass. Signal **C** stops the gate. Thus signal **A** gets through only in the time *between* signal **B** and signal **C**. Usually the ON-OFF gates are used in electronic counters, while the START-STOP are used in instru-



a



b

Fig. 5-a—A spdt switch can be made "bounceless" with a μL914. b—External circuit connections to IC for single make contact.

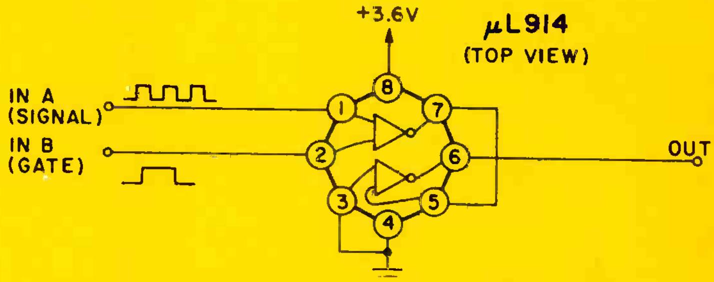


Fig. 6—Module on-off gate. If B is grounded, input A is passed. If input B is positive, output stays positive.

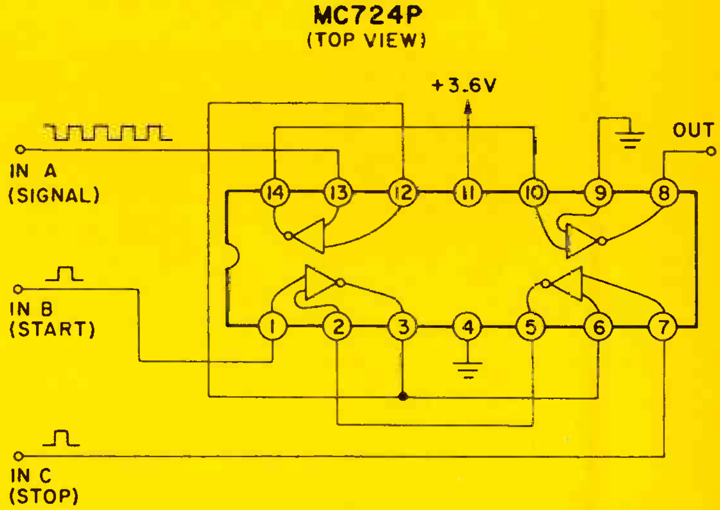
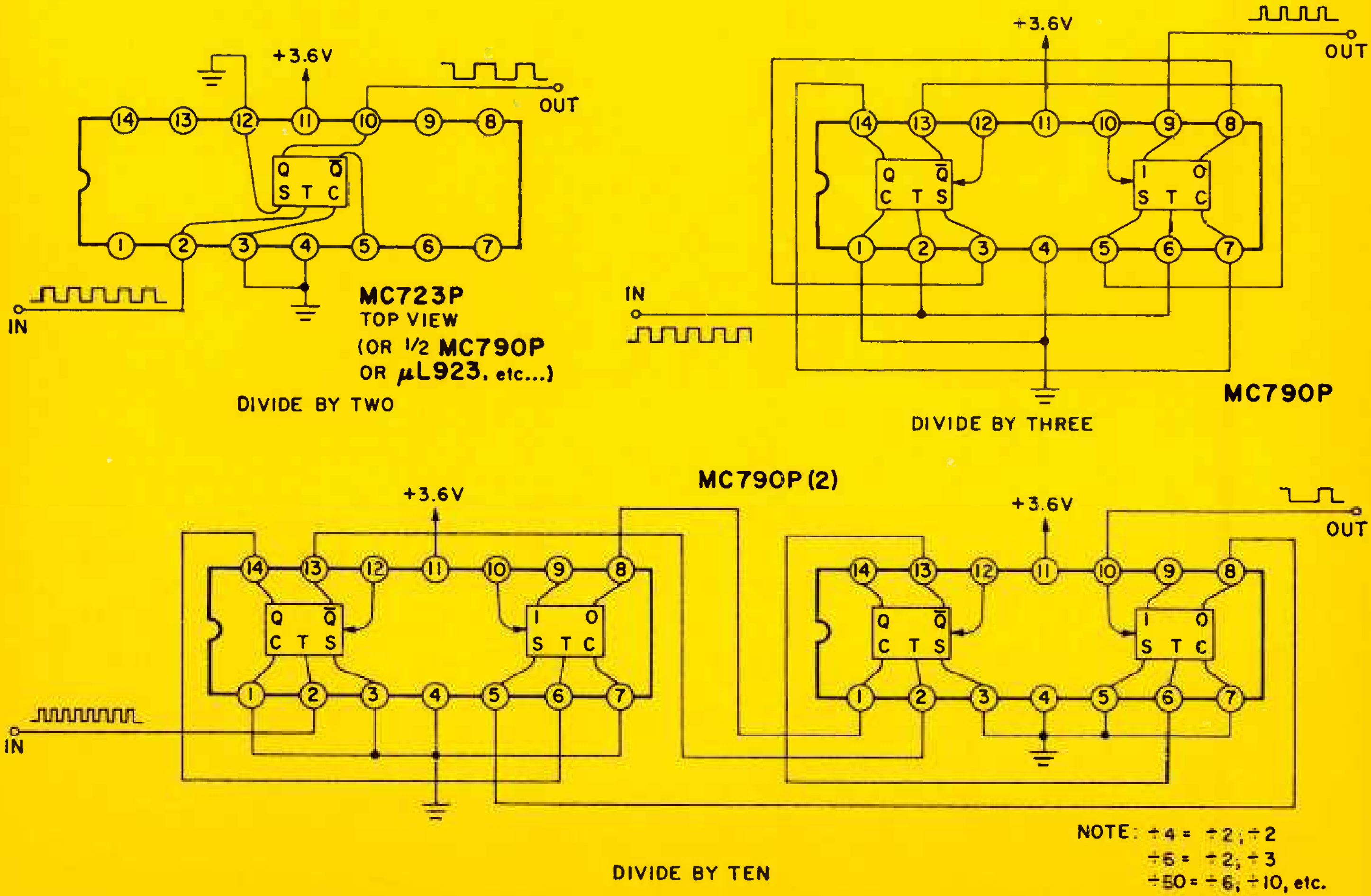


Fig. 7—Start-stop gate. Input A is passed only between pulses B and C. Input B must be off before C arrives.

Fig. 8—Scaling circuits divide input signals for easy counting. Divide by 2 circuit is a binary divider; two JK flip-flops with feedback form the divide by 3 circuit. The divide by 10 is a "Modulo ten minimum hardware circuit" without gates.



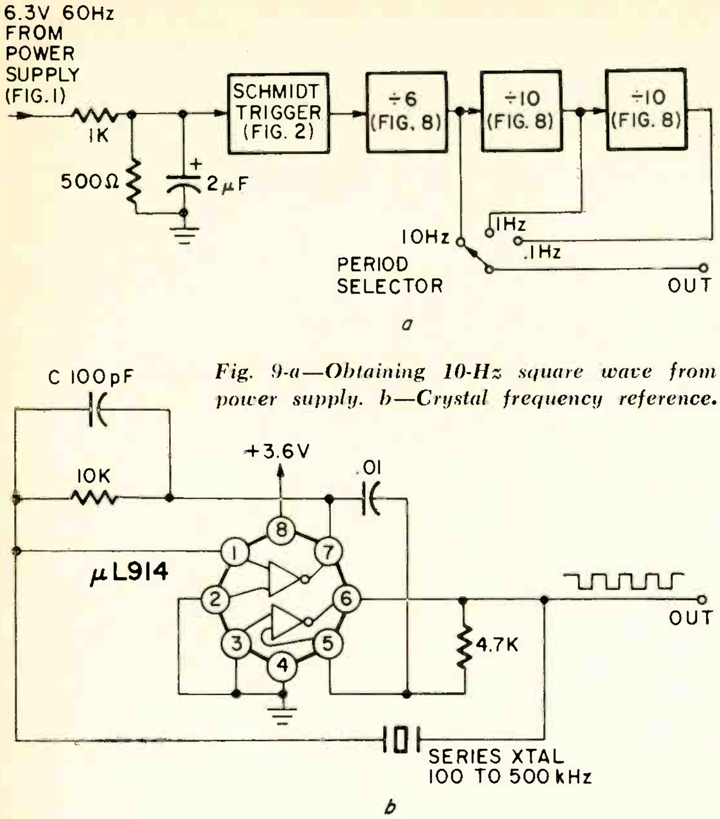


Fig. 9-a—Obtaining 10-Hz square wave from power supply. b—Crystal frequency reference.

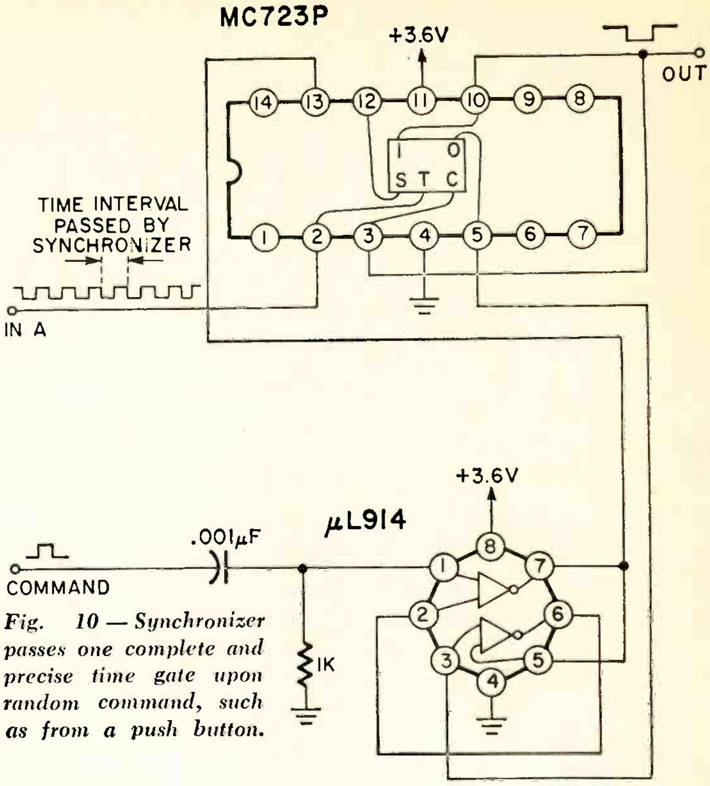


Fig. 10 — Synchronizer passes one complete and precise time gate upon random command, such as from a push button.

ments that take two inputs, such as a drag-strip trap speedometer.

Scaling

We will also need a way to divide down signals, perhaps for a 10-MHz input signal that needs reduction to 100 kHz so it is easily counted, or a 60-Hz power-line signal that is divided by 6 to get 0.1-second pulses, or by 60 to get 1-second pulses. These are called scaling circuits and are easily built from the same JK flip-flops we used in the decimal counting modules. The most common factors we would like to scale by are 2, 3, 6, and 10. The required connections are shown in Fig. 8. The divide by 2 is simply a binary divider, while the divide by 3 uses two JK flip-flops and feedback to produce the division by three. A divide by 6 is nothing but a divide by three followed by a divide by two. The divide by 10 is called a "Modulo ten minimum hardware" circuit, and requires no gates to produce a division by ten.

Time and frequency bases

All but the straight counter applications of the decimal counting modules require either a source of a stable reference frequency or some gates of precisely known time widths. The accuracy of the instrument depends entirely upon the accuracy and stability of these references. A 4-decade instrument is inherently capable of 0.1 to 0.01% accuracy—if the references used *exceed* these figures.

The 60-Hz power line is a handy source of accurate time gates. In most parts of the country, the line is held to within 0.05% of 60 Hz, and the short-term stability is even better. This time base is good enough for most three- and four-place digital instruments, and far cheaper than starting with a high-frequency crystal and dividing down. Fig. 9-a shows how we borrow a 6.3-V ac reference off the power supply, filter it to remove noise, Schmitt trigger it, and divide it by six. This gives us a 10-Hz square wave. Two scalings by ten will then give us 1 Hz and 0.1 Hz, with their equivalent periods of 0.1, 1 and 10 seconds.

For a frequency reference [You'll rarely need both references in a single instrument], we can turn to a crystal, possibly 100 kHz, 500 kHz, or some other frequency that is the magic number that makes the readout and the answer fit the measuring problem. This oscillator (Fig. 9-b) produces a square wave that will directly drive any of our circuits without conditioning. Capacitor C is adjusted to insure the crystal is oscillating on the proper mode and not on an unwanted overtone.

Synchronizing

This is a tricky little problem. How do we produce *one* precise time gate, say one second long, on the command of some totally random event, such as a pressed button? We cannot just use a gate, for we may only get a quarter second's worth of gating if we hit the button at the wrong time. And, if we stay on the button too long, we might get several 1-second gates in a row, piling up the numbers in the decimal counting modules. The required circuit is called a synchronizer, and lets one complete cycle of the input pass upon a random command. The output is a grounded signal that lasts the time between negative transitions of the input signal, and one only is produced upon command. The circuit is shown in Fig. 10. It takes two gates connected as a set-reset flip-flop that drives a synchronizing JK flip-flop.

Voltage to frequency

You'll need a voltage-to-frequency converter anytime you wish to digitally measure an input voltage, such as in a digital voltmeter, ohmmeter, or thermometer. In a digital voltmeter, for example, you scale your input voltage, convert it to a frequency, and then measure the frequency in an events-per-unit-time setup.

You'll find the 0.1% accuracy you need too tight for a conventional voltage-controlled oscillator or multivi-

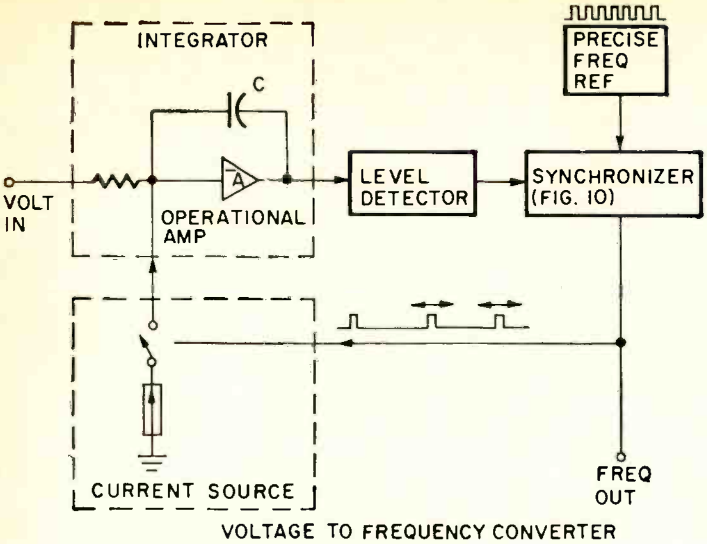


Fig. 11—This charge-integrator circuit offers 0.1% accuracy.

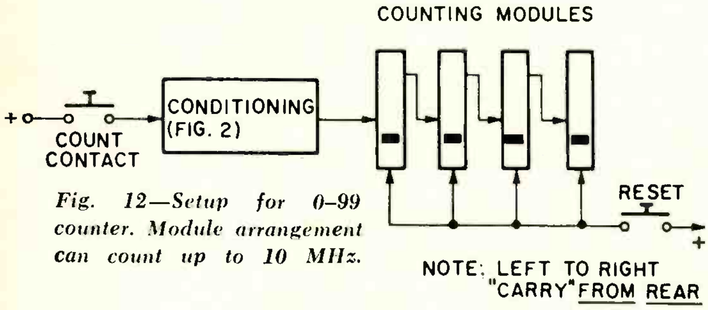


Fig. 12—Setup for 0-99 counter. Module arrangement can count up to 10 MHz.

Fig. 13—By grouping the counting modules in twos, a slot-car lap counter can judge and announce races.

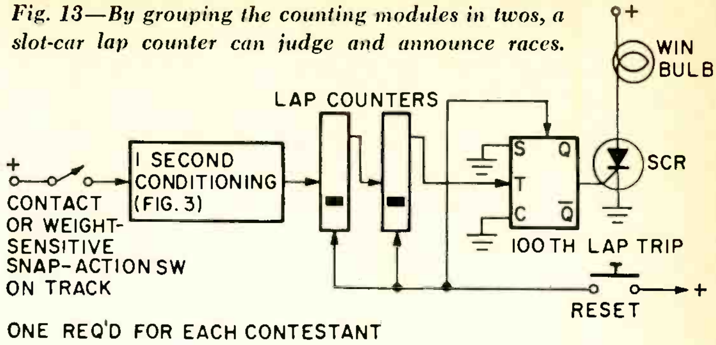
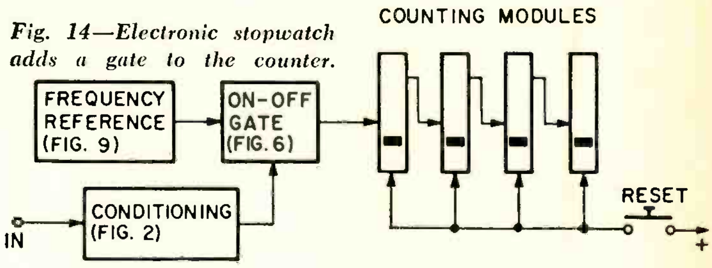


Fig. 14—Electronic stopwatch adds a gate to the counter.



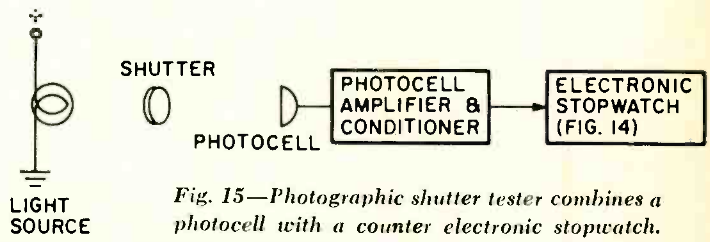


Fig. 15—Photographic shutter tester combines a photocell with a counter electronic stopwatch.

brator setup. Instead a charge integrator circuit, like the one in Fig. 11 is needed. Operational amplifier A charges capacitor C with the input current. Everytime capacitor C swings positive, the output-level detector reaches around and *removes* a constant slug of charge from the capacitor. This is done with a constant current applied for a constant reference time. As charge equals current × time, a constant amount of charge is removed each time the input manages to recharge the capacitor. The greater the input voltage, the faster the capacitor charges, and the *more often* constant charge has to be removed from the capacitor. The output is a series of pulses of accurate width whose frequency varies very accurately with changes in the input voltage.

Let's build some instruments

We now have all the pieces and parts we need for most any digital instrument. Now, how do we put them together? Anything we build will take three or four decimal counting modules, a power supply, and a box. You might like to try a package similar to the one shown in the photo—it's a deep drawn aluminum case about 3 x 4 x 9 in., and with some careful layout, can house almost any digital instrument you like. If you are careful, you can get by on 1/10 the size, 1/10 the cost, and 1/10 the weight of all but the newest equivalent commercial gear!

Let's start with a straight 0-9999 counter built up like Fig. 12. With square-wave electronic input or mechanical contacts with set-reset conditioning, you can count as fast as 10 MHz. The monostable conditioning circuits are limited to a top speed of 20 counts or so per second. The reset pushbutton need not be conditioned. Resetting a counter 193 times is just as good as resetting it once.

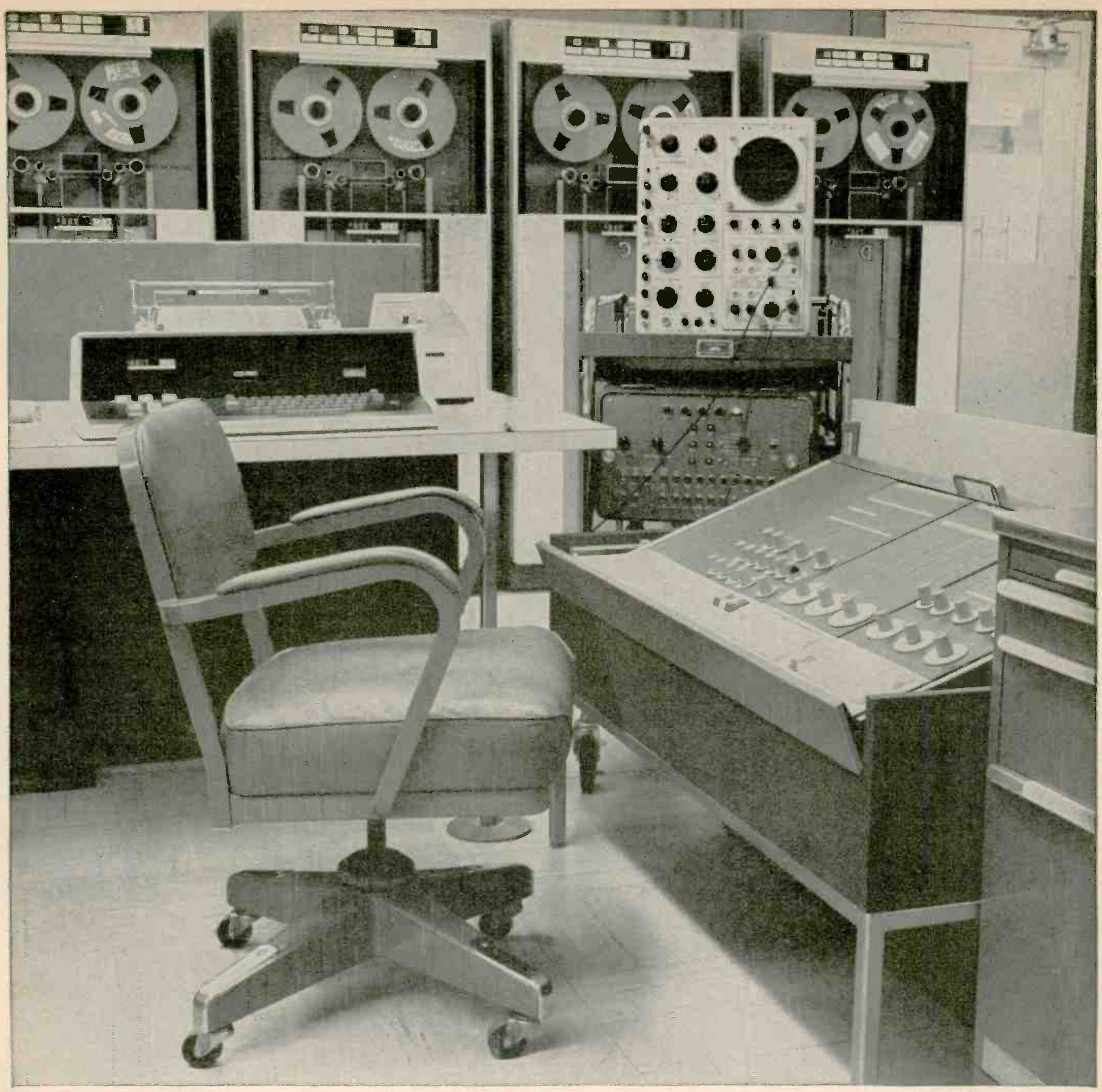
Group your counting modules by twos, and you have a lap counter for a slot car race that not only keeps track of the laps, but provides an output signal on the 100th lap. Details are in Fig. 13. You can arrange a mechanical, photoelectric, or weight sensitive track pickoff and run it through 1 second contact conditioning, just to be sure the car's bouncing does not register a false lap.

The heart of many of the instruments is an electronic stopwatch, or events-per-unit-time instrument. The simplest type is shown in Fig. 14. All we do is add a gate to the basic counter, and open and close the gate with the event we wish to measure. We obtain an input from a reference frequency source. Your choice of frequency determines the range and resolution. A 1-MHz clock gives you 1-μsec resolution and a 10-msec range, while a 10-Hz clock gives you 0.1-second resolution and a 100-second range. Make sure your event measuring has an accuracy commensurate with your resolution. Your gating waveform must come up in less than one clock cycle and stay there without noise or breaks for the entire time. Then it must fall in less than a clock cycle. Any other response limitations must be taken into account. You're not about to measure a 10-μsec pulse with a cadmium sulfide photocell with a 10-msec plus rise time. Nor is anything you do requiring human response on a pushbutton going to be much more accurate than 0.1 second.

Photographic shutter tester

This is a snap. We just put a good photocell in front of our counter connected as an electronic stopwatch and shine light on it only when the shutter is open. Of course you'll need a good quality silicon photocell with a 50-μsec rise time or so. A 5-kHz clock is a good choice, as it will cover 1/1000 second down to 1/2 second. The 1/1000 second accuracy will only be 20%. If this is not good enough, a faster clock may be switch selected. Details are in Fig. 15.

A start–stop gate is needed for either the ballistic



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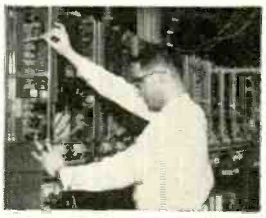

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velocity meter of Fig. 16 or the drag-strip trap speedometer of Fig. 17. In the bullet meter, either photoelectric pick-offs or the usual screens may be used. By knowing the *distance* between the trips and the *frequency* of your reference clock, you can precisely calculate the *time* it takes for the bullet to travel through the screens, and then calculate the velocity. For instance, suppose we have a 4-ft screen separation, a 100-kHz clock, and a bullet causes a 200 reading on a three-place counter. Each clock pulse is spaced 10 μsec from its nearest neighbor, so it apparently took 2000 μsec or 2 msec for the bullet to travel four feet. Four feet in 2 msec is equivalent to 2000 feet per second.

The calculation is the same at the drag strip, only now we are dealing with a greater spacing and most likely, lower velocities.

Electronic piano tuner

The note is picked up with a contact microphone, and is this time to measure the time between zero crossings of the fundamental component of a piano note (Fig. 18). The note is picked up with a contact microphone, and is well filtered to pick out the fundamental frequency. It is then amplified and limited with a high-quality limiter. After the limiting, a binary divider chain octave selector reduces all the notes to square waves having a fundamental frequency between 28 and 56 Hz. A note detector [a monostable of some sort] resets the counting modules [four are needed for sufficient accuracy] and waits till the middle of the note. In the middle of the note, a synchronizer is told to produce a gate exactly two positive zero crossings wide. This routes a 250-kHz clock to the decimal counting modules, producing a number which is converted into frequency by consulting a conversion chart or table.

There are two important advantages to this method compared to conventional instruments. First, no skill at beat detection is required, and second, with a carefully calibrated chart, it is possible to "stretch" the piano tuning in exactly the manner a professional tuner does.

Frequency counters

it, you can measure any frequency from 10 MHz on

This is perhaps the most useful digital instrument. With

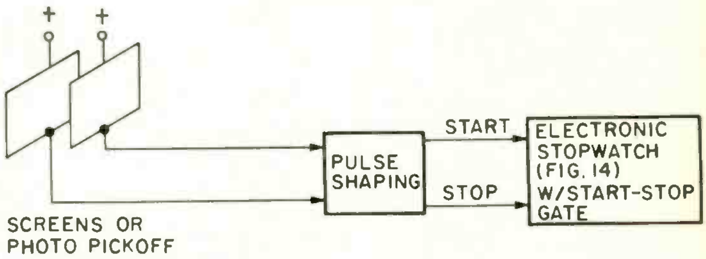


Fig. 16—Ballistic velocity meter needs a start-stop gate.

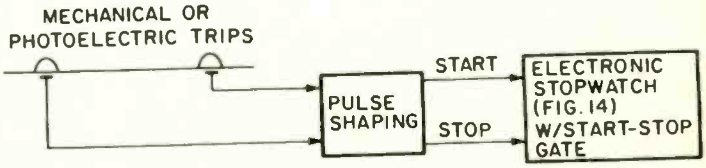
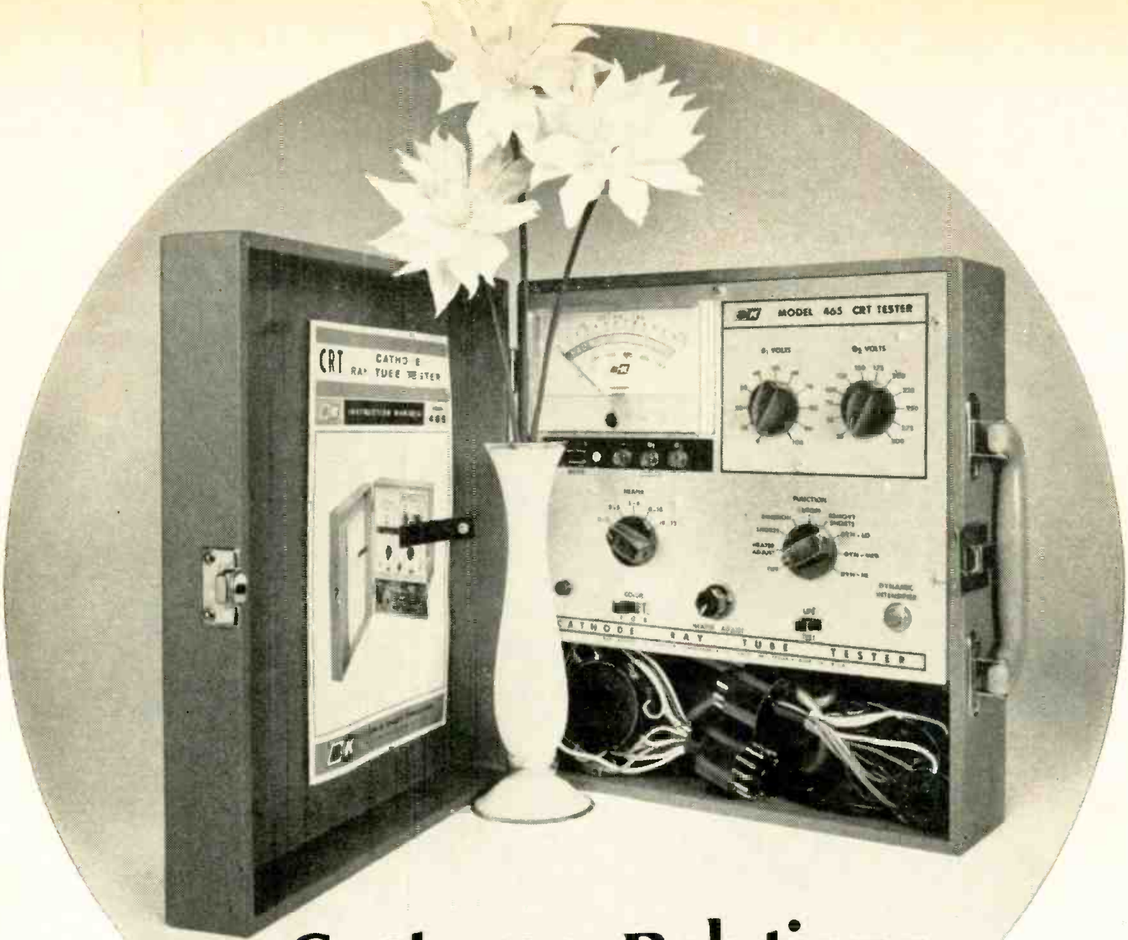


Fig. 17—Similarly, drag-strip speedometer measures time.

465



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EQUIPMENT REPORT

Heathkit Band Box and Playmate

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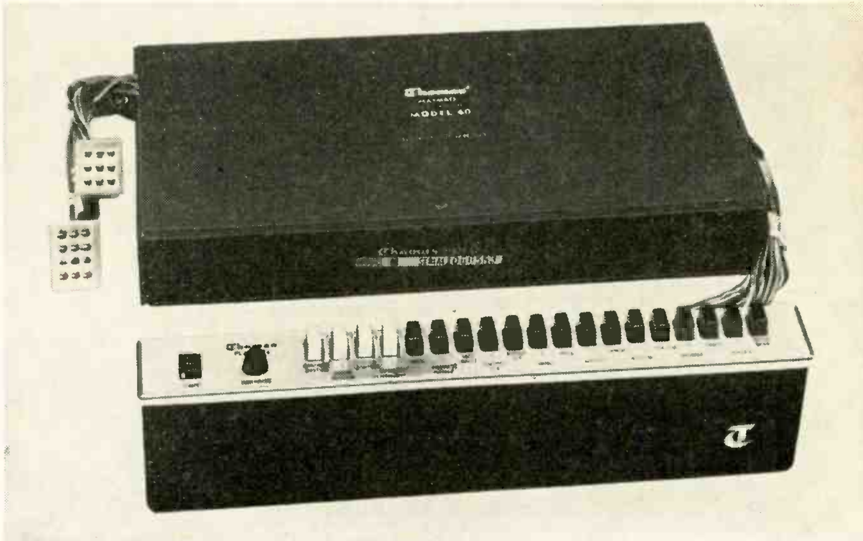

By FRED SHUNAMAN

WHEN THE OPPORTUNITY CAME TO add the Band Box and Playmate to the "Thomas by Heathkit" organ my daughter Ellen and I had put together two years ago, I was interested. The additions would, in effect, make it a theater organ, and I had played around a little with an ancient theater-type organ of the pre-electronic days. It must have been about 30 feet long, and it played the actual instruments (enclosed in glass-fronted compartments), pounding on the bass drum and striking cymbals together on command of a perforated paper music roll.

Ellen was enthusiastic—again. "A Viennese waltz with bongo drums!" The very incongruity appealed to her. "I'd like to play that!" But I noted carefully that her enthusiasm didn't include a promise to "do all the work," as it had when we built the organ.

What were the Band Box and Playmate I was ordering? Briefly, the Band Box is a way of adding—electronically—ten percussion instruments to the Heatkit organ. These can be played together with the regular note from either the great keyboard or the pedals.

Two of the ten percussion voices—the drum roll and castanets—sound continuously as long as the key is held down; the others sound once each time the key is pressed. Any combination of the ten (crash cymbal, brush cymbal, bass drum, snare drum, drum roll, two bongos, block, clave and castanets) may be played at the same time, on either pedals or keyboard or—in one position of the switch—on both at the same time. Thus you can have the crash cymbal and bass drum sound when you press the pedal, while actuating one or more of the others with the keys. (Drum roll and snare drum do *not* sound at the same time.

The Band Box has its own keyboard—a set of fingertip tabs that can be played independently of the organ. So you can use it to accompany other instruments or as part of a dance ensemble where the rock might be considered too hard for organ music.

A little drawer that slides under the knee rail of the GD-983 organ houses the Band Box, or it can be installed integrally in the newer TO-67. The electronic part consists of three circuit boards mounted in a flat frame that also mounts under the great manual shelf on the GD-983 or installed inside the newer-model organ.

Playmate

And what is the Playmate? Automation applied to the Band Box! With the Playmate installed and connected to the Band Box and organ, a supply of rhythms ranging from the Viennese waltz to the watusi can be created. Tempo can be varied with a thumb wheel on the Playmate. Pushing down the key marked ORGAN RHYTHM and not using any of the Band Box voices, you can have a simple percussive organ note repeated in the desired rhythm.

Adding any Band Box voice lets you add any of the instruments to the keyboard note. For automatic accom-

paniment, release the ORGAN RHYTHM button, push down BAND BOX RHYTHM, and away you go . . . the rhythm continues ad infinitum, until you stop it. Any or all of the voices can be used.

If you leave BAND BOX RHYTHM on and push down the TOUCH CONTROL button, the Band Box rhythm is heard only as long as the organ key (or pedal) is held down, the organ giving forth with its own steady note meanwhile. There is a DOWN BEAT ACCENT button, and a down beat indicator lamp that flashes at the beginning of each measure.

The number of combinations is almost infinite and most fascinating. You can even play the great keyboard without any of the voicing stops down; thus producing no music, but controlling the Band Box rhythm with the organ keys. Other interesting effects can be produced by pressing down two rhythm buttons at the same time, like adding rock beat to waltz tempo.

Actual construction is easier than it looks. One of the three Band Box boards is already assembled. Work progresses rapidly on the others. Every time I get a new kit, there are improvements, either in the actual kit, in the instructions or in both. (So, if each job seems easier, it is not practice alone that is responsible.) **R-E**

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COLOR ORGAN SYSTEMS control groups of colored lamps which respond to a certain frequency band and blink in variety of brightness to the intensity of the music. Smallest, *Model 1900*, weighs 24 oz. Costs $39.95. *Model 71,102*, 200 W, features an indicator light and brightness control for each channel as well

as a master control. Costs $99.95. *Model 71,104*, 1000 W, has base, treble and mixer controls and features both line input and a built-in mike for $149. Above units are all 3-channel. *Model 71,103*, 2000 W, 4-channel, includes gain controls and weighs 10 lb 11 oz. Costs $195. Single-channel Do-It-Yourself Kit, *Model 60,759*, costs $9.95.—**Edmund Scientific Co.**

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STEREO HI-FI SYSTEM, solid-state *RK-570*, combines a 12-watt FM receiver, 4-speed record player and a cassette tape recorder for recording and playing 4-track stereo or 2-track mono. Two detached, acoustically matched 2-way speaker systems, each containing a 5" woofer and 3" tweeter. FM section fea-

tures an FET front end at 2.5 μV (IHF) sensitivity. Amplifier is rated at 12 watts output into 8 ohms with a response of 20–30,000 Hz ±2 dB. $249.95. Plastic cover and mike available at $7.95 and $5.95, respectively.—**Lafayette Radio Electronics.**

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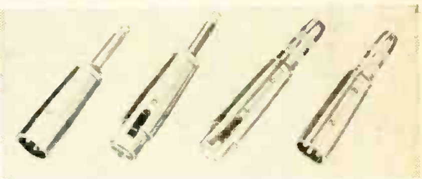


AUDIO CONNECTOR ADAPTERS, four models. *Nos. 383P1* and *384P1* accept a standard 2-conductor phone plug and adapt it to a 3-contact audio connector. The former adapts phone plug to a 3-pin receptacle, and the latter to a 3-contact connector. The other two adapters connect a standard 2-conductor jack to a 3-contact audio connector. *No. 386P1* adapts the jack to a 3-pin re-

79

ceptacle, while *No. 387P1* adapts to a 3-contact receptacle. All units include a separate ground terminal and ground contactors. All completely shielded.—**Switchcraft Inc.**

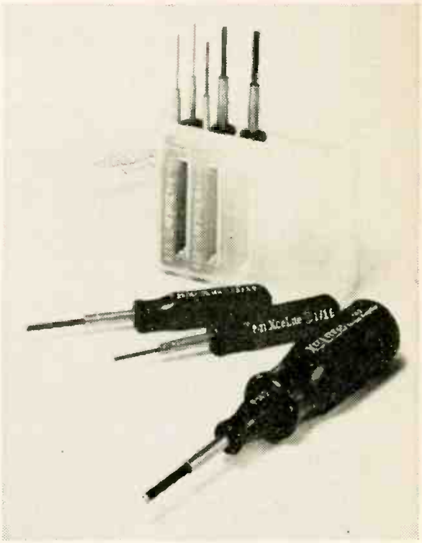
Circle 48 on reader's service card

REGULATED POWER SUPPLY, *Model IP-18*, can be programed for ac or dc. Voltage is regulated to a 40-mV variation; output change: less than .05%; input change: from 105–125 Vac. The unit is current-limiting and continuously variable from 10 to 500 mA. Noise distortion: under 0.1 mV; transient response time: 25 μsec. Output impedance is 0.5 ohm or less up to 100 kHz. The all-silicon tran-

sistor power supply and circuit board construction. $19.95.—**Heath Co.**

Circle 49 on reader's service card

SCREWDRIVER SET, *No. PS-89*, contains 8 midget hex-type socket screwdrivers in sizes from 0.028" to ⅛". Included is a "piggyback" torque amplifier handle to provide larger gripping surface, extended reach and increased driving pow-



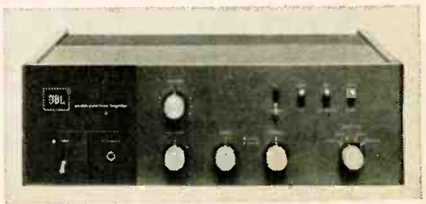
er. Useful with drivers for precision work. Housed in a sturdy, compact, see-through plastic case which can be carried in a hip pocket or used as a bench stand.—**Xcelite Inc.**

Circle 50 on reader's service card

REALISTIC WALKIE-TALKIE LINE, six models: *TRC-1B*, 100 mW; *TRC-35* (illus.), 1 W; *TRC-45*, 2 W. All are single-channel. *TRC-25A*, 100 mW, dual-channel with separate speaker and mike. *TRC-99A*, 3 W, 3 channels; *TRC-100*, 5 W, 6 channels. Prices range from $13.95 to $99.95. All models come with batteries, telescopic antenna and crystals for CB channel 11. 1–5-W units include a carrying case.—**Radio Shack.**

Circle 51 on reader's service card

120-WATT INTEGRATED AMPLIFIER, *Model SA660*, offers 60 watts of rms power per channel with less than 0.2% distortion at frequencies from 20



to 20,000 Hz, both channels operating. IM distortion is less than 0.2% at 120 watts or any lower power level. Noise is 85 dB below rated output from high-level inputs, 72 dB from low-level inputs. Special features include concentric bass and treble controls for optimum response from both channels and built-in stereo balancing system. $435.—**James B. Lansing Sound Inc.**

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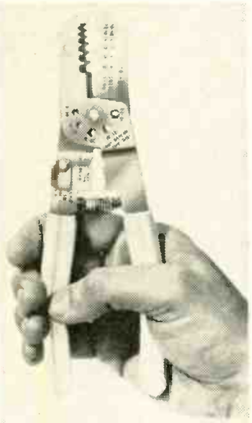
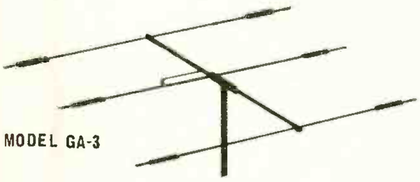


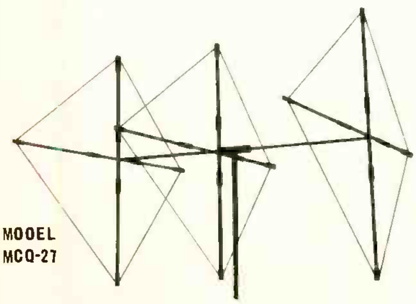
BIG-7 WIRING TOOL, made of steel, measures 8" and weighs 7 oz. Stripping holes are precision-ground to strip size No. 18 solid or stranded through No. 6 solid and No. 8 stranded wire. Blades cut aluminum and copper conductors, including UF and Romex cable. Bolt buster cuts 4-40, 6-32, 8-32, 10-32 and 10-24 unhardened machine screws. Insulated or plain terminals and connectors from Nos. 22–10 can be crimped. Handles have large Hand-eze grips and the two halves are held by a Sta-Fast adjustable bolt. Under $5.—**Holub Industries Inc.**

Circle 53 on reader's service card

ANTENNAS, two models: *Model GA-3* (*Gamma 232*), is a 3-element Yogi, comes with all its parts preassembled and color-



MODEL GA-3

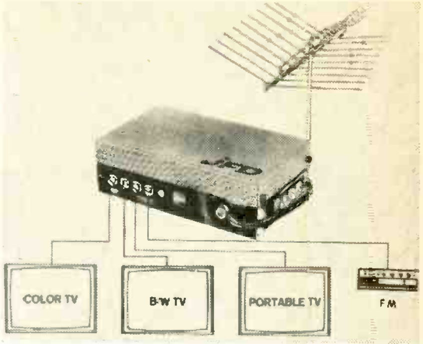


MODEL MCQ-27

coded and has a forward gain of 7.5 dB (over reference dipole); maximum length: 141" and boom length 108". *Model MCQ-27* (*CB Cubical Quad*) has a forward gain of 9 dB and boom length of 14'. Both units are unidirectional with a front-to-back ratio of 25 dB; SWR of 1/5/1 or better; feed-point impedance: of 52 ohms. Three elements.—**Mosley Electronics Inc.**

Circle 54 on reader's service card

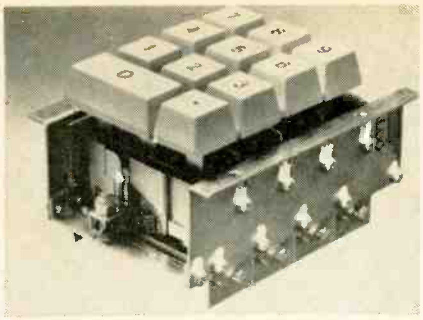
PROGRAM CENTER SYSTEM, solid-state, amplifies signals from a single rooftop antenna and distributes them throughout the home. Handles up to 4 TV sets; can be expanded for 8 or more. Five models: *PC4312-CD* covers vhf (channels 2–13) and FM only, using twin-lead. Similar *PC4712-CD* uses co-



axial cable. *PC4382-CD* covers vhf, FM and uhf, using twin-lead. Coax version of this model is *PC4782. PC4500-CD* is a combined twin-lead and coaxial unit. Prices range from $30 to $65.—JFD Electronics Co.

Circle 55 on reader's service card

KEYBOARD SWITCH, *Model SB-033*, suitable for test equipment, communication gear and many other applications has the following features: Rating—100 mA @ 48 V, Operating force—5 oz. Mechanical life—1,000,000 cycles; electrical life, 10,000,000 cycles. Full stroke travel 7/32", travel contact 5/32" and 3/16" high black symbols. All switch positions contain a "positive lockout" between sections and rows. An extra "decimal" button



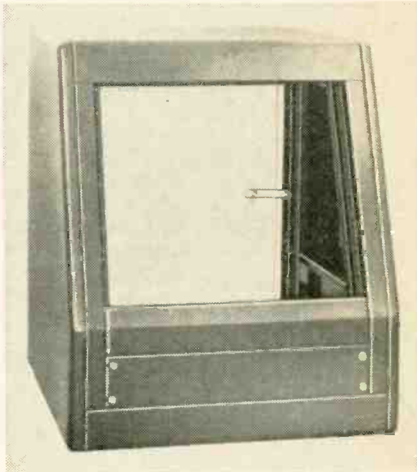
provided. $28.50.—Alco Electronic Products Inc.

Circle 56 on reader's service card

CB TRANSCEIVER, *Model CWT-10*, 100 mW, 11 transistors, 3 channels. Unit puts out and pulls in clear signals. No license required. Crystals supplied for channel 9. Other features include beep-tone call-in, strong-signal limiter, separate mike and speaker, squelch control, battery-life meter, earphone jack and external power jack. Measures 10¼" x 1⅝" x 2¾" and weighs 1½ lb. $29.95 with earphone, hand strap and shoulder strap.—Courier Communications Inc.

Circle 57 on reader's service card

CONVERTIBLE CABINET provides a rugged enclosure for delicate instruments and systems and can be placed on a table or bench or on top of a cabinet. All-welded 14-gauge steel frame has ad-



justable front and rear mounting rails tapped 10-32 with W.E. spacing. In 3 sizes with several optional construction features.—Bud Radio Inc.

Circle 58 on reader's service card

AM-FM FM-MPX RECEIVER, *Model RA-999*, 150 W, has a tuning range of 88–108 MHz FM/535–1605 kHz AM. Sensitivity: 1.5 μV for 30 dB quieting. Stereo separation: more than 30 dB. Frequency response: 30–20,000 Hz ±3 dB.

Tone compensation: bass, 50 Hz ±12 dB; treble, 10 kHz ±10 dB. Hum and noise: —55 dB. Output impedance: 4, 8 and 16 ohms. Transistors: 25 plus 14 diodes. Size: 18 7/16" x 14¼" x 5¾." 110–120 volts ac, 50/60 Hz. $250 with a walnut-finish wood cabinet.—Olson Electronics Inc. R-E

Circle 59 on reader's service card

NEW LITERATURE

All booklets, catalogs, charts, data sheets and other literature listed here with a Reader's Service number are free for the asking. Turn to the Reader's Service Card facing page 76 and circle the numbers of the items you want. Then detach and mail the card. No postage required!

LIGHTING GUIDE, *LG-468*, consists of four main sections, designed to aid in the selection of lamps and lamp holders best suited to particular applications or products. Sections are titled Lamp Selection Guide, Lampholder Selection Guide, Bracket Guide and a Condensed Catalog. Detailed drawing and specs provided.—**Leecraft Mfg. Co.**

Circle 60 on reader's service card

175 SEMICONDUCTORS, books and accessories in the Motorola HEP line of devices for hobbyists, experimenters and professional service techs are listed in *Catalog MHA27–4*. Of special interest to technicians is the "Equal-or-Better" replacement series.—**Motorola Semiconductor Products Inc.**

Circle 61 on reader's service card

BOOK CATALOG, 16 pages, describes over 100 current and forthcoming books covering broadcasting, basic technology, CATV, electric motors, electronic engineering, television, radio and electronics servicing, audio and hi fi, hobbies and experiments, test instruments and transistors.—**Tab Books**

Circle 62 on reader's service card

CROSS-REFERENCE GUIDE, *HMA07–4*, 64 pages, lists almost 18,000 semiconductors with their equivalents from the HEP line as well as tips on using replacement devices and outline drawings and dimensions. For hobbyists, experimenters and professional service technicians.—**Motorola Semiconductor Products Inc.**

Circle 63 on reader's service card

LOUDSPEAKER SYSTEMS. Three models in the *Row 10 Series, LS-10, LS-20* and *LS-30*, designed to reproduce music in livingrooms, not test tones in anechoic chambers, are described with frequency charts, pictures and specs in *Catalog No. 549*.—**Bogen Communications Div.**

Circle 64 on reader's service card

AUDIO CATALOG NO. 680, 20 pages, illustrated with diagrams and charts, contains technical data on magnetic heads for drum, disc or tape uses. Application form provided for information on any desired magnetic head not listed.—**Michigan Magnetics, Div. of VSI Corp.**

Circle 65 on reader's service card

Write direct to the manufacturers for information on items listed below:

ELECTRONIC COMPONENTS AND EQUIPMENT of over 500 major product lines are detailed in this 720-page 1969 catalog. Prices for all items and availabilities in industrial quantities are indicated.—**Newark Electronics Corp.,** 500 No. Pulaski Road, Chicago, Ill. 60624

VIDEO RECORDING for professional broadcasters and amateurs with techniques of TV tape production is outlined, with photographs and diagrams, in the 44-page *Producers Manual*. A glossary of terms used in video recording practice is included.—**Magnetic Products Div. of 3M Co., Marketing Services Dept., 3M Center,** St. Paul, Minn. 55101. **R-E**

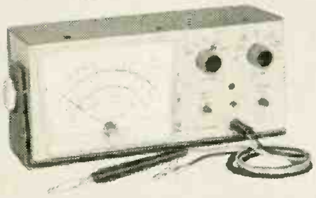
84

Make This Christmas

Kit IM-18
$28.50
Wired IMW-18
$47.95

NEW HEATHKIT IM-18 VTVM

The new IM-18 is a direct decendent of the world's most popular VTVM — the Heathkit IM-11, and continues the features that made the IM-11 famous . . . 7 AC and 7 DC voltage ranges that measure from 0-1500 volts full scale . . . 7 ohms ranges for resistance measurements from 0.1 ohm to 1000 megohms . . . single probe convenience that ends tangled leads & enables you to change from AC to DC/Ohms measurements with a flip of the switch on the probe . . . the light circuit loading of 11 megohm input impedance . . . ±1 dB 25 Hz to 1 MHz response . . . precision 1% resistors . . . DC polarity reversing position on the function switch . . . measurement capability for RMS and Peak-To-Peak AC voltages and dB . . . precision 4½", 200 uA meter for extra sensitivity. In addition, the new IM-18 includes wiring options for 120V. or 240 VAC operation and a three-wire line cord for added safety. 5 lbs.



kit IM-28
$36.50
Wired IMW-28
$56.95

NEW HEATHKIT IM-28 "Service Bench" VTVM

The new Heathkit IM-28 bears the proud tradition of the IM-13, and it has the same performance specifications as the new IM-18 above — an unbeatable combination! But it also has a number of features that put it in a class by itself, like a large 6" meter with easy-to-read markings . . . extra 1.5 and 5 volt AC ranges for additional accuracy . . . a secure gimbal mounting that allows you to put the IM-28 above, below or in front of your most convenient mounting surface . . . "Set and Forget" calibration — all calibration controls are screwdriver adjustable from the front panel to eliminate disassembly . . . smooth ten-turn vernier control of Zero and Ohms Adjust for greater accuracy and easier setting . . . dual primary transformer for 120/240 VAC operation . . . safe 3-wire line cord as well. The new look of Heathkit instrument styling is evident too — handsome beige & brown color scheme, and new knobs that are easy to turn and fast to read. 7 lbs.

Kit IM-38
$39.50
Wired IMW-38
$54.95

NEW HEATHKIT IM-38 Laboratory AC VTVM

For all around general service work, audio design and trouble-shooting or laboratory analysis, you couldn't find a better value than the new Heathkit IM-38 AC VTVM. Here's why — 10 voltage ranges measure from 0.01 to 300 volts RMS full scale . . . an extended frequency response of 10 Hz to 500 kHz at ±1 dB . . . 10 megohm input on all ranges for higher accuracy and minimal circuit loading . . . wide dB range: —12 to +2 on the meter and ten switch-selected ranges from —40 to +50 in 10 dB steps . . . VU-type ballistic meter damping . . . amplifier filament voltage transformer winding that's balanced to ground for low AC noise . . . 120/240 AC wiring options and new Heathkit styling in sharp beige & brown with an easy-to-grasp, easy-to-read knob. Heathkit engineering has made assembly easy and performance tops. 5 lbs.

kit IM-17
$21.95

HEATHKIT IM-17 Solid-State Volt-Ohm Meter

Another very popular volt-ohmmeter from Heathkit engineering and it's easy to see why — all solid-state circuitry . . . high impedance FET input, 11 megohms on DC, 1 megohm on AC . . . 4 AC voltage ranges . . . 4 DC voltage ranges . . . 4 ohm ranges . . . 4½" 200 uA meter . . . 3 built-in test leads . . . DC polarity reversing switch . . . zero-adjust & ohms-adjust controls . . . continuous 12-position function switch. And that's not all — the IM-17 is battery powered for complete portability and comes in a rugged polypropylene case with built-in handle. Simple circuit board assembly. 4 lbs.

kit IT-18
$24.95

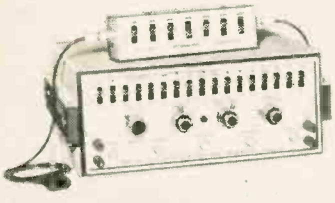
HEATHKIT IT-18 In-Circuit Transistor Tester

In-Circuit transistor testers don't have to be expensive, and the IT-18 is proof of that . . . tests DC Beta 2-1000, in or out-of-circuit . . . leakage Icbo and Iceo current 0-5000 uA out-of-circuit . . . identifies NPN or PNP devices . . . tests diodes in or out-of-circuit for opens & shorts . . . identifies unknown diode leads . . . matches PNP & NPN transistors. The IT-18 is completely portable — runs on just one "D" cell. Easy to use too . . . rugged polypropylene case, attached 3' test leads, big 4½" 200 uA meter, all front panel controls, 10-turn calibrate control. 4 lbs.

kit IP-18
$19.95

HEATHKIT IP-18 1-15 VDC Power Supply

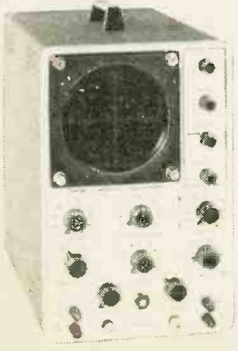
If you work with transistors, this is the power supply for you. All solid-state circuitry provides 1-15 VDC at up to 500 mA continuous. Features adjustable current limiting, voltage regulation, floating output for either + or — ground, AC or DC programming, circuit board construction, and small, compact size. 110 or 220 VAC. 5 lbs.



kit IG-57
$135.00
wired IGW-57
$199.00

HEATHKIT IG-57 Solid-State Post Marker/Sweep Generator

The new IG-57 plus a 'scope is all you need . . . no external sweep generator required. Switch selection of any of 15 crystal-controlled marker frequencies (you can view up to six different frequencies on one 'scope trace). Select the sweep range and you are ready to instantly see the results of any changes you make. Four markers for setting color bandpass, one for TV sound, eight at IF frequencies between 39.75 & 47.25 MHz plus picture and sound carrier markers for channels 4 & 10. Three sweep oscillators produce the 5 most-used ranges . . . color bandpass, FM IF, color & B&W IF and VHF channels 4 & 10. Save hundreds of dollars and put full alignment facilities in your shop too — order your IG-57 now. 14 lbs. Kit IG-14, same as IG-57 w/o the sweep, 11 lbs. $99.95.



kit IO-18
$84.95
wired IOW-18
$139.95

HEATHKIT IO-18 Wide-Band 5" 'Scope

The New Heathkit IO-18 is destined to be the world's most popular 'scope, just as its predecessor, the IO-12 was. Features 5 MHz bandwidth, the famous Heath patented sweep circuit — 10 Hz to 500 kHz in 5 ranges, two extra sweep positions which can be preset to often-used rates, frequency compensated vertical attenuation, built-in P-P calibration reference, Z-axis input, retrace blanking, wiring options for 120 or 240 VAC operation and new Heathkit styling in beige and brown. 24 lbs.

A Heathkit® Holiday

Wish Your Family Merry Christmas This Year With A New Heathkit Color TV . . . A Better Buy Than Ever With New Lower Prices

NEW Deluxe Color TV With Automatic Fine-Tuning—Model GR-681

kit GR-681 **$499.95** (less cabinet)

The new Heathkit GR-681 is the most advanced color TV on the market. A strong claim, but easy to prove. Compare the "681" against every other TV — there isn't one available for any price that has all these features. Automatic Fine Tuning on all 83 channels . . . just push a button and the factory assembled solid-state circuit takes over to automatically tune the best color picture in the industry. Push another front-panel button and the VHF channel selector rotates until you reach the desired station, automatically. Built-in cable-type remote control that allows you to turn the "681" on and off and change VHF channels without moving from your chair. Or add the optional GRA-681-6 Wireless Remote Control described below. A bridge-type low voltage power supply for superior regulation; high & low AC taps are provided to insure that the picture transmitted exactly fits the "681" screen. Automatic degaussing, 2-speed transistor UHF tuner, hi-fi sound output, two VHF antenna inputs . . . plus the built-in self-servicing aids that are standard on all Heathkit color TV's but can't be bought on any other set for any price . . . plus all the features of the famous "295" below. Compare the "681" against the others . . . and be convinced.

GRA-295-4, Mediterranean cabinet shown **$119.50**
Other cabinets from $62.95

Deluxe "295" Color TV...Model GR-295

now only **$449.95** (less cabinet)

Big, Bold, Beautiful . . . and packed with features. Top quality American brand color tube with 295 sq. in. viewing area . . . new improved phosphors and low voltage supply with boosted B+ for brighter, livelier color . . . automatic degaussing . . . exclusive Heath Magna-Shield . . . Automatic Color Control & Automatic Gain Control for color purity, and flutter-free pictures under all conditions . . . preassembled IF strip with 3 stages instead of the usual two . . . deluxe VHF tuner with "memory" fine tuning . . . three-way installation — wall, custom or any of the beautiful Heath factory assembled cabinets. Add to that the unique Heathkit self-servicing features like the built-in dot generator and full color photos in the comprehensive manual that let you set-up, converge and maintain the best color picture at all times, and can save you up to $200 over the life of your set in service calls. For the best color picture around, order your "295" now.

GRA-295-1, Walnut cabinet shown **$62.95**
Other cabinets from $99.95

Deluxe "227" Color TV...Model GR-227

now only **$399.95** (less cabinet)

Has same high performance features and built-in servicing facilities as the GR-295, except for 227 sq. inch viewing area. The vertical swing-out chassis makes for fast, easy servicing and installation. The dynamic convergence control board can be placed so that it is easily accessible anytime you wish to "touch-up" the picture.

GRA-227-1, Walnut cabinet shown **$59.95**
Mediterranean style also available at $99.50

Deluxe "180" Color TV...Model GR-180

now only **$349.95** (less cabinet)

Same high performance features and exclusive self-servicing facilities as the GR-295 except for 180 sq. inch viewing area. Feature for feature the Heathkit "180" is your best buy in deluxe color TV viewing . . . tubes alone list for over $245. For extra savings, extra beauty and convenience, add the table model cabinet and mobile cart.

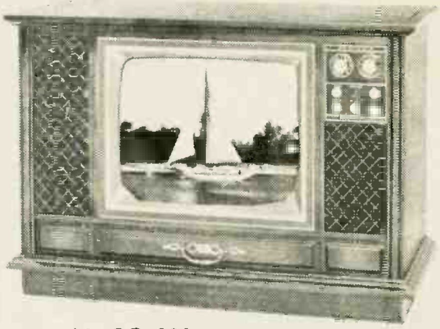
GRS-180-5, table model cabinet and cart **$39.95**
Other cabinets from $24.95

Now, Wireless Remote Control For Heathkit Color TV's

Control your Heathkit Color TV from your easy chair, turn it on and off, change VHF channels, volume, color and tint, all by sonic remote control. No cables cluttering the room . . . the handheld transmitter is all electronic, powered by a small 9 v. battery, housed in a small, smartly styled beige plastic case. The receiver contains an integrated circuit and a meter for adjustment ease. Installation is easy even in older Heathkit color TV's thanks to circuit board wiring harness construction. For greater TV enjoyment, order yours now.

kit GRA-681-6, 7 lbs., for Heathkit GR-681 Color TV's **$59.95**
kit GRA-295-6, 9 lbs., for Heathkit GR-295 & GR-25 TV's **$69.95**
kit GRA-227-6, 9 lbs., for Heathkit GR-227 & GR-180 TV's **$69.95**

Now There Are 4 Heathkit Color TV's . . . All With 2-Year Picture Tube Warranty



kit GR-681

kit GR-295

kit GR-227

kit GR-180

New Wireless TV Remote Control For GR-295, GR-227 & GR-180 **$69.95**

New Wireless TV Remote Control For GR-681 **$59.95**

Circle 111 on reader's service card

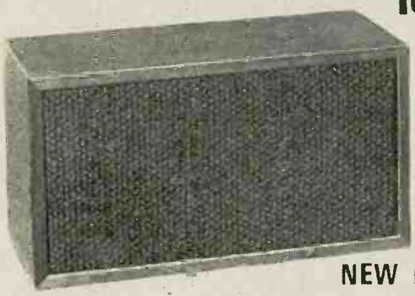
There's A "Just Right" Heathkit®

NEW kit AD-27

$169^{95}

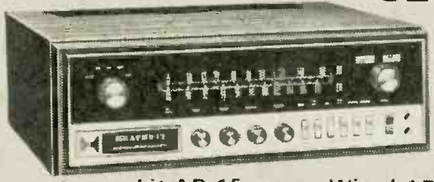
NEW kit AD-17

$109^{95}



NEW kit AS-18

$32^{95}



kit AR-15 $339^{95}*

Wired ARW-15 $525^{00}*

NEW kit AJ-15

$189^{95}*

NEW kit AA-15

$169^{95}*

NEW HEATHKIT AD-27 FM Stereo Component-Compact

This new Heathkit AD-27 stereo compact has features not found in other units costing twice as much for one very simple reason. It wasn't engineered to meet the usual level of compact performance. Instead, Heath took one of its standard stereo/hi-fi receivers, the AR-14, and re-arranged it physically to fit a compact configuration. The result is performance that is truly high fidelity without compromise. It features 31 transistor, 10 diode circuitry with 15 watts per channel dynamic music power (enough to let you choose most any speaker system you prefer), full-range tone controls, less than 1% distortion, and 12 to 60,000 Hz response. The pre-assembled FM stereo tuner section with 4-stage IF offers 5 uV sensitivity, excellent selectivity, AFC, and the smoothest inertia tuning. The BSR McDonald "500" turntable offers features usually found only in more expensive units . . . like low mass tubular aluminum tone arm, anti-skate control, cueing and pause control, plus a Shure magnetic cartridge with diamond stylus. It's all housed in a smart oiled walnut cabinet with sliding tambour door that disappears inside the cabinet. For value and performance choose the AD-27, the new leader in stereo compacts. Shpg. wt. 41 lbs.

NEW HEATHKIT AD-17 Budget-Priced Component-Compact

Heath engineers took the stereo amplifier from the AD-27 above, matched it with the top rated BSR McDonald 400 Automatic Turntable and put both of these able performers in an attractive walnut cabinet. The result is the high performance, low cost AD-17. The all solid-state circuit delivers 15 watts music power per channel — more than enough to drive any reasonably efficient system. Wide response of 12 Hz to 60 kHz ±1 dB and harmonic & IM distortion both less than 1% at full output are your guarantee of clean, full range sound. Stereo headphone jack, filtered tape outputs and Tuner & Auxiliary inputs too. The BSR McDonald 400 Automatic Turntable features a cueing and pause control, adjustable stylus pressure, variable anti-skate control and manual or automatic operation on all four speeds. Comes complete with a famous Shure magnetic cartridge. The Heathkit manual makes it easy to build . . . the sound makes it a pleasure to own. Order yours now. 27 lbs.

NEW HEATHKIT AS-18 Miniature Acoustic Suspension System

The new AS-18 features famous high quality Electro-Voice® speakers — 6″ woofer and a 2½″ tweeter. The wide frequency response of 60 Hz to 20 kHz and the clear, natural sound of these miniature systems will really amaze you. They're the ideal performance mates to the Component Compacts above and are especially suited for apartments, mobile homes, offices, etc. — anywhere that you need superior stereo sound from a small space. Handles up to 25 watts program material and has a high frequency balance control so you can adjust the sound to your liking. Order 2 for superb stereo now. 16 lbs.

HEATHKIT AR-15 Deluxe Stereo Receiver

The World's Most Sophisticated, Most Praised Stereo Receiver. And here are just a few of the reasons why leading audio critics and testing organizations, as well as thousands of owners rate the AR-15 as THE stereo receiver. The all solid-state circuit with 69 transistors, 43 diodes and two integrated circuits has many new design concepts to deliver superior performance. The amplifier section has 150 watts of music power . . . 75 watts per channel. Harmonic and IM distortion are both less than 0.5%. The special design FET FM tuner boasts sensitivity of 1.8 uV, selectivity of 70 dB and harmonic & IM distortion both less than 0.5%. The Crystal Filters provide an ideally shaped bandpass and are a Heath first in the high fidelity industry. You'll hear stations you didn't even know existed in your area, and the Noise-Operated Squelch, Adjustable Phase Control, Stereo-Only Switch, Stereo Threshold Control and FM Stereo Noise Filter Switch will let you hear them in the clearest, most natural way. Other features include two front panel stereo headphone jacks, positive circuit protection, loudness switch, speaker switch, front panel input level controls, recessed outputs, two external FM antenna connectors and one for AM, Tone Flat control, electronically filtered power supply and "Black Magic" panel lighting. Seven circuit boards and three wiring harnesses simplify assembly and you can mount your completed AR-15 in a wall, your own cabinet or the Heath assembled walnut cabinet. For the ultimate in a stereo receiver, order your AR-15 now. 34 lbs. ***Optional walnut cabinet AE-16, $24.95.**

HEATHKIT AJ-15 Deluxe Stereo Tuner

For the man who already owns a fine stereo amplifier, Heath now offers the superb FM stereo tuner section of the AR-15 receiver as a separate unit. The new AJ-15 FM Stereo Tuner has the exclusive FET FM tuner for remarkable sensitivity, exclusive Crystal Filters in the IF strip for perfect response curve and no alignment; Integrated Circuits in the IF for high gain, best limiting; Noise-Operated Squelch; Stereo-Threshold Switch; Stereo-Only Switch; Adjustable Multiplex Phase, two Tuning Meters; two Stereo Phone jacks; "Black Magic" panel lighting. 18 lbs. ***Walnut cabinet AE-18, $19.95.**

HEATHKIT AA-15 Deluxe Stereo Amplifier

For the man who already owns a fine stereo tuner, Heath now offers the famous amplifier section of the AR-15 receiver separately. The new AA-15 Stereo Amplifier has the same superb features: 150 watts Music Power; Ultra-Low Harmonic & IM Distortion (less than 0.5% at full output); Ultra-Wide Frequency Response (±1 dB, 8 to 40,000 Hz at 1 watt); Front Panel Input Level Controls; Transformerless Amplifier; Capacitor Coupled Outputs; All-Silicon Transistor Circuit; Positive Circuit Protection. 26 lbs. ***Walnut cabinet AE-18, $19.95.**

Gift For Everyone On Your List

Heathkit MI-18 Solid-State Tachometer

The Professional Tach. That's the new Heathkit MI-18. **In Design:** breaker point, "tach" lead or unique inductive pickup connection; use it with any spark-type engine and any ignition system, 2 cycle 1-6 cyl. engines or 4 cycle, 2-8 cyl. engines . . . all electronics are in the tach itself. **In Performance:** 0-6000 & 0-9000 RPM ranges . . . 250° edge-lighted dial . . . temperature-compensated, ±4% accuracy from 0° —120° . . . adjustable red line pointer . . . 10.5 to 17.5 VDC operation. **In Styling:** stainless steel hardware, splash-proof black & chrome case and scratch-proof glass face for use in rugged conditions. The MI-18-1 mounts in your dash — requires only a 3¼" hole & 2¼" depth. The MI-18-2 comes with mounting case & hardware. Put a Professional Tach in your car, boat, dune-buggy, or bike now — the Heathkit MI-18! Shpg. wt. 3 lbs.

NEW kit MI-18-1 $29.95 Panel Mount

NEW kit MI-18-2 $32.95 With Case

Heathkit GR-17 Solid-State AM-FM Portable Radio

Here's performance the others can't match. The new Heathkit GR-17 portable has a 12 transistor, 7 diode circuit with the same front end as used in Heathkit hi-fi tuners. AM or FM at the flick of a switch and what reception! Big ½" ferrite rod antenna, three tuned transformers and amplified AGC pull in more AM stations. The FM section features a collapsible 34" whip antenna, three IF stages and 5 uV sensitivity for reception over greater distances than you would expect from a portable. The 4" x 6" speaker and an audio output of 350 mW provides clean sound and the GR-17 will keep you entertained for up to 300 hours on a single set of batteries. For the greatest sound everywhere, get your GR-17 today. 5 lbs.

NEW kit GR-17 $43.95

NEW HEATHKIT HW-100 SSB-CW 5-Band Receiver

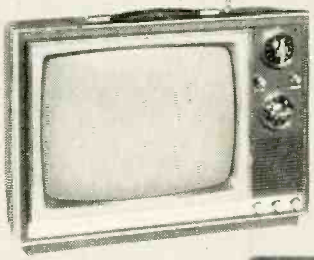
The new Heathkit HW-100 has all the features and performance of the competition at a money saving kit price. And here's what it delivers: the receiver portion has sensitivity of less than 0.5 uV for a 10 dB S+N/N ratio for SSB. Crystal filter selectivity is 2.1 kHz at 6 dB down, 7 kHz at 60 dB down. Image & IF rejection are better than 50 dB. The transmitter has a 180 watt input on either USB or LSB and 170 watts on CW. It operates PTT or VOX on SSB and break-in CW work is provided by operating VOX from a keyed tone, using grid-block keying. Outstanding frequency stability — less than 100 Hz per hour drift after 30 minute warmup . . . less than 100 Hz variation under a 10% line voltage variation. The HW-100 is a really loaded rig — solid-state (FET) VFO . . . 80-10 meter coverage . . . patented Harmonic Drive™ dial mechanism . . . built-in 100 kHz calibrator . . . TALC and much more. Put this hot rig in your shack — order your HW-100 today. 22 lbs.

NEW kit HW-100 $240.00

HEATHKIT GR-104A Solid-State Portable B&W TV

The perfect portable . . . that's the GR-104. Small and light enough to carry from room to room . . . rugged enough to take it . . . and the picture is the sharpest, most realistic you've ever seen, thanks to Heathkit total engineering. 74 sq. in. viewing area . . . all solid-state circuit for extra reliability and performance . . . covers all VHF and UHF channels, 2-83 . . . 2-speed UHF tuning . . . "memory" VHF fine tuning . . . 3-stage IF for maximum gain with controlled bandwidth . . . gated AGC for steady, jitter-free pictures . . . transformer regulated power supply . . . circuit breaker protection . . . one-piece swing out chassis for easy assembly and servicing . . . runs on house current or battery power with the optional GRA-104-1 rechargeable battery pack. 27 lbs.

GRA-104-1, 9 lbs. **$39.95**



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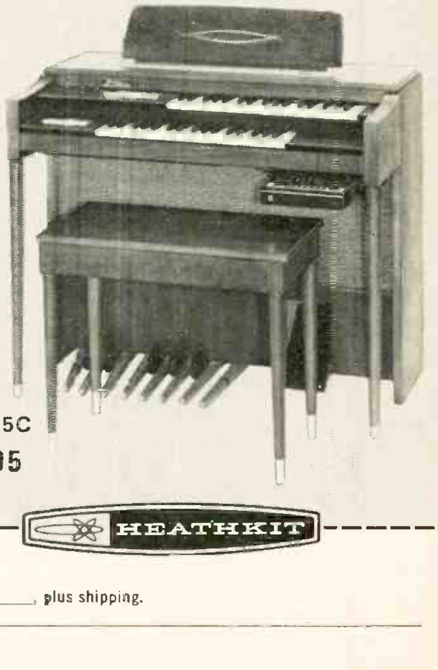

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Service Clinic

By JACK DARR
SERVICE EDITOR

Chronic sound drift; triple image

This Admiral 16R12 needs a sound realignment every couple of months. I've checked components, but no luck. Also, in a Magnavox CT-214, I get a triple image; I've checked capacitors around the horizontal circuits, including the yoke capacitor. I guess the next step would be a new yoke. What would you suggest.—J. H., Baltimore, Md.

I believe your trouble in the Admiral could be cured by replacing the discriminator transformer. This is the cause of most complaints of this kind, that is, slow drifting off alignment. It is probably due to aging of the base assembly with its tiny capacitors.

In the Magnavox, the triple image is basically due to the horizontal oscillator running away off frequency. A triple image means that the oscillator is running at one-third normal speed, or somewhere around 5,250 cycles. This could be the fault of a leaky capacitor, a resistor somewhere in the frequency-determining circuits that has drifted off value, or to a defective horizontal oscillator coil or transformer. Grid resistors are always prime suspects for this kind of trouble. This series uses a synchroguide oscillator circuit. Follow the standard procedure for realigning it. Short out the "waveform" coil, set the hold control in the center of its range, and tune the frequency slug for a single floating picture. If you cannot get a single picture with this procedure (and all coils, capacitors and resistors are good), then the transformer is bad and you'll have to replace it.

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.

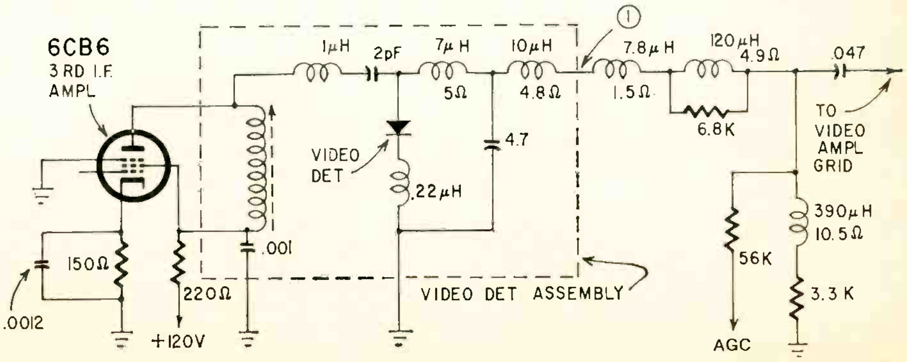
Sound, No Picture

I'm afraid I'm stuck. I have raster and sound but no picture on a G-E M6 chassis. Tubes and other parts check okay. If I clamp the agc, I lose the sound. What's going on here? —E. D., N. Y., N. Y.

Most likely possibility is a bad video detector diode. Note the detector is not in series but shunted from the signal path to ground (see diagram). Works just the same, of course, but can have different *symptoms*.

You can check this with an ohmmeter. Take a resistance reading from the last rf choke outside the detector can (point 1) to ground. Reverse the leads and you should have a "diode reading"—high resistance one way, comparatively low the other. If you get a high reading both ways the diode is open; low resistance both ways, it's shorted.

Possible reason for getting sound through bad detector stage: with a shunt detector, the signal could go on through to the video amplifier. There, it could be "grid-rectifying," thus developing a sound-i.f. signal. Incidentally, if this chassis has the small glass diode, you'll get better results by using a 1N34 or any of the older, bigger video-detector diodes. **R-E**



COMPUTER SCHOOLS

Here is a partial listing of specialized schools that offer courses in computer technology and programming.

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Business Electronics
209 W. Jackson Blvd.
Chicago, Ill. 60606

Canadian Institute of Science & Technology
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Capitol Radio Engineering Institute
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Central Technical Institute
1644 Wyandotte St.
Kansas City, Mo. 64108

Cleveland Institute of Electronics
1776 E. 17th St.
Cleveland, Ohio 44114

Commercial Trades Institute
1400 W. Greenleaf Ave.
Chicago, Ill. 60626

Cook's Institute of Electronics Engineering
P.O. Box 10634
Jackson, Miss. 39209

DeVry Institute of Technology
4141 Belmont Ave.
Chicago, Ill. 60641

Elkins Institute
2603 Inwood Rd.
Dallas, Texas 75235

Grantham School of Electronics
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Hollywood, Calif. 90027

Hill's Business University
920 N. Robinson Ave.
Oklahoma City, Okla. 73102

International Correspondence Schools
Scranton, Pa. 18515

LaSalle Extension University
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Chicago, Ill. 60605

Massey Technical Institute, Inc.
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Jacksonville, Fla. 32206

Midwest Automation Training—Kansas City, Inc.
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Kansas City, Mo. 64108

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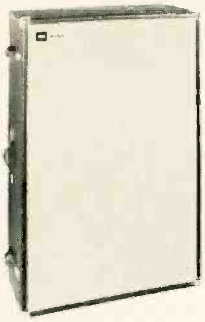

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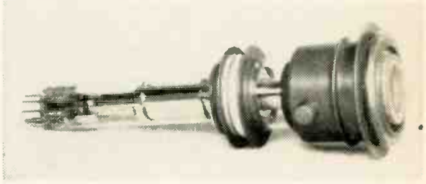

Bulletin TD-86-817, available from Westinghouse Electronic Tube Div., PO Box 284, Elmira, N.Y. 14902, includes full specifications and a suggested preamplifier design and schematic diagram.

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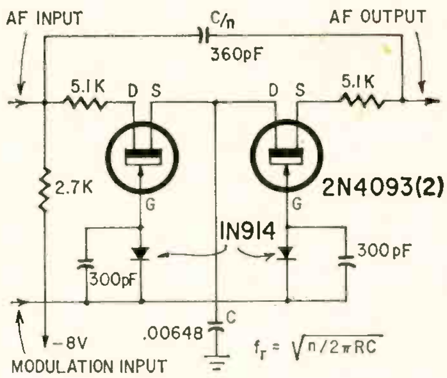

plifier and other factors. The author, M. Bronzite, selected a value of 18 which yields a peak attenuation of 20 dB.

The FET's are driven to saturation and to full off by a modulating voltage in the range of 100–500 kHz. They have an impedance of around 100 ohms when on. The value of the fixed series resistors should be around fifty times the on impedance of the FET's to minimize the effects of variations in transistor characteristics. In the spectrum analyzer, the effective resistance of each series leg varied over a range of 1 to 20 with modulation. **R-E**

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A computer expert takes the mystery out of logic circuits with a detailed explanation of JK flip-flops and other bistable digital circuits.

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A review for those planning a systematic study of electronics. Provides tips on studying, problem-solving and taking exams. After a review of addition, subtraction and division, other chapters cover fractions, decimals, percentage, squares and square roots. Chapters have problems and solutions as well as review questions.

THE RADIO AMATEUR'S HANDBOOK, prepared by the ARRL Staff, edited by Doug DeMaw, W1CER. *American Radio Relay League, Newington, Conn. 06111. 6½" x 9½", 704 pp. including 46 pp. amateur equipment catalog. Cloth, $6.50 in US, its possessions and Canada; $7.00 elsewhere.*

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Many of the construction projects that have been standards in earlier issues have been replaced by new ones that reflect recent advances in electronic technology. Transistor and tube data charts and reference tables have been revised.—*W2PWG*

SEMICONDUCTOR AND TUBE ELECTRONICS, AN INTRODUCTION, by James G. Brazee. *Holt, Rinehart & Winston, Inc., 383 Madison Ave., New York, N.Y. 10017. 6¼" x 9¼", 651 pp. Cloth, $10.95*

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WESTINGHOUSE SILICON POWER TRANSISTOR HANDBOOK. *Westinghouse Electric Corp., Semiconductor Division, Youngwood, Pa. Spiral-bound, $2.00*

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SCHOOL DIRECTORY

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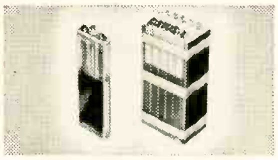

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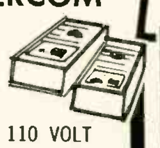

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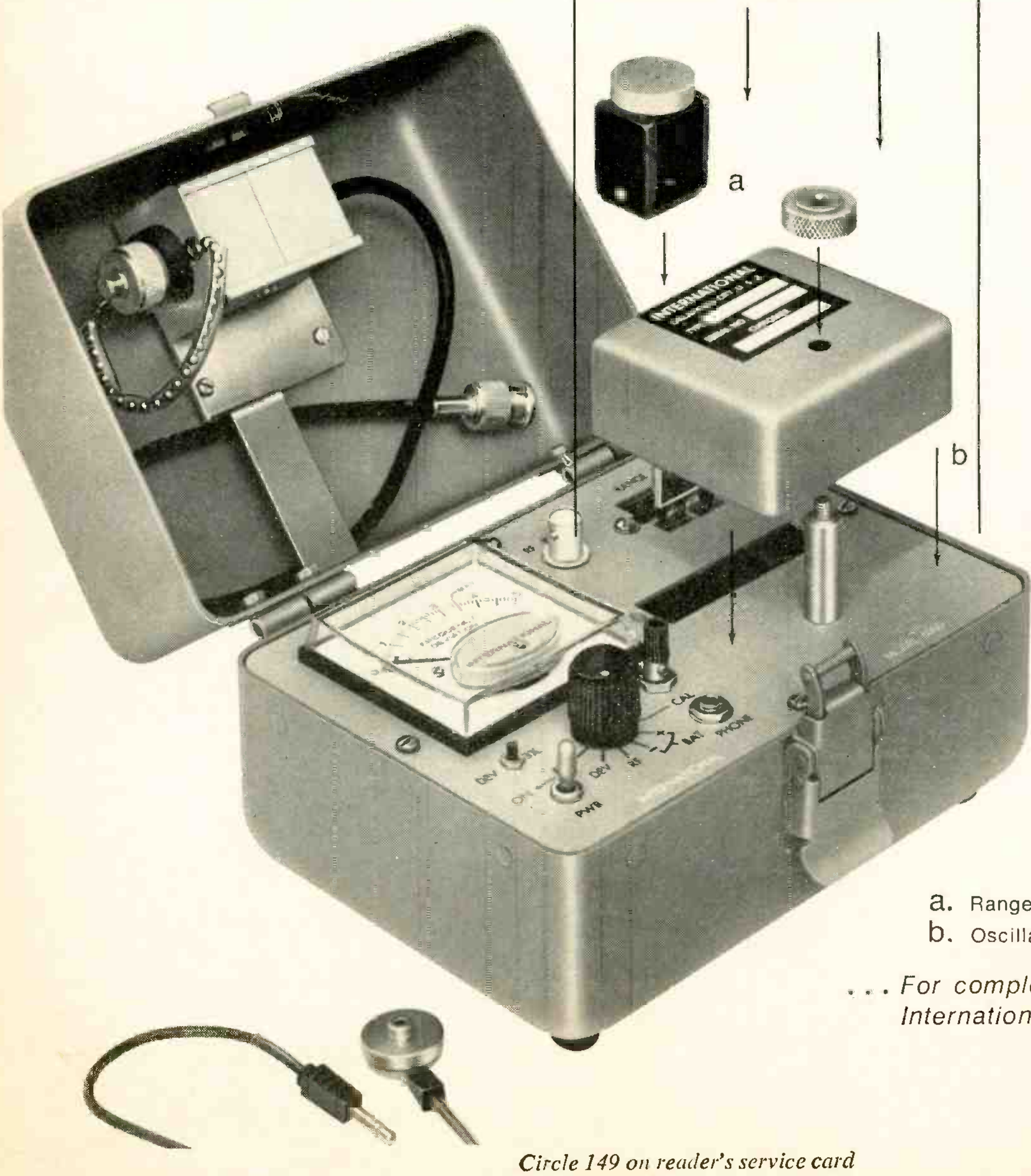

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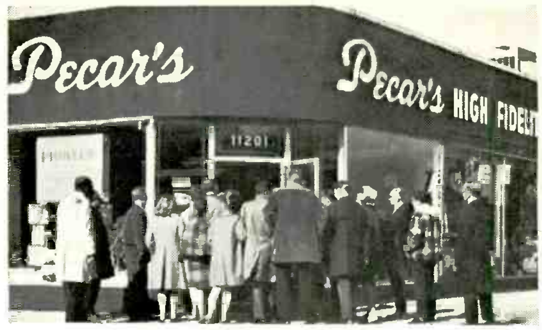

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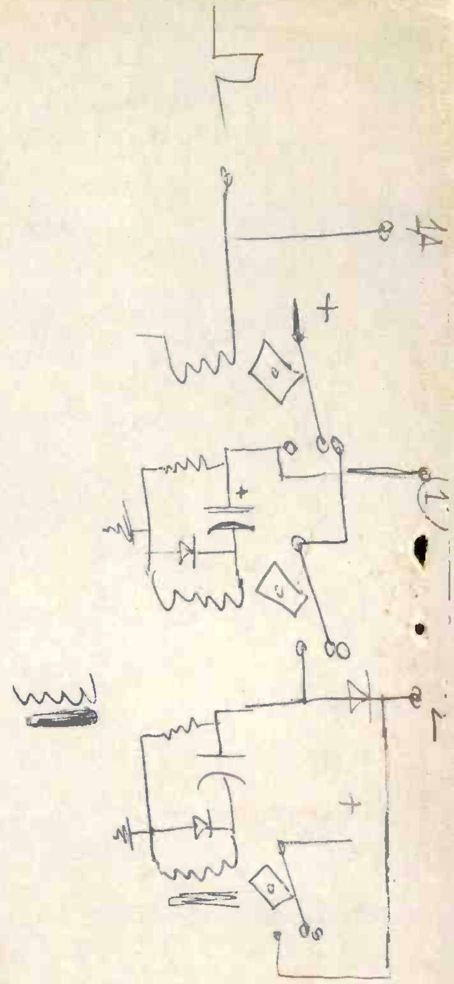

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