BUILD — Combination Tach-Dwell-Voltmeter

60c ■ JUNE 1968

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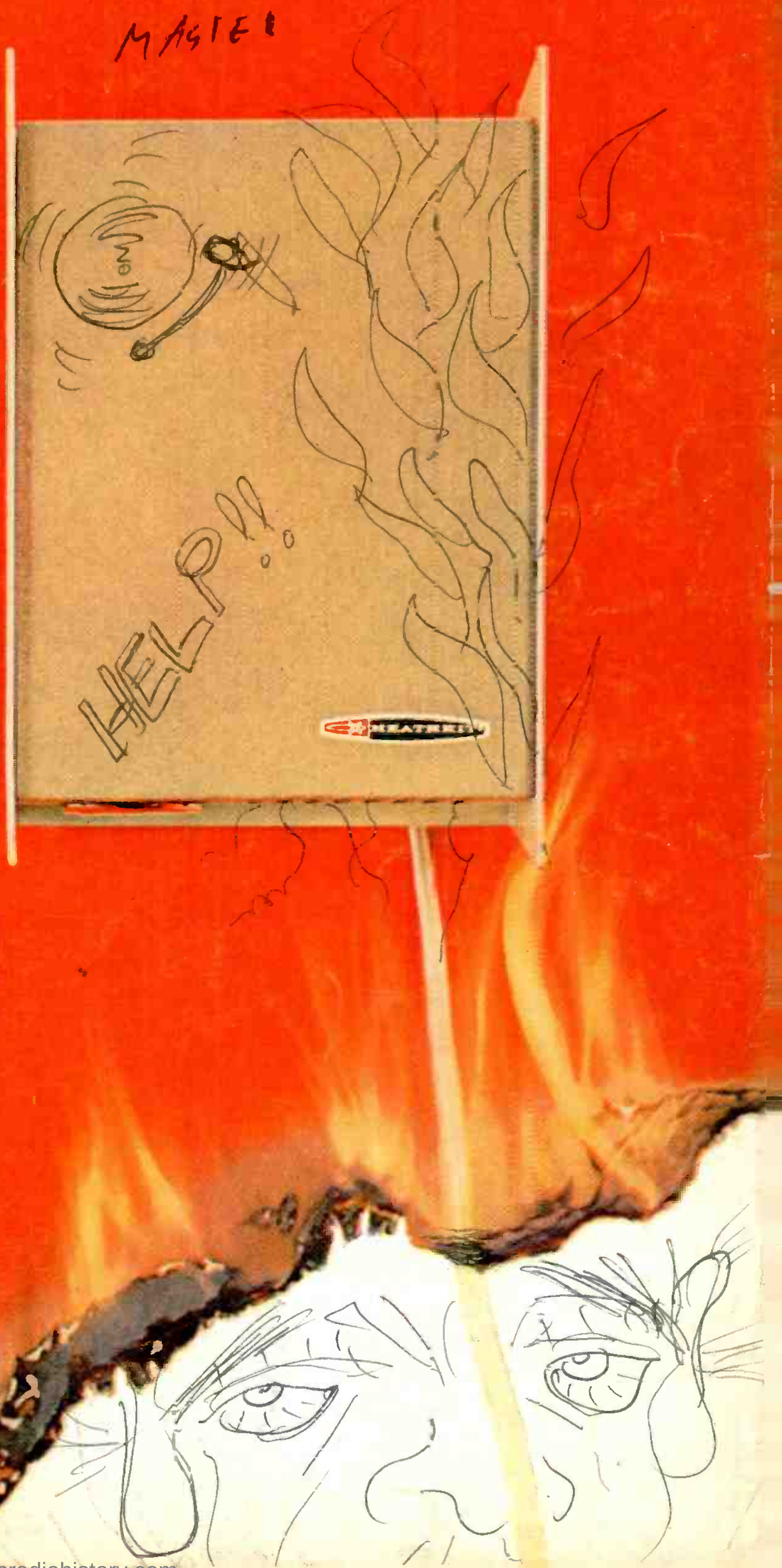
~ 1p 75-79 --
NEON LAMP meter p. 47

FOR EXPERIMENTERS

Audio Preamplifier

Unijunction Transistors

Solid-State Secrets



NEW HOME PROTECTION WIRELESS ALARM SYSTEM KIT

(see page 32)

SERVICE

Unusual TV Troubles

TV Color Alignment

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EXTRA QUALITY IS HIDDEN*

MODEL 630 V-O-M

PRICE† $61.00

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- Application Engineers
- Electrical, Radio, TV, and Appliance Servicemen
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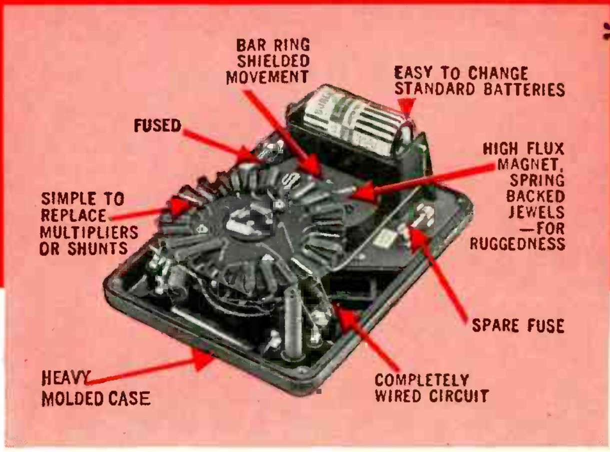
- Factory Maintenance Men
- Industrial Electronic Maintenance Technicians
- Home Owners, Hobbyists



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1. One selector switch minimizes chance of incorrect settings and burnouts.
2. 4.4 ohm center scale, reads from 0.1 ohm up to 100 megohms resistance in 4 ranges.
3. 20,000 ohms per volt DC sensitivity: 5,000 AC.

Attention to detail makes the Triplett Model 630 V-O-M a lifetime investment. It has an outstanding ohm scale; four ranges—low readings .1 ohm, high 100 megs. Fuse affords extra protection to the resistors in the ohmmeter circuit, especially the XI setting, should too high a voltage be applied. Accuracy 2% DC to 1200V. Heavy molded case.

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RANGES

DC VOLTS	0-3-12-60-300-1,200-6,000 at 20,000 ohms per volt.
AC VOLTS	0-3-12-60-300-1,200-6000 at 5,000 ohms per volt.
OHMS	0-1,000-10,000.
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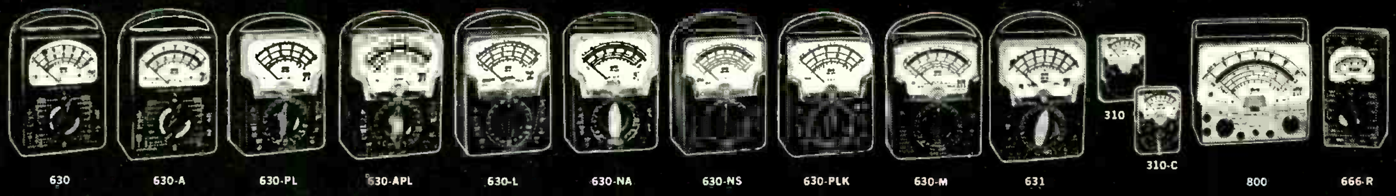
DC MICRO-AMPERES	0-60 at 250 millivolts.
DC MILLI-AMPERES	0-1.2-12-120 at 250 millivolts.
DC AMPERES	0-12.

DB: –20 to +77 (600 ohm line at 1 MW).

OUTPUT VOLTS: 0-3-12-60-300-1,200; jack with condenser in series with AC ranges.



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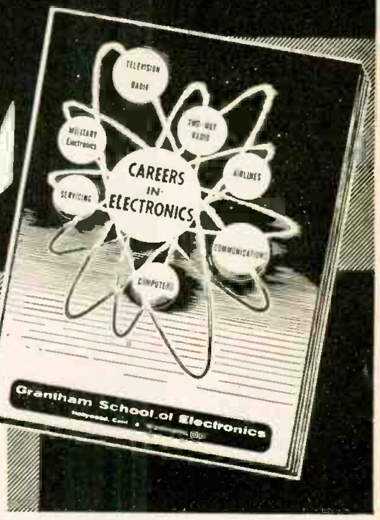

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LOOKING AHEAD

By DAVID LACHENBRUCH

Life in the old girl yet

Hold back those tears—the funeral of the vacuum tube isn't in sight, despite repeated inferences to the contrary. Spurred by the high level of TV production in recent years, tube sales still aren't far from their all-time high. And the prospect of any sudden industry-wide changeover to solid-state TV sets is remote.

Although transistorized TVs and consumer-product integrated circuits receive much publicity, the immediate future of TV is tied up with the receiving tube. One industry marketing expert estimates that only 3% of the color sets produced this year will be all solid state, while 14% will be tube-transistor hybrids and 83% will be of the all-tube type. Only 7% of this year's black-and-white sets will be solid state, according to the forecaster. Looking ahead as far as 1970, he predicts that 12% of color sets will be solid-state, 40% hybrid—and still 48% predominantly tube-type. He sees 60% of monochrome TV production as tube-type in 1970.

There are several strong reasons why the TV industry isn't galloping toward solid state. Tube sets are still less expensive, and generally require fewer components, thereby saving on labor as well as parts costs. While solid-state technology has developed rapidly, it's less widely noted that there have been many advances in the tube art, too, increasing reliability, life and numbers of functions per tube, as well as improving performance and lowering costs. Not the least important factor is that both design engineer and service technicians feel far more comfy working with the old familiar vacuum tube.

Interference-control law

The airwaves could become a little clearer as the result of anticipated passage of long-pending legislation which would give the FCC authority to control manufacture, import and sale of devices capable of interfering with radio transmission and reception. Main targets of the FCC-backed bill are the manufacturers of some types of remote-control garage-door openers, electric motors, fluorescent lighting, medical equipment and even automobiles, which sometimes generate large amounts of unnecessary rf noise. The new law would permit the FCC to get after the manufacturers of these devices. Except in the case of radiation from TV tuners, it now has jurisdiction only over the user.

Longer color warranties

The big stir in the color TV industry currently is over picture tube warranties, and there are many who believe that almost all set manufacturers will double the length of their present warranties to two years before 1968 is over. Four manufacturers already have lengthened their coverage. Admiral's warranty on color tubes in its sets now runs for three years, adding about $10 to the price. Magnavox is up to two years on its color line; Westinghouse and Emerson have two-year tube warranties on their more expensive sets. The theory behind the stretched-out policies (which cover the tube only, not replacement labor) is that potential tube failure is a major deterrent to color set purchases.

The extension of warranties could create changes within the TV service industry. Many more tube replacements now will become warranty jobs. The cost of service policies presumably will be trimmed substantially, since picture tube replacement is a major cost ingredient.

Self-repairing computer

A computer which can give itself a fix when it's busted is scheduled to go into experimental operation this fall at the Jet Propulsion Laboratory of California Institute of Technology. Called STAR (for Self-Testing And Repairing), the computer is completely modularized. Each module has one or more identical spares on a standby basis. When STAR detects failure of a working module, it switches the power to one of the standbys and resumes normal operation—all within a few thousandths of a second.

STAR detects its own faults and carries out repair and recovery functions by means of a special "repair control module." What happens if the repair control module goes on the blink? That gets replaced, too—in a completely democratic fashion. You see, there are three identical repair-control modules functioning at all times, and decisions on giving the heave-ho to one of them are made by majority vote. If the modules vote two to one, for example, this indicates a fault in the dissenting member and it is summarily—and automatically—replaced.

Who owns FM stereo?

It's taking longer to unwind the patent snarl over the standard FM stereo multiplex system than it did to invent it. Last year, a New York federal court, in a surprise decision, upheld Crosby Tele-Tronics as holder of the basic patent for FM stereo, despite the fact that the so-called "Crosby system" had been rejected by the FCC. Then, this spring, the appeals court reversed this decision by ruling in favor of General Electric, which had been sued by Crosby for alleged patent infringement. After the higher court decision, GE immediately served notice on manufacturers of broadcast and receiving equipment that it expects them to pay royalties on all FM stereo devices they make. But another manufacturer is on the scene. Zenith Radio Corp. also has claims on some aspects of the system and has indicated that it, too, will insist on royalties from other manufacturers. Most FM stereo makers, meanwhile, are waiting for the dust to settle. R-E

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FEATURE

AUDIO

CONSTRUCTION PROJECTS

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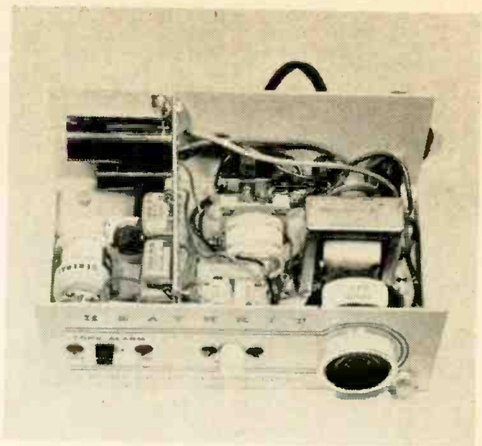
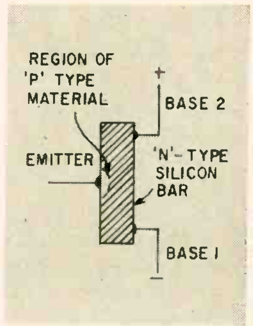


New way to protect life and property. Fire, smoke and other types of sensors can be made to trigger a transmitter which sends a pulsed signal into the house power line. One or more receivers can be used to pick up the signal and sound an alarm. It's fail-safe and in kit form.

See page 32

Take the guess work out of engine tune up and operation. Compare engine rpm with road speed . . . could be your transmission is slipping.

See page 44



Meet the unijunction transistor (UJT) and get to know how to make it work for you.

See page 36

DEPARTMENTS

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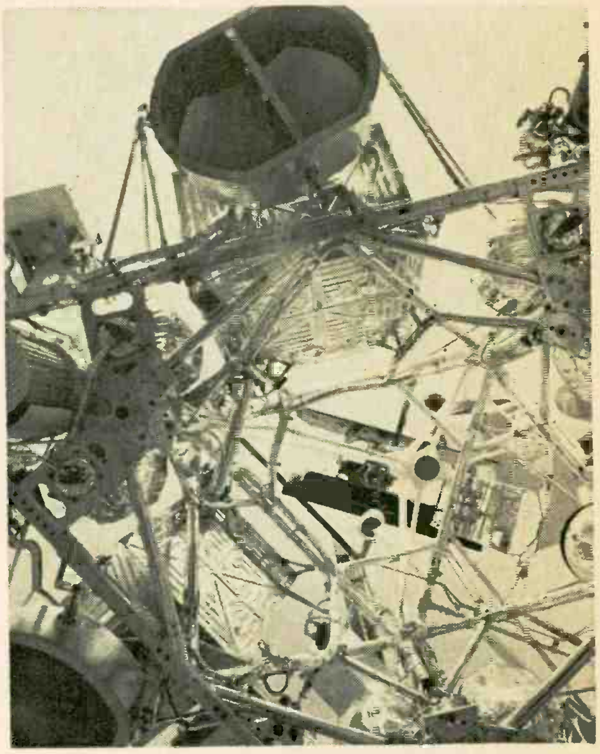
Radio-Electronics is indexed in *Applied Science & Technology Index* (formerly *Industrial Arts Index*)

New Infrared Laser: RCA's electroluminescent laser (magnified here 150X) is simplest laser yet. Dumbbell-shaped slice of gallium arsenide radiates infrared light without the built-in "junction" required in semiconductor lasers until now.

NEWS BRIEFS

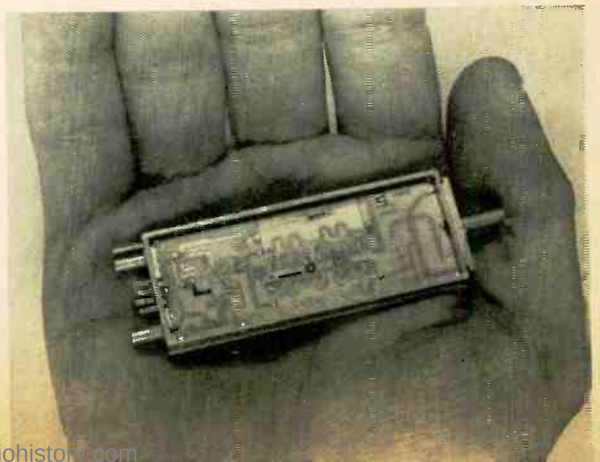
Super Switch: New Westinghouse vacuum interrupter can switch 12,000 amp—enough to light several office buildings. Current at 15.5 kV is switched in 1/50 sec. Device is used for power-line equipment, motor controls, radar transmitters.

360° Hologram: Multiple exposure photo approximates what viewer sees by moving head from left to right in front of flat hologram. Using new Bell Labs technique, the 3-D image appears to rotate through a full circle. Photo graininess is due to laser illumination.



Moon's-Eye View—If you happened to be on the moon during the soft-landing of Surveyor 7, here's how the spacecraft would have looked at its final descent. The maze of electronics gear mounted to the frame of this test model is identical to that on the last surveyor which added to the more than 60,000 TV photos transmitted from the lunar surface. Hughes Aircraft Co built all seven Surveyors.

Mini-Radar: Electronic module developed by Texas Instruments contains a radar transmitter, receiver and antenna. Panel of 604 modules eliminates need for rotating antenna and other failure-prone radar parts.



COLOR TV IMAGES SHARPENED

A new "image enhancement" technique that increases the sharpness and detail of color images on TV receivers is now being used in network broadcasting. A solid-state device examines coded color signals as they are transmitted and automatically adjusts vertical and horizontal picture details as needed to eliminate the "softness" of color images. Developed by CBS Laboratories, the device samples three successive scan lines, notes the differences between them, and adds these differences to the middle line to provide higher contrast.

MYSTERY SPACE SIGNALS

Precisely timed pulses from four objects in space are puzzling scientists. The objects, called pulsars, were discovered last year by British radio astronomers. Three pulsars have repetition rates from 1.18 to 1.33 sec.; two have pulse widths of .038 sec., although their pulse shapes differ. The regularity of the pulses has caused some speculation that they originate from another civilization. Recently, Dr. Thomas Gold, director of Cornell University's space research center, suggested that the pulsars are neutron stars spinning at tremendous velocities.

SIGNALS CONVERTED TO COLOR PATTERNS

A radically new method of converting electrical signals into colored patterns on a viewing screen has been developed at Westinghouse Research Laboratories. The technique utilizes a "liquid crystal" screen with a modified electron bean scanner. The liquid crystals can change colors in response to changing electric fields. Color patterns are electronically erased. The liquid crystal patterns can be seen in brightly lit areas because they are viewed by light reflected from the screen.

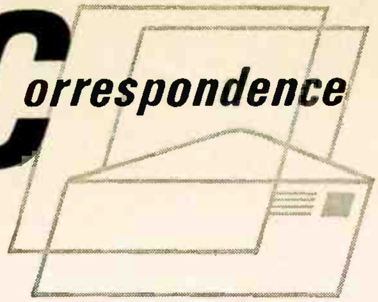
COLOR SLIDES ON TV

Sylvania will market this summer an all-around home entertainment center—combination color TV, slide projector-changer and cassette tape recorder. Home color slides are put on face of picture tube by built-in flying-spot scanner. Retail list price will range from about $700.

CONSUMER ELECTRONICS

The 1968 Consumer Electronics show will be held in New York City June 23–26 at the Americana and the New York Hilton Hotels. Exhibits—which include TV, radios, audio components and tape equipment—are open to the public. **R-E**

Correspondence



BLACK NOISE

We constructed your black noise generator as described in "Testing With Black Noise" (April 1968). It worked fairly well. We found that by modifying the dimensions of the loop in the cavity we were able to improve the performance, range and efficiency of the device.

DAVID B. DUFFUS
Hamilton, Canada

Several years ago, I designed and built a device similar to the one described in the article, except it was meant to be a regulated voltage source for O VDC and therefore did not have as great a frequency range of Mr. Sutheim's device. Since there may be some stray signal produced in the circuitry (sic) of the black noise generator or picked up by its output cable, a large capacitor could be used as a filter at the output end of the cable to eliminate any spurious signals. In order to be effective for the widest possible range of frequencies, the capacitance should be as large as possible.

JOSHUA LEVIN
Flushing, N.Y.

Please advise Mr. Sutheim that *two* black noise generators work just fine in stereo, if correct phasing is maintained.

RONALD PESHA, CHIEF ENGINEER
Broadcast Station KFIG

PERPETUAL MOTION

I installed a capacitor discharge ignition system in my 1965 Corvair (110 hp Monza). It starts really great, except it will not stop running. The ignition switch does not kill the engine. What's happening? Is there something inadvertently shunted. Hurry. I'm about out of gas.

E. MICH
Philadelphia, Pa

If you hooked up the new ignition system properly and your ignition switch is in good working order, chances are that your engine is dieseling . . . that is, running without the benefit of the *(continued on page 12)*

Radio-Electronics

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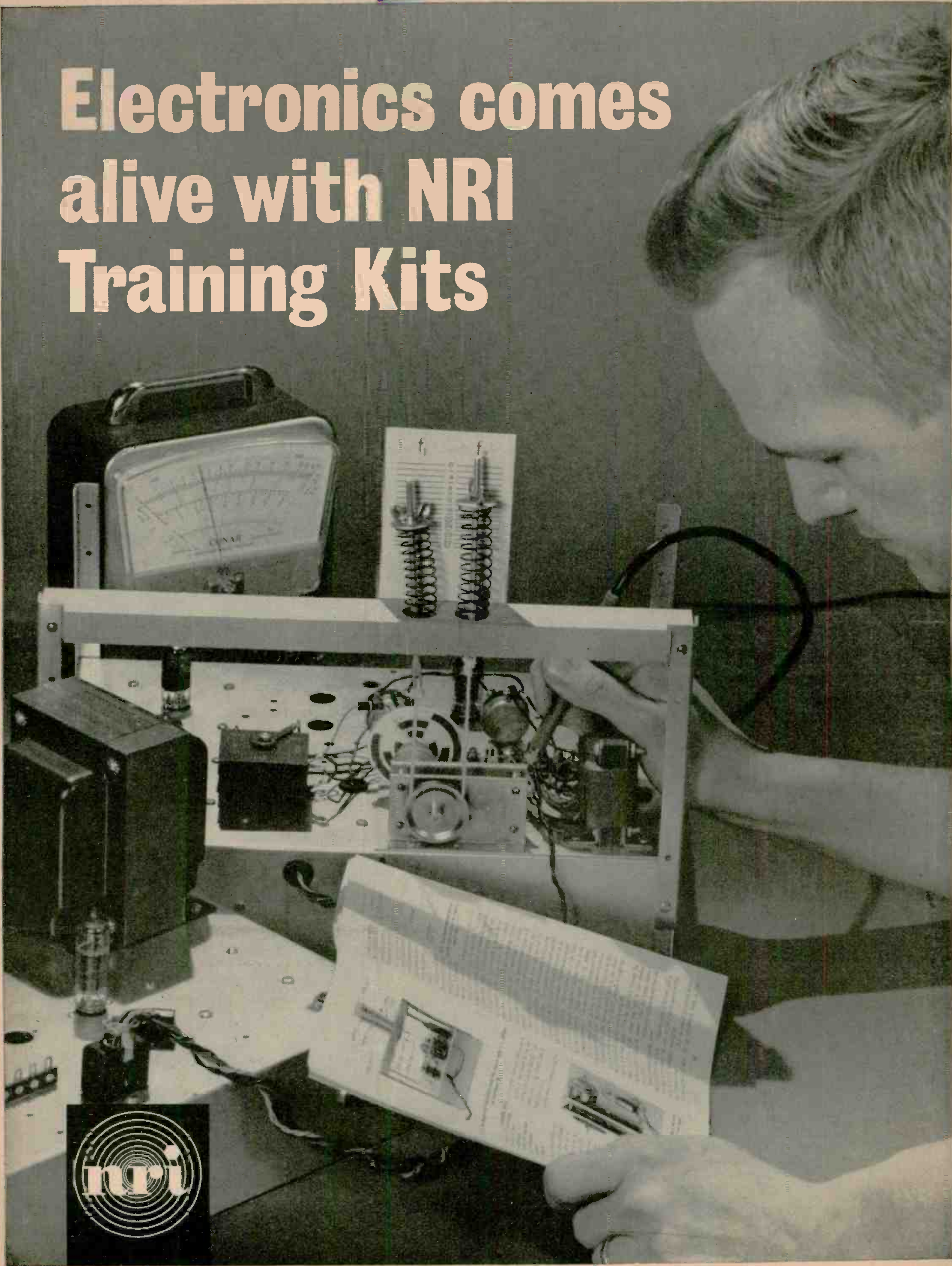
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* You must pass your FCC License exams (any Communications course) or NRI refunds in full the tuition you have paid.

CORRESPONDENCE
(continued from page 6)

ignition system. This is not too unusual for a hot, high-compression engine. If this is the case, the engine should operate in a normal manner when it is cold. You can take a page out of a small airplane operations manual, ". . . to stop the engine, shut off the flow of gasoline." If your car were equipped with a manual choke you could give it full choke, shut off the air supply and stop the engine. Perhaps, your best solution is check the ignition timing and try advancing the spark.

IN APPRECIATION

Thank you for printing my letter (March 1968) requesting help in finding service data. I would also like to thank all the people who sent me schematics and manuals for the PRI model 117B scintillator. I have received 20 to date.

RAYMOND A. MOORE
San Jose, Calif.

TRANSISTOR BIAS

I want to thank you so very much for the article "Update Your Solid-State TV Servicing" by Matthew Mandl (February 1968). I've read articles on this subject before, but this is the first time I've really been able to understand transistor bias.

WILLIAM DOULONG
Rosedale, Md.

TV X-RADIATION

My wife and I are very health conscious, we watch the kind of food we eat, take vitamin supplements, and make sure that we get our proper exercise. It is with somewhat of a shock that I read about the hazards of servicing TV sets. I'm hoping to see an article in your peerless magazine soon.

MATHEW RUSKOSKI
Pittsburgh, Pa.

Much controversy exists about the hazards, real and imaginary, of radiation from TV sets. We have been monitoring the activities of both industry and government agencies and we will report any significant findings. Servicemen have been alerted and advised how to adjust a TV set properly to prevent radiation hazard. At the moment, it is pretty much of a blind-alley kind of a situation . . . without suitable radiation detection equipment, it is impossible to tell the presence or absence of radiation. What is needed is a low-cost, readily available piece of test equipment to do the job. Here's
(continued on page 14)

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COLOR SPECTRUM™ ANTENNAS

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STRENGTH OF UHF SIGNAL AT RECEIVING ANTENNA LOCATION	Strength of VHF Signal at Receiving Antenna Location: NO VHF	VHF SIGNAL STRONG	VHF SIGNAL MODERATE	VHF SIGNAL WEAK	VHF SIGNAL VERY WEAK
NO UHF		CS-V3 $10.95	CS-V5 $17.50 / CS-V7 $24.95	CS-V10 $35.95	CS-V15 $48.50 / CS-V18 $56.50
UHF SIGNAL STRONG	CS-U1 $9.95	CS-A1 $18.95	CS-B1 $29.95	CS-C1 $43.95	CS-C1 $43.95
UHF SIGNAL WEAK	CS-U2 $14.95	CS-A2 $22.95	CS-B3 $49.95	CS-C3 $59.95	CS-D3 $69.95
UHF SIGNAL VERY WEAK	CS-U3 $21.95	CS-A3 $30.95	CS-B3 $49.95	CS-C3 $59.95	CS-D3 $69.95

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NOTE: In addition to the regular 300 ohm models (above), each model is available in a 75 ohm coaxial cable downlead where this type of installation is preferable. These models, designated "XCS", each come complete with a compact behind-the-set 75 ohm to 300 ohm balun-splitter to match the antenna system to the proper set terminals.

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a real challenge to our test equipment manufacturers to produce such a unit.

UNDERWATER RADIO

I was interested in the article "Build Hydronic-Radiation Transmitter" (May 1967) by Jack Althouse. In the article he presents a controversy concerning the operation of an underwater antenna system. I would like to add my "two bits" and suggest possible answers for the unusual phenomena he presents and also to propose some experiments which should shed light on the subject. I would like to take the viewpoint that the system utilizes the same electro-magnetic "modes" of operation as ordinary "landlubber" systems except that it is particularly well-matched, by virtue of the large end plates, to its water surroundings. Transmission of radiation in a medium such as fresh or salt water is characterized by the following phenomena: the velocity of propagation is reduced by about 9 times as a result of the high dielectric constant of water; and the fact that the medium conducts means that the wave will be attenuated as it travels away from the radiator . . . the attenuation is greater in salt water than in fresh water. A direct result of the first phenomena is that the wavelength for any frequency (up to about several hundred megahertz) is reduced by a factor of 9. (In air the wave length of a 1 MHz wave is 300 meters, in water it is about 33.3 meters.) Referring now to the article, he presents essentially two pieces of data: that the radiation seems to be off the ends, when the antennas are close together; and that the signal strength is a function of depth when the antennas are far apart. Unfortunately, this is not enough data for a good evaluation of the system. First, I suggest that the "endwise" effect may be a result of a close-in induction field present around any radiating antenna. (The induction field effect would be especially enhanced if the plates actually are "grounding" elements in which large currents circulate.) The pertinent question here is, does the effect persist at large distances, or is orientation then unimportant?

The "up-and-over effect" at the outset may seem to be a real puzzler. However, I present the following possible explanation taken directly from the field of optics. I suggest that the effect may be the result of the "internal reflection" of the radiation at the

(continued on page 16)

Circle 16 on reader's service card →

14

Model 635A Dynamic Microphone $82.00 List. (Normal trade discounts apply.)

How can a microphone as good as the E-V Model 635 be made obsolete? By making it better! It wasn't easy. After all, professional sound engineers have depended on the 635 since 1947.

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The new 635A is totally new inside, too—and all for the best. A new four-stage filter keeps "pops" and wind noise out of the sound track, while guarding against dirt and moisture in the microphone, completely eliminating any need for external wind protection. Of course you still get high output (—55db) and smooth, crisp response. And you can still depend on the exclusive E-V Acoustalloy® diaphragm that is guaranteed against failure for life* (it's that tough)!

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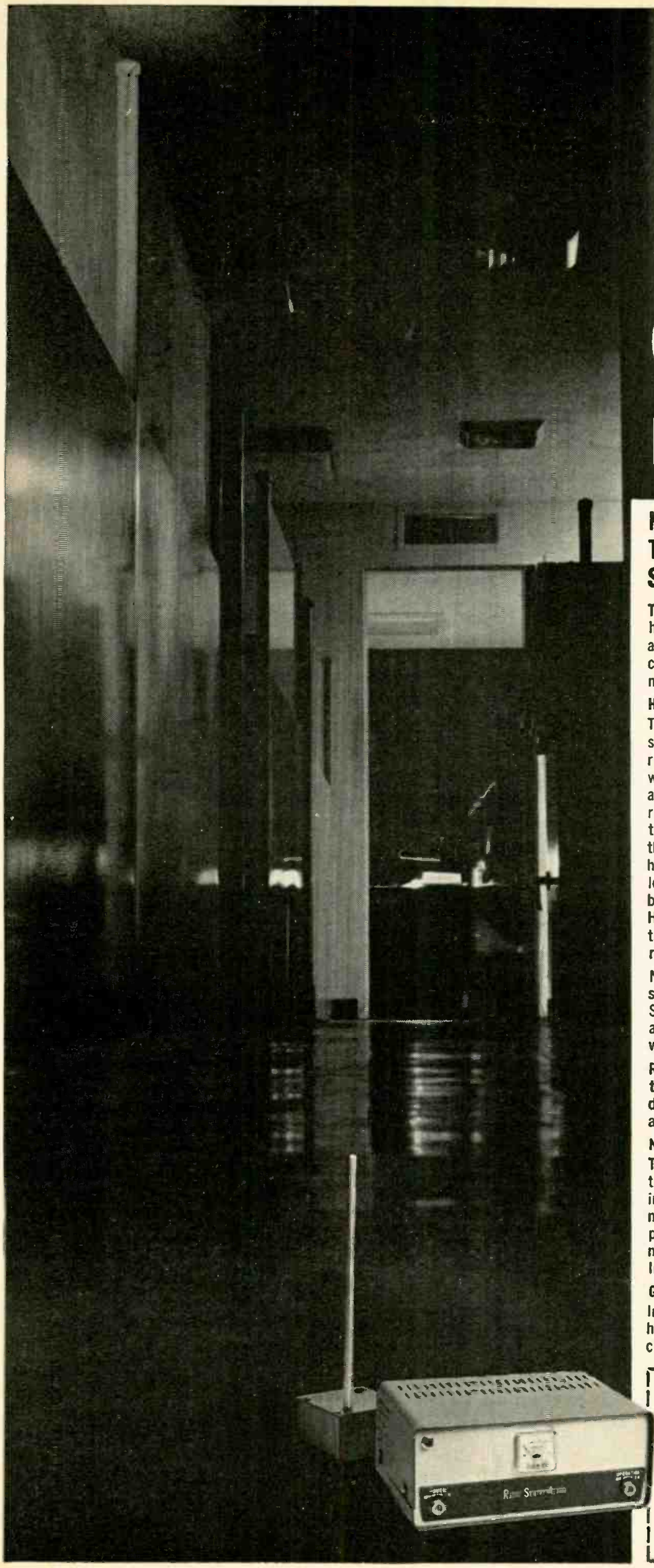
Electro-Voice®
SETTING NEW STANDARDS IN SOUND

CORRESPONDENCE
(continued from page 14)

surface of the water. (The phenomenon of internal reflection is explained in any good fundamental physics book. It is easy to understand, partly from an intuitive viewpoint, and partly with the aid of Snell's Law.) Some of the "rays" of electromagnetic energy near the water surface pass out of the lower medium of refractive index (water = 9) and into the upper of refractive index (air = 1). Some of the rays are also reflected back into the water and one ray also travels along the surface. If the angle between the ray and the water surface is small enough, the ray will be reflected back into the water. This maximum angle of incidence, as calculated by Snell's Law is about 83.5°. Consider now a radiating antenna and a receiving antenna at a large distance apart. Obviously, the distance traveled by the ray that bounces off the surface of the water is a function of the depth of the receiving and transmitting antennas. A test of this explanation would be to measure the radiation which escapes from the water (when the antennas are far apart). Evidently one should measure an appreciable signal only in the region just above the radiating antenna. The operation of the antenna may be more closely investigated with particular attention paid to the following question, reason and experiment for it: *Question*—Is the antenna voltage (high-impedance) or current (low-impedance) fed? Mr. Althouse did not make this clear in his article. The 25-turn pickup loop on the transmitter coil could have a rather large impedance as it was wound on the ferrite core along with the transmitter coil. Perhaps fewer or more turns (like 10 as compared with 50) would produce significant changes in the radiating efficiency of the antenna.) **Reason**—If voltage fed, one would expect that a ½-wave antenna would have the current maximum at the ends. Consequently, large plates at the ends would be necessary to insure grounding and low impedance. On the other hand, if current fed, one would expect a ½-wave antenna to have voltage at the ends. In this case, large capacitive loading plates would be necessary to make up for the fact that the antenna isn't long enough. **Experiment**—Make a ½-wave antenna, about ⅑ as long as the free space length and investigate loading, grounding plates, etc.

BRUCE MACCABEE
Physics Dept.
The American University
Washington, D.C. **R-E**



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MICROWAVES!

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The Radar Sentry Alarm is simple, yet foolproof. Completely solid state, its main components are a control unit and a remote detector. A very stable oscillator generates microwaves (400 MHz) which are radiated out into the protected area by the remote detector—actually an antenna. Each remote detector saturates a 5,000 square foot area, floor to ceiling. Because the oscillator is connected directly to the antenna, it is very sensitive to changes in load. Any human movement in the area will change the antenna load (small animals will not). This change will be reflected back into the oscillator, changing the frequency by a few Herz. The frequency change is amplified by a series of 8 transistor stages, detected, and used to close the alarm relay.

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RE-6

Circle 20 on reader's service card

"CIE training helped pay for my new house,"

says Eugene Frost
of Columbus, Ohio

Gene Frost was "stuck" in low-pay TV repair work. Then two co-workers suggested he take a CIE home study course in electronics. Today he's living in a new house, owns two good cars and a color TV set, and holds an important technical job at North American Aviation. If you'd like to get ahead the way he did, read his inspiring story here.

IF YOU LIKE ELECTRONICS—and are trapped in a dull, low-paying job—the story of Eugene Frost's success can open your eyes to a good way to get ahead.

Back in 1957, Gene Frost was stalled in a low-pay TV repair job. Before that, he'd driven a cab, repaired washers, rebuilt electric motors, and been a furnace salesman. He'd turned to TV service work in hopes of a better future—but soon found he was stymied there too.

"I'd had lots of TV training," Frost recalls today, "including numerous factory schools and a semester of advanced TV at a college in Dayton. But even so, I was stuck at $1.50 an hour."

Gene Frost's wife recalls those days all too well. "We were living in a rented double," she says, "at $25 a month. And there were no modern conveniences."

"We were driving a six-year-old car," adds Mr. Frost, "but we had no choice. No matter what I did, there seemed to be no way to get ahead."

Learns of CIE

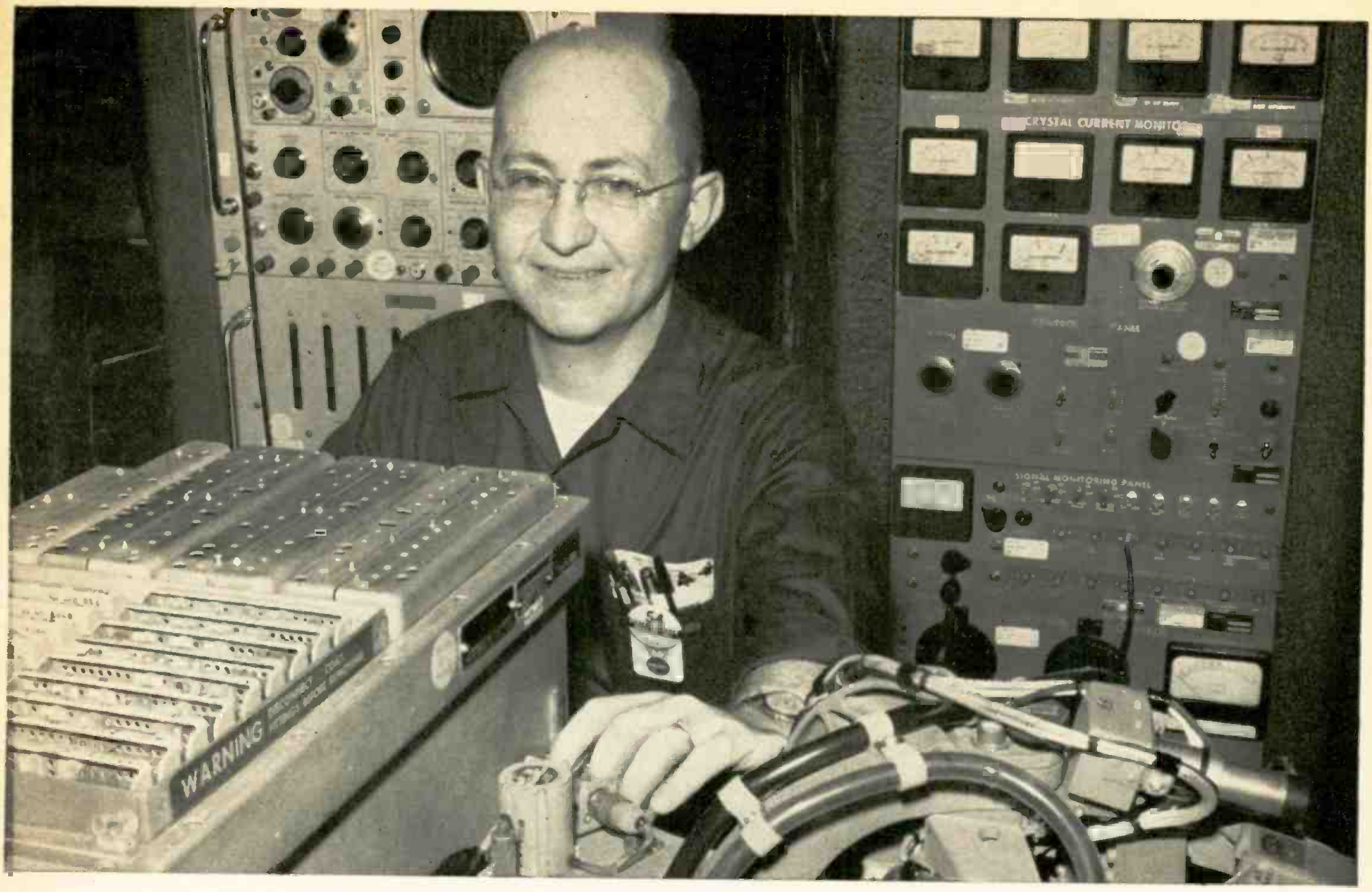
Then one day at the shop, Frost got to talking with two fellow workers who were taking CIE courses . . . preparing for better jobs by studying electronics at home in their spare time. "They were so well satisfied," Mr. Frost relates, "that I decided to try the course myself."

He was not disappointed. "The lessons," he declares, "were wonderful—well presented and easy to understand. And I liked the relationship with my instructor. He made notes on the work I sent in, giving me a clear explanation of the areas where I had problems. It was even better than taking a course in person because I had plenty of time to read over his comments."

Studies at Night

"While taking the course from CIE," Mr. Frost continues, "I kept right on with my regular job and studied at night. After graduating, I went on with my TV repair work while looking for an opening where I could put my new training to use."

His opportunity wasn't long in coming. With his CIE training, he qualified for his 2nd Class FCC License, and soon afterward passed the entrance examination at North American Aviation. "You can imagine how I felt," says Mr. Frost. "My new job paid $228 a month more!"



Currently, Mr. Frost reports, he's an inspector of major electronic systems, checking the work of as many as 18 men. "I don't lift anything heavier than a pencil," he says. "It's pleasant work and work that I feel is important."

Changes Standard of Living

Gene Frost's wife shares his enthusiasm. "CIE training has changed our standard of living completely," she says.

"Our new house is just one example," chimes in Mr. Frost. "We also have a color TV and two good cars instead of one old one. Now we can get out and enjoy life. Last summer we took a 5,000 mile trip through the West in our new air-conditioned Pontiac."

"No doubt about it," Gene Frost concludes. "My CIE electronics course has really paid off. Every minute and every dollar I spent on it was worth it."

Why Training is Important

Gene Frost has discovered what many others never learn until it is too late: that to get ahead in electronics today, you need to know more than soldering connections, testing circuits, and replacing components. You need to really know the fundamentals.

Without such knowledge, you're limited to "thinking with your hands" ...learning by taking things apart and putting them back together. You can never hope to be anything more than a serviceman. And in this kind of work, your pay will stay low because you're competing with every home handyman and part-time basement tinkerer.

But for men with training in the fundamentals of electronics, there are no such limitations. They think with their heads, not their hands. They're qualified for assignments that are far beyond the capacity of the "screwdriver and pliers" repairman.

The future for trained technicians is bright indeed. Thousands of men are desperately needed in virtually every field of electronics, from 2-way mobile radio to computer testing and troubleshooting. And with demands like this, salaries have skyrocketed. Many technicians earn $8,000, $10,000, $12,000 or more a year.

How can you get the training you need to cash in on this booming demand? Gene Frost found the answer in CIE. And so can you.

Send for Free Book

Thousands who are advancing their electronics careers started by reading our famous book, "How To Succeed In Electronics." It tells of the many electronics careers open to men with the proper training. And it tells which courses of study best prepare you for the work you want.

If you'd like to get ahead the way Gene Frost did, let us send you this 40-page book free. With it we'll include our other helpful book, "How To Get A Commercial FCC License." Just fill out and mail the attached card. Or, if the card is missing, write to CIE at the address below.

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Circle 21 on reader's service card

NEW BOOKS

101 WAYS TO USE YOUR HAM TEST EQUIPMENT, by Robert G. Middleton. *Published by Howard W. Sams & Co., Inc., 4300 W. 62 St., Indianapolis, Ind. 46206. 5½" x 8½", 160 pages, soft cover, $2.95*

Describes basic tests of ham equipment. It covers uses of such instruments as grid-dip meters, antenna impedance meters, vom's and vtvm's, oscilloscopes, reflected-power and SWR meters, bridges, etc. The uses described range from basic to complex, yet explanations are concise and easy to follow. The book is well illustrated.

ENCYCLOPEDIA OF ELECTRONICS COMPONENTS, edited by Dr. Alva C. Todd. *Published by Allied Radio Corp., 100 N. Western Ave., Chicago, Ill 60680. 5½" x 8½", 112 pages, soft cover, $1*

Alphabetically lists, describes and illustrates components now in use. Descriptions are easy to understand. Each component's use is explained and any special handling or installation requirement is covered. A handy reference.

HOW TO USE SIGNAL GENERATORS (3 books), by John D. Lenk. *Published by John F. Rider Publications, 116 W. 14 St., New York, N. Y. 10011. 6" x 9", approximately 100 pages in each, soft covers, $3.25 each*

Each book specializes in a particular field—the laboratory; color TV servicing; radio/TV/hi-fi servicing. All three of these books give step-by-step instructions on how to apply all types of signal generators, etc. The books include methods for testing and calibrating signal generators. Well illustrated.

ESSENTIAL CHARACTERISTICS (Twelfth Edition), by D. G. Beasley and R. G. Kempton. *Published by General Electric Co., 2100 Gardiner Lane, Suite 301, Louisville, Ky. 40205. 8½" x 6", 360 pages, soft cover, $2*

Prepared by G.E's Tube Department, this "single-source reference" has been updated to include more than 300 of the newest receiving and TV tubes. It provides excellent guidance for service technicians, design engineers and hobbyists—3287 tubes (741 black-and-white and color picture tubes) are described. In addition, this manual contains data on receiving-, five-star and special-purpose tubes, capacitors, photoconductive cells, photoconductive cell–lamp combinations and reed switches. Practically every tube found in any piece of electronic equipment is described. Bottom part of the book contains tube drawings and pin identification, on pages which can be flipped independently of the upper portion. **R-E**

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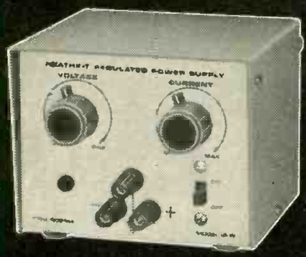
At last, a realistic price for in-circuit testing of transistors! The new Heathkit IT-18 Tester has the facilities you need and it costs a lot less. It measures DC Beta in-or-out-of-circuit in 2 ranges from 2 to 1000 (the spec. commonly used by mftrs. and schematics to determine transistor gain). It tests diodes in-or-out-of-circuit for forward and reverse current to indicate opens or shorts. Measures transistors out-of-circuit for ICEO and ICBO leakage on leakage current scale of 0 to 5,000 uA. Identifies NPN or PNP devices, anode and cathode of unmarked diodes; matches transistors of the same type or opposite types. Cannot damage device or circuit even if connected incorrectly. Big 4½" 200 uA meter. 10-turn calibrate control. Completely portable, powered by "D" cell (long battery life). Front panel socket for lower power devices. Attached 3' test leads. Rugged polypropylene case with attached cover. Build in 2 hours. 4 lbs.



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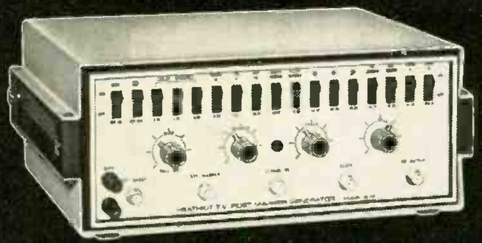
Labs, service shops, hams, home experimenters . . . anybody working with transistor circuitry can use this handy new Heathkit All-Silicon Transistor Power Supply. Voltage regulated (less than 40 mV variation no-load to full-load; less than 0.05% change in output with input change from 105-125 VAC). Current limiting; adjustable from 10-500 mA. Ripple and noise less than 0.1 mV. Transient response 25 uS. Output impedance 0.5 ohm or less to 100 kHz. AC or DC programming (3 mA driving current on DC). Circuit board construction. Operates 105-125 or 210-250 VAC, 50/60 Hz. 6 lbs.



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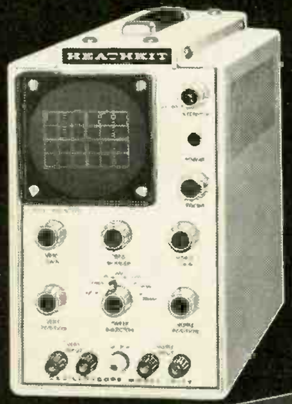

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From Heath

NEW HEATHKIT AJ-15 Deluxe Stereo Tuner

For the man who already owns a fine stereo amplifier, and in response to many requests, Heath now offers the superb FM stereo tuner section of the renowned AR-15 receiver as a separate unit. The new AJ-15 FM Stereo Tuner has the exclusive design FET FM tuner for remarkable sensitivity, the exclusive Crystal Filters in the IF strip for perfect response curve and no alignment; Integrated Circuits in the IF for high gain, best limiting; elaborate Noise-Operated Squelch; Stereo-Threshold Switch; Stereo-Only Switch; Adjustable Multiplex Phase, two Tuning Meters; two variable output Stereo Phone jacks; one pair variable outputs plus two fixed outputs for amps., recorders, etc.; front panel mounted controls; "Black Magic" panel lighting; 120/240 VAC operation. 18 lbs. *Walnut cabinet AE-18, $19.95.

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2-Meters at low cost. And the HW-17 Transceiver has 143.2 to 148.2 MHz extended coverage to include MARS, CAP, and Coast Guard Auxiliary operation. Output power of tube-type transmitter is 8 to 10 watts, AM. 4 crystal sockets plus VFO input. Relayless PTT operation. Double conversion solid-state superhet. Receiver has 1 uV sensitivity with prebuilt, aligned FET tuner, ANL, Squelch, "Spot" function, and lighted dial. Signal-strength/relative power-output meter. Battery saver switch for low current drain during receiving only. 15 transistor, 18 diode, 3 tube circuit on two boards builds in about 20 hours. Built-in 120/240 VAC, 50-60 Hz power supply and 3" x 5" speaker; low profile aluminum cabinet in Heath gray-green; ceramic mic. and gimbal mount included. 17 lbs. *Optional DC mobile supply, HWA-17-1, $24.95.

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Circle 26 on reader's service card

In the Shop . . . With Jack

By JACK DARR

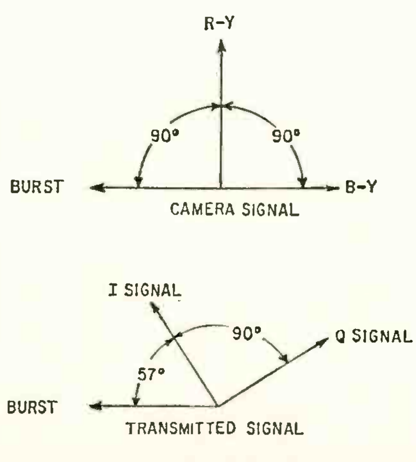
STATION COLOR TROUBLES

IT'S NEVER PLEASANT TO GET BLAMED for something we didn't do. We get enough blame for the things we *did* do. So, let's take up some subjects that draw unjustified complaints from set owners about color reception. They are caused by station trouble.

The basic complaint is: "The pictures aren't the same colors all the time," or "people look different." One technician told me, perfectly serious, that out of three stations in his area, ". . . no two of them transmitted the same color burst frequency! You have to adjust the tint control all the way to one end for one, in the middle for the other, and all the way to the other end for the third!" This is a fascinating theory, but *it ain't so.* Let's see why.

On-screen color is determined by the phase angle of the chrominance signals, with respect to a 3.579545-MHz subcarrier. This subcarrier is generated at the "point of origin" *of the program,* no matter where this is. The two color-difference signals are locked to the reference burst. In the receiver, the oscillator locks to the 3.58-MHz burst signal *which comes with the program.* Right? It had better lock in; if it doesn't, you're going to have rainbows running all over the place!

Now, look at the diagram, which shows the I and Q signals at their proper angles. (The I and Q signals are produced at the station by shifting the phase of the R – Y and B – Y signals from the camera.) This is a complete signal from one TV station. Turn the page on either side or upside down. What happens to the *phase angles?* They're *still the same!* The 3.58-MHz signal from the station, by FCC rule, must be within 10 Hz of 3.579545 MHz. The receiver local oscillator and control circuitry has a pull-in range of maybe ±20 Hz. So, as long as your oscillator stays locked to the *program* subcarrier, you'll get the right colors for that program! Even if the burst isn't within its allotted 10-Hz tolerance, the receiver color-phase circuits will lock on to it.



The normal lock-in time for such a control circuit is very short. It's possible for the receiver to lock within one cycle on different color programs; this is true even if the subcarriers should be different between program sources.

You've told us what *isn't* the trouble—now tell us what *is!* There *will* be color differences between shows, between stations and even between program and commercial material on the same station! You've seen that yourself. But they won't be a subcarrier difference! It is a difference in the *color response* of the various cameras at the studio, or between a video-tape machine, live or film-pickup camera.

The difference you see on the screen lies in the *amount* of each color transmitted, and in its saturation or amplitude. Watch any multiple-source program, such as network news shows, and you'll see what I mean.

Perhaps most noticeable of all is the difference between a live picture and film or video-tape segments. This can be caused by the different responses of the image-orth tubes in the live cameras, and the vidicons in the film chains, by the response of the video-tape machines and their adjustments, and so on.

Incidentally, you'll see a tape trouble on color that won't even show on b-w. It's an orange stripe across a pink or blue background, and it's caused by a wee phase shift somewhere in one of the video-tape heads. It's the equivalent of the loss of sync which used to make b-w video tapes break up into sawteeth on vertical lines and zigzags.

So, when you get complaints about improper colors, check very closely to be sure that the problem isn't station trouble. It's awfully hard to fix poor color at a studio in Hollywood when you're in Ohio! If it's consistent trouble, however, and shows up on all stations with the same symptoms, then you'd just as well get ready to take the chassis out of the cabinet! Watch the set in operation long enough to tell whether it is really a set trouble. Usually, about half of a short program and a couple of commercials will give you a pretty good idea. **R-E**

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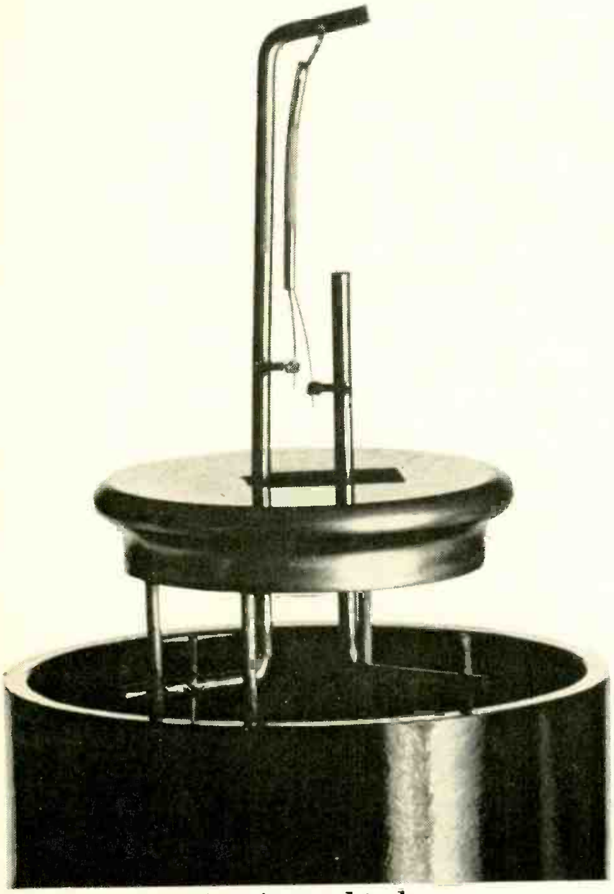
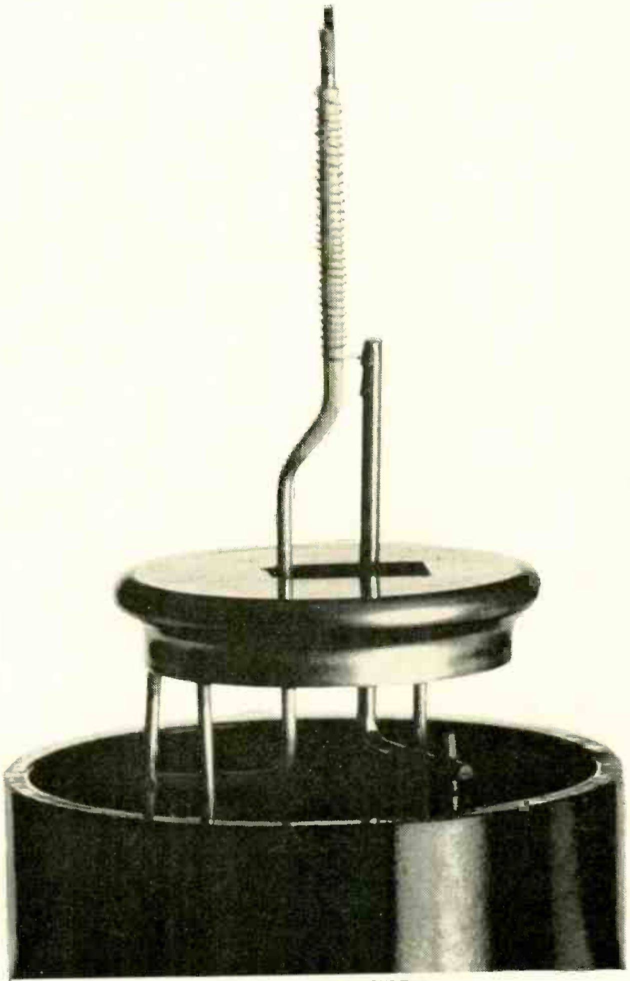


How it used to be.



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The uniform electric field around the rigid support reduces high voltage stresses. Arcing and its resulting troubles are eliminated.

The 3CU3 is interchangeable with 3A3 and 3A3A high voltage rectifiers. And it's made exclusively by Sylvania.

The 3CU3 is just one of a new "posted filament" family which includes the new 3BL2 and 3BM2. They're designed for use in new color TV sets. These tubes are especially good for transistorized TV where their fast warm-up fits in with the "instant on" feature of solid state circuitry.

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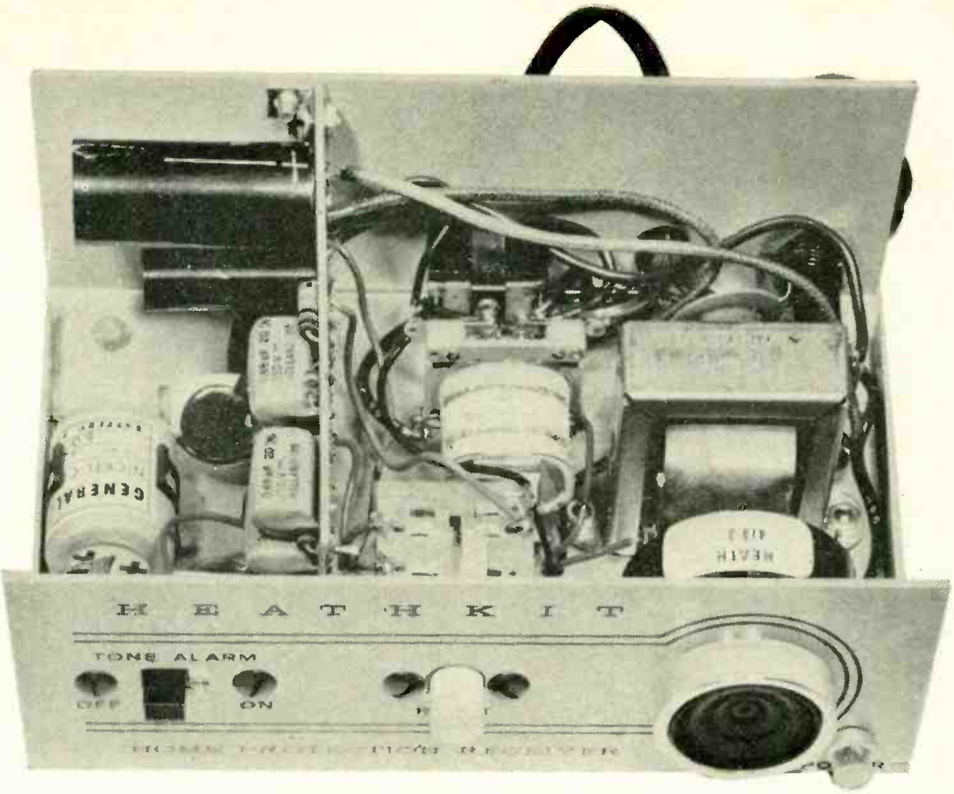

New Home Protection Alarm Kit

New wireless fire, smoke and burglar alarm system can save lives and protect property

By THOMAS R. HASKETT

HEATHKIT'S NEW HOME PROTECTION System serves as a round-the-clock watchman and can sound an alarm when life and property are threatened. A first of its kind in kit form, the system features a smoke detector, a heat detector and a multi-purpose alarm capability. You can be warned of intruders, temperature changes, rain, flood, etc.

The kits become an ac line-operated wireless system. You don't have to run signal wires along baseboards and under rugs. Just plug the units into the nearest ac line outlet. Signals from the detector (transmitter) units are carried by the power line to the alarm (receiver) unit. One, two or more transmitters can be used with one or more receivers. The receiver (GD-77) contains a 2800-Hz solid-state transducer, which serves as an internal sounder. Connections for an additional remote bell, buzzer, siren or light indicator are provided as well.

Transmitters are the Smoke Detector (GD-87), which also contains a heat sensor and provisions for one or more external heat sensors, and the Utility Transmitter (GD-97), which accommodates other alarm sensors operated in either or both normally open and normally closed circuits. The transmitters put out a 50-kHz signal when triggered. In the absence of the signal, the receiver remains "quiet." Should the signal be put on the ac line for any reason, the alarm will sound.

Solid-state circuitry and a minimum number of components are common to all units. Also, the system has excellent fail-safe features. For example, failure of certain key components in the transmitters, a power failure or disconnecting the receiver from the ac line will sound an alert. If power is removed from the receiver, rechargeable batteries take over to power the internal alarm.

The smoke-detector circuit (Fig. 1) consists of a light-dependent resistor (LDR), SENSITIVITY control R5 and the gate circuit of silicon controlled rectifier D5. A half-wave, voltage-doubler power supply (diodes D3 and D4, and capacitors C2 and C3) supplies 325 volts dc to the SENSITIVITY control.

Voltage across the LDR is determined by the setting of R5. The LDR is mounted—along with lamp PL-1—inside the smoke-detector assembly. When the LDR is in the dark, its resistance is 1 to 3 megohms. When smoke enters the detector assembly, however, some light is reflected off the smoke onto the LDR and causes its resistance to decrease. This decrease in resistance is directly proportional to the light reflected on the LDR.

As the resistance of the LDR decreases, more current flows through the LDR, R6 and R7. (Resistor R6 is a current limiter used to protect the SCR gate from damage.) Current flow through R7 sets up a positive voltage on the gate of the SCR and triggers it into conduction. Pulsating dc voltage is then applied across the transmitter module (described later), which generates the 50-kHz signal to trigger the alarm.

Fail-safe smoke detector lamp

The 12.6-volt secondary of power-supply transformer T1 provides supply voltage for smoke-detector lamp PL-1. The lamp is connected in a bridge circuit with R1, R2 and R3. Normally the bridge is near balance and only a small current flows through diode D2. This residual current is too small to provide sufficient voltage drop across R7 to gate on the SCR.

However, if PL-1 burns out or is removed from its socket, bridge balance is upset. Current flow increases from the bridge, through D2 and R7, and back to the bridge. As before, the voltage drop across R7 gates on the SCR, which applies pulsating dc voltage across the transmitter module to generate the alarm signal.

Heat-detector

Supply voltage for the heat detector is furnished by the 6.3-volt winding of T1, rectified by D1 and filtered by C1. Heat sensor TS-1 is in series with any remote heat sensors and the coil of relay RLY-1, which is energized by current flow through the circuit. When TS-1 or an external heat sensor detects high temperature (about 133°F), current to the relay coil is interrupted. The normally closed contacts (N.C. on the diagram) close, applying sufficient voltage across R6 and R7 to gate on the SCR and turn on the transmitter section.

All transmitter components (except R8 and C5) are preassembled in a module. A conventional emitter-coupled multivibrator (transistors Q101 and Q102) generates alarm signals. The multivibrator is tuned to approximately 50 kHz and trimmer capacitor C5 is used for frequency adjustments.

Transmitter output is coupled, via C103 and R106, to the base of switching transistor Q103. (Diode D101 protects the base of Q103 by limiting negative voltage peaks.) When the transmitter is turned on, transistor Q103 switches off and on at a 50-kHz rate.

One end of the C104–R8 combination is connected to one side of the ac line and the other end to the collector of Q103. When Q103 switches, its collector-to-emitter resistance is quite low, in effect placing C104 and R8 across the ac line (through the SCR, which is also conducting).

The transmitting multivibrator is connected to one side of the ac line through R101. The emitters of Q101 and Q102 are connected to the anode of the SCR. When the SCR conducts, it turns on the multivibrator by supplying it with a 60-Hz pulsating dc voltage rectified from the ac line.

Alarm signal

Switching transistor Q103 connects C104 and resistor R8 in parallel across the ac line on alternate half-cycles of the 60-Hz voltage. As waveform A of Fig. 1 shows, the 50-kHz rf signal is modulated by these half-cycles. The result (waveform D) is 50-kHz modulation of alternate half-cycles of the 60-Hz voltage on the ac line—in other words, a burst of 50-kHz signal transmitted 60 times per second.

Therefore, whenever heat or smoke is detected or lamp PL-1 burns out, a 50-kHz signal is transmitted through the ac line. Since the 50-kHz signal is not transmitted continuously, but only on alternate half-cycles of the 60-Hz line voltage, the signal consists of a 50-kHz signal pulse modulated

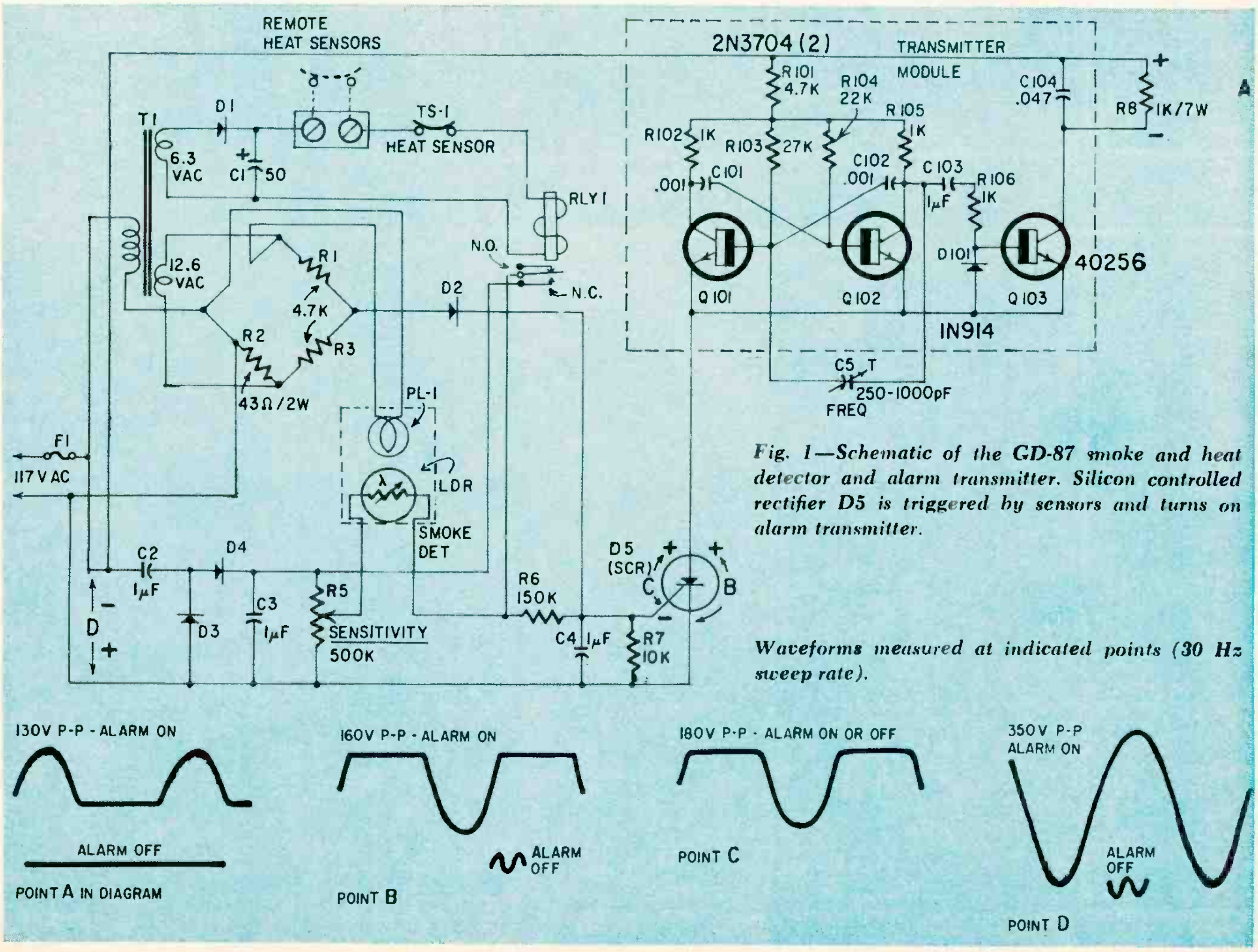

Fig. 1—Schematic of the GD-87 smoke and heat detector and alarm transmitter. Silicon controlled rectifier D5 is triggered by sensors and turns on alarm transmitter.

Waveforms measured at indicated points (30 Hz sweep rate).

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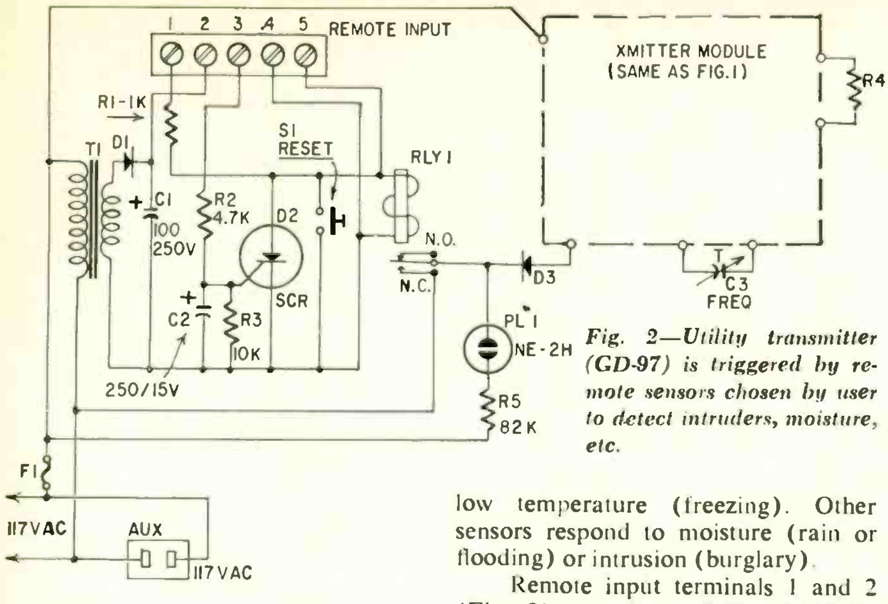


Fig. 2—Utility transmitter (GD-97) is triggered by remote sensors chosen by user to detect intruders, moisture, etc.

by 60 Hz from the ac line.

GD-97 is not supplied with remote sensors, but the user may select a wide variety of them to fit many applications. Thermostats may be used to indicate high temperatures (fire) or low temperature (freezing). Other sensors respond to moisture (rain or flooding) or intrusion (burglary).

Remote input terminals 1 and 2 (Fig. 2) are designed for normally closed sensing devices, with a resistance of 800 ohms or less. Terminals 2 and 3 are for normally open devices with open resistance of 350,000 ohms or more, and terminals 4 and 5 for normally open devices which have an open resistance of 1000 ohms or more.

The power supply (T1, D1 and C1) furnishes rectified dc for the remote sensors and transmitter trigger. Current from the supply flows through the normally closed sensor connected across terminals 1 and 2, through current-limiting resistor R1 and the coil of relay RLY-1, energizing it. Since its normally open contacts are then made, the transmitter stays off.

Should a sensor connected across terminals 1 and 2 open, the relay is de-energized and its normally closed contacts make. This action lights lamp PL1 and connects ac to D3, which rectifies the ac and supplies pulsating dc to the transmitter. As mentioned above, the transmitter then supplies the pulsed rf signal to the ac line.

Silicon controlled rectifier D2 is connected across the coil of RLY-1. However, since the SCR is not conducting, anode-to-cathode resistance is high and current flows through the relay coil. When a normally open sensor across terminals 2 and 3 closes,

(continued on page 61)

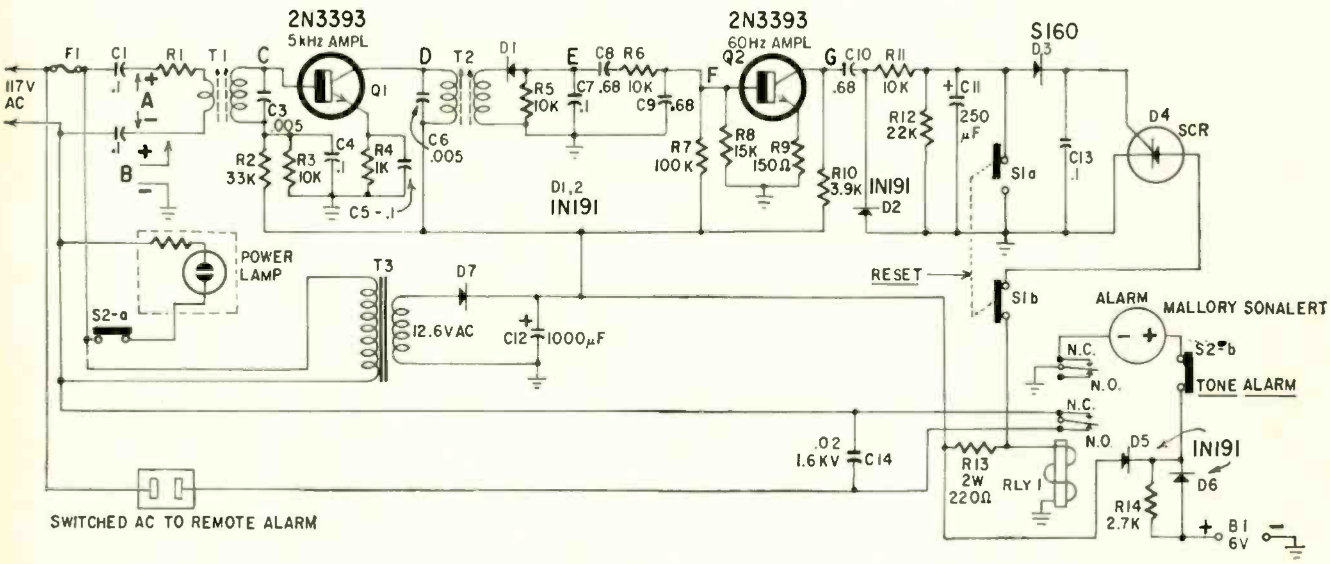
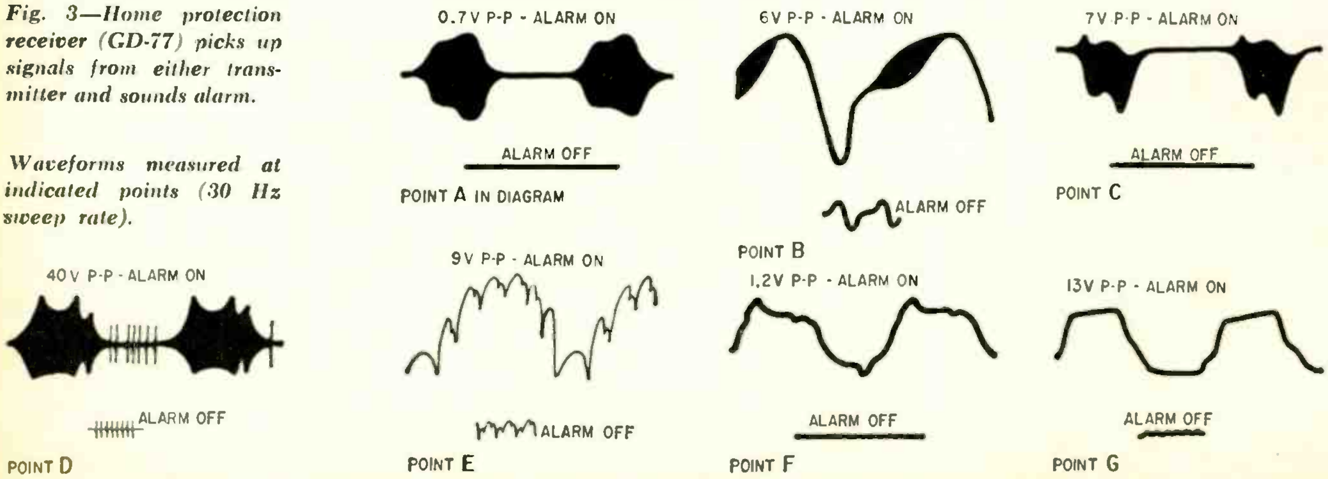


Fig. 3—Home protection receiver (GD-77) picks up signals from either transmitter and sounds alarm.

Waveforms measured at indicated points (30 Hz sweep rate).



Recipe For A Preamp

Start with a transistor, add a few resistors . . .

By B. E. JOHNSON

AN ELECTRONICS ENTHUSIAST OFTEN gets his start by building a kit. All parts and instructions are supplied; there is little or no place for creativity or initiative. He may start one degree higher —or possibly "graduate" to this level: He may build a device from a magazine article. This is exactly like following a recipe: a list of ingredients is provided, together with instructions for "assembling" them, precautions to be observed, results to be expected, and so forth. Depending on your experience and your nerve, you may make one or more changes to suit your taste. But you're still kind of helpless when you can't find a published diagram for what you want.

Most electronics hobbyists never get beyond this stage, unless they have had electronics engineering training. This article takes you on the first step beyond the cookbook. It shows you a simple process for *designing* a single-stage transistor amplifier. Nothing tougher than arithmetic here.

The impetus for this little project came because I needed a compact, self-contained package of gain as a mike and phono-pickup level booster. I wanted a combined mono output from the pickup or a pair of mikes, but for various reasons I also wanted to be able to pick off separate signals, hence the little resistive mixing network at the input. I needed a voltage gain of only about 5 (14 dB).

Further, it looked like a good idea to design the booster to operate at such a low dc power level that I could enclose a penlight cell in the same box and forget about an on/off switch.

The design procedure, and the device itself, are worked out so neatly that it seemed worth sharing. The schematic shows the result, and here's how it was conceived.

RA, RB and RC are the combining network resistances. With this network, each right and left pickup channel works into its designed impedance, and the output will work into a preamp of the same impedance.

The three R's are all the same value and are found by:

$$R = \frac{Z(N-2)}{N} \qquad (1)$$

where N is the number of branches, in this case 3, and Z is the impedance of any branch, all branches being equal. My pickup and preamp are 47,000 ohms, so this entire design is built around that value. Since R then computes to 15,667, we use 15,000 ohms, an available 10% value.

Throughout all computations, there is liberal rounding. Component variations are much more significant than any rounding we do.

The voltage loss, L_v, of this type network is:

$$L_v = N - 1 \qquad (2)$$

In this case it's 2.

C1 and C2 are noncritical, and 2μF should be big enough for anyone. I used 30 μF's as they were available.

The low voltage gain required does *not* mean Q1 can be a low-gain transistor. The 2N2923, with a beta range of 90–180 at 2mA is about as low as practical. The high beta is needed for easier control of input impedance.

Amplifier input resistance R_{AI} is the combination of R1, R2 and transistor input resistance R_I in parallel:

$$R_{AI} = \frac{1}{\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_I}} \qquad (3)$$

As explained above, we want it to be 47,000 ohms. For bias stability, current through R1 and R2 should be a significant fraction of collector current. If we choose $I_C = 40\mu A$ for long battery life, then a good value for I_{R2} is 4μA.

Using the base voltage shown on Fig. 1 to avoid a false start or two:

$$R2 = \frac{0.6}{4 \times 10^{-6}} \qquad (4)$$

or 152,500 ohms (150,000 is close enough). R1 carries this same current plus base current. Since we have decide on 40 μA collector current, then R1 must be chosen to furnish the base current to establish that 40 μA.

$$I_b = \frac{4 \times 10^{-5}}{\text{dc beta}} \qquad (5)$$

At such a low I_C, both dc and ac beta drop considerably below the values at 2 mA (55 for both is pretty close). So:

$$I_b = \frac{4 \times 10^{-5}}{55} \qquad (6)$$

or 0.73 μA. R1 is then found by:

$$R1 = \frac{1.5 - 0.6}{4.73 \times 10^{-6}} \qquad (7)$$

About 190,000 ohms. Use 180,000 ohms, a standard value.

R1 and R2 are effectively in parallel for ac signals, because the low internal resistance of the battery "shorts" the positive and negative supply lines. Their parallel resistance is:

$$R1 \| R2 = \frac{150{,}000 \times 180{,}000}{150{,}000 + 180{,}000} \qquad (8)$$

$$= 84{,}000 \text{ ohms}$$

So desired input resistance becomes:

$$R_I = \frac{84{,}000 \times 47{,}000}{84{,}000 - 47{,}000} \qquad (9)$$

$$= 107{,}000 \text{ ohms}$$

This input resistance is determined by transistor beta and emitter resistance:

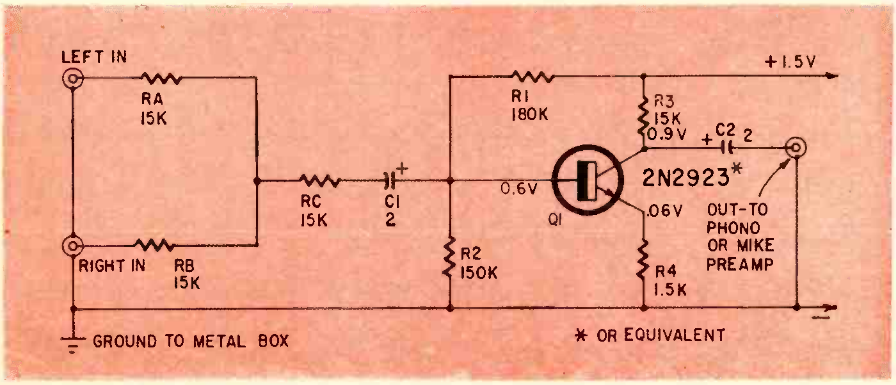
$$R_I = 107K = (\beta + 1)(R_e + R_4) \qquad (10)$$

$$= 56R_e + 56R_4$$

Therefore:

$$R4 = \frac{107{,}000 - 56R_e}{56}, \qquad (11)$$

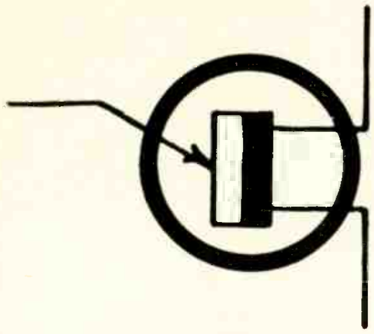
where R_e is the internal emitter resistance of the transistor. The formula to determine it, below, is based on the physics of the device. I can't even try to explain it.



Circuit design provides 14 dB gain as a booster for a mike or phono-pickup

(*continued on page 92*)

See Sept p 14



Part I of 2 parts—to acquaint you

20 UNIJUNCTION

By R. M. MARSTON

ALL THAT MOST ELECTRONICS AMATEURS know about the unijunction transistor is that it is sometimes used as a simple code practice oscillator or as a trigger for SCR's. Actually, the device has many more uses: It can be used as a very stable wide-range oscillator, and can be made to generate a whole range of different waveforms. It can also be made to act as an analog-to-digital converter, as a frequency divider, as a lamp flasher, as a time-delay unit, or as a number of other useful circuits.

In this article we'll show you what the unijunction transistor is and how it works. Then we'll introduce you to 20 or so circuits you can build around this amazing little device.

Basic theory

The unijunction transistor is a very simple device. Its symbol is shown in Fig. 1-a and resembles the actual construction, as shown in Fig. 1-b. The device is made of a bar of n-type silicon material with nonrectifying contacts (base 1 and base 2) at both ends, and a third, rectifying, contact (emitter) alloyed into the bar part way along its length. The third contact forms the only junction within the unijunction transistor (UJT).

Since base 1 and base 2 are nonrectifying contacts, a simple resistance appears between these two points. This interbase resistance is that of the silicon bar and is given the symbol R_{BB}. Normally the value of R_{BB} is between 4000 and 12,000 ohms, depending on the construction of the UJT. It measures the same in either direction.

In use, base 2 is connected to a positive voltage and base 1 is connected to ground (or the negative side of the supply). Thus R_{BB} acts as a voltage divider with a gradient varying from maximum at base 2 to zero at base 1. As the emitter junction is at some point between base 1 and base 2, some fraction of the applied voltage also appears between the emitter junction and base 1. This fractional part of the applied voltage is the most important parameter of the UJT and is called the *intrinsic standoff ratio*, or η. The value of η is usually between 0.45 and 0.8.

The equivalent circuit—Fig. 1-c—of the UJT clearly illustrates the above points. Symbols r_{B1} and r_{B2} represent the resistances of the silicon bar, and diode D1 represents the rectifying junction formed between the emitter and the bar. When an external voltage (V_{BB}) is applied between base 2 and base 1, a voltage equal to η times V_{BB} appears across r_{B1}.

If a positive input voltage (V_E) is now applied between the emitter and base 1, and is less than η times V_{BB}, diode D1 will be reverse-biased, and no current will flow from emitter to base 1. Thus, under this condition, the emitter input appears as a very high impedance. This impedance is that of a reverse-biased silicon diode, and typically has a value of several megohms.

When V_E is increased above η times V_{BB}, a point will be reached where D1 becomes forward-biased and current starts to flow from the emitter to base 1. This current consists mainly of minority carriers injected into the silicon bar. These carriers drift to base 1, causing a decrease in the effective resistance of r_{B1}. This decrease in resistance causes the forward bias of D1 to increase, thereby causing the current to increase even more, and in turn causing r_{B1} to fall even more. A semiregenerative action takes place, and the emitter input impedance falls, typically, to about 20 ohms.

Thus, the unijunction transistor acts as a voltage-triggered switch. The precise point at which triggering occurs is called the peak-point voltage (V_P). It is given by $V_P = \eta \times V_{BB} + V_D$, where V_D = forward voltage drop of the emitter diode (usually about 600 mV).

One of the most common applications of the UJT is the relaxation oscillator shown in Fig. 2-a. Here, when the supply is connected, C charges exponentially toward V_{BB} via R, but as soon as the capacitor potential reaches V_P the unijunction fires and C discharges rapidly into the emitter. Once C is effectively discharged, the UJT switches off, C starts to charge up again, and the process is repeated. A sawtooth waveform is generated between Q1 emitter and ground.

In this circuit, final switchoff actually occurs in each cycle when the capacitor discharge current falls to what is known as the *valley-point current* (I_V), generally a value of

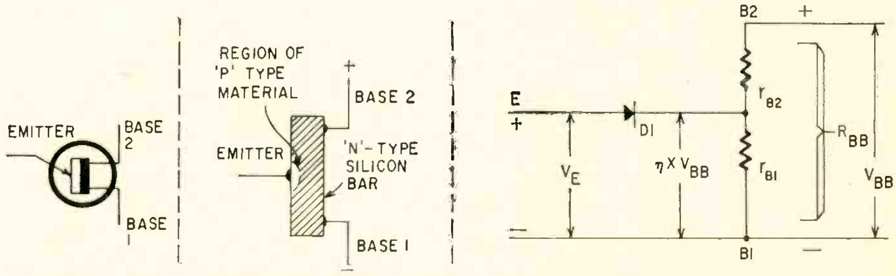


Fig. 1 (left)—Symbol of the unijunction transistor. (center)—Physical construction of the UJT. (right)—Equivalent circuit of the typical unijunction transistor.

with this versatile solid-state device

TRANSISTOR APPLICATIONS

several milliamps. A minimum current is needed to start the switch-on action; it is known as the *peak-point emitter current* (I_P), typically a value of several microamps.

The frequency of operation of the circuit is given approximately by $f = 1/CR$, and is virtually independent of supply line potential. A 10% change in supply voltage results in a frequency change of less than 1%. The actual value of R can be varied between a minimum of about 3000 and a maximum of about 500,000 ohms. Hence a very attractive feature of the circuit is that it can be made to cover a frequency range greater than 100 to 1, using a single variable resistor.

Frequency stability is very good with changes in temperature, being about 0.04%/°C. The main cause of this frequency variation is changes in V_D with temperature, these changes being about −2mV/°C. If better frequency stability is required, it can be obtained either by wiring a couple of diodes in series with base 2, or by connecting a stabilizing resistor (R_S) in the same place.

The interbase resistance of the unijunction increases by about 0.8%/°C, so the fall in V_P (with rising temperature) can be fully counteracted by the rising voltage on base 2 resulting from the changing potential-divider action of R_S and the interbase resistance. The correct value of R_S is given by

$$R_S = \frac{0.7\,R_{BB}}{\eta \cdot V_{BB}} + \frac{(1-\eta)\,R_B}{\eta}$$

where R_B = external load resistor (if any) in series with base 1. The exact R_S value is not, however, of great importance in most applications.

In some circuits, R_B is wired between base 1 and ground, as shown in Fig. 2-b, either to control the discharge time of C or to give a positive output pulse during the flyback period. A negative-going pulse is also available, if needed, across R_S in the flyback period.

The unijunction transistor used in the circuits below is a 2N2646. Fig. 3 shows its base connections, while Table I lists its characteristics.

Similar to the oscillator shown previously, the pulse generator of Fig. 4 gives a large-amplitude, negative-going pulse across R4, and a positive-going pulse across R3. Both pulses have a voltage amplitude of about half the supply-line value, are of similar form, and are low impedance. The R4 pulse is suitable for triggering an SCR.

With the component values shown, the pulse width is constant at about 30 μsec over the frequency

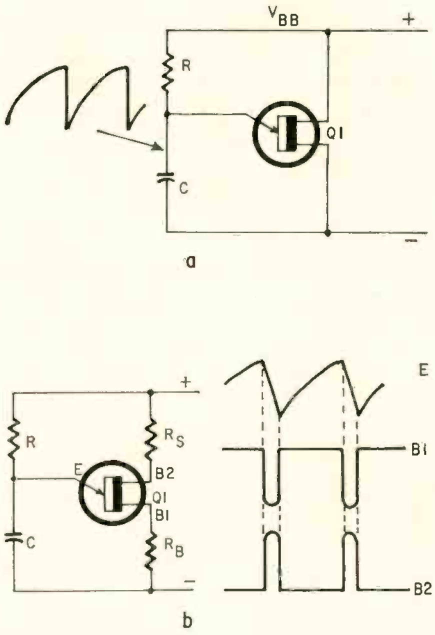


Fig. 2-a—A basic relaxation oscillator using the UJT. b—By adding base resistors, the oscillator is made relatively immune to wide variations in temperature.

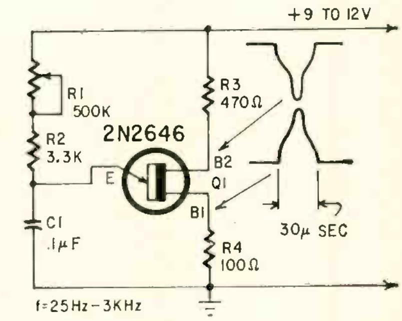


Fig. 4—Wide-range pulse generator.

Table I—2N2646 Characteristics

Emitter reverse voltage (max)	30 volts
Interbase voltage (max)	35 volts
Peak emitter current	2 amps
Rms emitter current	50 mA
Power dissipation (max)	300 mW
Intrinsic standoff ratio (η)	0.56–0.75
Interbase resistance (R_{BB})	4,700–9,100 ohms
Peak-point emitter current (I_P) (max)	5 μA (1) 25 μA (2)
Valley-point current (I_V) (min)	4 mA
Case	TO–18
(1) GE	
(2) Motorola	

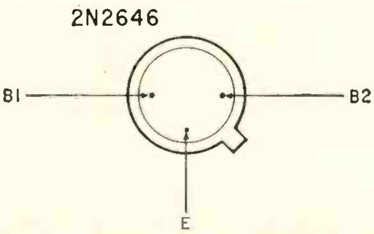


Fig. 3—Base connections of 2N2646 UJT.

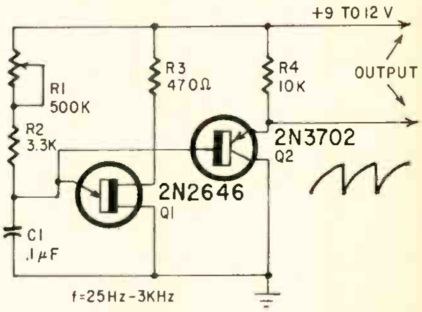


Fig. 5—Wide-range sawtooth generator.

range 25 to 3000 Hz (adjustable with R1). The pulse width and frequency range can be altered by changing the value of C1. Reducing the value of C1 by 10 (to 0.01 μF) reduces the pulse width by a factor of 10 (to about 3 μsec) and raises the frequency range by a decade (250 Hz to 30 kHz). C1 may be from about 100 pF to 1000 μF.

A sawtooth waveform is generated at the emitter, but is at a very high impedance level and is thus not readily available externally.

Wide-range sawtooth generator

In this circuit (Fig. 5) the sawtooth waveform from the emitter of Q1 is fed to emitter follower Q2. Hence the sawtooth appears at the Q2 emitter at an impedance of about 10,000 ohms. Output coupling may be made, either directly or via a coupling capacitor, to an external load of 10,000 ohms or greater, without adverse effects on the waveform or the operating frequency.

Frequency range is about 20 to 3000 Hz with the values shown, so the range is greater than 100 to 1 via R1. If a smaller range is required, reduce the value of R1. Operating frequency can be varied from less than one cycle per minute (0.017 Hz) to over 100 kHz by suitable choice of C1.

If an output impedance lower than 10,000 ohms is required, wire a second emitter follower with an emitter load of 2700 ohms to the emitter of Q2.

Linear sawtooth (time-base) generator

The sawtooth at the emitter of the basic UJT oscillator is exponential (nonlinear). In some applications—such as an oscilloscope time-base circuit—a perfectly linear sawtooth is required. This can be obtained by charging the main timing capacitor from a constant-current source, as in Fig. 6.

In this circuit, Q1 is wired as an emitter follower with emitter load R4, and feeds its collector current into the main timing capacitor (C1). The emitter current of Q1—and thus the Q1 collector current and C1 charging current—is determined solely by the setting of R2. It is totally independent of Q1 collector voltage. C1 charging current is thus constant, and the capacitor therefore charges linearly up to the striking voltage of the unijunction. At this point Q2 fires and the capacitor discharges rapidly. Then the timing cycle starts over again.

The signal from Q2's emitter is fed to emitter follower Q3, giving a final linear sawtooth output at Q3's emitter at an impedance of about 10,000 ohms. This signal is suitable for feeding to the external time-base input of a scope. In this application, the flyback pulses from R6 can be taken via a high-voltage blocking capacitor and used for beam blanking.

This time-base oscillator can be synchronized with an external signal by feeding the external signal to base 2 of Q2, via C2. This signal, which should have a peak amplitude of 0.2 to 1 volt, effectively modulates the supply voltage, and thus the triggering point of Q2. This causes Q2 to fire in sync with the external signal.

C2 should be chosen to have a lower impedance than R5 at the sync signal frequency. It should also have a working voltage greater than the external voltage from which the signal is applied.

With the component values shown, the operating frequency can be varied over the approximate range 50 to 600 Hz using a 9-volt supply, or 70 to 600 Hz using a 12-volt supply. Operating frequency can be varied from a few cycles per minute to about 100 kHz by suitable choice of C1.

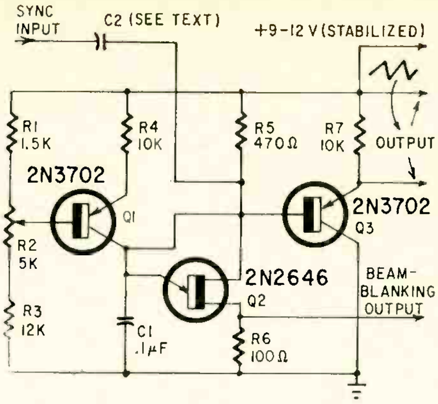


Fig. 6—Linear sawtooth (time-base) generator. Frequency range is 50–600 Hz for a 9-volt supply, and 70-600 Hz for 12.

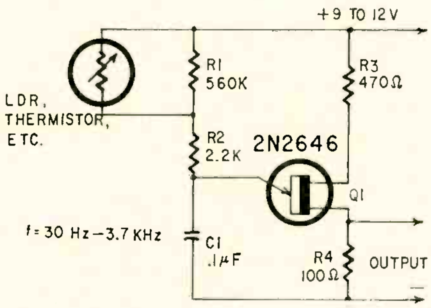


Fig. 7—Analog/digital converter (resistive); variable resistance varies the frequency over a range of 30 Hz to 3.7 kHz.

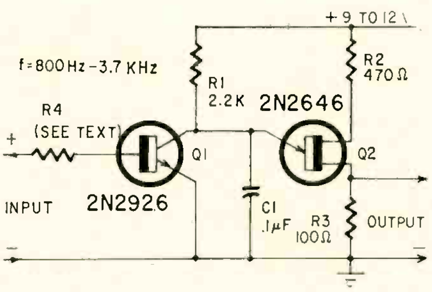


Fig. 8—Analog/digital converter, shunt type. Variable voltage applied to input varies frequency from 800 Hz to 3.7 kHz.

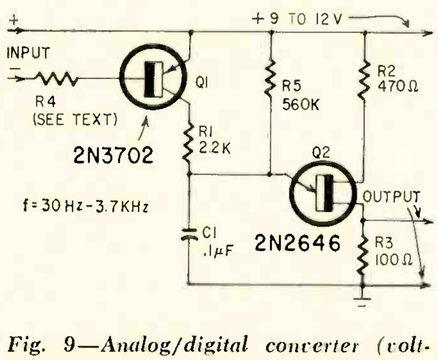


Fig. 9—Analog/digital converter (voltage), series type. Variable input voltage swings output from 30 Hz to 3.7 kHz.

Analog/digital converter, resistive

The circuit of Fig. 7 converts changes in light level, temperature or any other quantity that can be represented by a resistance, into changes in frequency. The resistive element (LDR, thermistor, etc.) is wired in parallel with R1, and so controls the charging time constant of C1, and thus the frequency of operation. A frequency range of 30 Hz to 3,700 kHz is available, the lower frequency being obtained with the variable element open circuit.

Output is taken across R4, and consists of a series of pulses. When fed to an earphone, these can be clearly heard, even at the lowest frequency.

The unit is of particular value in remote reading of such things as temperature, the output pulses being used to modulate a radio or similar link. At the receiver end of the link, the digital information can be converted back to analog via a simple frequency meter circuit.

Analog/digital converters, voltage

These circuits have applications similar to those of the resistance-controlled circuit. However, their operating frequencies are controlled by voltage or by any quantities that can be represented by a voltage—photovoltiac cells, thermocouples, etc.

Figure 8 shows a basic shunt-controlled converter. Q1 shunts the main timing capacitor (C1) and so shunts off some of its charging current and affects the operating frequency. If zero voltage is fed to Q1's base, Q1 is cut off, and the circuit operates at maximum frequency (about 3.7 kHz). When a positive voltage is fed to Q1's base, the transistor is driven on and the operating frequency falls.

A restriction in this circuit is that, as Q1 is driven on, Q1's collector voltage falls; and when it falls to less than V_P, the circuit ceases to operate. The operating range is thus rather restricted, about 800 Hz minimum in this case.

The value of R4 is chosen, by trial and error, to suit the control voltage in use. Usually, it will have a value of a few hundred thousand ohms at potentials up to about 10 volts, and a few megohms at 100 volts.

Figure 9 shows a basic series-controlled converter. Here, the C1 charging current is controlled almost entirely by Q1. When Q1 is driven hard on (saturated) by a voltage applied to R4, the charging current is limited by R1, and the circuit operates at about 3.7 kHz. When zero voltage is applied to R4, Q1 is cut off, and C1 charges via R5, giving an operating frequency of about 30 Hz. Between these two extremes, the frequency can be smoothly controlled by the voltage applied to R4 (which controls the collector current of Q1). The value of R4 is found by trial and error, as in the case of Fig. 8.

In the circuits of Figs. 8 and 9, Q1 is cut off until a forward voltage of about 600 mV is applied to its base, so the operating frequency is not affected by voltages less than this. This difficulty can be overcome by applying a standing bias to Q1 base, as shown in Fig. 10. This modification allows use of input voltages right down to zero, or even reverse voltages.

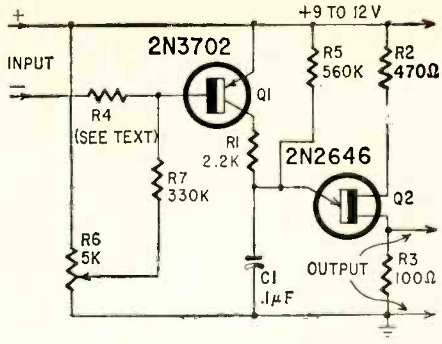


Fig. 10—An improved series type analog/digital converter (voltage operated).

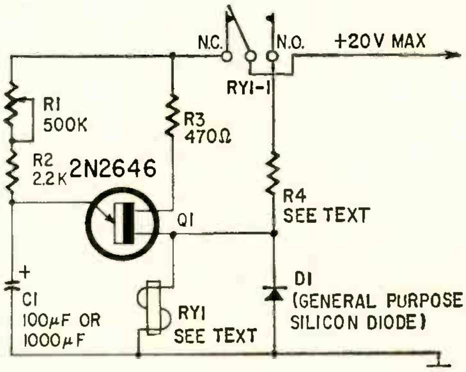


Fig. 11—Basic relay delay unit. If C1 is 100 μF, delay is adjustable from about 0.5 to 50 seconds. If C1 is 1000 μF, delay is variable from 3 seconds to 8 minutes.

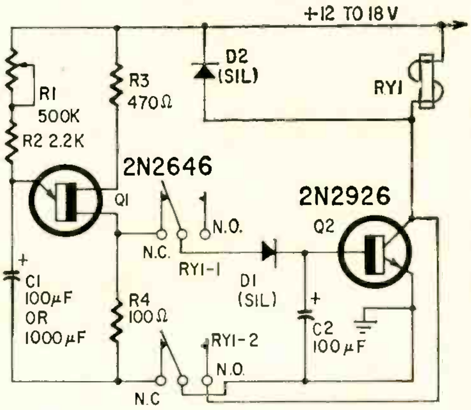


Fig. 12—Another relay delay unit. Time delays are same as specified for Fig. 11.

Relay time-delay circuits

These circuits enable time delays ranging approximately from 0.5 second to 8 minutes to be applied to conventional relays. That is, there is a delay from the moment at which the supply is connected to the moment at which the relay switches on. In Fig. 11, one set of normally closed relay contacts is wired in series with the positive supply line. Hence, power-supply current is fed to the unijunction circuit via these contacts. After a delay determined by the setting of R1 and the value of C1, the unijunction fires and drives RY1 on. As RY1 switches on, the supply to the UJT is broken by the relay contacts and the positive supply line is connected to RY1 via R4, holding the relay on.

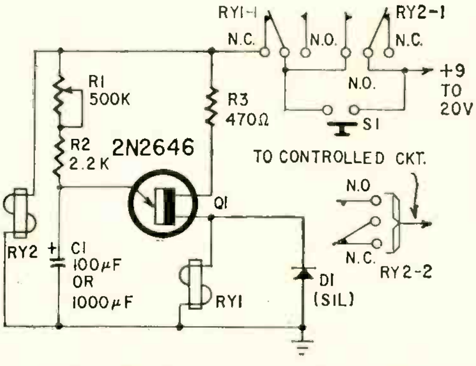


Fig. 13—Two non-critical relays replace a critical one in this version of Fig. 11.

In this circuit, the relay must be a fast-acting low-voltage type with a coil resistance of less than 150 ohms. The supply-line potential should be at least 4 times the relay operating voltage. Also, the value of R4 should be chosen to keep the "on" current within limits when the relay is fed from the positive supply line.

One difficulty with the circuit of Fig. 11 is that the relay type must be carefully selected. This trouble is overcome in the circuit of Fig. 12. Here, the relay is connected in the collector of Q2, and is normally unactivated. When the UJT fires, a positive pulse is fed from R4 to the base of Q2 via D1, driving Q2 and RY1 on, and rapidly charging C2. At the end of the pulse, the UJT switches off and D1 is reverse-biased, so C2 discharges into the base of Q2, holding the relay on for about 100 msec. Thus C2 is used as a pulse expander, and eliminates the need to use fast-acting relays.

As soon as RY1 starts to close, the negative supply (ground) line to the UJT is broken via the relay contacts, but is still connected to Q2. Once RY1 is fully closed, the supply is connected directly across RY1, holding it on, and cutting Q2 out of the circuit.

The relay in this circuit may be any type with a coil resistance greater than about 100 ohms, and with a working voltage of 6 to 18.

In the two relay circuits considered so far, the relays lock on and draw current indefinitely once they have been triggered. Fig. 13 shows a different arrangement of the circuit of Fig. 11, in which two relays are used.

This circuit's positive supply is connected via the normally closed contacts of RY1 and the normally open contacts of RY2. The RY2 contacts are shunted by pushbutton switch S1. As soon as this button is pressed, the supply is connected to the UJT and to RY2, which instantly switches on. When RY2 is activated, its contacts close, keeping the positive supply connected once S1 is released. After the preset time delay, the UJT fires, driving RY1 on and thus breaking the positive supply line to both the UJT and RY2, which switches off and thus completely breaks the supply to the circuit. The output of this circuit can be taken from the spare RY2 contacts.

When fed with a series of constant-width input pulses, the circuit of Fig. 14 produces a linear staircase out-

(continued on page 60

POOR MAN'S POWER SUPPLY

Series capacitor drops voltage and minimizes heat loss

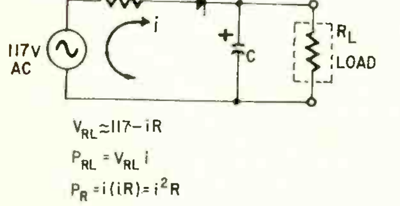
By Donald E. Bowen

ONE OF THE SIMPLEST WAYS TO MAKE a low-voltage power supply is to connect an appropriate resistor in series with the ac line and, if dc is required, to add a suitable rectifier and filter capacitor. The result is the so-called constant-current power supply shown in Fig. 1.

This arrangement has been used successfully for years, in spite of one significant disadvantage: excessive heat losses. The voltage drop across the series resistor, multiplied by the current passing through it, gives the power dissipation in watts. This power, which often amounts to many times the power consumed by the actual load, is a total loss, going into the air as heat. Obviously such an arrangement is grossly inefficient.

A transformer power supply is more efficient. But available transformers don't always provide the desired voltage. Besides, a transformer might be too large to fit the space. Another consideration is that conventional transformers are usually constant-voltage sources. For some purposes a constant-current source might be more desirable, especially when operating thermal devices (where heat is proportional to I^2R) and electromagnetic devices (where magnetic field strength is proportional to ampere-turns).

So there are times when you might want a series dropping element in a power supply to maintain a nearly constant current through a varying load. We ought to find a series element that consumes no power. Ridiculous? Not at all. All purely reactive elements fall into this category. A capacitor is the nearest thing to pure reactance.



$V_{RL} \approx 117 - iR$

$P_{RL} = V_{RL}\, i$

$P_R = i(iR) = i^2R$

Fig. 1—In conventional constant-current supplies, current through a dropping resistor often wastes more power in the form of heat than supply delivers to load.

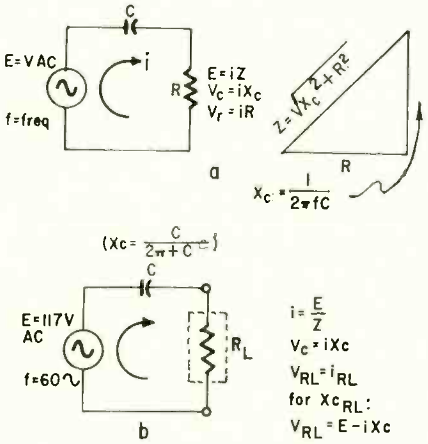
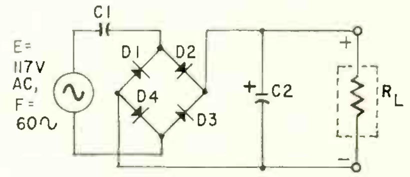


Fig. 2—Reactance of a resistor–capacitor circuit (a) can be determined with impedance triangle (b). It's an application of $a^2 + b^2 = c^2$, where a and b are the resistance and capacitive reactance and c is the circuit reactance in ohms.



To find C,

1. E and two of the following are known: V_{RL}, i_{RL} or R_L
2. Find Z:
   $I_{RL} = i_Z = i$
   $Z = \frac{I}{E}$
3. Find X_c:
   $X_c = \sqrt{Z^2 - R_L^2}$
4. Find C:
   $C = \frac{10^6}{2\pi f X_c}\ \mu F$ or $\frac{2650}{X_c}\ \mu F$

Fig. 3—Basic configuration of capacitance-drop dc supply, with steps to be followed in figuring the proper value for C.

From elementary theory we learn that impedance in ac circuits is roughly equivalent to resistance in dc circuits, and can be treated as such in Ohm's law for ac circuits. Impedance, however, comprises both resistive and reactive components, as indicated in Fig. 2-a. This idea is extended in Fig. 2-b to show impedance composed of a series capacitor and a resistive load. This is the basic circuit for a constant-current source with no heat losses.

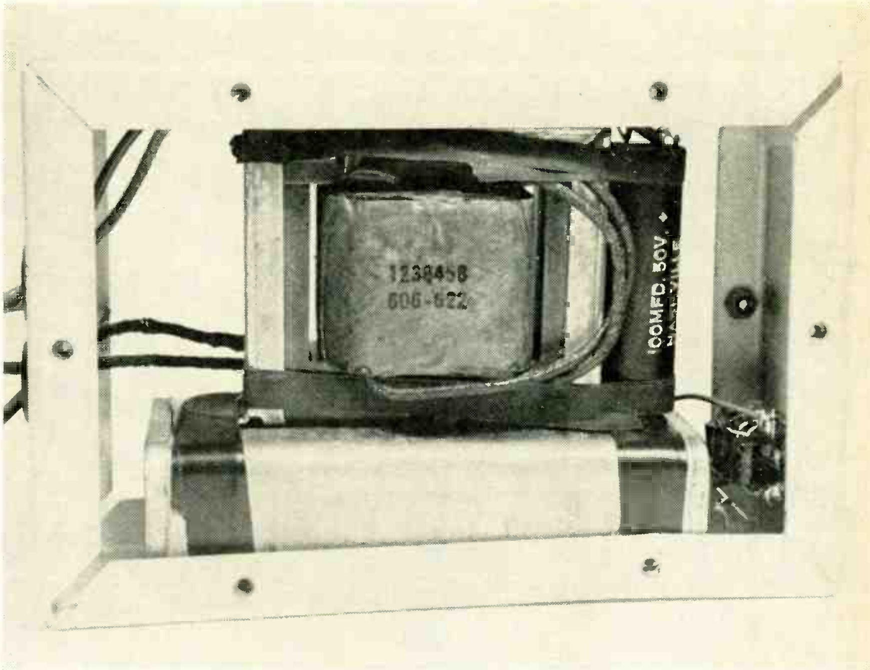
Finding X_c

Figure 2 shows that some basic ac circuit theory is required to determine the correct value of capacitance for a given requirement. However, if X_c, the capacitor's reactance, is large compared to R (8:1 or greater), the value of X_c can be found from the fundamental Ohm's law formula, exactly as for a series dropping resistor. The only remaining job is to determine the capacitance required to give the desired X_c.

Even this job, however, need not be difficult if a reactance chart or nomograph is used, or one of the currently available reactance slide rules. Table I presents some of the standard values for commercial capacitors, along with X_c at 60 Hz.

Thus, with the capacitor, we have a method of providing a low voltage directly from the ac line without consuming power in the process. But what if we need a dc voltage? In a resistive power supply, a series diode will suffice, along with a suitable filter capacitor. In a power supply with a capacitive element, however, a full-wave bridge rectifier is far more successful, and requires a smaller filter capacitor because of the full-wave output. This is shown in Fig. 3. The added cost is negligible, since four semiconductor diodes similar to the 1N2069 (200 V at 750 mA) cost less than many vacuum-tube rectifiers. Several manufacturers are now making epoxy-encapsulated bridge rectifiers. The Motorola MDA or HEP assemblies are smaller than four separate diodes of equivalent ratings.

Another thing worth mentioning is that this power supply, unlike the resistive power supply, is short-circuit-proof! If the output of a resistive power supply is shorted in operation, the resistor is likely to overheat and burn out; or, if that doesn't happen, the diode is sure to go. This is not the case with the capacitor power supply because, with the output shorted, there is nothing more than a capacitor across the ac line. The current is 90° out of phase with the voltage; hence there is little chance that the diodes can be destroyed by overdissipation—there is very little power available when the output is shorted (see Fig. 3).



Use of isolation transformer.

I first applied this circuit in an industrial power supply that was to operate a small electromagnetic device. The device would be subjected to ambient temperatures ranging from just below room temperature (around 50°F) to 185°F. Not a particularly stringent requirement, when compared to some military specifications, but the magnetic field had to remain constant throughout that temperature range.

The real problem was the coil resistance. It varied some 15% in either direction from its nominal value as a result of the temperature change. Thus, to keep ampere-turns constant, a constant-current power supply was required.

Table I

60-Hz REACTANCE OF COMMON CAPACITANCE VALUES

C (μF)	X_c (ohms)	C (μF)	X_c (ohms)
250	11	1.0	2650
25	110	0.68	3900
10	265	0.5	5300
8	332	0.47	5650
6	442	0.33	8040
5	530	0.27	9820
4	664	0.25	10,600
3	884	0.15	17,700
2	1320	0.1	26,500

Values correct to three significant figures. Computed from

$$X_c = \frac{1}{2\pi fC}.$$

Which, when f = 60 Hz and C is in μF,

$$= \frac{2650}{C}(\mu F).$$

An additional problem was the fact that the power supply had to be mounted in the same environment as the electromagnetic device, but could not add sensible heat to that environment. This eliminated the resistor as a possible element for supplying a constant current, but the capacitor power supply was made to order for the job. Fig. 4-a is a schematic of the result.

After that, I began to experiment and found that the method was good to keep in mind, especially around the home workshop. By using large capacitors, it is possible to pass a lot of current and still come up with almost any voltage. And no burned fingers from accidentally picking up hot power resistors!

Oil-filled capacitors are practical where large values are required, although they are bulky. A better solution is to use two electrolytic capacitors connected back to back. It even helps to realize that electrolytics, when so connected, do not behave as do other capacitors, which follow the reciprocal-of-the-sum-of-the-reciprocals formula for series connection.

When two electrolytic capacitors, each having the same value, are connected back to back, the net capacitance is equal to the value of either one of the capacitors; and, likewise, the voltage rating is the same as either one of the two capacitors. In other words, connecting two identical electrolytic capacitors back to back pro-

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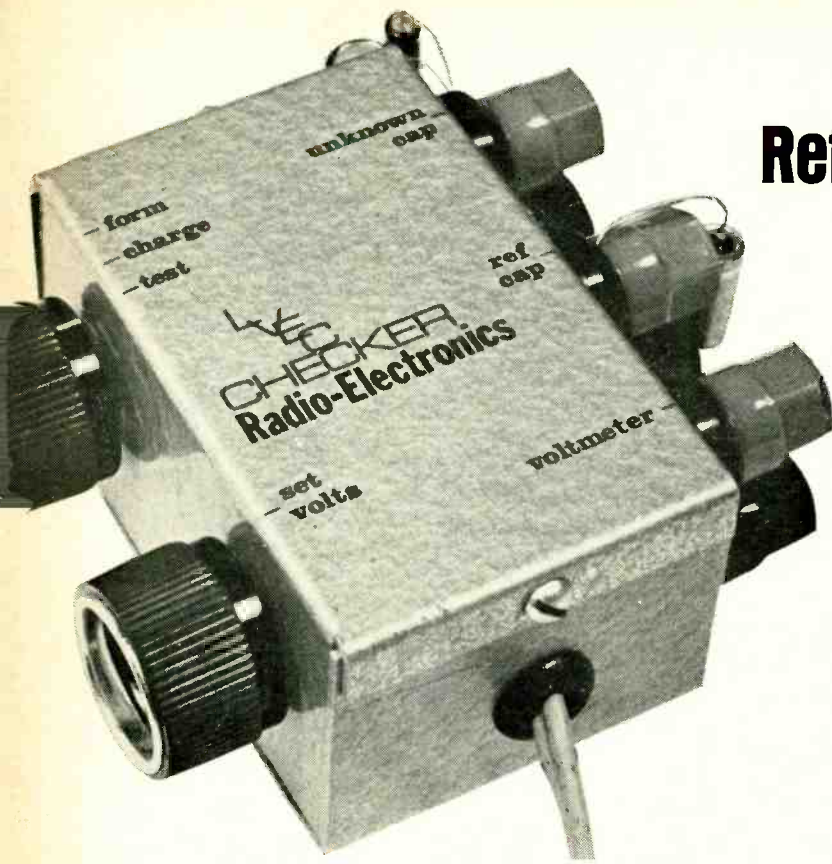


Reform and Measure Low-

Match-patch hookup easily

By MELVIN CHAN

THE POPULARITY OF SOLID-STATE ELECTRONIC circuits has produced a rapid growth in the use of low-voltage capacitors (e.g., 3, 10, 15 and 25 volts dc) whose capacitances range from 0.1 μF to 5000 μF and higher. There is a need to know with reasonable accuracy the actual, rather than the rated, capacitance of electrolytics which are manufactured with very wide tolerances. Here is a simple method that you can use to measure capacitance.

All you need is a vtvm (or other high-impedance voltmeter), a dc voltage source, one or more reference capacitors of known value and the simple circuit shown in Fig. 1.

In use, reference capacitor C1 is charged to a voltage which does not exceed the voltage rating of C1 or C2 (the unknown capacitor), whichever is lower. The charging voltage is then disconnected, and C2 is placed in parallel with C1, causing the original charge on C1 to be shared by C2. At this time, the meter will show a decrease in voltage, which is a function of the relative capacitance of the reference and unknown capacitors. (Obviously, the voltages on both capacitors are equal at this lower level.)

The initial voltage (E1) on reference capacitor C1, and the lower voltage (E2) resulting when C2 is in parallel with C1, are substituted in the formula

$$C2 = C1 \frac{(E1 - E2)}{E2}$$

Electrolytic capacitors which have been idle for a period of 2 weeks or longer should be reformed before measuring or return to service. This process consists of applying (with correct polarity) the rated working voltage to the capacitor until a voltmeter across the capacitor stabilizes at that voltage. The time required for the voltage to stabilize is a function of capacitance, leakage current and the length of time the capacitor has been out of service. Reforming time may range from only a few seconds to a minute or more.

Measuring capacitance

1. Connect the charging-voltage source and the vtvm as shown in Fig. 1. Turn R1 (SET VOLTS) to reduce the meter reading to zero.

2. Set switch S1 at FORM, connect C1 and C2. Adjust R1 until the meter reading reaches the voltage rating of C1 or C2, *whichever is lower.*

3. When the meter stabilizes at the rated voltage, throw S1 to CHARGE. Readjust R1 to hold the voltage (E1) on capacitor C1 at the level estab-

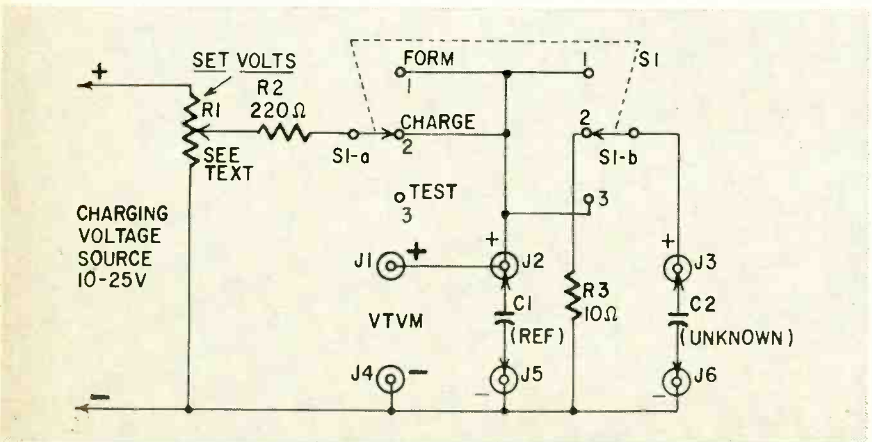


Fig. 1—Unknown electrolytic capacitors can be reformed, discharged and measured in a 1-2-3 procedure at the flip of S1. Voltage levels can be set by control R1.

Parts List

R1—1000-ohm potentiometer, linear taper (see text)

R2—220-ohm, ½-watt, 10% resistor

R3—10-ohm, ½-watt, 10% resistor

S1—2-pole, 3-position nonshorting rotary switch (Mallory 3323J or similar)

J1, J2, J3—Pin jacks or 5-way binding posts, red

J4, J5, J6—Pin jacks or 5-way binding posts, black.

C1—100-μF, 12-volt electrolytic capacitor (Sprague TE1119.3 or similar); **Optional:** 15-μF, 12-volt electrolytic capacitor (Sprague TE 1129 or similar) 450-μF, 3-volt electrolytic capacitor (Mallory TPG-4503T, Cornell-Dublier type NLW Electromite or similar)

Chassis—aluminum box, 3¼" x 2⅛" x 1⅝"

Voltage Electrolytic Capacitators

covers from 1 to 5000 µF

lished in Step 2. (Meanwhile, C2 discharges through R3.)

4. After a few seconds throw S1 to TEST. Read the new voltage (E2) on the meter.

5. Substitute the capacitance of C1 and voltages E1 and E2 in the equation above and calculate the capacitance of C2.

For example, if C1 is 100 µF, E1 is 10 volts and E2 is 7.25 volts, the equation becomes:

$$C2 = 100\ \frac{(10 - 7.25)}{7.25}$$

$$= 100\ \frac{2.75}{7.25}$$

$$= 38\ \mu F \text{ (approx.)}$$

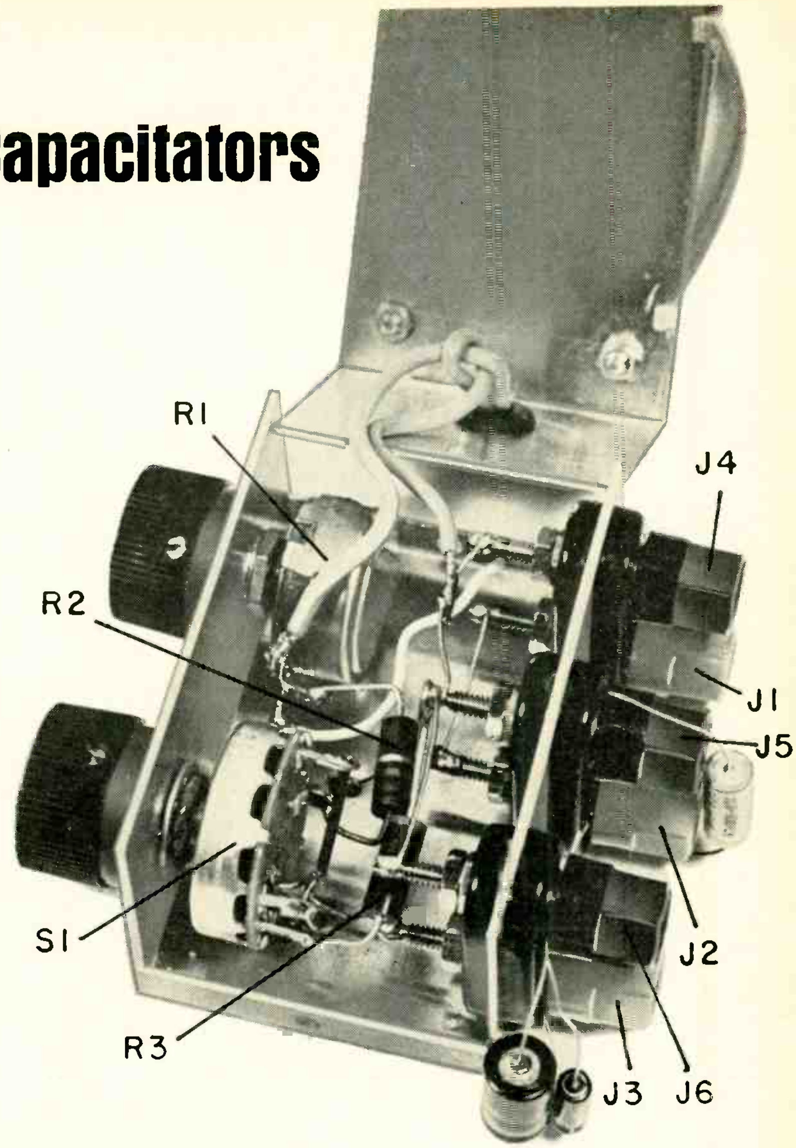
Obviously, the more precisely the capacitance of C1 is known and the lower its leakage current, the more exact will be the value of C2 as calcuated from the formula. If you avoid mathematics whenever possible, Table I is for you. It gives the multiplier of C1 capacitance for charge voltages of 3 and 10, at useful voltage-difference levels. Thus, if E1 is 3 volts and E2 is 2, E1 − E2 = 1 volt. Find 1.0 in the E1 − E2 column and read 0.5 on the same line in the 3-volts column. If C1 is 450 µF, C2 is 0.5 × 450 or 225 µF.

The resistance of R1 should be selected to limit its bleeder current to about 15 mA. For example, with a 15-volt dc supply R1 should be 1000 ohms (15/0.015). Resistor R2 limits the charging current; R3 fully discharges C2 after it has been reformed and before it is paralleled across charged capacitor C1.

Table I
C1 multiplier (see text)

$E_1 - E_2$	Charge Voltage	
	3 Volts	10 Volts
0.1	0.03	0.01
0.2	0.07	0.02
0.3	0.11	0.03
0.5	0.2	0.05
0.6	0.25	0.06
0.7	0.3	0.075
0.8	0.36	0.09
0.9	0.43	0.10
1.0	0.5	
1.25	0.7	
1.5	1.0	
2.0	2.0	0.20
2.25	3.0	0.20
2.4	4.0	0.31
2.5	5.0	
2.6	6.5	
2.75	11.0	0.38
3.0	0-C*	
3.5		0.54
4.0		0.67
5.0		1.0
6.0		1.5
7.0		2.33
7.5		3.0
8.0		4.0
8.5		5.5
8.75		7.0
9.0		9.0
9.25		12.3
10.0		0-C*

*0-C = C2 open circuited



Extending the range

Using a 100-µF, 10-volt capacitor for C1 permits measuring capacitances ranging from 1 µF to 1200 µF. The use of 15-µF, 12-volt and 450-µF, 3-volt capacitors for C1 will extend the range from 0.15 µF through 4950 µF. If two or more standard capacitors are to be used for C1, they may be plugged into tip jacks (J2 and J5).

The charging voltage may be supplied by dry cells connected in series, or by any 10–25-volt dc supply. It is not necessary to charge C1 to more than 10 volts when measuring unknown capacitors.

The parts in the basic test unit cost between $6 and $10. Be sure to use the 10% tolerance tantalum capacitor as the reference unit for best accuracy. **R-E**

Build—Low Cost Solid-

Combination instrument checks auto

By J. COLT and L. M. BOGGS

THE IDEAL AUTOMOTIVE TEST INstrument should be able to measure everything from headlamp candlepower to the water content of exhaust gases. It should be self-powered and thin enough to carry in your wallet. Cost should be less than 50 cents.

You may have to wait a few years for that instrument. For the time being, you might like an instrument that measures rpm and dwell (4, 6 or 8 cylinders) and includes a 3-volt and a 15-volt range for individual-cell and system voltage measurements. It costs approximately $10.

The TDVM's (Tach-Dwell-Voltmeter) low cost and professional appearance come from using low-cost components and a predrawn meter face and from combining circuit functions (Fig. 1). Many of the electronic parts come from discount-house "2-for" or "5-for" buys—for example, the switches, Zener diodes and the 0.1-μF capacitors three of which are paralleled to make C1. Even if you decide to build the TDVM with name-brand components, the price of the completed unit should be well under what you'd expect to pay for a comparable commercial unit.

Try to use the meter specified. If you have a different 1-mA movement you want to use instead, you may have to make a new meter face and choose correct multiplying resistors for the voltmeter ranges. Substitutions for transistors Q1 and Q2 are not recommended unless you're *sure* your substitutes have an h_{FE} of at least 100.

For clarity, the description will be divided into three parts, each section describing one of the three functionally separate subcircuits (see Fig. 2).

The tachometer consists of a monostable (one-shot) multivibrator whose output is a constant-width pulse. Since the output is of constant width, the dc component of the output pulses varies linearly with the repetition rate of the pulses fed into the one-shot multivibrator. These pulses are taken from the engine breaker points.

Speed range is increased by switching the timing resistors; R4 is for low speed, and R5–R6 for high speeds. This changes the discharge time of C1.

To make both 6- and 8- (or 4-) cylinder measurements, the output of the one-shot is fed to the meter through two different resistors, R15 and R16, which are adjusted to give accurate readings. Both are current-limiting resistors. At 600 rpm, a 6-cyl-

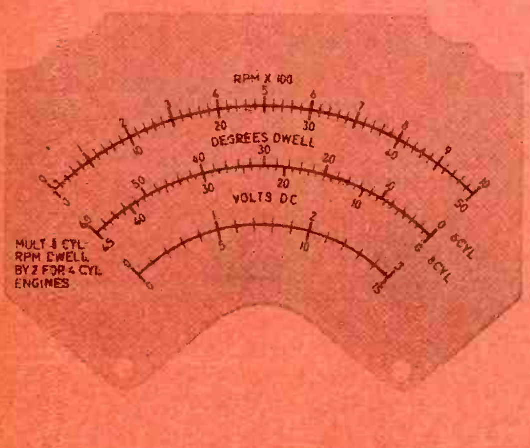


Fig. 1—Meter scale for the TDVM is reproduced here actual size. Drawing can be traced or photostated.

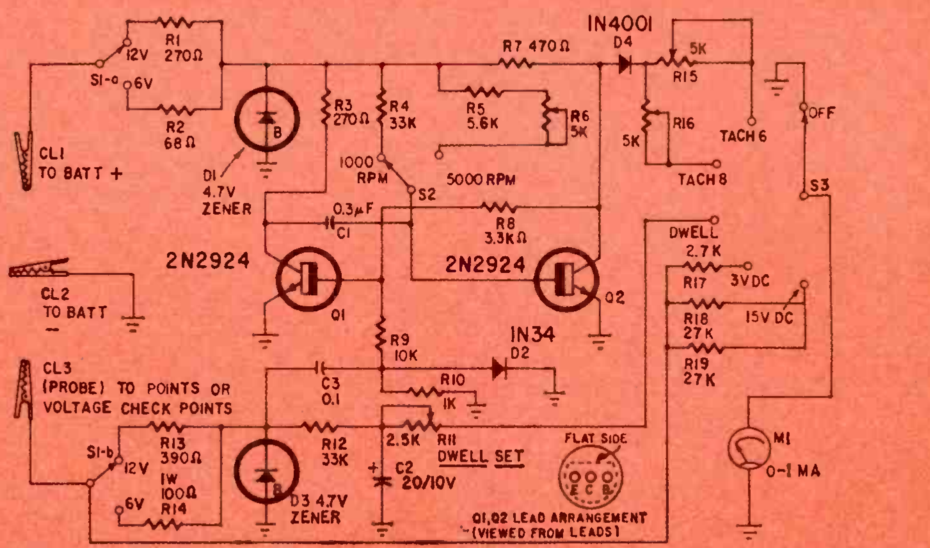


Fig. 2—One-shot multivibrator generates pulses for TDVM's tachometer section.

See Sept p 14

State Tach-Dwell Voltmeter

engine speed and electrical system

inder, 4-stroke engine generates (across the points) 30 pulses per second, and an 8-cylinder engine generates 40 pps—two different rates which must give identical currents through the meter. Since the dc output of the one-shot is going to vary, the obvious way to obtain identical readings is to provide two different current paths for the two conditions.

D4 is included because transistor Q2 has a small saturation voltage across it when it is fully on. This voltage tends to bias the meter in error everywhere except an original calibration point. Q2's saturation voltage is approximately 0.2 volt, and the turn-on voltage of D4 is approximately 0.6 volt, so that the meter reads zero when Q2 is saturated. D4 can be any good silicon diode.

Power for the multivibrator is supplied from the car battery via the shunt regulator combination R1 or R2 and D1. R1 and R2, as well as R13 and R14, are switched to provide essentially constant voltage across the Zener diodes used in the tachometer and dwell-meter sections.

Note that the clip lead marked (+) need be connected to the car battery only when using the TDVM tachometer function.

The dwell-meter section is made up of R13, R14, D3, R12, C2 and R11. It operates on the principle that, for a particular dwell angle, the duty cycle (ratio of "on" to "off") of the pulses across the car's points is constant. Since constant amplitude is assured by D3, we have a train of constant-amplitude, constant-duty-cycle pulses which has a certain dc component. The only way to change this dc component is to change the duty cycle, i.e., change the dwell. The dc component is read at the meter as dwell angle.

To calibrate the dwell meter apply full battery voltage (engine running) to PROBE and adjust R11 so that the pointer reads full scale (0° dwell).

A short comment on dwell settings is in order. Most auto manufacturers design their ignition systems for 40° (or thereabouts) dwell for 6-cylinder cars, 30° for 8-cylinder and 60° for 4-cylinder cars. This amounts to points open one-third, points closed two-thirds of the time or a duty cycle

C1—0.3-μF capacitor
C2—20-μF, 10-volt electrolytic capacitor
C3—0.1-μF capacitor
CL1—Heavy-duty clip
CL2, CL3—Alligator clip
D1, D3—Zener diode, 4.7 volts, 1 watt
D2—Germanium diode (1N34, 1N54, etc.)
D4—Silicon diode (1N4001 or similar)
M—1-mA meter movement (Lafayette 99 H 5040)
Q1, Q2—2N2924 transistor (G-E)
R1, R3—270-ohm resistor
R2—68-ohm resistor
R4—33,000-ohm resistor
R5—5,600-ohm resistor
R6, R15, R16—5,000-ohm adjustable resistors (Mallory MTC-1 or MTC-4)
R7—470-ohm resistor
R8, R12—3,300-ohm resistor
R9—10,000-ohm resistor
R10—1,000-ohm resistor
R11—2,500-ohm potentiometer
R13—390-ohm resistor
R14—100-ohm, 1-watt resistor
R17—2,700-ohm resistor
R18, R19—27,000-ohm resistor
S1—D.p.d.t. slide switch
S2—S.p.d.t. slide switch
S3—S.p.6.t. rotary switch (Radio Shack 275-1382, Burstein-Applebee 18 D 105; two positions not used.)
MISC: Perforated phenolic board and push-in terminals; knobs; test leads, etc.

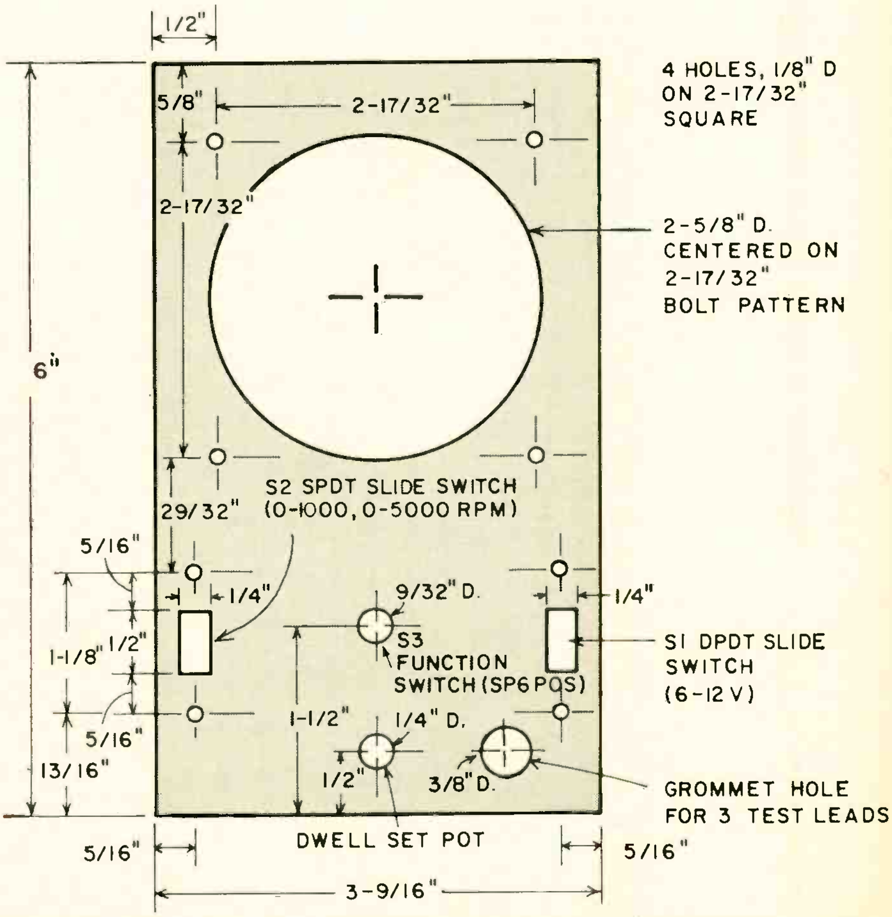
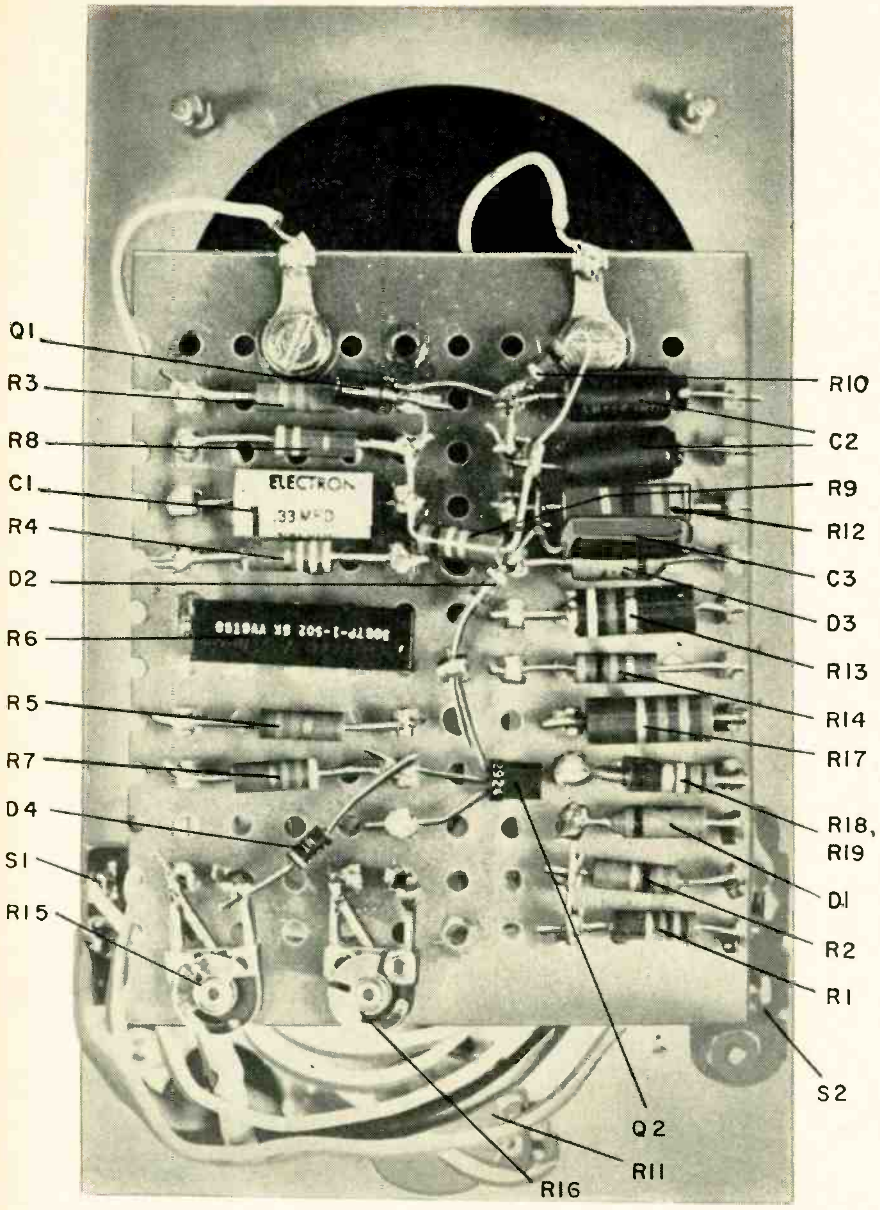


Fig. 3—Author's front-panel dimensions. Parts and controls layout is not critical.



Construction is not critical. Components are mounted on push-through pins. The perforated board is held in place by the two terminals on the meter. Observe polarity of the diodes. Avoid excessive heating of the leads from the diodes and the transistors.

of 33⅓%. This is also the reason that the 40- and 30-degree marks coincide on the 6- and 8-cylinder dwell scales. If you're ever caught without specs for a particular auto, you will almost always be within a few degrees of correctness by setting dwell to the 40°–30° mark.

The dwell-meter section is common to the tachometer portion in that input pulses are provided to the one-shot through a high-pass filter (differentiator), R10–C3. D2 eliminates negative spikes from the one-shot. R9 is an isolating resistor. The differentiator is required because at low engine speed —or 4-cylinder operation—input pulses from across the auto's points are longer than the output of the one-shot. Without the differentiator, this would lead to inaccurate readings, since the input would tend to hold the multivibrator on for the duration of the input pulse.

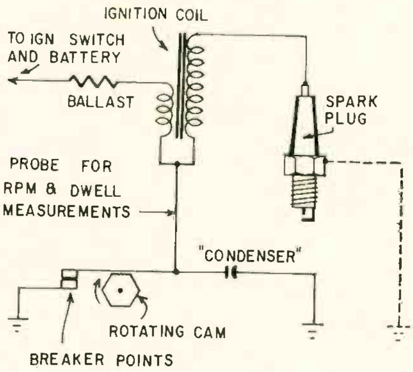


Fig. 4—Connect TDVM probe to conventional ignition system as shown, with ground clip to a convenient point.

The voltmeter is a basic series-resistance ammeter configuration. In the interests of economy, the voltmeter input is provided from the probe common to all other tests. The only drawback of this scheme is that when measurements are made of voltages higher than the Zener voltage of D3, D3 conducts. Dissipation in D3 is no problem for input voltages up to 15. The main disadvantage is that when V_z is reached, the voltmeter is no longer a basic 1000-ohms/volt device, because the voltage source being measured must supply current to D3 as well as to the meter. If you expect this to be a problem, a separate voltage-test lead could be provided. But the circuit as it stands has proved more than adequate for everyday automobile system checks.

When used with the meter movement specified, the values of R17 and R18–R19 provide acceptable accuracy. These are not precision resistors, just good name-brand 10% resistors.

Diasssemble the meter and remove the original face. Be very careful. The movement can be ruined by excessive force on the pointer. A good rule of thumb is that *any* external force is too much. It might be a good idea to engage the help of a calm, nearsighted friend for this step. Also, turn off fans and air conditioners, avoid drafts and try not to breathe into the works.

Copy the meter face shown in Fig. 1. Using the white dots as guides for the meter-face screw holes, rubber-cement the new scale to the back of the old one. (You might want to use the 1-mA scale again some day.) To prevent wrinkles, press the new scale until it is dry, then trim the new scale to the size of the meter face. A good idea is to make a couple of copies or photostats of Fig. 1 in case the first attempt flops, or in case you want to build another unit later.

Construction

The dimensions given in Fig. 3 should make layout easy. Of course, you may wish to "human engineer" to suit your particular needs or desires.

Circuit wiring was done on a 3″ x 3¾″ piece of perforated phenolic board with push-through terminals. Drill two holes in one end of the board,

(continued on page 66)

It works better than a calibrated screwdriver

Neon Lamp Meters

By Dr. J. MERINO y CORONADO*

PERHAPS THE SIMPLEST AND LEAST expensive way to measure voltage, resistance and capacitance is with a neon glow lamp. Such a lamp ignites (fires) when a certain voltage is applied to its electrodes. Once fired, a lesser voltage is required to maintain ignition. In each individual lamp these voltages remain fairly constant once the lamp has been aged.

By shunting the lamp across a voltage-divider potentiometer, it is possible to bring the lamp to either the point where it starts to glow or where it just goes out, and thereby measure voltages. The values are read directly from a calibrated dial or scale on the potentiometer. While handbooks and catalogs list specified igniting and extinguishing voltages for neon lamps, these values are averages.

Exact firing and extinguishing voltages vary from lamp to lamp. If you try one of the circuits here, obtain a lamp and measure the voltage it requires—after aging. (To age, operate the lamp at its rated current for about 100 hours.) Then you will know exactly what the reference voltages of that lamp are.

Neon-lamp voltmeter

All you need is a potentiometer, series resistor, lamp, test leads, and a box to mount the parts in. Arrangement is simple (Fig. 1) and so are parts values. Potentiometer R1 should be at least 500,000 ohms to avoid circuit loading and excessive current. A 1-meg value would be even better. The value of R2 depends on the particular lamp used; this value is listed in parts catalogs beside the lamp type.

The scale will be linear only if the potentiometer is. Wirewound potentiometers are nearly linear for every degree of rotation from approximately 20–85% total rotation.

Calibration is made (Fig. 2) by using a variable-voltage transformer across the ac line. An ordinary vom (or better) will do for measuring applied voltage. This method is good up to about 150 volts; above that you can use a plate transformer ahead of the variable transformer. For dc calibration, use a battery and another potentiometer.

Start calibration by setting R1 at full value, so the lamp is across the entire applied voltage. Adjust the transformer until the lamp ignites. If you intend to use ignition (or firing) voltage as your reference, measure the voltage at this point and mark the dial of R1. If you intend to use extinguishing voltage as your reference, back off the variable-voltage transformer until the lamp just goes out, and measure the voltage at that setting. Mark the potentiometer dial accordingly.

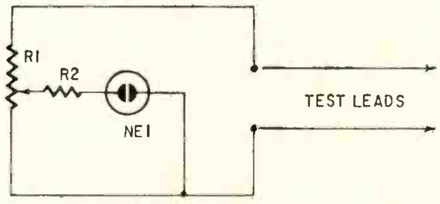


Fig. 1—Neon-lamp voltmeter utilizes fixed firing potential of different lamps.

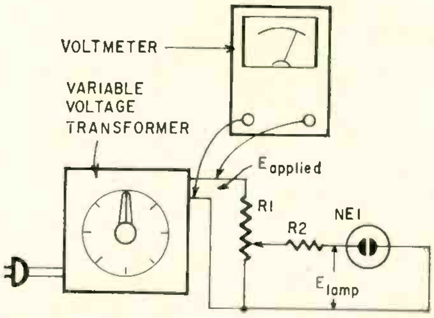


Fig. 2—To calibrate the neon-lamp voltmeter, a series of voltages are applied to R1, R2 and the lamp. The lamp's on-off values are read on the voltmeter, and R1's dial is then calibrated accordingly.

Next reset the variable transformer to a convenient voltage as measured on the voltmeter. (If you found a firing voltage of 90, you might want to use 5-volt steps, and choose 95 volts for the next dial marking.) Vary R1 (*not the transformer*) until the lamp fires (or extinguishes) and again mark the scale. Repeat these steps for each marking you desire.

Neon-lamp ohmmeter

This is simply a substitution technique. Potentiometer R1 (Fig. 3) must be calibrated in ohms with an ohmmeter. To operate, terminals A and B are shorted and R1 adjusted until the lamp ignites (or extinguishes).

Next, unknown resistor R_x is substituted for the short across terminals A and B. Now the potentiometer must be reset to cause the lamp to ignite (or extinguish): in other words, you must decrease the resistance between the arm of the pot and terminal A. The amount of resistance decrease is equal to the value of the unknown resistor. With a dial calibrated in ohms, the value is easily determined.

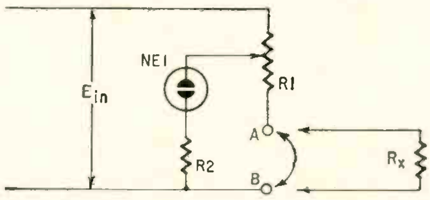


Fig. 3—Potentiometer R1 is calibrated in ohms. Lamp on-off condition determines the value of the unknown (R_x).

A more practical circuit is shown in Fig. 4. Current-limiting resistors R1 and R2 prevent shorting the ac line and allow safe measurement of low-wattage resistors. Two potentiometers are used—R4 for measuring up to 50,000 ohms, and R5 for up to 500,000 ohms.

While this method of using ac to measure resistance isn't as accurate as the conventional dc technique, it will do where close accuracy isn't important.

The system of Fig. 4 can also be used to measure capacitance. You must use ac, of course, and you will actually be measuring capacitive reactance. But by calibrating the dial with several capacitors of known, accurate value, you will be able to make fairly accurate measurements.

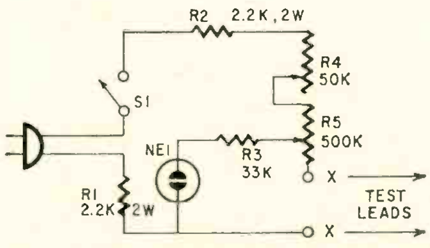


Fig. 4—This ohmmeter uses two pots to provide greater range of measurements.

Neon glow lamps are inexpensive (the NE-2 can be had for 10¢) but amazingly reliable. Perhaps you have need of an inexpensive, reasonably accurate voltohmmeter. Why not try the circuits above? **R-E**

*Research physicist and professor of acoustics and electronics, Institute of Geophysics and Polytechnic Institute of Mexico.

New Ultraviolet/TV-Microscope System

Important medical research development permits instant chemical analysis of live specimens . . . spans gap between optical and electron microscopes

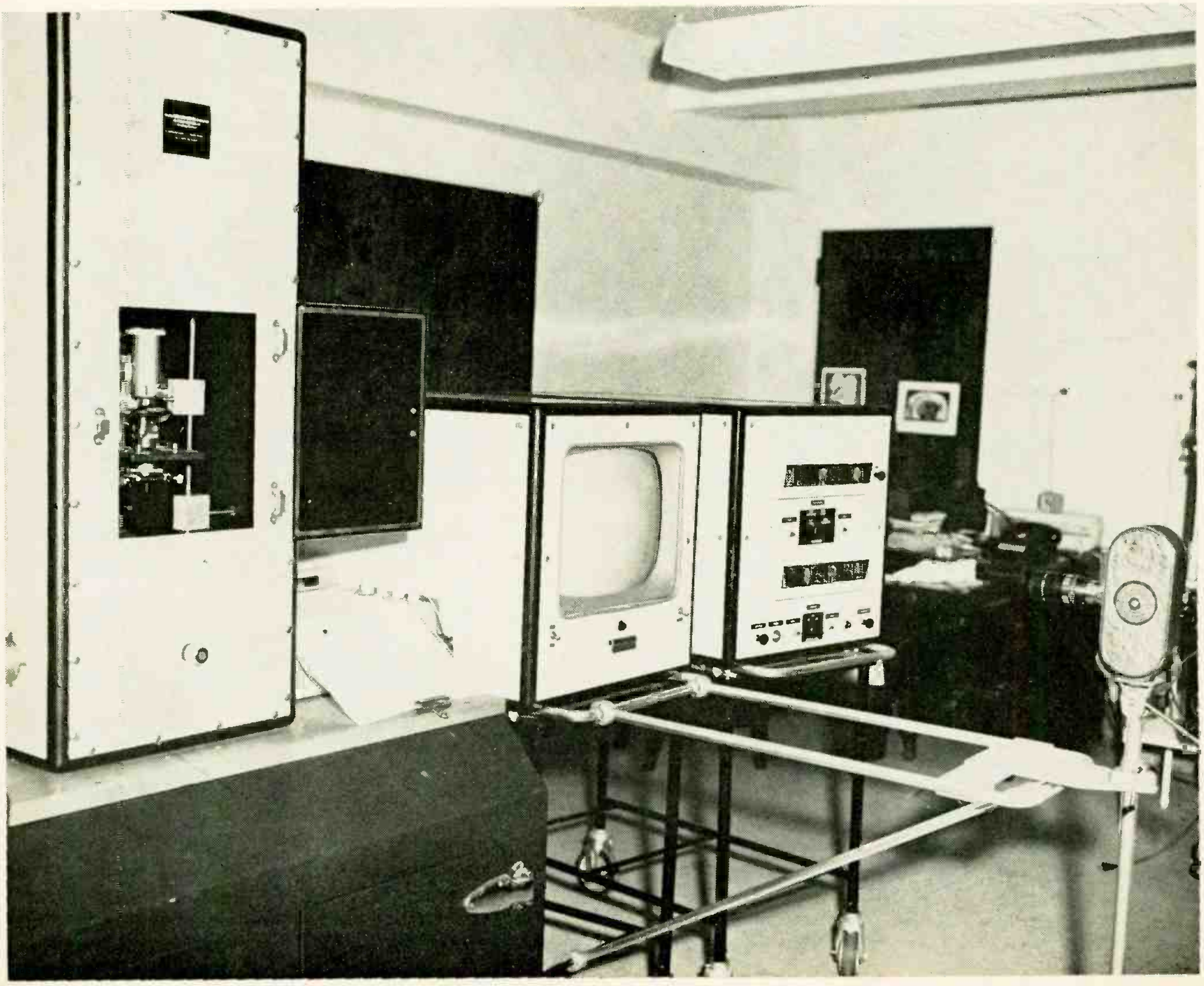
By F. J. G. VAN DEN BOSCH, D.SC., PH.D.

A NEW TYPE OF MICROSCOPE FILLS IN the range between the optical and the electron microscope. The instrument is the first to permit immediate qualitative chemical identification of the observed specimen, by spectographic analysis. This was possible only with today's closed-circuit TV technology.

A microscope presents an enlarged view of a small area. As the enlarging (or magnification) factor grows, it becomes more difficult to obtain a sharp, undistorted picture. This problem has led to the development of such things as lens correctors and specific lenses for particular uses.

There is, however, a limit to the size of objects one can see as separate entities. This point—called the separating or resolving power—defines the limit at which two adjacent lines or objects can be seen separately and not as one. The limit is determined by the angle of the aperture of the objective

Microscope setup for recording images on film. At left, the microscope proper, with open door to permit specimen insertion. Inside the rack are the camera head and lenses. Picture-tube monitor is in center, with keyer and spectograph at right.



lens and by the wavelength of the light source.

The resolving power of a microscope is given by:

$$\frac{0.61\lambda}{d}$$

where λ is the wavelength of light and d represents the numerical aperture of the objective lens. From this expression it can be seen that using an objective lens with an aperture of 0.85–0.90 and with white light of 6,000 Angstroms, the resolving power is in the region of 3,500 Angstroms.

Because the lens aperture is limited, the only way to increase resolving power is to use light of a shorter wavelength. The obvious solution is ultraviolet light (see Fig. 1).

This technique requires staining biological materials with chemical solutions, to reveal their details. The staining process kills living organisms, so this method can be used only with specimens which are not living. To study living specimens requires another type of microscope.

The solution

This newly developed instrument fills the gap in the range of microscopes in use today. In terms of magnification factor, the new instrument is situated between the optical microscope (maximum magnification of 2,000 times) and the electron microscope (maximum magnification of 500,000 times).

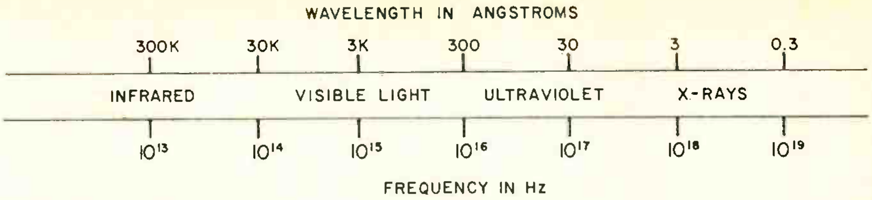
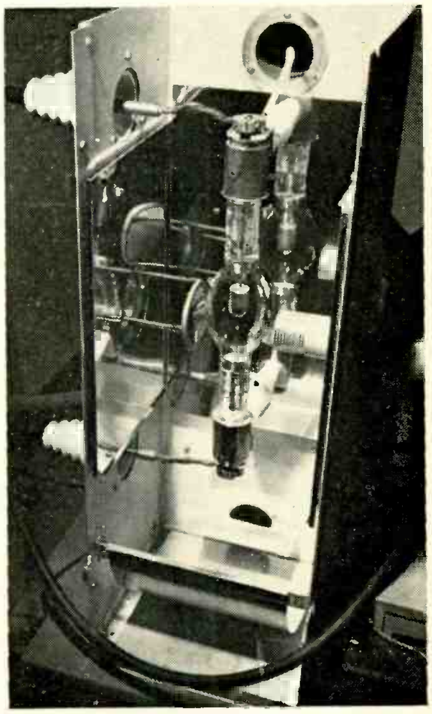


Fig. 1—Portion of the electromagnetic spectrum occupied by light waves. The newly developed microscope uses light in ultraviolet region around 20 Angstroms.

This instrument magnifies up to 20,000 times. Through the greater resolution possible with ultraviolet light, this microscope allows viewing of objects one-third the size of those visible with an optical microscope. In addition, the new instrument allows observation of live subject matter, such as blood cells and bacterial cultures. No chemical staining is required.

Referring to Fig. 2, the light source is a newly developed 5,000-watt arc lamp made of fused silica. It has a prism monochromator, which can be used to break up the light into discrete wavelengths. This fulfills the objective of using light with a short wavelength. The entire optical system, including lenses, is immersed in nitrogen to eliminate air (which absorbs ultraviolet radiation below 30 Angstroms). This feature allows the use of a wavelength of 20 Angstroms. The limit is set by transmission conditions of the fused silica.



Light source for the microscope is this 5,000-watt arc lamp. It is driven by a 180-ampere, 35-volt dc power supply.

Microscope electronics

Light from the UV lamp passes through the monochromator, lenses

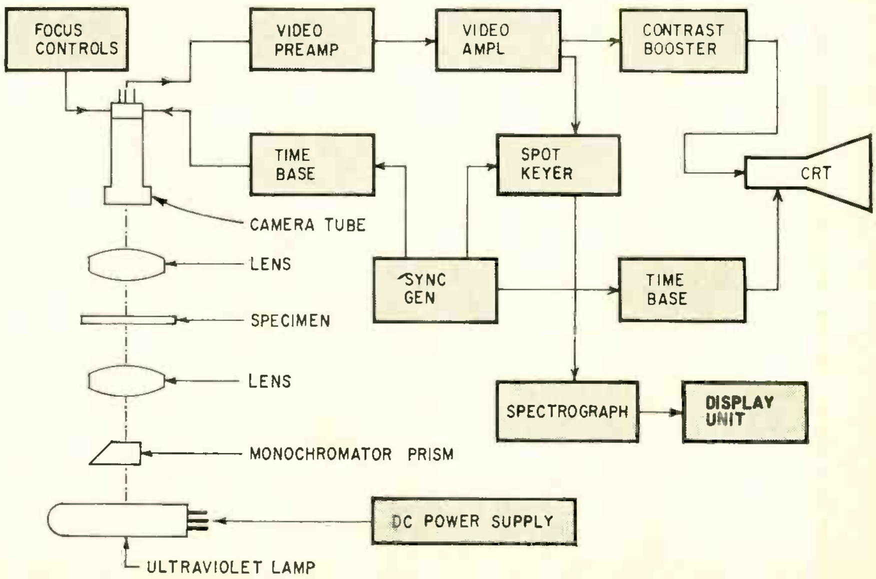
ABOUT THE AUTHOR

F. J. G. van den Bosch was born in Antwerp, Belgium, in 1904. He received a D.Sc. in Physics in Paris in 1927, and a Ph.D. in Physiology in London in 1930. During the 1930's, he did pioneering work in developing secondary-emission tubes, and elements of television and radar. In World War II, he collaborated on classified scientific projects for the Allies.

In the 1950's, Dr. van den Bosch did extensive research in the field of medical electronics and bioengineering. He is the author of several papers and articles on these subjects; some were published in this magazine. He pioneered in the development of TV microscopes and was awarded a Scientific Merit Medal at the Brussels World's Fair in 1958.

A member of several scientific and professional societies. Dr. van den Bosch is at the State University of New York, Downstate Medical Center.

Fig. 2—Block diagram of the new microscope. Camera tube is special type of image orthicon sensitive to ultraviolet light, using fused silica faceplate.



and specimen, and is focused on the photocathode of a special ultraviolet-sensitive image orthicon TV camera tube. This tube is scanned with 1000 horizontal lines—about twice the US commercial TV standard—for high vertical resolution.

In the camera head are the video preamp and amplifier, which are unusual in that they do not use peaking coils for high-frequency response. Type EF80 pentode tubes are used in a low-gain circuit which has a bandwidth of 20 MHz, thus affording high horizontal resolution.

To further increase resolution, picture whites are removed and the contrast is boosted by a special circuit. The picture developed by UV light is then displayed on a conventional picture-tube monitor. As it is sometimes desirable to view both positive and negative images of a specimen, a switch in the video amplifier allows the picture waveform to be reversed in polarity.

Spectrographic spot

In addition to going to the CRT, the video signal is fed to a spot keyer which is timed by the sync generator. Spot-keyer controls permit the operator to key out a portion of one or more horizontal lines from the video waveform, and feed them to an absorption spectrograph for analysis. Spot size is variable out to a full-width line; even multiple lines may be used. A counter device using neon tubes allows the operator to determine instantly the width of the spot in scanning lines, for resettability.

As the spot is keyed into the spectrograph, an identical pattern is traced on the monitor CRT, so the operator knows exactly what area is being viewed by the spectrograph. The spot is movable over the entire raster, allowing any portion of a specimen to be analyzed.

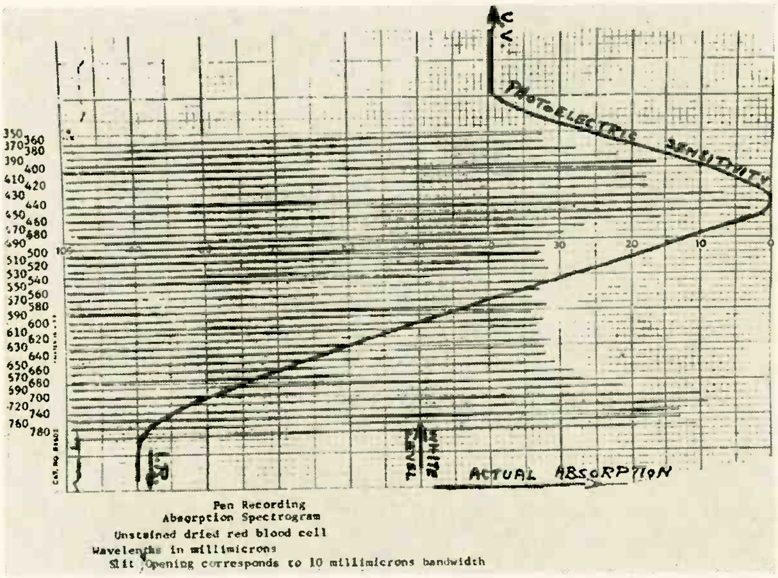
By gradually changing the wavelength of the arc light with the monochromator prism, the entire visible-light spectrum ca be covered. Hence, a meaningful spectrogram can be recorded, making positive identification of the specimen.

While other microscopes may convey valuable structural information about a specimen, only this new instrument permits chemical identification without regard to image shape.

The new instrument is therefore a valuable tool for scientists studying bacteria, viruses—indeed nearly any minuscule specimen. With this microscope, the researcher can identify living organisms which cannot be identified by any other means. **R-E**

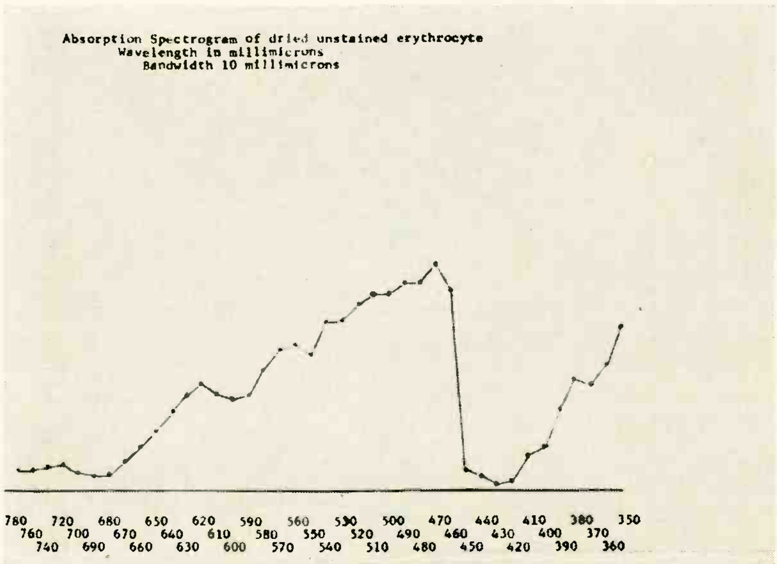
Spectrograph Records

Pen recorder graph shows spectrum absorption of center portion of red blood cell. Each horizontal line represents percentage of absorption at specific wavelengths of light (vertical axis). Spectrum absorption lines are generated in recorder by one or more

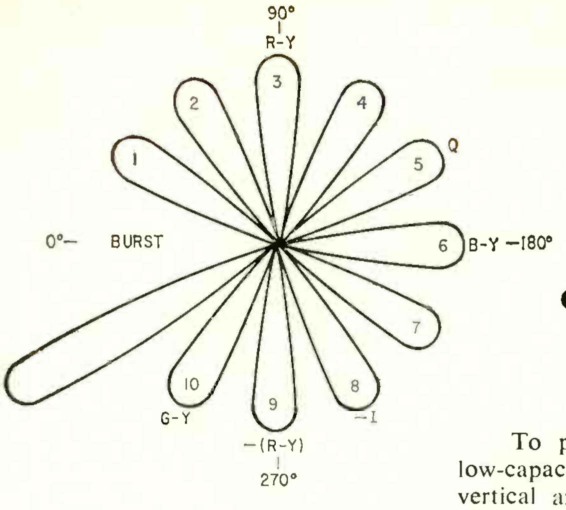


horizontal lines from video signal selected with spot keyer. Solid curve shows sensitivity of photocathode to changing light wavelengths. Actual absorption is the distance between the end of the horizontal lines and the sensitivity curve.

Amounts of absorption at each wavelength (from above) are plotted on the vertical axis to give scientists a "picture" of a cell's chemical composition. Use of TV/spectrograph system permits rapid identification of abnormal cells by comparing



their spectrograms with those of normal cells. Peaks at 620 and 470 mμ indicate this cell is normal.



Vectorscope Speeds Color TV Servicing

Color-bar generator + ordinary scope = vectorscope

By FLOYD L. BERG

A "DAISY" CAN TELL YOU A GREAT DEAL about your color TV set. It can tell about phase shift and relative amplification of any color. It can tell if the bandpass transformers need adjusting, how well the tint control works, and it helps you adjust the reactance and plate coils of the color oscillator. The "daisy" is quite a tattle-tale, and all you need to obtain one is a gated color-bar generator and oscilloscope with low capacitance probes.

A "daisy," in this case, is the petal-shaped Lissajous pattern (above) produced on the oscilloscope when a gated color-bar signal is connected to the TV antenna terminals and the amplified outputs of the R—Y and B—Y chroma demodulators are hooked to the scope's vertical and horizontal inputs respectively.

In color TV, the B—Y and R—Y voltages are 90° apart as are the vertical and horizontal deflection plates in the oscilloscope. If the R—Y signal is connected to the vertical amplifier and the B—Y to the horizontal amplifier of the scope, a vectorscope pattern will be obtained, which will reveal the phase angle and strength of the different colors.

The B—Y and R—Y signals can be picked up from the leads going to the control grids of the blue and red guns, respectively. Either use alligator clips that puncture the lead insulation or obtain the signals at the chassis or picture-tube end of these leads, whichever is most convenient.

For your first try at using this method choose a chassis similar to the RCA CTC15, which uses a reactance tube as the color oscillator control and three color amplifiers in the output circuit. Select a set that is operating properly.

To prevent circuit loading, use low-capacitance probes for both the vertical and horizontal scope inputs. Also, adjust the vertical and horizontal gain controls to obtain a circular pattern.

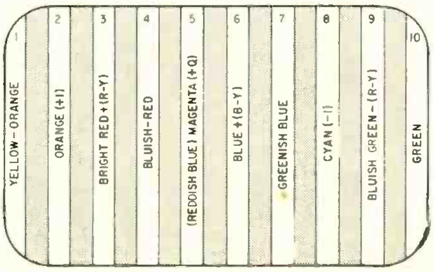
Turn on the color generator. Set the function switch to color and adjust color modulation to 100%. Fine-tune the TV set, and adjust the TV color gain control on the generator for normal color.

It is better to be slightly on the weak side of color saturation than to overdrive the color amplifiers. Color distortion can be noticed very easily on the vectorscope. If your scope has a switch that permits you to make positive voltages swing the trace on the scope either up or down, let positive be up.

Most scopes are built to conform with conventional vector addition. This means plus voltages are up on the vertical trace and left on the horizontal. If your scope is conventional, is connected as described and you are using a gated color-bar generator, you should be able to adjust the horizontal and vertical amplifiers to get a "daisy" pattern. If the pattern is not as illustrated, chances are that the TV set needs adjusting.

Adjusting the set

Before attempting any adjustments of the color circuits, check the fine tuning of the TV set. It should be set just before the point where sound bars appear on the CRT. Check the color control on the generator to be certain that the color amplifiers aren't being overdriven.



Color-bar generator display on CRT looks like a daisy on the vectorscope display.

If the 4.5-mHz sound trap is poorly adjusted, the pattern will appear to be blurred or out of focus. The blur is due to sound getting into the color circuits.

The color bar generator can be used to set the frequency of the color oscillator in the TV set if the generator frequency is accurate. Be sure the fine tuner is properly set. Short the reactance-tube grid to ground as some manufacturers recommend. The colors should just drift across the face of the picture tube.

Unless the color oscillator is set very close to its design center, you will lose the vectorscope pattern. It will become a blurred circle. If necessary, adjust the reactance coil until you see the pattern. When it holds in one position or drifts slowly right and left, you have the correct frequency within a fraction of a percent. Remove the short from the reactance tube and your "daisy" should hold as steady as a rock.

If the pattern should drop to a dot, grounding the reactance tube may have triggered the color killer into biasing off the color. To correct this, turn off the color killer.

Place the tint control in the center of its range. The third petal, counting from the left, should be at 90°. If it isn't, adjust the burst transformer until this petal is standing straight up. The tint control should now be able to move the petal an equal distance right and left.

Now try adjusting the color bandpass transformers. Keep the gain down and try for narrow petals that are similar in appearance. The more these petals look alike—without a big curilicue at the top—the better the color will be.

The quadrature-coil method of color demodulation is easy using the vectorscope. One slug of the quadrature coil will make the pattern larger and the other will affect its roundness. Adjust the slugs for the largest and roundest pattern you can get. **R-E**

SOLID STATE SECRETS

A programmed course in semiconductor fundamentals

By GLENN M. RAWLINGS

Secrets of solid-state devices such as transistors, diodes, silicon controlled rectifiers can be learned without too much difficulty. The programmed text that follows is a modern self-teaching method designed to improve comprehension and retention of the subject matter.

As you read through each block section, and follow the directions given, you will be led to a better understanding of solid-state principles.

Knowledge breeds knowledge . . . if you can cope with this material chances are that you will be stimulated toward additional investigation into the subject. Go to Block 1 and follow the instructions.

1

To understand what a solid-state device is we must first analyze its general construction. The term *semiconductor* is used with solid-state devices. Why? Because the elements of which they are made have electrical characteristics somewhere between an insulator and a conductor. Re-

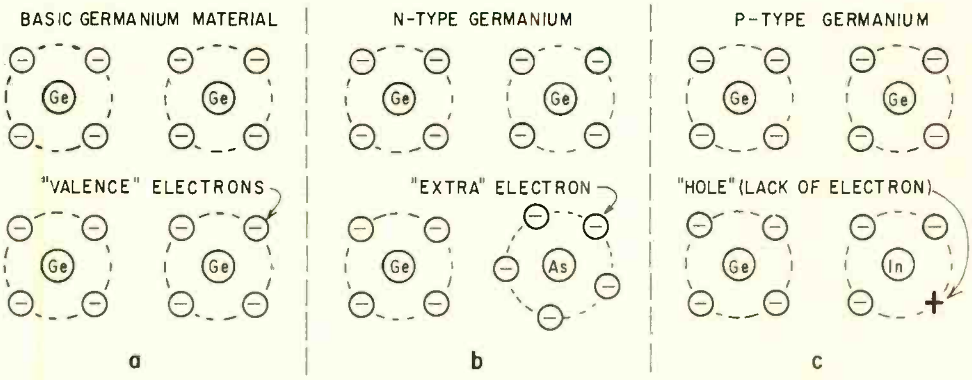


Fig. 1—Atomic structure of semiconductor materials. a—Pure germanium atoms have four electrons. b—N-type germanium forms when arsenic doping adds electron. c—Indium causes electron hole.

member that a conductor is a material with many "free" electrons, whereas an insulator has relatively fewer of these free electrons.

The two most common semiconductor materials are silicon and germanium. They are similar in structure and the descriptions to follow are applicable to either in most instances. Only the germanium material will be used for explanation.

In Fig. 1-a the atomic structure of germanium is seen in a simplified way. Orbiting around the center core or nucleus of the atom are four *valence* electrons. These valence electrons are the important thing to remember. They are rather loosely bound to the center core. As you'll see later, they are used for current *carriers*.

Two basic modifications are performed on germanium during the semiconductor manufacturing process. First, impurity atoms (such as arsenic) are doped with the basic germanium atoms. The impurity atoms in this case have, not four, but five valence electrons in their orbit. As seen in Fig. 1-b, this causes the basic material to have a few extra electrons distributed within its structure. You recall that electrons by definition are *negative* charges? Then it should be easy to remember that this material is *n*-type.

In the second modification to the basic germanium material, impurity atoms (such as indium) are doped in the same manner as before. The impurity atoms of indium have only three valence electrons in their orbit. As seen in Fig. 1-c, the material now has a number of empty "pockets" or "holes" distributed within its structure. It has fewer electrons than the n-type material of Fig. 1-b; therefore by definition it is a more *positive* material. We call it p-type material.

Question: Which of the following best describes an n-type germanium material?

- ☐ It has fewer electrons than normally found in the basic germanium material. Go to **Block 7.**
- ☐ It is an insulator. Go to **Block 20.**
- ☐ It has more electrons than normally found in the basic germanium material. Go to **Block 8.**

2

Your answer is *wrong!* Return to **Block 3** and restudy. Select another answer.

3

Would you believe . . . you're *right!* The holes in a sense, are "recombined" with electrons from the n-type material.

A simple Zener diode voltage regulator consists of a voltage source, a current-limiting resistor and a Zener diode selected for the desired output voltage. Refer to the schematic of Fig. 2-a. The arrow of the diode always points to the positive voltage source in a circuit such as this. If the output load decreases, the Zener current will increase to maintain a constant output voltage. This is a very simple and effective regulation circuit.

Zener diodes are available with breakdown (operating) voltages anywhere from 2 to several hundred volts. An important parameter of Zener regulators is wattage rating. The wattage is determined by the product of the Zener voltage and maximum Zener current for any particular application.

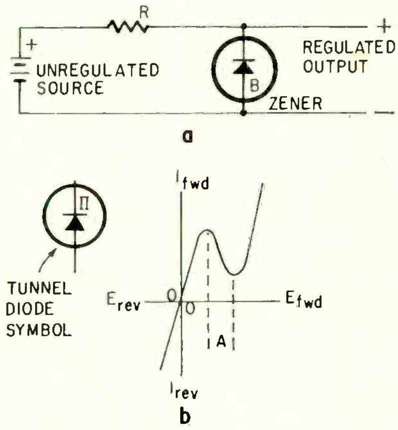


Fig. 2—Zener diodes effectively regulate voltage. b—Tunnel diode conduction curve.

What else can we do with these p- and n-type materials? Another item we should briefly mention is the *tunnel diode*. Its construction is identical to an ordinary diode's, with one exception: more impurity atoms are added to the basic material. This causes the diode's forward conduction characteristic to appear as in Fig. 2-b. Section A is a "negative-resistance" region. Notice that the current actually decreases while the voltage is increasing. This characteristic of the tunnel diode is used for many applications, especially in the amplification of high-frequency signals.

Question: If the Zener diode in Fig. 3-a is a 10-volt device and the maximum current through it is 1 ampere, what is its wattage dissipation?

- ☐ 1 watt Go to **Block 19.**
- ☐ 3 watts Go to **Block 2.**
- ☐ 10 watts Go to **Block 11.**

4

Your answer is . . . **Correct!**

It could get pretty confusing if we tried to analyze an amplifier under its dynamic conditions without some type of graph or chart to tell us what happens at any specific time. We know the collector current, base current and collector voltage are all related to each other. For instance, if base current is increased, collector current increases and collector-to-emitter voltage decreases. This can be seen by referring to the transistor "load-line" drawing of Fig. 3.

The load line, once established, will tell us the dynamic operating characteristics of a particular transistor type. The transistor manufacturer usually supplies the basic graph and the user then plots the load line to suit his requirements. Much knowledge of transistor action can be obtained by learning the fundamentals of this graph. The steps used to draw the load line of Fig. 3 are:

1. Determine collector voltage when collector current is zero (With no collector current flowing, there is no voltage drop across the 1200-ohm resistor. Hence the full −30 volts appears at the collector. This is shown as point A.)

2. Determine collector *current* when collector *voltage* is zero. (If the collector is at zero volts the transistor would have to be turned full on. Thus for practical purposes, the 1200-ohm resistor is the only limit to collector current.

   Since $I = \frac{E}{R}$ then $I = \frac{30 \text{ volts}}{1200 \text{ ohms}}$

   $= 25$ mA.

3. Draw the load line between points A and B.

4. Determine a dc *operating point* on this line. (A linear area is usually chosen where the base-current change is equal on each side of the operating point.)

Refer to Fig. 3. You will see that when the base-current change is 20 μA, the collector current will change a total of 12 mA. Likewise, the change in collector voltage will be 15 volts.

This is a good time to mention two terms encountered in transistor theory. The first is *beta* (β), which is simply the ratio between the base-to-emitter current and the collector current. In our example, it would be $\frac{12 \text{ mA}}{20\ \mu\text{A}} = 600$. This example would represent a very high-gain transistor circuit.

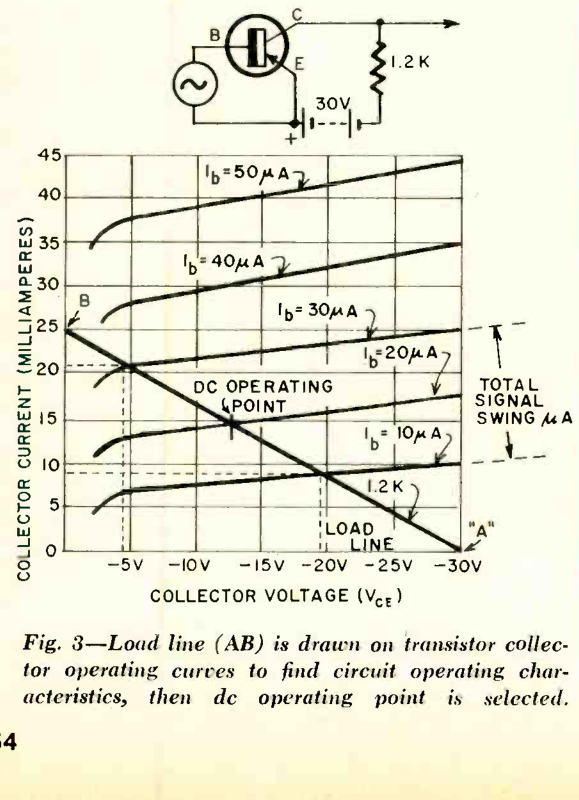


Fig. 3—Load line (AB) is drawn on transistor collector operating curves to find circuit operating characteristics, then dc operating point is selected.

The second term encountered is *alpha*. This is the ratio between the collector and emitter currents. Since these currents are almost identical (the emitter contains the small additional base current) this ratio is generally close to unity.

Question: If the base current of a transistor is increased, the collector current will decrease.

☐ True. **Go to Block 9.**
☐ False. **Go to Block 15.**

5

Your answer is right . . . for a *transistor* (ordinary two-junction type), but not for a *unijunction* transistor. A unijunction has *one* emitter and *two* base leads. Go to **Block 6.**

6

You are correct.

One problem when using ordinary transistors in certain circuits is the loading effect they present. For instance, it is difficult to match the high impedance of a crystal transducer to the considerably lower input impedance of a conventional transistor base circuit. This problem is eliminated by the *field-effect transistor* (FET). Just as its name implies, it uses a field as shown in Fig. 4-a to control current flow through its main section. As shown, the drain is made positive with respect to the source, so electrons flow from source to drain. The gate is biased negative—and the more

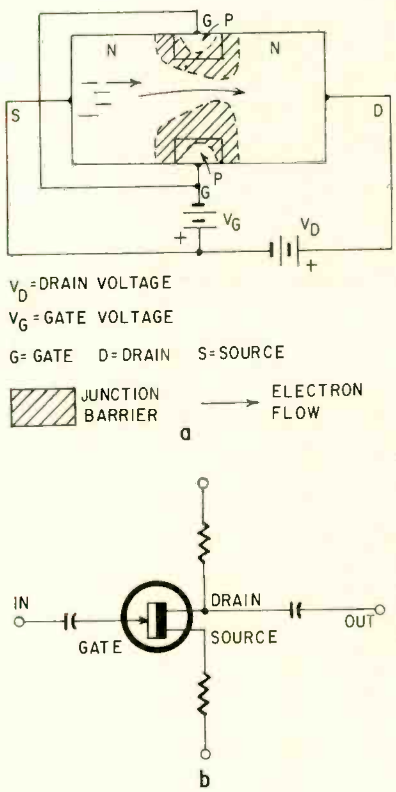


Fig. 4-a—Field-effect transistors (FETs) have advantage of high input impedance. Negative bias on gate (G) is used to regulate electron flow (arrows). b—Arrow direction on gate indicates this is an n-channel FET. If arrow is reversed, it is p-channel FET with p-type material in its body.

negative it becomes, the more the field blocks current flow to the drain.

Operation is very similar to a vacuum-tube grid; each has a very high input impedance.

If the FET body is made of n-type material, the device is called an *n-channel* FET. If the body is made of p-type material, it is called a *p-channel* FET. FET elements are called source, gate and drain. They perform much the same functions as their names imply.

Fig. 4-b shows a typical n-channel FET amplifier circuit. If the arrow on the gate lead were pointing in the other direction, the device would be a p-channel type. Remember the great similarity between the field-effect transistor and its grandfather, the vacuum tube.

Question: An important characteristic of the field effect transistor is . . .

- ☐ Its ability to open a gate and drain a source. Go to **Block 14.**
- ☐ Its high output impedance. Go to **Block 16.**
- ☐ Its high input impedance. Go to **Block 21.**

7 Sorry about that . . . Go back to **Block 1** and refer to Fig. 1-b. Select another answer.

8 Your answer is right!

And now that you know what n-type and p-type semiconductor materials are, you may well say, "So what?" Let's take a block of n-type and a block of p-type germanium and place them together, as shown in Fig. 5-a. The positive terminal of the battery is connected to the p-type material, the negative terminal to the n-type. Now the fun begins. The junction is said to be forward-biased and the "extra" electrons in the n-material will move in the direction of the junction. Since they are loosely bound in the valence bond, they may leave each nucleus rather easily. When a free electron reaches the junction, it will exchange places with a hole. (That is, it will fill a hole in the p-type material and leave a hole in the n-type material from whence it came.)

This always sounds a little confusing at first. Just remember that the electrons flow from the n- to the p-type material, and the hole flow is the opposite. Some of you younger readers may call this exchange of positions a "happening." Actually it's just what takes place in an ordinary solid-state diode.

Fig. 5-b shows the characteristic curve for a typical diode. The amount of forward current that flows is directly dependent upon the forward voltage applied across the diode terminals.

If we reverse the battery connections to the n- and p-type materials—as in Fig. 5-c, a very interesting thing takes place. The free electrons and holes are actually pulled away from the junction. Current flow ceases, except for a very small leakage current. Obviously the diode conducts in only one direction.

So far, we have been assuming the reverse voltage applied to the diode is insufficient to cause a breakdown of the pn junction. If we continue increasing this voltage, however, a breakdown will take place—as shown in Fig. 5-b. A heavy current flows and, due to the sharpness of the

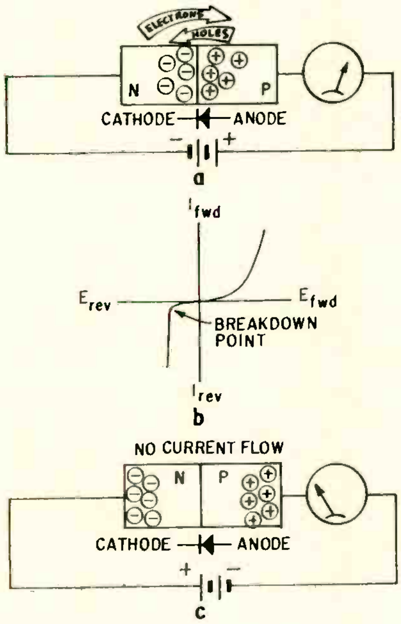


Fig. 5-a—With positive battery terminal connected to anode, electrons flow to p material, holes move to n material. b—No current flows when polarities are reversed (c); if voltage is increased to breakdown point, current jumps sharply.

breakdown, a very small voltage change takes place. This characteristic is used in *Zener* or *breakdown* diode applications. Since silicon gives the sharpest breakdown curve, this material is used for most Zener diodes.

Question: When a pn junction is forward-biased, the holes do which of the following:

- ☐ Flow away from the junction. Go to **Block 18.**
- ☐ Flow into the junction where they are subsequently occupied by an electron from the n-type material. Go to **Block 3.**
- ☐ Remain stationary. Go to **Block 12.**

9 Your answer is not correct. Return to **Block 4**, study Fig. 3 and then go directly to **Block 15.**

10 *Wrong!* Go to **Block 11** and select another answer.

11 Your answer is *correct!* If the Zener has a 10-volt drop across it and 1 ampere of current, the dissipation is 10 watts (P = IE). For this example, at least a 15-watt Zener would be used.

By now you are probably wondering what

happened to the good old transistor encountered in everything these days. So far we have been discussing semiconductor devices that are constructed of one slice of n-type material and one slice of p-type material. These can all be classified as *two-layer diodes.* Suppose we sandwich a thin slice of the p-type material between two pieces

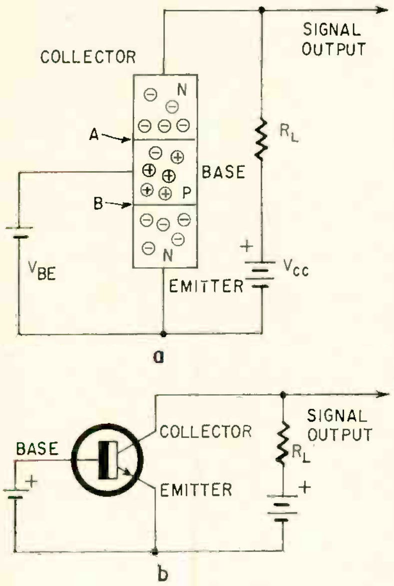


Fig. 6-a—Internal make-up and circuit connections for three-layer npn transistor. Junction A is reverse biased, junction B is forward biased. b—Schematic notation for npn transistor circuit.

of n-type, as shown in Fig. 6-a. With the battery voltage applied as shown, junction A has a reverse bias applied to it. Junction B is forward-biased. The current that will flow through resistor R_L depends on the amount of bias at these two junctions. If V_{BE} is increased (as would be the case with an input signal) current through R_L will increase.

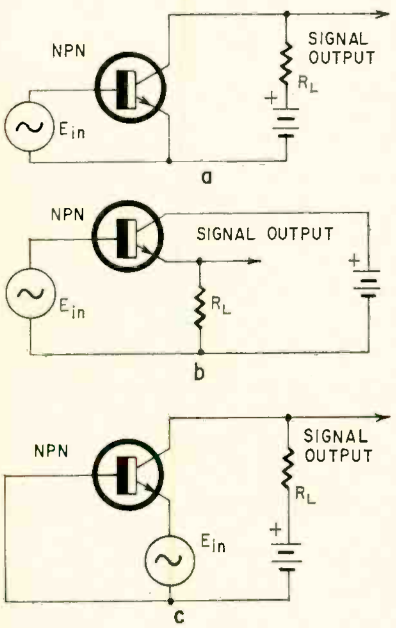


Fig. 7—Three commonly used amplifier circuits. a—Common emitter has high voltage, current and power gain. b—Common collector: no voltage gain, high current and low power gain. c—Common base: high voltage gain, low current gain, and medium power gain.

A pnp transistor is constructed in the same manner as the npn, except that a thin slice of n-type material is sandwiched between two of p-types. The operation of both transistor types is identical. In fact, an npn may be directly interchanged with a pnp (of similar characteristics) if the supply voltage polarity is reversed. (In practice this is seldom done, as polarized capacitors might be damaged.)

An important thing to remember about transistors is that the base-to-collector junction is reverse-biased, while the base-to-emitter is forward-biased. For any normal transistor configuration this must be true. Notice that Fig. 6-b is the schematic version of Fig. 6-a and represents the bias conditions just mentioned.

Fig. 7 shows the three most common amplifiers used in transistor work. Note the characteristics associated with each. A great deal of practical knowledge can be gained by becoming familiar with these three configurations.

Question: In a typical transistor circuit, which of the following statements would be correct?

- ☐ The base-to-emitter junction is reverse-biased, while the base-to-collector is forward-biased. Go to **Block 17.**
- ☐ The base-to-emitter is forward-biased, while the base-to-collector is reverse-biased. Go to **Block 4.**
- ☐ Both the base-to-emitter and base-to-collector junctions are forward-biased. Go to **Block 10.**

12

Would you believe . . . *Wrong!* For our purposes, it is best to consider the holes as actually moving. Return to **Block 8** and select another answer.

13

Sorry about that . . . your answer is not correct. Go back and review **Block 15** and then select another answer.

14

In a sense this may be true, but it is not the correct answer here. Better return to **Block 6** and select another answer.

15

You are absolutely right!

Another type of semiconductor device is the *unijunction transistor* (UJT). This device has no collector element in the normal sense. It consists instead of two base leads and one emitter. Its construction is shown in Fig. 8-a. The body consists of a piece of n-type material. The resistance of this silicon is relatively high between the base 1 and base 2 connections; normally very little current will flow between these elements.

But suppose we apply a voltage between the emitter and base 1 junction—a voltage high enough to forward-bias the junction. Then the resistance between the emitter and base 1 becomes very small. When this happens, the resistance of the body (from base 1 to base 2) is suddenly lowered and current flow increases. This effect is put to good use in timing and pulse-generation circuits. As an example, some recent video pattern generators use a UJT for timing functions.

Fig. 8-b shows the unijunction transistor symbol and a typical timing circuit. As capacitor C1 charges through resistor R1, the voltage eventually becomes great enough to forward-bias the emitter-to-base 1 junction. This causes the capacitor to discharge suddenly through base 1 and resistor R2. When the capacitor discharges, the cycle starts all over again. The values of R1 and C1 determine the time between output pulses.

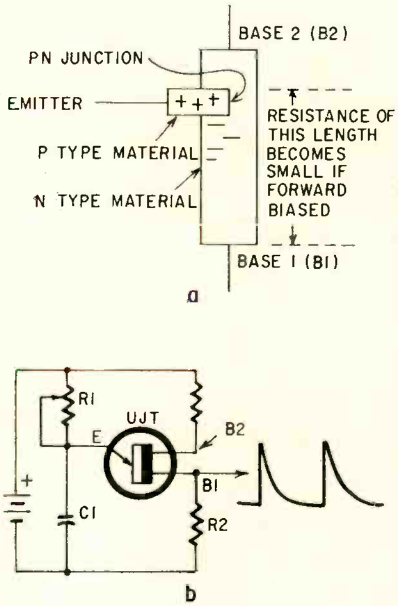


Fig. 8-a—Unijunction transistor has two base leads and one emitter. Normally high resistance between B1 and B2 can be quickly lowered by emitter voltage, permitting current to flow. b—Timing circuit utilizes this resistance-breakdown effect.

After seeing the various configurations and arrangements of the two basic n- and p-type materials and their applications, can there be more? Yes! You remember that a pnp transistor is made of a thin slice of n-type material sandwiched between two p-types. Suppose we add another n-type to this arrangement, as shown in Fig. 9-a. This is called a *four-layer diode,* or *pnpn switch.*

By taking advantage of the biased junctions and leakage currents across these junctions, several valuable devices have been developed. The first is exactly as shown in Fig. 9-a. When the applied voltage across this four-layer device reaches a certain level, junction 2 will actually break down, and a very low resistance will exist across the terminals. The point at which this occurs is relatively sharp and a current pulse is available as an output.

The characteristics of a four-layer diode are similar to a thyratron tube; each has a distinct firing (or breakdown) point. Once the device is turned on, it will remain on until the anode voltage is removed or reduced to a very low level. The breakdown may be controlled by attaching another lead as shown in Fig. 9-b. This device is known as a *thyristor* or *silicon controlled rectifier*

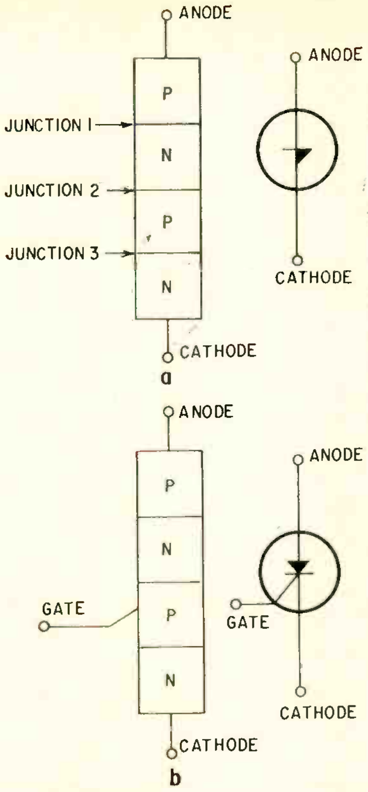


Fig. 9-a—A four-layer diode, or pnpn switch. At certain level of applied voltage across terminals junction 2 breaks down, resulting in very low resistance between anode and cathode. Current pulse that results is available as an output. b—In thyristor or silicon controlled rectifier, this breakdown is controlled by bias on the gate.

(SCR). It has found its way into a multitude of uses such as electronic switching, motor speed control, light dimmers, etc. Like the thyratron's control grid, the SCR's gate loses control once conduction takes place.

Question: The unijunction transistor consists of which of the following?

- ☐ Two emitters and one base lead. Go to **Block 13.**
- ☐ One emitter and two base leads. Go to **Block 6.**
- ☐ One emitter, one collector and one base lead. Go to **Block 5.**

16 Your answer is *wrong!* Return to **Block 6,** restudy and try again.

17 Would you believe . . . wrong. Return to **Block 11** and try again.

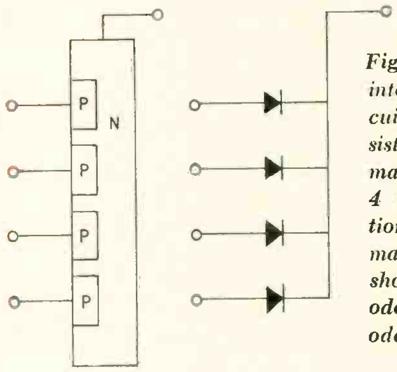
18 Your answer is not correct. A reverse bias would cause the positive holes to flow away from the junction. Return to **Block 8** and try again.

19 Your answer is incorrect. As described in **Block 3,** the wattage is the product of the Zener voltage and current (10 watts). Go directly to **Block 11.**

20 Your answer is wrong. Return to **Block 1** and select another answer.

21 You have chosen the correct answer once again. Since we began at **Block 1,** we have touched upon ordinary diodes, four-layer diodes, silicon controlled rectifiers, ordinary transistors, unijunction and field-effect transistors, and Zener and tunnel diodes. All these do a better job and take up less space than we could have imagined just a few years ago. But even so, the latest trend is even more amazing. Someone apparently opened the case of a transistor and discovered a great deal of wasted space there. In the *integrated circuit* many components are now put inside a case the size of a single transistor. These components are all made of semiconductive materials like those we have been discussing. Transistors, capacitors, diodes and resistors are constructed on a small chip that would fit under your thumbnail.

Figure 10-a shows a very simple integrated circuit of four diodes with common cathode connections. Fig. 10-b is the same circuit shown schematically.



a b

Fig. 10-a—Basic integrated circuit (IC) consists of n-type material with 4 p-type junctions. b—Schematic of (a) shows four diodes with cathodes common.

Use your imagination and you will see that many entire circuits could (and in fact are) constructed in a very small area. This technique is the future of electronics. And after this, you may wonder what could possibly come next. Would you believe . . . L.S.D.?* **R-E**

*Liquid-state diodes

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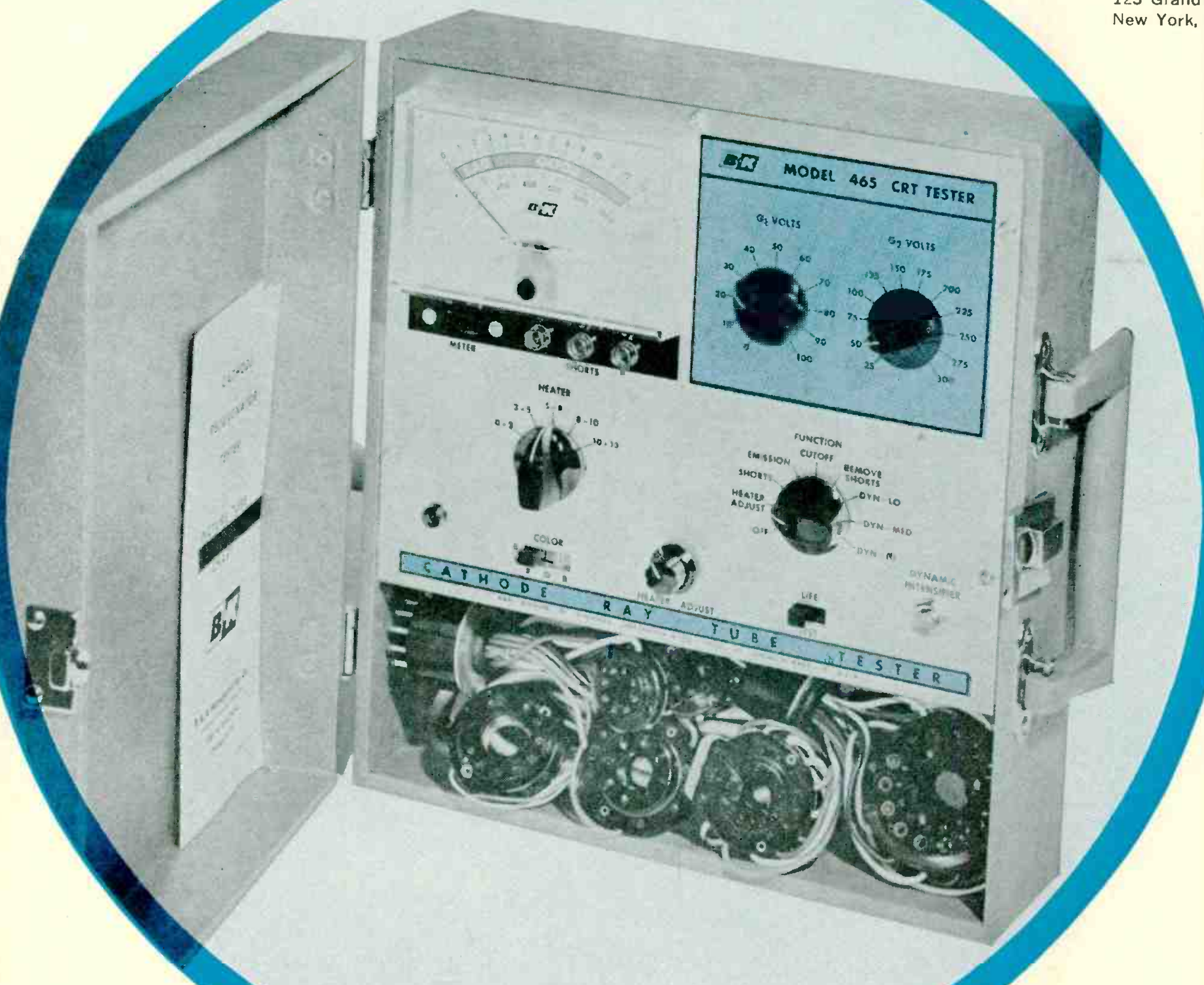

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20 Unijunction Transistor Applications

(*continued from page 39*)

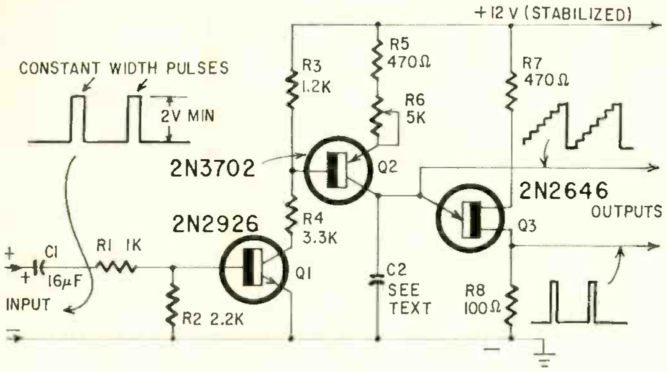


Fig. 14—This staircase divider/generator can be used to "count" number of input pulses.

put waveform that has a repetition frequency equal to some subdivision of the input frequency. Alternatively, if the input frequency is not constant, the circuit "counts" the number of imput pulses, and gives an output pulse only after a predetermined number have been counted. Thus, the circuit can be used as a pulse counter, frequency divider, or step-voltage generator for use in such applications as transistor curve tracers.

Circuit operation is as follows: In the absence of an input pulse, Q1 is cut off, and Q2's base is shorted to the positive supply line via R3, so Q2 is cut off also, and no charging current flows into C2. If a constant-width positive-going input pulse is now fed to the circuit via C1, Q1 and Q2 will be driven on and C2 will start to charge via the collector of emitter-follower Q2; the charging current can be controlled via R6. C2 charges linearly, as long as Q2 is on, and since Q2 is on only for the fixed duration of the input pulse, the C2 voltage will increase by a fixed amount every time a pulse is applied to it.

In the absence of the pulse, there is no discharge path for C2, so the charge voltage stays on C2. The next pulse again increases the C2 charge by a fixed amount, until, after a predetermined number of pulses, C2 voltage reaches the trigger potential of Q3, and the UJT fires, discharging C2 and restarting the counting cycle.

If the input pulses are applied at a constant repetition frequency, the signal across C2 will be a linear staircase waveform, and an output pulse will be available across R8 every time the UJT fires. If the input frequency is not constant, the staircase will be nonlinear, but the R8 pulse will appear after a predetermined number of input pulses have been applied. Stable count or division ratios from 1 up to about 20 can be obtained.

Finding division ratio

Important: this circuit must be fed with constant-width input pulses if stable operation is to be obtained. Also, the width of the pulses must be small relative to the pulse repetition period. The value of C2 is determined by these considerations, and is best found by trial and error. Once a value of C2 has been selected, the division ratio can be varied over a range of about 10 to 1 via R6.

Now you know how the unijunction transistor works, and you've seen the first 11 projects. In the next article we'll show 9 additional applications.

Continued next month

HOME PROTECTION SYSTEM KIT

(*continued from page 34*)

positive voltage from the power supply, limited by R2, is applied to the SCR gate. This voltage gates the SCR on, making its anode-to-cathode resistance very low. This shunts current flow around RLY-1, de-energizing it.

Once gated on, the SCR stays on, even if the sensor should open again. RESET switch S1 turns off the SCR by shorting it anode-to-cathode. Switch S1 is also connected across the relay coil, and shorts the coil (de-energizing the relay) when pressed.

When a normally open sensor connected across terminals 4 and 5 closes, it shorts the relay coil, de-energizing the relay and turning on the transmitter. No reset function is used for this mode. Once the sensor returns to its open state, RLY-1 is energized and transmitter power is removed.

Receiver unit

To trigger an audible alarm, pulsed rf signals from transmitters must be detected on the ac line by receiver GD-77. Fig. 3 shows how this is accomplished. The ac line is coupled, via C1 and C2, to 50-kHz input filter transformer T1. (Resistor R1 helps match T1 to the power line.)

Waveforms A, B and C show most of the 60-Hz ac component removed by the time the 50-kHz burst signal arrives at the base of Q1. This transistor amplifies the signal (waveform D), which is then fed to 50-kHz output filter transformer T2. In the secondary circuit of T2, D1 detects the negative half of the signal and C7 filters out the 50-kHz carrier, leaving only the 60-Hz modulated pulse (waveform E). Frequencies above about 60 Hz are removed by an integrator (R6–C9), and the resulting 60-Hz signal is fed to the base of Q2 (waveform F).

When no signal is present at Q2, it is held at saturation by base-bias voltage divider R7–R8. When a signal is received, however, it lowers the conducting point of Q2 and increases its collector voltage, causing the transistor to conduct and pass the pulse (waveform G). Following this amplifier, the signal is fed to integrator R11–C11, whose time constant is very low. Hence several 60-Hz pulses are required to charge C11. (Resistor R12 discharges any noise or static signals which tend to charge C11, and diode D2 limits any negative voltage which might discharge C11.)

When capacitor C11 is fully charged, D3 conducts, turning on SCR D4. When the SCR conducts, it shorts the positive end of the relay to ground through switch S1-b and the anode–cathode circuit of D4.

Normally the alarm unit is plugged into the ac line. The power supply (T3, D7 and C12) furnishes a nominal 16 volts dc for the transistors and energizes RLY-1, thus making the normally open contacts. Hence, the alarm circuit (including battery B1 and diode D6) is open and the alarm does not sound.

When SCR D4 conducts, however, it shorts the positive end of the RLY-1 coil to ground, de-energizing the relay and causing the normally closed contacts to make. With the alarm circuit closed, the alarm transducer (a Mallory Sonalert) produces its 2800-Hz audible signal.

After an alarm signal has been received and its cause corrected, the receiver is restored to standby mode by pushing the RESET switch. Section S1-b of the switch opens the circuit from the SCR to the relay coil and S1-a discharges C11, which prevents D3 and D4 from conducting until another alarm signal is received.

Power for the alarm transducer is furnished by battery B1, which is trickle-charged from the ac line through R14 and diode D5. If power to the receiver fails, voltage to the coil of RLY-1 is cut off, causing the normally closed relay contacts to make. The alarm would then sound to indicate the power loss.

External alarms used with the receiver are connected through a socket which supplies 117 volts ac, switched by another set of contacts on RLY-1.

How does it work?

The prewired system I tested worked well. The detectors responded to smoke and to heat from an open flame, triggering the alarm with 50-kHz signals.

If several isolated sensors are wired into the system, the user will not be able to determine quickly which sensor triggered the alarm unit. Also, there may be some interaction between separate systems in multiple-dwelling units. (According to the company, the receiver unit will *not* be activated by triggering signals if there is a power-line transformer between the transmitters and receiver.)

The construction manuals are clear and complete. A number of applications for the GD-97 Utility Transmitter are given, with useful suggestions for remote sensors. **R-E**

"He's a good worker. I'd promote him right now if he had more education in electronics."

Could they be talking about you?

You'll miss a lot of opportunities if you try to get along in the electronics industry without an advanced education. Many doors will be closed to you, and no amount of hard work will open them.

But you can build a rewarding career if you supplement your experience with specialized knowledge of one of the key areas of electronics. As a specialist, you will enjoy security, excellent pay, and the kind of future you want for yourself and your family.

Going back to school isn't easy for a man with a full-time job and family obligations. But CREI Home Study Programs make it possible for you to get the additional education you need without attending classes. You study at home, at your own pace, on your own schedule. You study with the assurance that what you learn can be applied to the job immediately.

CREI Programs cover all important areas of electronics including communications, radar and sonar, even missile and spacecraft guidance. You're sure to find a program that fits your career objectives.

Solid-State Tach-Dwell-Voltmeter

(continued from page 46)

and mount it cantilever style with the meter posts as support. This arrangement has proved more than adequate; if you decide that you need added rigidity, the board can be supported at other points.

As part of the usual precautions, observe correct meter, diode and electrolytic-capacitor polarities. Pay particular attention to the basing diagram of transistors Q1 and Q2, shown in Fig. 2 along with the schematic.

Calibration

Calibration of the dwell meter has been described; it should be re-emphasized that the meter should be set to 0° dwell *with the engine running*. System voltages are higher with the engine running, and this is, of course, when the dwell meter will be used.

Tach calibration should need be done only once, barring unforeseen circumstances such as the calibration resistors being jarred out of position.

If you have a friend with an accurate tachometer, you've got it made, as far as tach calibration goes. If you don't, another method will be described shortly, but we'll assume for now that you do have access to an tachometer and an 8-cylinder auto.

Start by setting R6, R15 and R16 to mid-range. Set S1 to either 6 or 12 volts, depending on the car; S3 to TACH 8 and S2 to 1000 RPM. Attach CL1 and CL2 to battery positive and ground, respectively, and CL3 to the low-voltage wire connecting the distributor and coil. (See Fig. 4 for a typical auto ignition schematic.) Adjust the engine idle to 600 rpm (as measured by the reference tach), and set R16 so that the meter reads 600. Now switch S3 to TACH 6 and adjust R15 so that the meter reads 800. (The reason for this is that, for a given rpm, a 6-cylinder engine generates 3/4 as many pulses across the points as an 8-cylinder engine; conversely, for a given point rep rate, the 6-cylinder engine is turning at 4/3 the speed of an 8-cylinder engine.) Switch S2 to 5000 rpm and set the idle screw so that the engine is running at say 2000 rpm. Adjust R6 so that the meter reads 2000. The tachometer is calibrated.

If you have a 6-cylinder car, calibration for the low end can be carried out as above, but with S3 set to TACH 6. Then switch to TACH 8 and adjust R16 so that the meter reading is 3/4 of the TACH 6 reading.

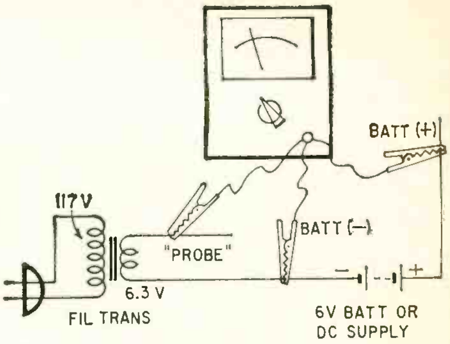


Fig. 5—Bench calibration requires only a dc supply and 6.3-volt filament transformer for 60-pulse/sec-signal source.

You can calibrate your instrument on the bench by using a 6.3-volt filament transformer and a 6-volt lantern battery, or other 6-volt dc supply, as shown in Fig. 5. For this calibration scheme, short out C3. Set S1 to 6 volts, and then plug in the transformer and turn the tach on, having preset R6, R15 and R16 to mid-range. Set S2 to 1000 RPM, S3 to TACH 8 and adjust R16 for a meter reading of 900 rpm. Then switch S2 to 5000 RPM, and adjust R6 so that the meter reads 900 rpm in the high scale. Now switch S3 to TACH 6 and adjust R15 so that the meter reads 1200 rpm. The tach is now calibrated, having never left the bench.

If you're concerned about the accuracy of the voltmeter with the 10% components specified, you can substitute appropriate adjustable resistors of the type used for R6, R15 and R16, and calibrate the voltmeter to greater accuracy, using an appropriate reference scheme. The cost of two more adjustable resistors of this type will not increase total cost of the instrument by more than about 60 cents.

Use

The instrument is designed for use on negative-ground systems, since almost every auto made today is wired this way. The dwell meter, however, can be used on positive-ground systems by simply reversing the roles of PROBE and NEG (ground) leads.

If you own an auto with positive ground and want to build this instrument to help in tuning it up, all is not lost. Simply reverse all diodes, the meter and the electrolytic capacitor. Substitute pnp transistors for Q1 and Q2, but be sure they have an h_{FE} of 100 or more. Be sure you remember that, in this configuration, PROBE is connected to negative when making voltage measurements.

In use, the PROBE and GROUND leads are used for all tests, and the (+) lead is used only for tachometer measurements. **R-E**

Poor Man's Power Supply
(continued from page 41)

vides a nonpolarized electrolytic with ratings equivalent to one of the original capacitors. A power supply using this arrangement is shown in Fig. 4-b.

Observe a few precautions when using a power supply such as those described here. To begin with, these power supplies, like ac–dc radios, are common to one side of the ac line. A capacitor in each side of the line affords some protection. Don't forget that you now have two capacitors in series, and the values should be selected accordingly. A typical circuit is shown in Fig. 4-c.

Another safeguard is shown in Fig. 4-d. Here, a line isolation transformer was used to make a safe circuit. Naturally, this removes some advantages of the series-capacitor supply: low cost, small size and light weight; but the others remain: constant current and easily changed voltage.

The power supply should never be operated without enough load to keep the output voltage below the voltage rating of the filter capacitor. *Be sure that the rating of the series capacitor is high enough to take care of 1.414 times the voltage drop across it.*

This kind of power supply can be converted into a compact constant-voltage supply with the addition of a suitable Zener diode across the output, as shown in Fig. 4-e. Components should be selected so that, when the power supply is operated without load, the power dissipated by the Zener diode is just under its maximum wattage rating. **R-E**

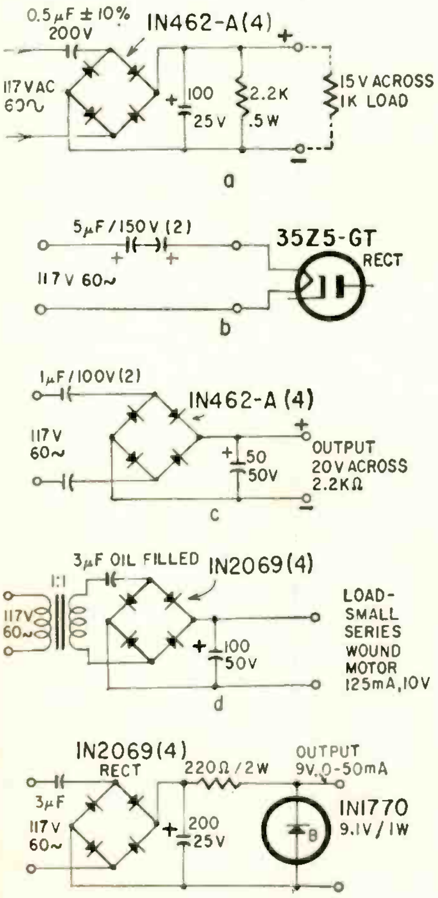


Fig. 4—Five versions of dropping-capacitor supplies: a—After Fig. 3, with built-in bleeder to prevent output voltage rising above a certain value. b—Capacitance used to drop line voltage to 35 for 35Z5-GT heater. c—Capacitance split and placed at both sides of the line, which affords some protection from accidental shorts to external grounds, and from shock. d—Isolation transformer (1:1 ratio) removes danger from common line–chassis connection through diodes. e—Zener-regulated supply is constant-voltage, ideal as battery substitute for low-power transistor circuits. A small amount of heat is dissipated by the Zener and resistor.

EDITOR'S NOTE

While preparing this article for publication, we discovered what seemed to be a paradox concerning the effective capacitance of two identical electrolytic capacitors connected in series back to back to simulate a nonpolar capacitor. Mr. Bowen, the author, claimed that the total capacitance of such a combination is the capacitance of one of the capacitors, in contradiction to the usual formula, which gives a total value of one-half the value of either capacitor. A second question arose: What is the effective voltage rating of the combination?

This puzzlement prompted us to query several makers of electrolytic capacitors. The replies turned up a fascinating and somewhat confusing flurry of information, and raised a third question: can a nonpolar capacitor legitimately be simulated simply by connecting two ordinary (polar) electrolytics in series back to back?

The answer is yes, provided that all the implications are recognized. Consensus among manufacturers seems to be as follows:

1. Total capacitance for two identical capacitors back to back is half the figure for either one: e.g., two 400-μF capacitors back to back are equivalent to one 200-μF nonpolar.

2. *Peak ac* voltage rating is equal to the dc rating of one of the capacitors: e.g., two 150-volt capacitors back to back should safely withstand a *peak* (not peak-to-peak, and not rms) voltage of 150. Assuming sine-wave input, this corresponds to an rms voltage of 106; hence 150-volt capacitors will often not be safe for the applications presented in this article.

Note that this discussion applies only to polar electrolytic capacitors (including tantalum types).

The basis of the misunderstanding was cleared up in a letter from D. F. Warner, senior applications engineer at the Capacitor Department of General Electric. He wrote: ". . . the back-to-back arrangement exhibits one-half capacitance of either unit to ac . . . but a capacitance equal to one unit when dc is applied, if the capacitors are completely discharged."

This strange situation becomes clearer if you examine the energy-storage relationships between two capacitors connected back to back, being alternately charged and discharged. An electrolytic subjected to an alternating current "looks" like a capacitor shunted by a rectifier (rectifier anode to capacitor cathode). That hint may be enough to get some of you EQ-lovers started. We aren't running a contest, but of course we welcome comments, criticisms, solutions or deobfuscations from readers. Soon we will probably put together an article from the folderful of information on electrolytics that we have collected as a result of our curiosity.

Other precautions

Capacitor makers tipped us off to two other things-to-look-out-for, which we pass on:

1. Electrolytics have a high dissipation factor—the ratio of effective series resistance to the capacitive reactance (the reciprocal of Q). Alternating current will therefore cause more internal heating than in other types of capacitor. Elevated temperature will hasten breakdowns. Under no conditions must the temperature be allowed to rise above the maximum figure given by the manufacturer (usually about 85° [185°] for conventional electrolytics and most tantalum capacitors). This limits the current rating of capacitive-drop power supplies designed around electrolytics. The heating follows I^2R; hence doubling the current increases heat generation by four times.

2. Electrolytic-capacitor tolerances are wide: the Allied catalog gives −10%, +150% for many types of conventional electrolytics. Better upward tolerance figures range from 50% to 100%. The tantalums are the best (±10% or ±20%, but they are very expensive. Such wide tolerance ranges make precise design difficult. It may be necessary to select the capacitors to be used from a pile of capacitors of the same value, either by trial and error or by measuring back-to-back pairs on an ac capacitance bridge.

Service Clinic

By JACK DARR

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. S., New York 10003.

Making shunts for old meter

I've got the meter out of an old Hickok S-44 vom. I'd like to make up a current meter, with ranges of 1.0 up to 500 mA. Can you tell me how to calculate the shunts?—A.C., Benicia, Calif.

"Calculating" the shunts is nice, *if* you've got a very accurate bridge, and a lot of precision equipment. The quickest way is to use good old "K&T" methods (Kut and Try).

Make up a lashup like Fig. 1. The battery and adjusting pot can be of any size, but you don't need too much voltage. Just be sure that you start out with maximum resistance in-circuit on each test, to keep from slamming the meters.

If this is old enough, the meter is probably an 0-1 mA movement. Check the scale; if it says "1,000 ohms per volt" then it is. So, there's your first scale already. Now, make up a shunt out of bare copper wire; say about 6-8 inches of #20, or something like that. Hook one end to the meter terminal, and then hook the other terminal about halfway, as in Fig. 2.

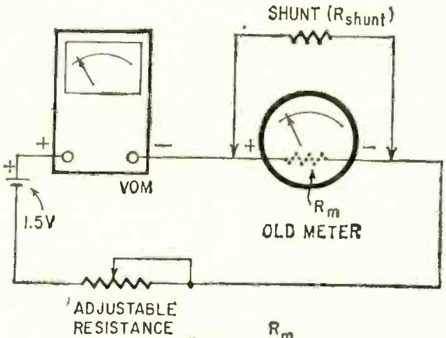


Fig. 1

$$R_{shunt} = \frac{R_m}{N-1}$$

R_m = METER COIL RESISTANCE
N = CURRENT MULT FACTOR

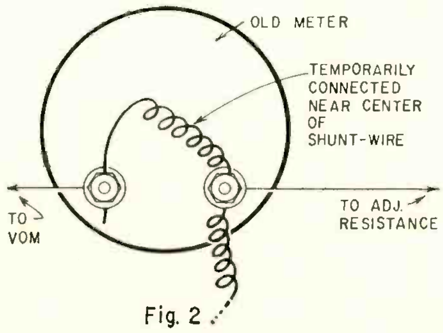


Fig. 2

Now, set the "calibrating" vom on the scale you want, say 0-500 mA dc, and cautiously turn up the current. See what your meter reads, at about half-scale, by checking the reading on the vom. Let's say you get 100 mA. half-scale; this means a 200-mA full-scale, and your shunt is too big—too much resistance.

So, turn the power off (first!) disconnect the free end of the shunt, and move the connection point so that you have less wire across the meter. Less resistance in the shunt means more current in shunt, less through meter. Recheck; your reading should go up. After a little juggling, you should be able to make the old meter read the same as the vom, and there you are.

One precaution: *don't* try to move the shunt tap with power on! If you do, you'll open the circuit temporarily, and you'll blow the meter! All of the high current will flow through the coil, and the experiment will be over, at least until you can locate another old meter!

This is a good deal for making usable meters out of some of those odd value Army surplus meter movements, with 0-15 mA movements and so on. Makes elegant current-meters for reading cathode current in horizontal output tubes in TV sets, and so on.

New changer for old

I've just finished rebuilding an old Sparton radio-phono combination. Radio works fine; now I want to overhaul the old single-speed changer so that it will play the newer records. What would you recommend?—W.P., North Plains, Ore.

A brand-new changer! Actually, it wouldn't be too much trouble to cut the speed down to 33 rpm on the old one, but there are other problems. The worst of these is the *mass* of the pickup arm, in those old record-players.

Modern records use a very low-mass arm. You have to get the stylus pressure down from the original 20–30 grams to about 3–4 grams. The old record players just don't have the mechanical perfection required for playing modern records.

Beats from 3.58-MHz oscillator

I get beats from the 3.58-MHz oscillator, in a Sears color TV set model 6164, mostly on low channels. I can kill this by pulling the oscillator tube. What do you think?—J.S., Maquoketa, Iowa.

You have an import set. I've never run into this problem in exactly the same way, but anything's possible! I believe I'd check the filters first, and then make sure that all shields were present and tight. This is obviously a harmonic beat-frequency "escaping" from the 3.58-MHz oscillator stage.

Try adjusting the color-killer a little tighter, to be sure that this interfering signal is not getting through some of the color stages (being amplified) and then getting into the video, etc. You may have to add some shielding to get rid of it completely, if the color-killer won't stop it.

Scope substitute for vtvm

To align my kit FM stereo generator, I'm told to use an ac vtvm. Can't I get this reading with a scope? If so, what probe would I use?—F. Y., Savannah, Ga.

You certainly ought to be able to do this. Especially if the reading happens to be peak to peak, or peak. A scope "naturally" reads peak-to-peak voltages. It must be calibrated first, of course, with a known ac voltage. Use a nice even value, to make the math come out easier! For instance, 10.0 volts rms comes out 28.28 volts p-p, or 14.14 volts peak.

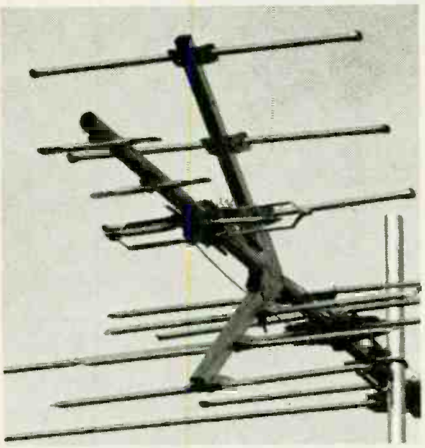
The probe used will depend on the impedance of the circuit where the reading is taken. If it's low, you can use a direct probe. In a high-impedance circuit, you'll probably have to use a low-capacitance probe. If so, don't forget to use the *probe multiplier* figure! Most lo-cap probes have a 10:1 attenuation, so you multiply readings by 10.

For In the Shop . . . With Jack see page 26

69

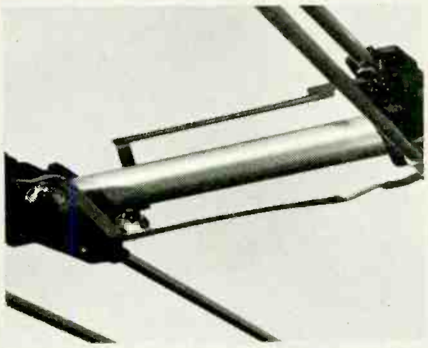
New RCA advances will change your thinking about antennas and rotators.

The era of compromise is over! Formerly, a UHF corner reflector (long known as the finest antenna for UHF reception) could not be combined with a VHF antenna without sacrificing gain on the VHF band. Now, RCA engineers who have had the experience of working on antenna space projects, have developed a corner reflector that doubles as a VHF director and actually *increases* gain.



High-gain UHF corner reflector with built-in VHF-UHF crossover network, also acts as VHF director.

The new RCA COLOR POWER combination antennas are the first broadband integral antenna design to deliver high gain and sharp directivity on both UHF and VHF bands—resulting in clear, crisp reception on Color and Black & White TV. The secret is in the combining network and balanced phasing lines. Note the parallel connecting bars in photo. They stay parallel, because they're thick aluminum strips, rather than wires that easily bend. Installation is fast because of



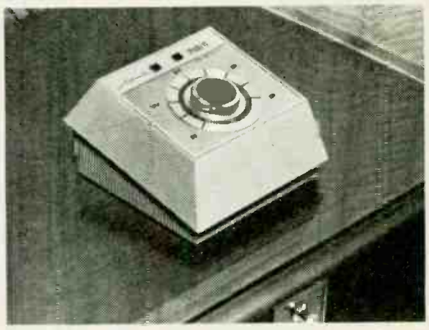
Balanced phasing lines, of rugged aluminum, stay in shape.

snap-lock elements. Ghost rejection is great, because of designed-in, deep electrical nulls resulting from straight, parallel dipoles and completely balanced design. All strong, tubular aluminum construction.

Until now, a rotator drive unit could have problems coping with wind, icing and large antenna loads. Now, RCA introduces a new dimension in antenna rotators with exclusive pre-turning momentum, that develops the torque necessary to handle such situations. Heavy-duty, rugged clamps also prevent mast slippage that can develop under these conditions.

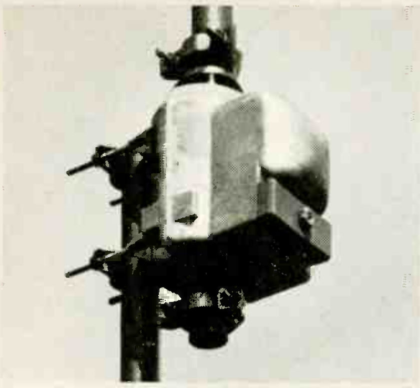
These new RCA rotators have the non-slip ruggedness of a main drive gear that's part of the shaft, meshed to a rugged worm drive.

RCA's exclusive over-running gear clutch permits motor momentum to develop before turning the mast—assuring the torque that is necessary to move heavy loads. You'll like its easy installation. The terminal board cover has an attached captive thumb nut. Weather resistance is assured by a plastic shield. High strength, light-weight aluminum housing results in less load on the supporting mast.



Rotator control is solid-state designed, to prevent mechanical wear and synchronize with drive unit.

RCA's rotator control unit was designed to please the decor-conscious housewife, as well as the family's TV fans. The RCA 707 is completely electronic too, for longer life.



Pre-turning momentum, for ice-breaking torque, is attained in RCA rotator drive unit.

Pin point directivity . . . the drive unit on the roof is always fully synchronized with the knob on the control unit. You are never in doubt as to the position of your antenna.

The "505", a manual control unit with full 360° indicating dial is also available.

Use an RCA COLOR POWER antenna and an RCA antenna rotator on your next installation. Pick them up from your RCA Distributor. They'll help you start your own revolution against call-backs.

RCA PARTS AND ACCESSORIES, Deptford, N.J.

RCA COLOR POWER UHF-VHF/FM Antenna. Model #10B930

RCA

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   For literature on products **advertised** in this issue, circle the number on the card that corresponds to the number appearing at the bottom of the advertisement in which you are interested. Use the convenient index below to locate quickly a particular advertisement.

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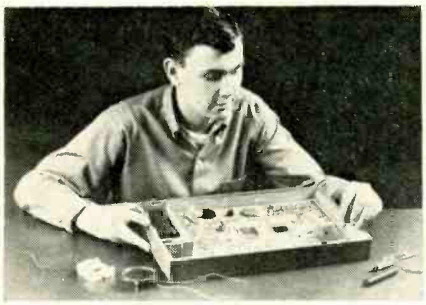
More information on new products is available free from the manufacturers of items identified by a Reader's Service number. Turn to the Reader's Service Card facing page 72 and circle the numbers of the new products on which you would like further information. Detach and mail the postage-paid card.

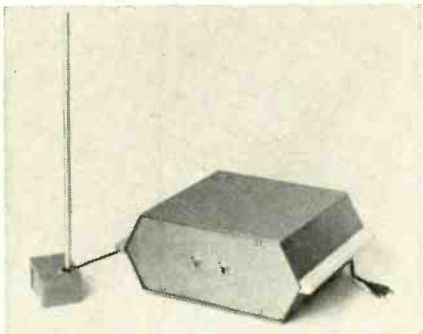
ELECTRONIC PROJECT KIT contains materials for making 50 electronic projects including a germanium crystal radio, one-transistor radio, two-transistor radio, Morse-code key, light-operated Morse-code key, home broadcasting station, 15 solar-energy projects. Youngsters learn the principles of electronics by building basic projects by breadboarding. Parts can



be moved or interchanged for additional experiments. Kit is absolutely safe; soldering is not necessary. 62-page instruction manual gives easy-to-follow directions. $17.95—**Radio Shack Science Fair Dept.**

Circle 46 on reader's service card

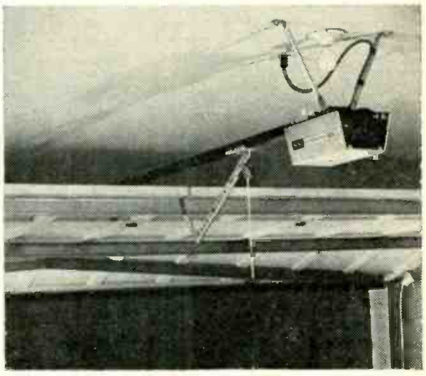
RADAR BURGLAR-ALARM SYSTEM. Watchdog alarm system is half the size, a tenth the weight of tube-type alarms. Because it contains no tubes, Watchdog



is sold with a 5-year warranty. The alarm system's basic unit can shield an area of up to 5,000 square feet. It protects property and possessions by transmitting an invisible shield of ultra-high-frequency microwaves. Sensitivity to metal allows it to be used for security or personnel screening purposes or to protect against concealed weapons. Also can trigger sirens, lights, cameras, horns, bells or buzzers, and can dial a predetermined telephone number. Internal power source keeps it in operation in case of power failure.—**Solid State Research Corp.**

Circle 47 on reader's service card

GARAGE-DOOR OPENER. *Liftmaster 600* is a solid-state, gear-driven, chain-drive garage-door opener, especially suitable for single or double sectional garage doors. Radio coding technique, with each receiver coded to discriminate against any signal disturbance except for its own distinct triple combination of signal and pause, permits unit to be utilized throughout large tracts. Features solid-state clutch, computer-logic motor control,



automatic garage-light control and instant stop control. *Liftmaster 600* has most of the features of the ultra-deluxe *Liftmaster G-6100* and retails for less money. —**Perma-Power Co.** R-E

Circle 48 on reader's service card

COMING NEXT MONTH

NATURALLY—PART II OF 20 UNIJUNCTION APPLICATIONS . . . There are only 2 parts. Part I is in this issue on page 36.

BUILD—AUTOMATIC WINDSHIELD WIPER—Pause Controller—All solid-state device uses only two semiconductors and no relays to swing the blades at their normal speeds, but only one sweep at a time. You can adjust the length of the pause between sweeps to cut down the dry runs. If your car isn't equipped with an electric windshield wiper motor, make a note of this gadget for your next car.

SOUP UP RELAY SENSITIVITY—The larger the relay the less sensitive it usually is. Large relays with an ability to respond to small signals are expensive and sometimes hard to find at your local distributor. Here's a simple, inexpensive solid-state circuit to boost relay action.

WHAT'S AN IC DECADE DIVIDER? Even if you don't know that it can accurately cut a 1 MHz signal down to 100 kHz for counting or to extend the capability of a signal generator, it can provide an electronics buff with an interesting project.

PSYCHEDELIC SPOTLIGHTS—Simple construction project tends to put your eyes where your ears are. For commercial, crowd-stopping applications or for the groovy set, this gizmo automatically varies light intensity in step with the loudness of music or commercial.

MR. HALL AND HIS EFFECTS are brought to light in this painless presentation. Many 19th century findings are still valid in our solid-state world and are being applied in new, sophisticated ways. Magnetic devices are here to stay.

KNOW YOUR COLOR TV BLANKERS—Tells how retrace lines are kept in the dark. Different circuits used, their troubles and the correction of these troubles when they arise are described.

TVI TRAPS—Another clear picture from Matt Mandl. Proper adjustment of traps is essential to keep audio signals out of the video and to keep the herringbones from showing up because of interference from other TV channels and other man-made noise. The more sensitive the TV front end and the more stations on the air, the more you have to have your traps properly set.

CAPACITOR TRANSDUCERS—What you should know about them and their related circuits. Tells how they work, how you should work with them, and their applications in home and industry.

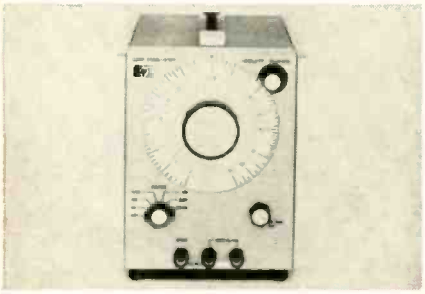
NEED A SPECIAL POWER SUPPLY? Sometimes you have to roll your own, right from design to construction. Follow an engineer's step-by-step procedure to come up with a desired voltage and current source with a desired amount of regulation and filtering. Described is a unique solid-state configuration having a very large capacitor filter action, but without the large capacitor.

PLUS—Still more feature articles, news and departments. Don't miss

July Radio-Electronics

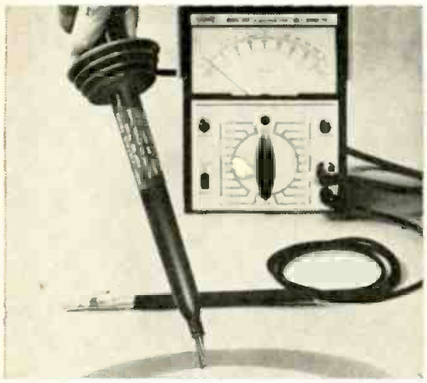
NEW TEST EQUIPMENT

RC WIEN-BRIDGE OSCILLATOR, *Model 204C.* Frequency response: better than 0.5% or 0.05 dB; frequency range: 5 Hz to 1.2 MHz; distortion: 0.1%; long-term frequency stability: 0.02%; amplitude stability: 0.2%. Amplifier frequency response is independent of transistor parameters, so transistors may be changed without recalibration. Can be synchronized with a signal or phase-locked to a frequency standard. $250 in ac line-operated form. Optional battery power supply $15, rechargeable battery power supply is $35 more than basic version. All are field interchangeable.—**Hewlett-Packard**



Circle 49 on reader's service card

HIGH-VOLTAGE TEST PROBE, *Model 72-265.* Permits user to perform accurate and safe high-voltage checks on all color and black-and-white receivers. Three ranges can be checked with the probe: 40 kV dc, 16 kV dc, and 4 kV dc. Advantages of this probe (that has been designed to work with the Triplett Model 600 TVO) include: lower current drain: a miniature spring-tensioned hook at the end of tip for hands-free high-voltage circuit tests and positive contact with circuit tested. Comes with 44" heavily insulated, high-voltage cable. Tip of probe is nickel-plated to insure better conductivity and longer life. $25.20—**Triplett Electrical Instrument Co.** R-E



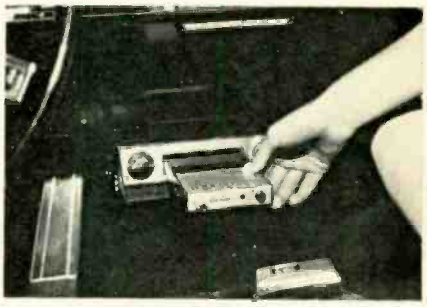
Circle 50 on reader's service card

NEW AUDIO EQUIPMENT

AM/FM RADIO, *Carmel, Model RE-6125.* Electronic tuning mechanism permits listener to tune in automatically any station by depressing a tuning bar. Distant/local sensitivity switch filters out multiple-station interference. Unit is housed in a low-profile black cabinet with silver trim, and comes with earphone and external speaker jack. $69.95—**Matsushita Electric Corp. of America**

Circle 51 on reader's service card

AM/FM CARTRIDGE TUNER. Adds AM/FM radio to any 4- or 8-track car stereo system. It slips in and out of the tape deck like any regular 4- or 8-track cartridge. Uses the existing amplifiers and stereo system to produce full sound comparable to stereo for AM and FM broadcasts. It is the only solid-state AM/FM cartridge tuner with afc on the market today. Unit is compact, easy to handle and attractively designed. Sells for under $50. —**GW Electronics, Inc.**



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PREAMPLIFIER, *Model ACP-1.* Can be used with any tape recorder for automatic control of recording level and with any PA system for maintaining constant output level and eliminating feedback. A low-noise high-impedance FET input stage is utilized in the 5-transistor 1-diode circuit. Compression range is 30 dB. Frequency response extends from 20 to 20,000 Hz.

Compressor–preamp installs easily in the microphone line of any tape recorder PA system, amateur radio or CB transmitter. —**Caringella Electronics, Inc.**

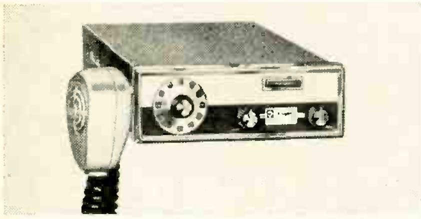
Circle 53 on reader's service card

SPEAKER, *Model AP-15.* 15-watt horn is compact and boasts a sound level of 121 dB with 110° dispersion. Vari-Tap Control/Connect Center eliminates the soldering iron as an installation tool. Only a screwdriver is required to mount and connect. Diaphrams may be replaced in the field with no soldering. Speakers carry lifetime guarantee against electro-acoustical failure when operated to specifications. The 8-ohm Model AP-15 lists at $33.25.—**Atlas Sound** **R-E**

Circle 54 on reader's service card

New Communications Equipment

CB TRANSCEIVER, *Knight-Kit Safari IV* is a versatile two-way CB radio in kit form, for base, mobile or portable use. Solid-state compact unit mounts quickly



in car, truck or boat and is easily portable. Twelve-channel, 5-watt unit features a superhet receiver with adjustable squelch to silence speaker between calls, silicon transistors, and built-in series-gate noise limiter. Sensitivity: 1.5 mV for 10 dB S/N ratio; adjacent-channel rejection: over 30 dB. Output impedance: matches 50-ohm antennas; modulation, 80% min. Power output: 3 watts. $79.95. Accessories available.—**Allied Radio Corp.**

Circle 55 on reader's service card

VHF CONVERTER, *Type CP.* Fully transistorized unit is self-contained with 18" telescoping antenna. Picks up vhf signals and converts them to the broadcast band. Receives input signals on a single channel within the 25–50, 108–136 and

148–175-MHz ranges. Additional channels may be tuned in on the broadcast receiver over a range of approximately 250 kHz. No connection between the monitor converter and a pocket or tabletop broadcast receiver is necessary. The combination will receive either AM or FM signals. $21.95, less batteries.—**AMECO, Div. of Aerotron, Inc.** R-E

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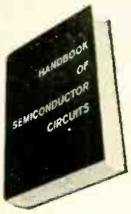

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Circle 110 on reader's service card

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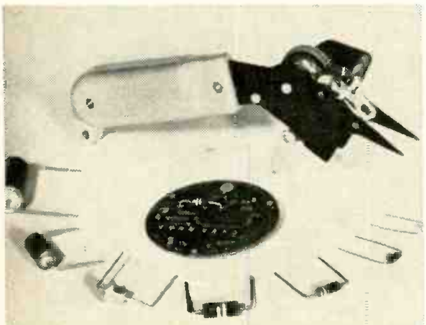
Circle 57 on reader's service card

LEAD BENDER, *Model N-300.* Hand tool eliminates measurement and trial-and-error bending of component leads. Match pointers with eyelet holes in circuit boards by spinning knurled wheel with

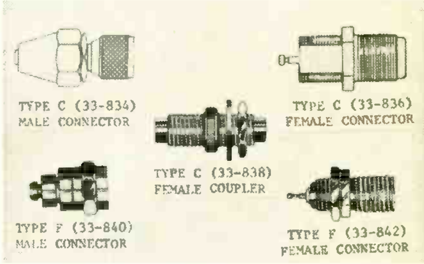


thumb, and unit automatically spaces bends for insertion of component into board. Can be used on resistors, capacitors, diodes, transistors, inductors, etc. up to ½" × ½" with maximum distance between inside of bends of 1.725". Made of anodized aluminum for maximum strength and wear, the unit sells for $29.50.—**Harwil Company** **R-E**

Circle 58 on reader's service card

New Antenna Equipment

TV ANTENNA FITTINGS. Solderless coaxial cable TV antenna fittings are available in two types (Type C and Type F) to ease all commonly encountered antenna hookup problems. Type C fittings include a male and female connector for



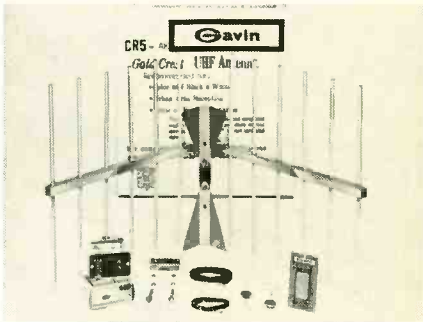
cable splicing or chassis feedthrough applications. Type F fittings adaptable to the newer cable antenna systems provide a male connector for crimp-on connection to the incoming cable, and a female connector, complete with hardware for chassis mountings. Both types are designed for use with 75-ohm RG-59/U, cable.—GC Electronics

Circle 59 on reader's service card

SCHOOL DIRECTORY

Circle 112 on reader's service card

UHF ANTENNA ADDITIONS. *Add On Kits* make it easy to add uhf to any existing vhf installation. Each kit contains a uhf antenna; a coupler to combine the two antennas into the existing down-lead; two lengths of twin-lead, cut to correct



length and with connectors attached; two snap-on standoff insulators; an indoor uhf/vhf/FM adapter to provide separate twin-leads for the uhf and vhf terminals of the TV set, and complete, easy-to-follow instructions. *Model CR-5AK* kit uses a 13-element corner reflector antenna—$15.95; *Model J-1AK* and a 7-element uhf Yagi—$15.50; *Model J-3AK*, 20-element uhf Yagi—$21.50.—Gavin Instruments. Inc. R-E

Circle 60 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 72 and circle the numbers of the items you want. Then detach and mail the card. No postage required!

ANTENNAS. Two brochures describe antennas for portable and console TV's, etc. (Indoor) and vhf/uhf/FM antennas and accessories. Models described in the UHF/VHF/FM booklet are *CR-*, *J-* and *FM series*. The second brochure describes indoor *Console* and *Monitor* series. Both brochures list prices and specs.—**Gavin Instruments, Inc.**

Circle 61 on reader's service card

FILTER DESIGNS. 12-page manual provides important engineering data, featuring descriptions of many of the low-, high-, and bandpass filters used in electronics today and how to specify them. Book illustrates typical filters in easy-to-understand language.—**Nytronics, Inc.**

Circle 62 on reader's service card

PRICE SCHEDULE. Catalog lists all electron tubes that *Unity* markets and that are manufactured by all leading tube manufacturers. Loose-leaf style makes for easy filing. 47 pages chock full of information.—**Unity Electronics**

Circle 63 on reader's service card

INDICATOR LIGHTS, ***Catalog L-68.*** 32-page catalog features photographs, line drawings and detailed specs on more than 60 indicator lights —ranging from 1" diameter to microminiature neon EMI-suppressed designs. Lamp-selection guide provides information for finding the right indicator assembly for any application.—**Marco-Oak, Div. Oak Electro/Netics Corp.**

Circle 64 on reader's service card

VOMs AND TEST EQUIPMENT, ***Catalog 52-T.*** 12-page catalog is fully illustrated and detailed with electrical and mechanical characteristics of newest and most popular portable electrical and electronic test instruments the company manufactures. Price list and ordering information are also included.—**Triplett Electrical Instrument Co.**

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SPRING '68 BROCHURE AND BULLETIN. Bulletin of 36 pages describes courses and how to enroll, provides useful information for the person interested in an electronics career or for the technician who wants to brush up on a given topic. Brochure is specifically for those who wish to obtain an FCC license.—**Grantham School of Electronics**

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Circle 68 on reader's service card

83

UNUSUAL TV TROUBLES

Shortcuts don't always save time

By MATTHEW MANDL

THE SERVICE TECHNICIAN IS CONfronted with an increasing variety of television receivers. Once the tube-type black-and-white console was the only model available. Now we have solid-state portables in b-w as well as color; consoles in both tube and solid-state types, in color or b-w, and an increasing number of miniatures.

All these still have the run-of-the-mill troubles which we can correct with routine procedures. Because of the wide variations in models, however, a greater number of unusual problems occur. These can become quite time-consuming if we apply ordinary servicing procedures. This is particularly true of multiple-symptom defects. These can be misleading because they *seem* to pinpoint faulty circuits—which later prove to be all right.

When two troubles are present simultaneously, try to find two or more sections of the receiver which could be causing them. First check the section which takes the least time, even though another may seem the more obvious trouble source. By saving for last the circuits which take longer to check, you often save time with unusual cases.

Thus, with no picture or sound, the trouble seems to be prior to the video detector. Before checking the tuner and video i.f. sections, however, check tubes or transistors in the audio and video amplifier circuits. It may be unusual, but a tube can go dead in the audio section *at the same time* that a video-amplifier tube fails.

Shortcut methods are always useful in dual-symptom troubles. If both sound and video troubles are present, make a quick check of the video-detector output, as shown in Fig. 1. A scope will display the detected picture signal at the output of the video detector, thus indicating that the signal is not lost in either the set's tuner or in the video i.f. amplifier stages.

Earphones can be used to pick up the characteristic video signal sound, to prove the point. If you aren't familiar with the particular sounds of video signals, try the earphone check on several receivers in good working order until you can recognize them.

This method was put to good use in the case of a Philco-Ford 19-inch set (17J28 chassis) which had poor sound as well as sync instability. A scope placed at the output of the detector module shown in Fig. 2 indicated good video-signal detection. The schematic showed that a 6GH8-A tube was used as both a sound i.f. amplifier and the sync separator, hence could easily produce both symptoms simultaneously. A tube checker showed poor emission for *each half* of the tube; a new tube corrected both of the troubles.

The extent to which dual symp-

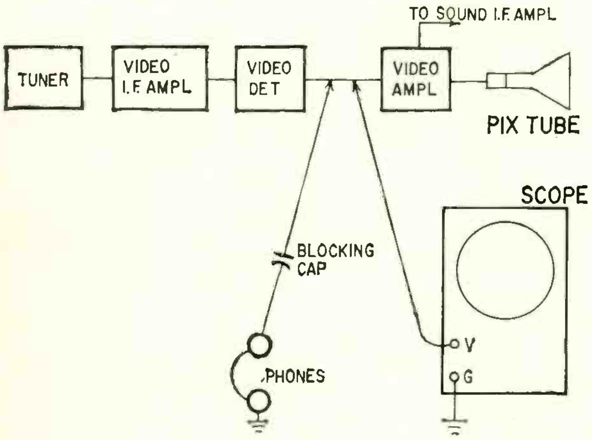


Fig. 1—How to make a quick check of the rf and i.f. sections. Scope should show the detected video plus sync; phones reveal the characteristic sound of 60-hertz sync buzz plus the video hiss and hash.

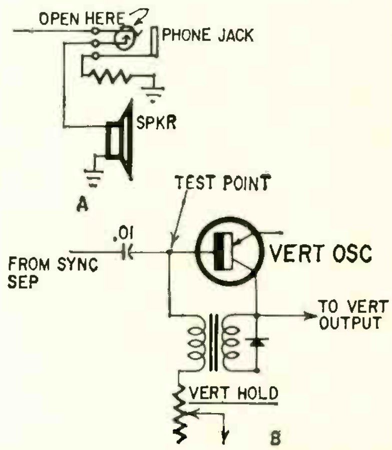


Fig. 3-a—Faulty phone jack disrupted audio to speaker. b—Vertical oscillator in Silvertone set. Output lead should come from bottom of transformer.

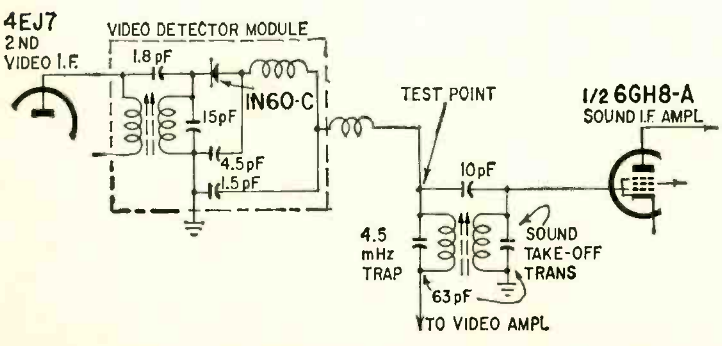


Fig. 2—Scope at test point showed good video signal, eliminating pre-detector stages as cause of dual symptoms. Weak multi-function 6GH8 tube caused problem.

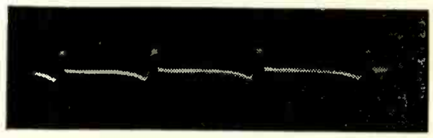


Fig. 4—Waveform at the base of the vertical oscillator transistor shown in Fig. 3-b. The p-p amplitude was low and the signal jittery. Vertical sync in the set was unstable. The coupling capacitor from the sync separator was slightly leaky.

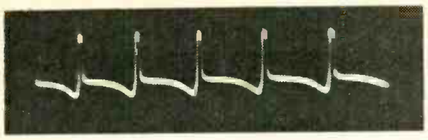


Fig. 5—After the capacitor was replaced, vertical sync was okay. The vertical test-point signal increased in amplitude; compare this with the weak signal in Fig. 4.

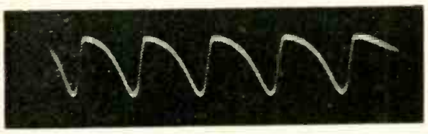


Fig. 6—Different receivers have different methods of obtaining and using vertical sync. This is the sync waveform input to the vertical oscillator in RCA's KCS153 solid-state television chassis.

Fig. 7—An excessively dark picture was the symptom; brightness and contrast controls had no effect. See circuit in Fig. 8 for the cause of the problem.

toms can be entirely unrelated was shown in a Silvertone solid-state receiver (chassis 564-10000) in which both the sound and vertical sync were affected (Fig. 3-a). This set has an earphone jack, for private listening. When earphones were plugged in, the sound could be clearly heard. The trouble was found in the phone jack; it did not connect the speaker after the phones were removed.

For the vertical, good sync could not be obtained for any setting of the controls. The scope was again used for a quick check. At the test point shown in Fig. 3-b, the scope pattern of Fig. 4 was obtained. The peak-to-peak amplitude was only 5 volts rather than the 18.5 called for in the service notes. In addition, when the scope waveform was expanded horizontally, a dual-trace pattern was visible, showing an intermittent change in signal amplitude. Because the sync separator signal appearing to the left of the 0.01-μF coupling capacitor had normal amplitude, the capacitor was pinpointed as the faulty item. With a new capacitor,

85

the waveform appeared as shown in Fig. 5, with full amplitude and a single trace when expanded. The vertical sync was restored to a normally stable condition.

Don't expect to get the pattern shown in Fig. 5 at the base of other solid-state oscillators. Check the service notes for the proper waveform. In an RCA 12-inch solid-state receiver (chassis KCS153) the vertical oscillator input waveform appears as shown in Fig. 6. It resembles a "mirror-image" sawtooth signal, quite different from the waveform shown in Fig. 5.

Double troubles

Sometimes a single symptom can be caused by dual defects, such as occurred in a Westinghouse V-2486 receiver. The picture was abnormally dark (Fig. 7) and could not be corrected with either the brightness or contrast controls. Half a 6CL8A is used for agc and the other half as the sound limiter. The tube was checked and the agc section was found defective. A new tube did little, however, to correct the trouble—even though agc voltages were now normal.

Next the contrast and brightness controls were checked; both showed smooth resistance change. With the set turned on, the bias voltage between picture-tube control grid and cathode was checked and found to be abnormally high. With a vtvm placed from the cathode test point (Fig. 8) to ground, voltage ranged from approximately 75 to 140 when the brightness control was varied. Normally, the range is about from 10 to 140 volts for this receiver. The cathode therefore had a high positive voltage, thus making the grid highly negative. The result was reduced beam current and an excessively dark picture.

A common cause of this trouble is a leaky coupling capacitor, which applies some of the 145 volts from the video-amplifier plate circuit to the picture-tube cathode. When the 0.22-μF capacitor was replaced both the contrast and brightness controls operated in normal fashion to restore proper picture shading.

Improving stability

In black-and-white sets, circuit instability is usually confined to the sweep sections. If voltages and components check out all right, a new tube or transistor will generally cure the trouble. If not, sync-separator circuits must be rechecked and the horizontal system realigned. In color receivers the same holds true, except that instability may also occur in the 3.58-MHz oscillator, color killer or burst-amplifier circuits.

The 3.58-MHz oscillator is crystal-controlled and instability is typically the fault of an intermittent tube. Unstable color sync, where color intensities vary, may be caused by a defective burst-amplifier tube. The color-killer tube should also be checked for possible contributing effects. In some instances a single-envelope dual-function tube such as the 6GH8A is used for both the killer and burst amplifier, as shown in Fig. 9 (partial schematic of RCA CTC19 chassis).

Where a 6GH8A tube is used as the burst amplifier. sometimes several new tubes have to be tried before good results are obtained. As a color receiver ages, component values may change very slightly and the circuit become more critical. Consequently, slight variations in tube characteristics may be sufficient to make a difference between two new tubes.

In one instance, stability could not be achieved, even with a new tube. It appeared that a careful check of component values would be necessary to bring the circuit to peak performance. Instead, a 6KE8 tube was tried; it produced excellent stability. The

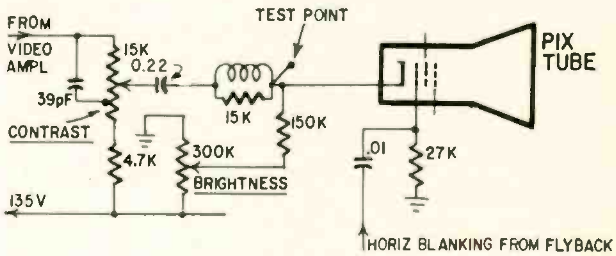


Fig. 8—The dark, uncontrollable picture of Fig. 7 was caused by a leaky coupling capacitor (0.22 μF) making the CRT cathode positive enough to nearly cut off the gun's beam current.

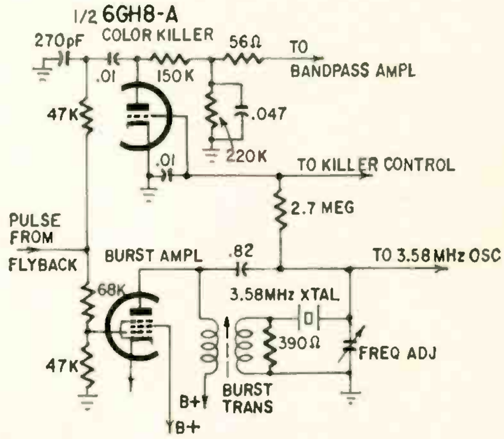


Fig. 9—A defective 6GH8A used as color killer and burst amplifier disrupted both functions. Due to changing values in critical circuits, sometimes several new tubes must be tried.

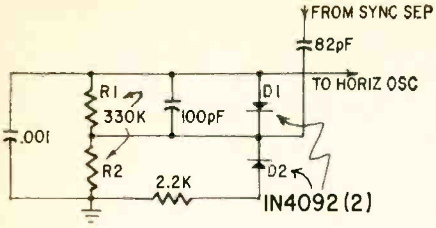


Fig. 10—In a phase detector, the resistors must be matched in value, as must forward and reverse resistances of the diodes.

6KE8 is an almost exact replacement for the 6GH8; each is a medium-mu triode and sharp cutoff pentode.

The pentode section of either tube is used for the burst amplifier of several receivers. In the 6KE8, plate resistance is lower than in the 6GH8. Also, the 6KE8 has higher transconductance; hence in this circuit the 6KE8 increases burst-signal amplitude and tends to improve critical color sync stability.

After tube replacement, recheck the tint control range to make sure a good color range is available from a blue-red tint to flesh tones. If not, readjust the burst-amplifier phase transformer at the plate output shown in Fig. 9. A half turn is usually sufficient to restore good tint range.

An unusual case of instability was found in a Sylvania DO5 color chassis, where the horizontal system was critical even after careful tube and component checking. Since good sync separator pulses were supplied to the horizontal system, suspicion centered on the horizontal phase detector shown in Fig. 10. Resistors and diodes checked all right. So did the 100-pF capacitor used in the upper section to obtain a perfect balance (because of the slight unbalance set up by the grounding of the lower portion of the circuit).

It was noticed that resistor R1 checked out about 20 ohms higher than its rated 330,000 ohms, while R2 read about 2000 ohms lower than it should. In addition, the forward resistance of diode D1 was some 30 ohms lower than D2, though the reverse resistance for both checked out all right. Evidently the slight variations between the four components were sufficient to upset the critical balance necessary for good sync stability. Resistor and diode replacement with matched units cured the trouble. The important point is that even though resistors are within the required 10% or 20% tolerance, and diodes check out all right with respect to forward and reverse resistance, replacement should be undertaken when other tests fail to disclose any serious faults. **R-E**

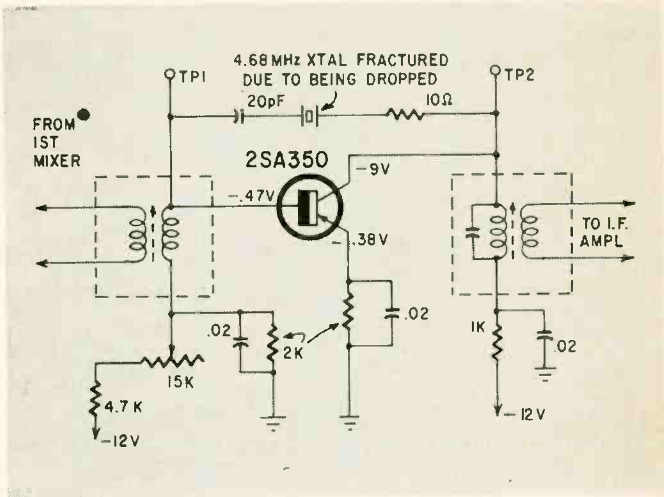
87

CB Troubleshooter's Casebook

Compiled by
Andrew J. Mueller*

Case 1: No receive. Transmit is okay.

Common to: Hallicrafters **CB-8, CB-18, CB-181.**

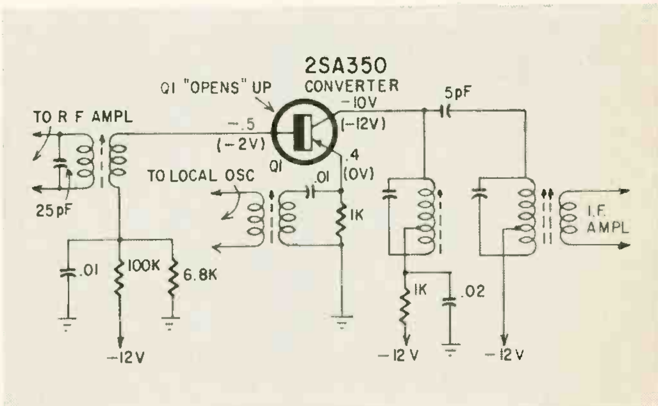


Remedy: Replace the 4.68-MHz crystal.

Reasoning: When the transceiver is accidentally dropped, the 4.68-MHz crystal fractures. This causes the unit to go dead except for some slight thermal noise. This can best be found by scoping the local oscillator at TP1 or TP2.

Case 2: No receive.

Common to: Midland **13-133B.**



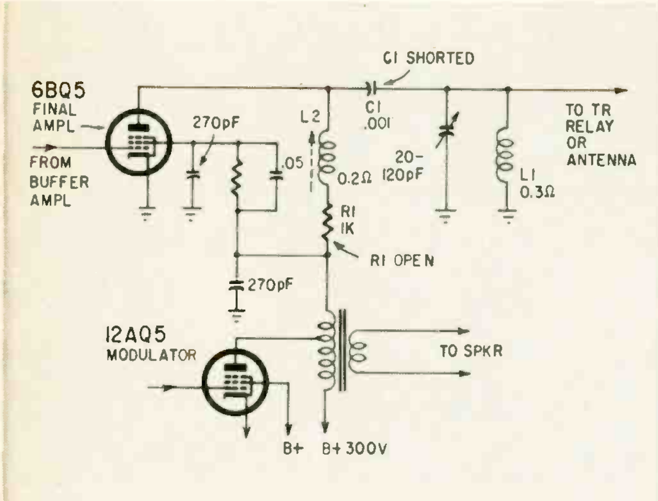
Remedy: Replace mixer transistor Q1.

Reasoning: In a majority of cases we find that Q1 "opens up." Voltage checks will usually reveal this fault. The first thing to do is to substitute the transistor.

* Service manager, Tel-Air Communications, Inc., Pewaukee, Wis.

Case 3: Transceiver blows fuses first; then it receives but does not transmit.

Common to: B & K **Cobra Cam 88.**

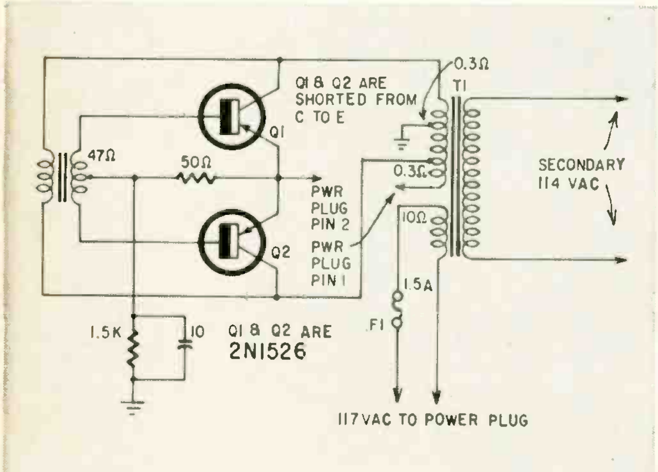


Remedy: Replace R1 and C1.

Reasoning: When C1 shorts, B+ is applied through R1 to the antenna circuit and L1. This shorts out the B+ line until R1 opens. Be sure to replace C1 with a 1.6-kV or higher-voltage disc capacitor to prevent future trouble.

Case ~~5~~ 4 Unit blows fuses and/or the power transformer smokes on 117 Vac. It also blows fuses on 12 volts dc.

Common to: Eico **779A**



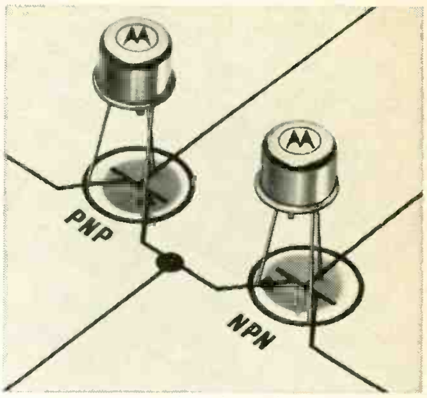
Remedy: Replace Q1, Q2 and possibly the power transformer.

Reasoning: Q1 and Q2 sometimes short after a lightning storm. This shorts out the secondary of T1, causing it to smoke if F1 is larger than it originally was. The transistors will also short out the A+ line if the unit is operated on dc. Use **only** the fuse called for in the instructions. this can save your set as well as your pocketbook. **R-E**

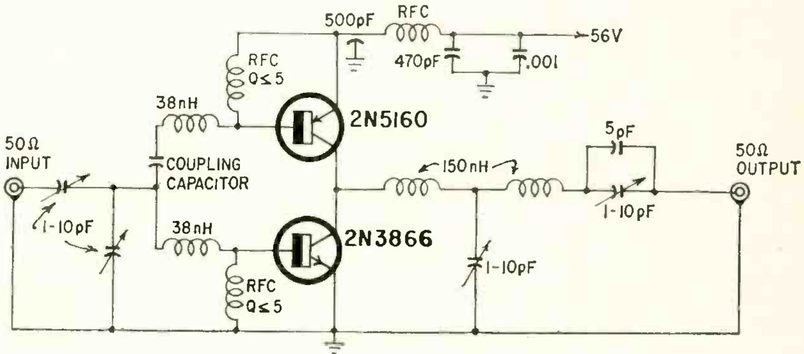
89

NEW TUBES AND SEMICONDUCTORS

FIRST PNP SILICON TRANSISTOR FOR LARGE-SIGNAL VHF/UHF



Motorola has introduced the 2N5160 large-signal silicon pnp transistor as the forerunner of a series of units complementary to the existing series of npn silicon devices. The 2N5160 is the complement of the 2N3866 for use in pnp/npn complementary vhf and uhf amplifiers. Another application will be nonsaturated switches handling currents higher than

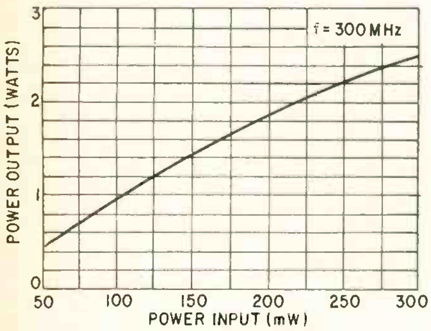


present pnp switches.

The minimum power gain of 8 dB and minimum power output of 1 watt at 400 MHz make this transistor ideal for use in Class-A, -B and -C amplifiers and drivers operating up to 800 MHz. The 2N5160 is fabricated using a multiple-emitter overlay technique and comes in a TO-39 package. Pertinent specifications are:

$$BV_{CEO(sus)} = 40 \text{ Vdc}$$
$$f_T = 500 \text{ MHz min. @}$$
$$I_C = 50 \text{ mA}$$
$$C_{cb} = 4 \text{ pF @}$$
$$V_{CB} = 28 \text{ Vdc}$$

The diagram shows the 2N5160 and 2N3866 in a 300-MHz complementary amplifier and the chart shows



the relationship between input driving power and power output. **R-E**

Transformer Preamp Design
(continued from page 35)

$$R_e = \frac{26}{I_e} \text{ approximately} \quad (12)$$

$$= \frac{26}{.0407} = 640 \text{ ohms}$$

I_e is emitter current in mA and is the sum of I_c and I_b. Substituting in equation (11):

$$R4 = \frac{107{,}000 - (640 \times 56)}{56}$$

$$= 1300 \text{ ohms} \quad (13)$$

Use 1500 ohms, a standard value. Then:

$$R_I = 56(1500 + 640) \quad (14)$$

$$= 120{,}000 \text{ ohms}$$

That's higher than we aimed for and it's because we used a stock, rather than a computed, value for R4. And, from (3):

$$R_{AI} = \frac{1}{\frac{1}{150K} + \frac{1}{180K} + \frac{1}{120K}}$$

$$= 48{,}700 \text{ ohms} \quad (15)$$

which is close enough.

If you want to work it out, you will find each input channel is terminated in about 46,400 ohms. This is below 47,000 ohms because our network resistances are a little smaller than computed.

Ordinarily, R3 is chosen to put the collector voltage, V_c, at about half the supply voltage. This gives it the maximum leeway to swing both negative and positive. In this case, output is only a few millivolts, so no matter where V_c falls, it will have plenty of room to swing. The determining factor for R3 here is the amplifier voltage gain, A_v. Our objective is 5.

$$A_v = 5 = \frac{R_L}{R_e + R4} \quad (16)$$

$$= \frac{R_L}{2100}$$

where R_L is R3 and the following amplifier input resistance of 47,000 ohms in parallel. Solving for R_L in (16) above:

$$R_L = 5 \times 2100 \quad (17)$$

$$= 10{,}500 \text{ ohms.}$$

And.

$$R3 = \frac{47{,}000 \times 10{,}500}{47{,}000 - 10{,}500} \quad (18)$$

$$= 13{,}500 \text{ ohms.}$$

Values within 10% are 12,000 and 15,000 ohms. Use 15,000, which will make A_v about 5.4.

V_c is determined by:

$$V_c = 1.5 - (1.5 \times 10^4)(4 \times 10^{-5})$$

$$= 0.9 \text{ volt} \quad (19)$$

To explain V_b = 0.6 V, which we used earlier: The emitter–base voltage in a silicon transistor is about 0.6 volt in the usual case. Here, because emitter current is so low, it is a little less, and 0.55 is very close. So:

$$V_b = 0.55 + V_e \quad (20)$$

And at 40.7 μA emitter current:

$$V_e = R4 \times I_e \quad (21)$$

$$= (1.5 \times 10_3)(4.07 \times 10^{-5})$$

$$= 0.6$$

So $V_b = 0.55 + .06 = 0.61$

This looks like a lot of figuring for a plain little amplifier, but this is really a simplified approach and well worth the effort. The amplifier will work beautifully the first time.

What if your transistor has twice or half as much gain? Work it out and see what the effect is! Remember, V_{eb} stays essentially the same.

R_e, in equations (11) and (12), needs a little more comment. As shown by equation (12), its value varies with emitter current. In our example it was 640 ohms. Now suppose that emitter current was 2 mA. Then

$$R_e = \frac{26}{2} = 13$$

Quite a difference. When it gets down into this range, there is something else to consider: base bulk resistance. In a high-performance transistor a value of 5 ohms is close. With a low-performance transistor it may go to 30 ohms. This must be added to R_e as computed above.

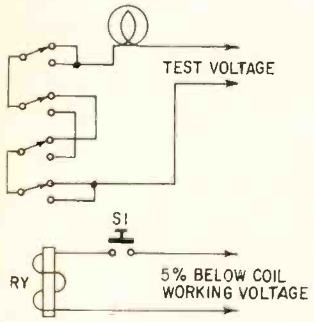
Back to our amplifier. Construction is strictly noncritical. The only precaution is to completely enclose the entire unit in a metal case. The amplifier is easily assembled on a scrap of perforated board.

As for cell life, I built my unit about 5 months ago and used a penlight cell that was just lying around. It measures 1.46 volts now. If you're fussy, you might change the cell every year whether it needs it or not. [A 50-μF, 3-volt electrolytic connected across the battery will help keep the amplifier's gain constant as the battery's internal resistance rises with age.—*Editor.*] **R-E**

TRY THIS ONE

CHECKING MULTIPOLE RELAYS

Servicing a piece of complex industrial equipment, I was faced with the problem of checking the contacts on a number of multipole relays. By using the circuit shown, I was able to check all of



a relay's contacts simultaneously.

When S1 is open, the lamp indicates the condition of the normally closed contacts. Closing S1 energizes the relay and makes the normally open contacts. The circuit is wired so that the lamp is in series with first the normally closed and then the normally open contacts.

If the lamp does not light, it indicates that at least one set of contacts is bad. The lamp does not identify the faulty contacts but, in a relay of this type, it is frequently cheaper to replace the relay than to have the equipment out of service while you try to repair the contact.

The voltage applied to the relay should be about 5% lower than the coil's normal working voltage, so if the relay is sluggish it will show up in the test. The lamp and its voltage should be selected so the contacts handle close to their maximum current.—*Thomas L. Bartholomew* **R-E**

"Now if I can just pull the picture down a little, I've got it made."

EIA SEEKS EASING OF AMATEUR RADIO LICENSE REQUIREMENTS

The Electronic Industries Association's amateur radio section has petitioned the FCC to amend its rules and regulations regarding Novice Class radio licenses in order to encourage more young people to participate in amateur radio use. Among the changes urged are a five-year license period, slower code speed requirements and use of the 145-147 MHz band.

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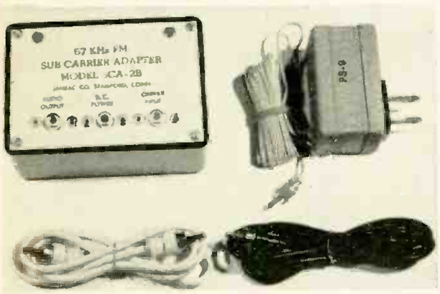

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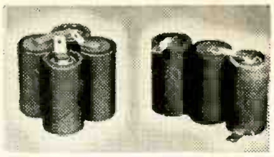

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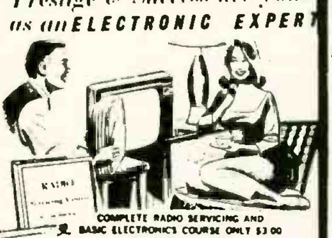

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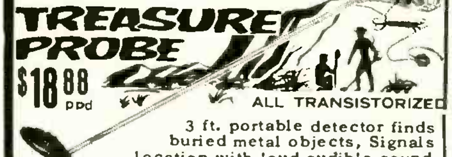

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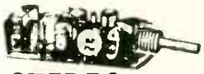

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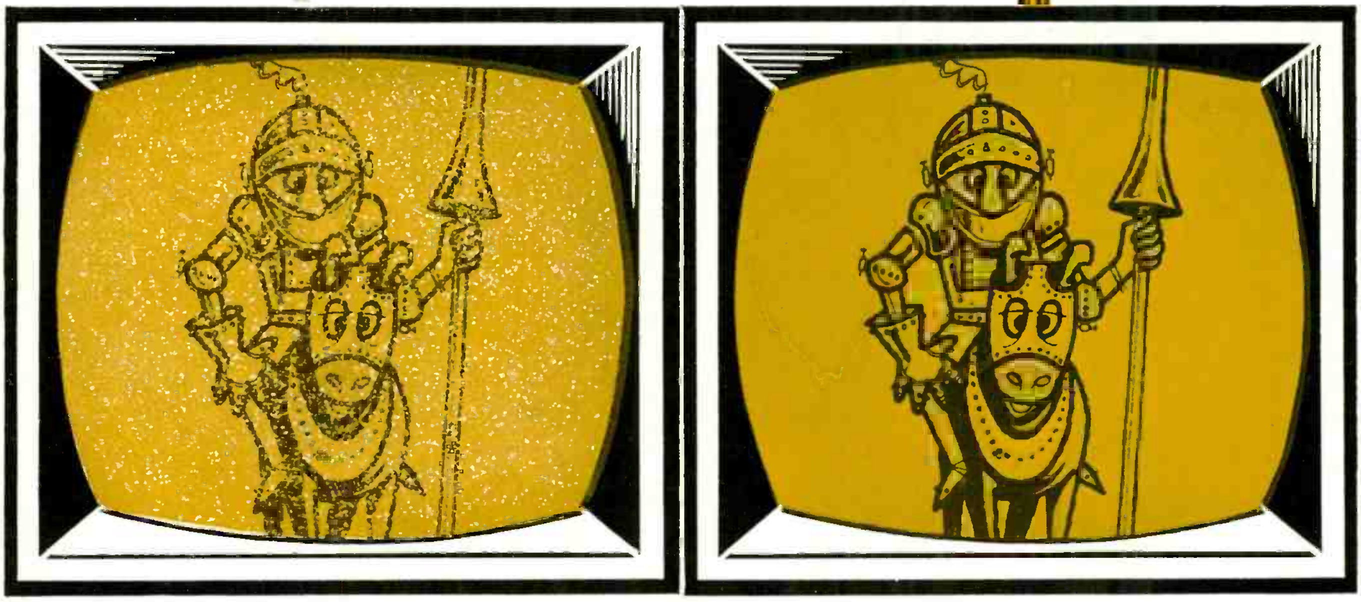

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