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JULY—AUGUST 75c

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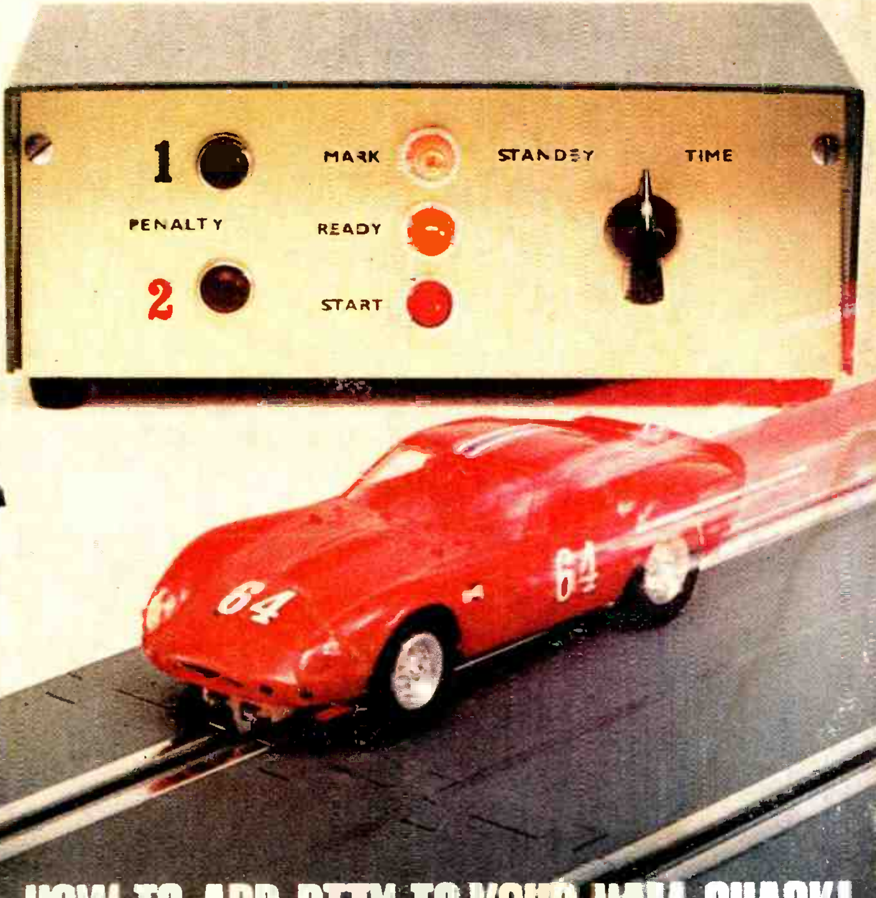

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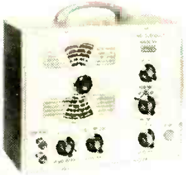

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Model ST70 70-Watt Integrated Stereo Amplifier. Best buy of highest ranked stereo amplifiers according to independent testing. **$99.95 kit, $149.95 wired.** ST40 40-Watt Integrated Stereo Amplifier, **$79.95 kit, $129.95 wired.** ST97 Matching FM MPX Stereo Tuner, **$89.95 kit; $139.95 wired.**

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ELEMENTARY ELECTRONICS

JULY-AUGUST 1966

THEORY

CONSTRUCTION

FEATURES

DEPARTMENTS

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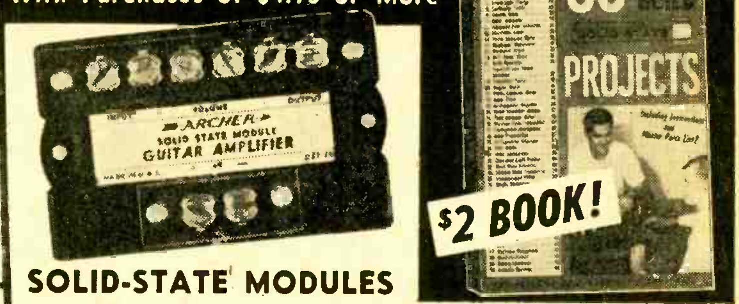

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(G) **Power Amplifier Module:** the ideal amplifier to use with tuners, microphones, paging systems, or as signal tracer. 27-253 ...... 4.95

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Optional Accessories for Modules Above

Cat. No.	Description	Key Letters	Each
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23-465	"C" Cells (4 required)	A	.14
27-1437	Battery Holder (2 required)	A	.25
23-006	6V Lantern Battery	B, C, D, E, G, H	1.05
27-258	AC Power Supply	B, C, D, E, G, H	1.95
27-259	Rectifier-Electronic Filter	B, C, D, E, G, H	3.95
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27-1264	100-Ft. Speaker Wire	C	2.39
33-100	Lapel Microphone	C, F	1.89
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ELEMENTARY ELECTRONICS

JULY-AUGUST 1966 Vol. 2 No. 3

Dedicated to America's Electronics Experimenters

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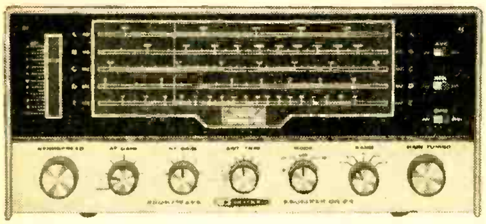
Deluxe 5-Band Shortwave Radio!



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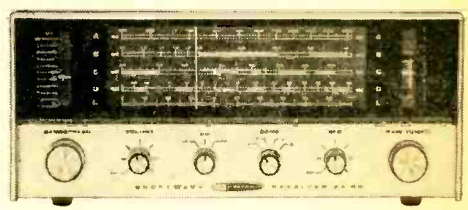

4 bands cover 550 kc to 30 mc. Built-in 5" speaker; bandspread tuning; signal strength indicator; 7" slide-rule dial; logging scale; BFO control for code & SSB; 4-tube circuit plus 2 rectifiers; noise limiter; external antenna connectors; Q-multiplier input; gray metal cabinet; AM antenna. 15 lbs.

Kit GR-64
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23-Channel 5-Watt Solid-State CB Transceiver!

Kit GW-14
$89[95]

Assembled GWW-14
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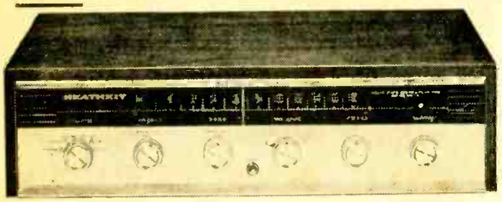
23 crystal-controlled transmit & receive channels for utmost reliability. Low battery drain . . . 0.75 A transmit, 0.12 A receive. Only 2⅞" H x 7" W x 10½" D . . . ideal for car, boat, any 12 v. neg. gnd. use. "S" meter, adjustable squelch, ANL, built-in speaker, PTT mike, aluminum cabinet. 8 lbs. Optional AC power supply, Kit GWA-14-1, 5 lbs. $14.95. Optional 6 to 12 v. DC converter, Kit GWA-14-4, 3 lbs. . . . $14.95. Special 23-Channel Crystal Pack (46 crystals), GWA-14-2, reg. $137.50 value, only $79.95. CB crystals $1.99 each with any Heathkit CB transceiver order.

Other 242 In FREE Catalog!

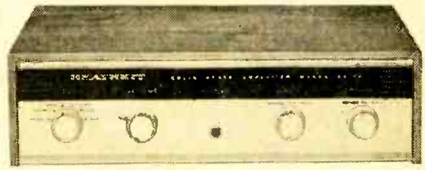
New 30-Watt Transistor FM Stereo Receiver



Kit AR-14 **$99.95** (less cabinet)

31 transistors, 11 diodes for transparent transistor sound; 20 watts RMS, 30 watts IHF music power @ ±1 db, 15-60,000 cps; wideband FM/FM stereo tuner, two pre-amplifiers, & two power amplifiers; compact 3⅞" H x 15¼" W x 12" D size. Assemble in around 20 hours. Mounts in a wall, or optional Heath cabinets (walnut $9.95, beige metal $3.95). 16 lbs.

Best Hi-Fi News of '66 . . . New Low Cost Transistor Stereo Twins!



New Transistor FM/FM Stereo Tuner

Assembles in only 4 to 6 hours! 14 transistor, 5 diode circuit; 5 uv sensitivity; less than 1% distortion; phase control for best stereo; 4-stage IF; filtered outputs; automatic stereo indicator light; preassembled & aligned "front-end". Install in a wall or either Heath cabinet (walnut $7.95, beige metal $3.50). 6 lbs.

Kit AJ-14 **$49.95** (less cab.)

Matching 30-Watt Stereo Amplifier

Assembles in 10 hours! 17 transistor, 6 diode circuit 20 watts RMS, 30 watts IHF music power @ ±1 db from 15-50,000 cps; Handles tuner, phono, auxiliary. No audio transformers . . . assures lower distortion, minimum phase shift. Install in a wall, or either Heath cabinet (walnut $7.95, beige metal $3.50). 10 lbs.

Kit AA-14 **$59.95** (less cab.)

Deluxe 6-Transistor AM Portable!

Kit GR-24 **$28.25**

Surpasses miniatures in performance and economy! Boasts large 4" x 6" speaker for a crisp, bold sound; slide-rule dial; "thumb-touch" controls; smooth vernier tuning; tuned RF stage & double-tuned IF stage for greater sensitivity and selectivity; big ½" diameter rod antenna for distant station pickup; handsome black simulated leather case. Build in 4 to 6 hours. Uses long-life "D" size flashlight batteries (not included). 5 lbs.

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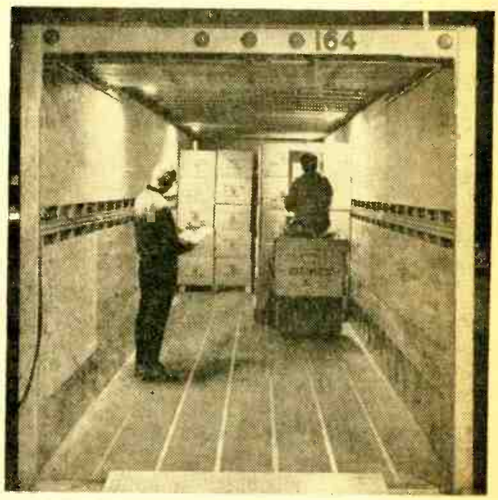
NEWSCAN

Out of the Dark

A newly designed lighting system for the interior lighting of trailers and truck bodies permits loading and unloading operations to be completed quickly, accurately and safely. The system is the first for van lighting which can operate fluorescent lamps off either conventional 120-volt dockside power or the truck's 12-volt battery power. Trailers normally loaded and unloaded at docks need to be equipped to utilize only 120-volt power from the loading dock. Delivery trucks and others which operate away from docks



Lighting system for truck trailers provides adequate illumination for rapid, accurate and safe loading and unloading of cargo. General Electric's newly designed system permits operation of 15-watt fluorescent lamps off either 120-volt dockside power or the truck's 12-volt battery.

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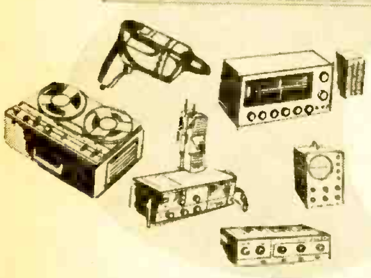

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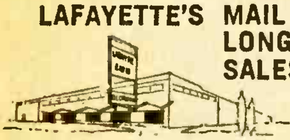

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should be equipped with a special General-Electric-developed inverter-ballast. This makes it possible for fluorescent lamps to be operated off battery power.

Basic components of the system in each trailer are four 15-watt fluorescent tubes housed in especially designed, single-lamp fixtures, and a male plug inside the door. The docks they use are equipped with a switch, cable and female plug. The fixtures, only about three inches deep, are higher than the door opening when mounted on the ribs of the trailer roof. This minimizes the possibility of damage during loading and unloading operations. Lighting levels are about eight footcandles, three times as high as exist in the average well-lighted parking lot.

High frequency current from the inverter-ballast increases the efficiency of fluorescent lamps. With this gain, plus the inherent efficiency advantages of fluorescent over incandescent light sources, the new system produces at least four times as much light as conventional light bulbs of the same wattage with no increasing battery drain.

Seeing Infrared

Infrared light like that used in many modern cooking ranges may soon carry valuable data to astronauts on expeditions into deep space. Beams of the invisible, infrared light may be used to carry thousands of coded messages between ground tracking stations and missiles. The light beams are part of a new data link system developed by the General Electric Company. The feasibility of this new method of sending information has been proven recently by the successful transmission of an extremely clear television picture.

The new system was designed to relieve the growing congestion of the airwaves at missile test ranges. Presently, the increased message load is straining the number of available radio channels. However, the situation will become even more acute in the future. For example, larger launch vehicles will require additional monitoring functions. Increased complexity of space missions will demand transmission of even greater quantities of messages. Interference-free transmission of messages is also a big advantage of the new data system. With the light beams there is no interference with or from radio waves.

Although the new gallium arsenide system is an outgrowth of laser technology, it does not employ a laser as a light source. The diode employed as the light source differs from a laser in that it produces light directly proportional to the current passed through it, whereas the laser diode produces more light at a higher rate than the increase in current. It is predicted that the new data system will be more popular than laser systems, especially for relatively short range use where total cost is of great importance.

In addition to transmitting data from the ground to a missile, the new system has other potential applications. For example, in sending guidance and instrumentation messages from missile pad to block house, block house to launch operation center and from range safety TV vans to launch operation control.

Television picture is transmitted over an invisible light beam, demonstrating new data link system developed by the General Electric Company's Radio Guidance Operation, Syracuse, N. Y. Actual system consists of compact transmitter shown at far left and receiver shown on top of the TV monitor. It may soon be used to carry valuable data to astronauts, to transmit other data from one location at a missile launch center to another, or to carry signals from a radio or TV studio to a transmitter.

The advantages of the gallium-arsenide method over conventional radio systems in these uses are: it has less equipment, is less costly, lighter and more compact. The new system consists, simply, of a transmitter which is about the size of a loaf of bread. It

has an electronic "bulb" which emits the infrared light. The light is then bounced off a flashlight-like reflector and beamed to a receiver the size of two loaves of bread end to end. The system is unique because it has the widest bandwidth ever reported in this type of device—the wider the bandwidth the greater the number of messages which can be transmitted.

Communications with a Bounce

A small satellite communications ground station enables an Army commander to go to isolated trouble spots anywhere on the globe and remain in contact via satellite with military and government authorities here in the U. S. or other world-wide communication centers.

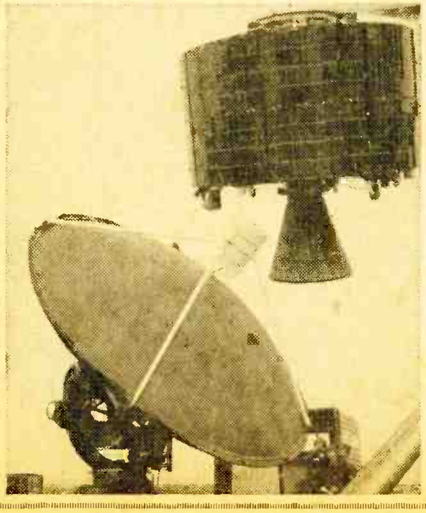
The experimental ground station provides an answer to a problem which has plagued military commanders throughout history—the need of far-ranging armies to maintain communications with their leaders back home. This system will enable a commander to literally take his telephone and teletype with him wherever he goes and 'plug in' to a satellite communications network.

Details of the compact unit, the first ever designed to be transported by helicopter, were disclosed as the portable station was turned over to the Satcom agency for field demonstration at MacDill Air Force Base, near Tampa, Fla. The ground terminal, consisting of a collapsible 15-foot antenna and a 6-by-8 hut, is designed for use with the Syncom communications satellite and will receive and transmit both telephone and teletype messages at the same time. It will also send and receive fascsimile pictures.

With three Syncoms in orbit, an Army unit could be flown to any brush-fire war area, set up its antenna in an hour, point it at one of the satellites and immediately be in direct voice contact with Washington.

Such satellite linkage uses microwave frequencies and is not subject to the magnetic storms which now hinder transoceanic radio telephone transmission and often knock it out for days at a time. Besides its use for military communications, the unit could be employed to restore civilian communications in areas where service is disrupted by disaster or war. It could be used to communicate with other ground terminals whether 10 miles away or 10,000 miles away.

The demonstration model built for the Army consists of three units—antenna, communications hut and power supply—weighing 10,000 pounds combined. It can be transported in cargo planes or lifted by helicopter into remote areas where no plane runways exist. It uses a transmitter and parametric amplifier, both manufactured by Hughes. The transmitter is a solid-state, liquid-cooled unit using a klystron converter tube with a power output of two to three kilowatts. Excess noise temperature of the parametric amplifier is 100 degrees Kelvin, it is uncooled, and has two stage 40 db gain. The receiver used with the station is a phase-locked FM tracking receiver with two IF bandwidths in the 30- and 10-kilocycle bandwidths, and has an IF frequency of 30 megacycles.



This new portable communications ground station has been developed as a "space link partner" of Syncom to enable isolated military units anywhere in the world to stay in constant touch, via satellite relay, with leaders back home or other units only 10 miles away. This first helicopter-transportable system for use in remote battle areas was developed by Hughes Aircraft Company for the U.S. Army's Satcom Agency. The 15-foot air-inflated collapsible antenna (at lower left) is shown in symbolic relation to the Hughes Syncom communications satellite (top right) which would relay the ground station's voice and teletype signals from its synchronous orbit 22,300 miles above the earth.

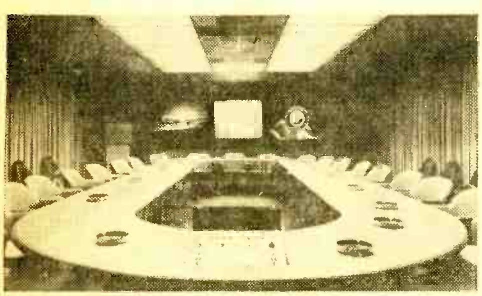
Electronic Conference Room

A unique conference room that can communicate with its occupants has been set up at the Federal Aviation Agency Aeronautical Center in Oklahoma City. It's a room where the ceilings have ears and the walls have voices. A flick of a switch can cause the room to dim its lights, create pictures on its walls, draw back curtains to reveal magnetic chalk-boards, and talk via audio tapes. The room can repeat conversations that took place within its walls only seconds before. This conference room, with is complete communications system, is a pacesetter that may be copied widely throughout government and industry in the next five years. It marks the first time that audio equipment has been used to its full capabilities in helping people communicate.

The difficult task of designing the facility, complete with audio-visual capabilities, was undertaken by engineers of the Aeronautical Center's Plant Engineering Division. They have created a communications system that is actually two complete sound systems within the conference room.

The first is a stereophonic speaker system linked to the AM-FM-Multiplex tuner, tape recorder, phono turntable, projection TV tuner and 16-mm projector. Comprised of three University Medallion speaker systems, the stereo sound units are mounted flush with the wall below the rear-projection screen.

The 18-foot wide rear projection screen may have a 16-millimeter moving picture and two 35-millimeter slides projected simultaneously. The projector lenses and light sources provide images balanced as to size and brightness.



Panoramic view of conference room at Oklahoma City's FAA Aeronautical Center shows placement of ceiling sound system. Microphones are behind audio grilles along inside edge of lights; speakers are mounted along outside rim of light fixtures. Air conditioning ducts form center of ceiling pattern.

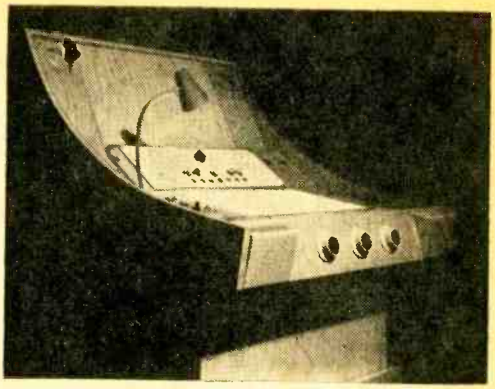
The second and more complicated sound system is designed to pick up and amplify voices within the room and to tape record conversations taking place at its conference table. This second system has given the most headaches to FAA engineers who designed the communications network. It has been largely a matter of experimentation, and the approach to the acoustics problem had to be altered several times.

This sound system includes nine University Model 1150 microphones and seven speakers in the ceiling, arranged so that the speakers do not interfere with the microphones. The microphones are special professional "cardioid pattern" like those used by many radio and television networks.

The ceiling sound system is arranged to cover every portion of the specially-built oval conference table which sits in the center of the room. Words spoken at the table are picked up by the overhead microphones, fed into amplifiers and back into the dual cone speakers in the ceiling. These microphones and speakers are engineered so that words picked up by mikes in the front of the room are amplified more in the speakers at the back of the room, and vice versa. Feedback from speakers to microphone is practically non-existent at optimum usable loudness.

Nerve center of the sound system is a control panel on the lectern at one end of the room and a duplicate control panel which is recessed into the end of the conference table opposite the removable portion.

The lectern itself has a built-in drinking water spigot for the speaker, a motorized height adjustment mechanism, an ash tray, clock timer, reading light and light to illuminate the speaker's face. Standing at the lectern or table control panel, the speaker can control the room merely by pushing buttons. A buzzer into the projection room signals the operator to start or change the viewgraph image. A dual setup for projectuals allows one to be switched while the other is being shown. The room's fluorescent lighting can be dimmed or turned off in sections—front, center and rear. Another button will automatically open and close drapes along one wall which conceal magnetized chalkboards. As the drapes open, lights come on to illuminate the chalkboard image. Fingertip control allows the speaker to record conversation in the room, stop the recorder, rewind it, play back what it has recorded, or move it forward. The 16-millimeter projector can be turned on and off by push-button control. The lectern and table panels also control the two speaker systems (stereo and overhead) and two 35-millimeter slide projectors. A digital selector allows random access to each 100-slide magazine, and both 35-millimeter projectors can be used at once.



Pushbutton lectern--at the FAA electronic conference room--as well as control board at center table--puts all sound and visual systems at the speaker's fingertips. Lectern raises and lowers automatically, has built-in lights, water spigot and ashtray.

Perhaps the most amazing thing about the room is that it has been put together with fully developed, manufactured sound equipment—yet its capabilities are almost unmatched anywhere.

Electronic Lung Power

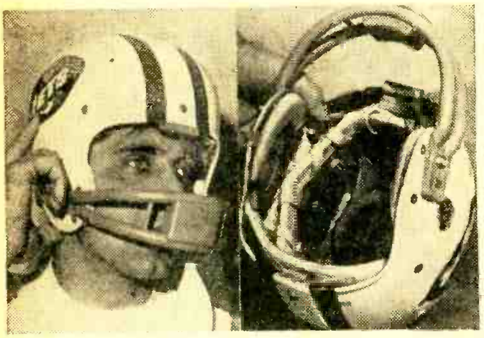
The New York Jets of the American Football League may have solved the problem of crowd noise that often drowns out the audible signals which quarterbacks frequently call at the line of scrimmage to change plays at the last minute. A specially designed helmet seems to be the answer. The helmet contains a transistorized public address system which boosts the quarterback's voice to about three times louder than a TV set turned on full blast. The Jets now have four of these helmets ready for use.

Six transistorized radio loudspeakers, modified by the Jensen Manufacturing Division/The Muter Company to blare out 50 times more power than those which charm the rock 'n' roll set, will carry the quarterback's normal speaking voice to the farthest split end or flanker. The tiny loudspeakers solved the problem raised by an American Football League ruling which prohibited the

Jets from using an earlier design which used autoradio type speakers mounted in outboard pods on the helmet.

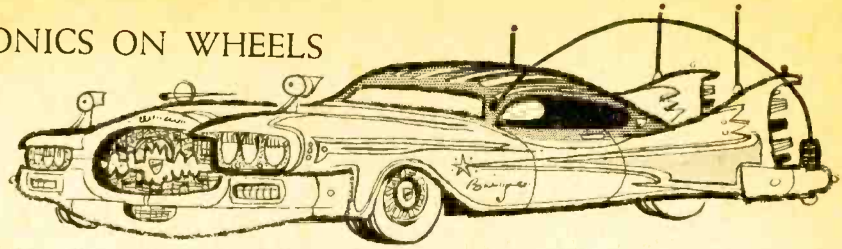
Jensen Manufacturing, developer of the first pocket-radio loudspeaker, was contracted by Technical Materials Inc., (developers of the helmet amplifier) to design a speaker system which would fit inside the helmet, and thus conform to AFL rules. Complaints from parents of teenagers aside, the tiny 2-inch speakers used in popular transistor radios aren't very loud, because they must try to reproduce a wide range of musical tones. Jensen engineers restricted the range of the speakers to voice frequencies (900-3000 cycles per second), and thus boosted their power to about 50 times normal ratings. The six speakers are mounted inside the helmet, three over each of the quarterback's ears. Small vents permit the sound of his amplified voice to issue freely from the helmet. Padded enclosures far from the helmet webbing protect the quarterback's head from bumping against the speakers or amplifier. All parts of the system, including the speakers, are completely waterproofed.

When he chooses to call an audible at the line of scrimmage, the quarterback speaks into a small microphone fastened firmly to the inside of his face guard. A switch cuts off the loudspeakers while signals are called in the huddle. More than the lungs of professional football quarterbacks will be saved by the new helmet—countless yards lost each year when confused linemen jump off sides will be added to the offensive might of the Jets and other teams. ■



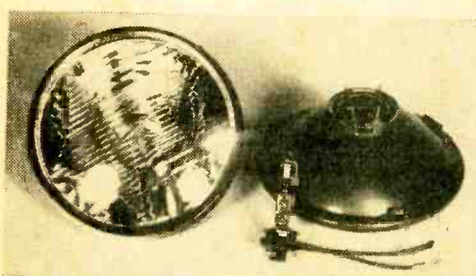
Star player of New York Jets, Joe Namath, points to speakers' grill. By limiting frequency response, speakers' (3 on each side of helmet) rating is boosted to about 50 times output of average transistor radio.

ELECTRONICS ON WHEELS



■ Make a better mouse trap and sooner or later someone is going to add electronic circuitry to it. The automobile is no exception—electronics is not falling behind as Detroit runs its horsepower race. Three new products worth knowing about can add more *oomph* to the family car, increase night visibility, and bring a "toot-toot" to those factory installed horns.

Quartz Iodine Hi-Beams. The typical sealed beam bulb used in automobile "brights" give 23,000 cp (candle power) of light at 100 feet—now you can get up to 65,000 cp from new replacement headlamps with quartz iodine elements without drilling any holes, rewiring, or any other modifications to your car. The new lamps are universal replacements for cars and trucks using 5¾-inch sealed beam bulbs. Truly a breakthrough, the iodine quartz bulbs give three times the light of conventional units without taking any extra current from the battery—with an added plus of longer bulb life. Since the quartz iodine element is a separate part of the unit, the lamp will continue to "burn" even when the glass lens is broken—safe driving is possible as you wheel your way home or to a local garage. A pair of 5¾-inch High-Beam Headlights with Quartz Iodine Elements (No. 89-1716) is available from *J. C. Whitney & Co.* for only $19.95. A replacement element (No. 89-1718) is ony $4.95. Send order to *J. C. Whitney & Co.*, 1917 Archer Avenue, Chicago, Illinois 60616. While you are at it, ask them to send you their latest catalog.

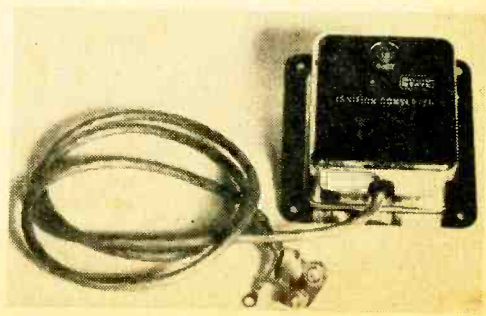


Quartz Iodine Hi-Beams look very much like ordinary auto seal-beam lamps until you peek at the back—Iodine quartz light element is removable.

Fail-Safe Ignition Converter. The one thing that has not changed on vehicles over the years is the ignition system (the method of igniting the gasoline by an electric spark). The Kettering ignition system was invented in 1911 and is still used in almost all vehicles today. Its great *virtues* are its reliability and simplicity. Its greatest *weakness* is the fact the points will *burn* and pit after just a few thousand miles of operation, which can throw a car's entire tune-up and timing completely off. This, of course, wastes gas, causes mis-firing and slower starting—that's if you start at all.

Real cool transparent packaging shows the Fail-Safe Ignition Converter to the buyer. Nothing is left to waste. Complete installation instructions are on back of box—comes complete with hardware.

Norman Industries have changed all this with their "Fail-Safe" solid-state ignition converter. The device converts your car's ordinary ignition into a solid-state system—it allows the points to make and break contact without passing the damaging high-voltage from the coil's inductive



Long cable and terminal strip in Fail-Safe unit permits rapid installation without special tools.

kick that causes the points to arc and pit. The heart of the Fail-Safe system is a heat resistant SCR, which is an improvement over conventional transistors and capable of handling higher currents and voltage. The payoff comes back to the driver in better gas mileage performance, faster cold weather starts, 50,000 miles plus on points and an all important feature—the unit *fails safe.* In the event the unit fails the ignition system reverts back to its original design—no getting stuck on back roads on dark nights.

Designed for 12-volt, negative-ground systems Fail-Safe can be installed in 10 minutes. Sells for about $29.95 at most auto accessory stores. For more information write to *Norman Industries Incorporated,* Dept. NK, 814 Diversey Parkway, Chicago, Ill. 60614.

Electronic Two-Tooter—New Call of the Road. The first application of electronics to produce a distinctive new sound in auto horns has been introduced by *Kinematix, Inc.* The device, called the "Two-Tooter", is a tiny transistorized unit that converts the ordinary simultaneous sound of paired auto horns to a rhythmic alternation of the individual high and low notes. The "Two-Tooter" is establishing a brand-new trend in auto horns. The bright continental Paris-Rome-Vienna flair has already captured the enthusiastic support of drivers everywhere, especially among the younger set, and your car can be equipped, too!

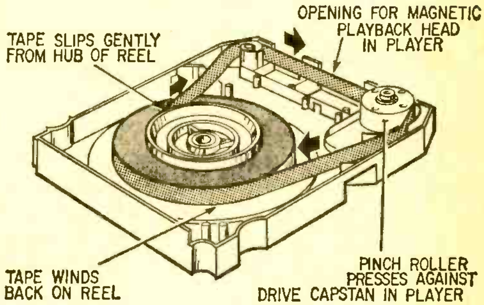
Measuring only 6½ inches long, the converter mounts under the hood in minutes, requiring only four simple connections. The compact, all-solid state circuit contains several of the latest type of semi-conductor devices yet retails for under $25. The complete unit, suitable for use in both 6-volt and 12-volt electrical systems, also incorporates a variable repeat-speed control inside the car that enables the driver to use his horns as a distinctive, easily recognizable salute or an urgent warning as needed. With no moving parts and nothing to wear out, the converter carries a full year's guarantee. Complete information and prices on the new *Kinematix* "Two-Tooter" can be obtained by writing to: *Kinematix, Inc.*, 2040 Washington Boulevard, Chicago, Illinois, 60612, attention of Martin J. Santa, Director of Sales Development. ■

The "Two-Tooter" is all solid state and mounts under the hood—anyone can do it.

TRAFFIC A GO GO

IF YOU PREFER the twang of guitar music with bongos á la stereo when motoring—it's yours. A stereo tape cartridge player will "surround" you with music of your choice within the confines of your car. There are no dead reception spots, as in radio, no static, no need to take your eyes off the road to fuss with the dial, and even a child can start and turn off the music. So great is the cry for travel entertainment by tape cartridge players, three major automobile manufacturers will include stereo cartridge players as original equipment in 1967 cars. Reaction to car stereo systems has been so spontaneous that the one millionth unit will be sold early in 1967—and this was made possible with the development of the tape cartridge.

How It Works. What is a tape cartridge? And how does it work? A cartridge is a flat, small (about 4" x 5") plastic container housing, on a single reel, an endless loop of ¼-inch recorded and specially lubricated audio tape—no threading or rewinding to trouble the operator. On insertion, the tape is automatically moved by the player's drive mechanism from the hub or inside of the reel past the playing head and back onto the outside of the same reel. Use of a lubricated tape and a loose wind on the reel eliminates friction as tape layers must constantly pass over each other as the tape works its way toward the hub of the reel.



Redrawn from drawing made by **Audio Devices, Inc.**

Four-track recordings, consisting of two pairs of stereo tracks, were the earliest type and are still going strong—the playing time of a four-track stereo tape is equivalent to both sides of an LP disc. But 8-track stereo, which has required major development in the art, doubles playing time on the same length of tape, and is well on the way to becoming the accepted cartridge. As in all stereo production, one pair of tracks is played at a time for the full length of the tape. The player then automatically transfers to each succeeding pair of tracks until the recording ends, and will continue to cycle (returning to the first pair of tracks) until the player is

(Continued on page 107)

ELEMENTARY ELECTRONICS ETYMOLOGY

By Webb Garrison

Broadcast

▲ Perfection of instruments and methods by which to transmit messages without use of wires led to a sharp break in the stream of western speech. For though Americans called the new medium of communication the "radio," English technicians in the field stubbornly insisted on referring to it as the "wireless telegraph."

Yet even the most conservative Britishers recognized radical distinctions in the two media. A telegraph message (at least in those days) went to only one receiving station. A message transmitted by wireless radiated over a huge area and could be received by any number of instruments simultaneously. What to call so public an act of communication?

Centuries earlier, farmers of Britain had used two techniques in planting. Sometimes they carefully dropped seeds into precise rows, drills, or holes. But when sowing grain, turnips, and other crops they walked through their fields casting handfuls on both sides.

Influence of the latter practice led to wide use of the farm-born term. Orators and writers who urged political reforms took pride in their ability to broad cast their ideas. Fused into a single word, the hoary term for the act of scattering seeds or ideas at random became *broadcast*.

Ohm

▲ By the mid-point of the 19th century, research workers realized that they needed some unit by which to measure electrical resistance, and a name by which to speak of it. At the 1861 meeting of the British Association for the Advancement of Science Sir Charles Bright suggested that the term "ohmad" be adopted. This action, he urged, would perpetuate the name of a pioneer.

E/E ETYMOLOGY

Georg Simon Ohm, one of the earliest theoretical physicists to work with electricity, produced a great volume of published work. Only one of his reports, issued in 1827 when he was 40, is today regarded as marking a milestone in the progress of science. This brief paper presents findings that throw much light on processes that produce electricity.

"Ohmad" proved too cumbersome a verbal memorial to the German experimenter. But clipped to the form of his surname, it soon entered the international vocabulary of science. By edict of Queen Victoria, the *ohm* was legally defined as "the resistance to an invariable electric current by a column of mercury at the temperature of melting ice, 14.4521 grammes in mass, of a constant cross-sectional area, and a length of 106.3 centimetres." Methods of measurement have been greatly refined, but the name of Georg Ohm remains basic to the vocabulary of electronics.

Feedback

▲ No one knows exactly when or how radio operators discovered that circuits can be coupled in such fashion that part of the energy in one is transferred to the other. Instead of being the fruit of costly professional research, this was probably the result of random experiments by amateurs.

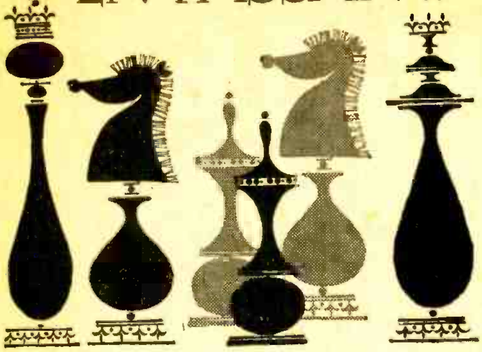
At first it was considered interesting but not especially important that one can feed back current in this fashion. Important practical applications were soon discovered, however, and deliberate use of feed-back techniques was coming into vogue before the end of World War I.

Already, operators of public address systems and radios had observed that under some conditions part of a system's output is returned to it. It was logical to extend the use of "feedback" to name such processes as well as those operating by linked circuits.

Refinement of electronic amplifying systems led to recognition that feedback can increase volume, decrease it, or reduce quality of control.

Jumping from electronics into general speech, the term came to name any return to input of part of the output of a system, machine, or process. Now used in such diverse fields as biology and economics, *feedback* is a basic concept in cybernetics. ■

EN PASSANT



BY JOHN W. COLLINS

■ Chess columns are beginning to appear in the most unexpected places — literary magazines, medical magazines, religious newspapers. And now in this electronics magazine. All to the good, chess being, among other things, an art, an anodyne, a way of life and a discipline. Always eager to spread the gospel of the *Royal Game,* I was delighted to accept Editor Julian Sienkiewicz's offer of a column in ELEMENTARY ELECTRONICS. We both believe that many of those interested in electronics are also interested in chess. His vision and imagination are admirable. I hope the readers who play the game will derive enjoyment and instruction from the columns and I hope the ones who are unfamiliar with it will be enticed into learning.

En Passant will appear in every issue of ELEMENTARY ELECTRONICS. It will present book reviews, games, endgame studies, instruction, news and two move problems. It will look at the game, in its various forms, here at home and abroad, and at its past and present.

News and Views. Grandmaster Robert (Bobby) J. Fischer of Brooklyn, a former prodigy now 23, won the U. S. Championship (for the seventh time!) last December in New York. He scored 8½-2½, losing to R. Byrne and S. Reshevsky and drawing with W. Addison. In 1964, in a somewhat weaker field, he swept the boards 11-0.

World Champion Tigran Petrosian and challenger Boris Spassky, both of the U.S.S.R., will meet in a twenty-four game match for the world title beginning sometime in April in Russia.

The second Piatigorsky Cup Tournament will be played in Santa Monica, California, during July-August. Eight leading grandmasters (probably including Fischer and Petrosian) will compete for the $3,000 first prize. Gregor Piatigorsky is a world famous cellist and his wife Jacqueline, a former Rothchild, is a top woman chessplayer and a patron of the arts.

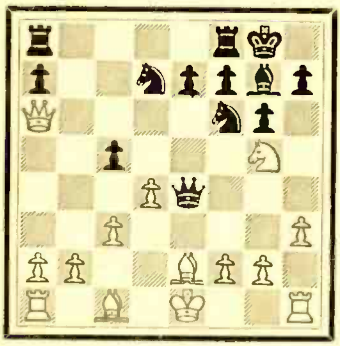
Lombardy Wins. Grandmaster William Lombardy of New York, a siminarian at St. Joseph's, won the Western Open in St. Louis last July with

EN PASSANT

a score of 8-1 (7 wins and 2 draws). Directed by a woman, Pearl Mann, the event had 143 entries. One of Lombardy's cleverest wins was from Bill Bills of Houston, Texas. The opening was a Caro-Kann Defense, Two Knights' Variation and was a 14 move miniature which went like this—

1.	P-K4	P-QB3	8.	NxB	Q-R4#
2.	N-QB3	P-Q4	9.	P-B3	QxN
3.	N-B3	PxP	10.	Q-N3	O-O?
4.	NxP	P-KN3?	11.	QxP!	QN-Q2
5.	P-Q4	B-N2	12.	B-K2	Q-K5
6.	P-KR3	B-B4	13.	Q-R6	P-B4
7.	N-N3	N-B3	14.	N-N5!	Resigns

Position after 14 N-N5!



Why did Black resign? Because he is already a Pawn behind, he must lose either his Queen, a piece, the exchange (Rook for Bishop) and because he knows he is playing a *Grandmaster!* Here is the analysis—

A. If 14 . . . Q-B7 15 B-Q3, N-N1 16 Q-B4 and the Black Queen is lost.

B. If 14 . . . Q-B4 15 P-KN4, Q-Q4 16 B-B3, Q-Q3 17 QxQ, PxQ 18 BxR and White has won the exchange.

C. If 14 . . . QxNP 15 B-B3, N-N1 16 Q-N7 and the Black Queen is lost.

D. If 14 . . . Q-Q4 15 B-B3 wins the exchange.

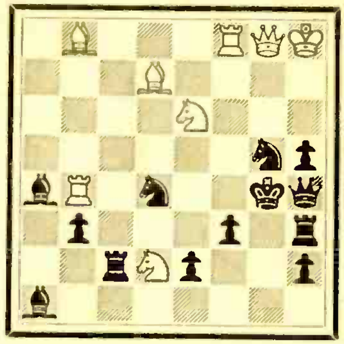
E. 14 . . . Q-R5 15 P-KN3, Q-R3 16 NxBP and White wins the Queen for Bishop and Knight.

F. 14 . . . N-N1 15 NxQ, NxQ 16 NxN# BxN 17 BxN, PxP 18 PxP, BxP 19 0-0 and White is a whole piece ahead.

There is an old saw among chessplayers which warns "never take the Queen Knight Pawn!" (it loses too much time). Lombardy exploded that myth in this one!

Problem. Many are the ways to enjoy chess. One is solving problems—the poesy of the game. I shall give a two mover in every column, sometimes an old classic and sometimes a new original. This first one dates to 1938, has a cross-check theme and earned First Prize for a great American Composer.

Problem 1.
By F. Gamage
Black



White

White to move and mate in two.
Solution in next issue.

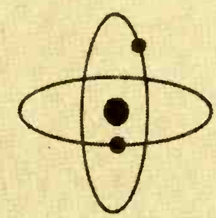
Learn by Reading. A number of excellent books are available to those who want to learn to play chess. I recommend "An Inviation to Chess" by Irving Chernev and Kenneth Harkness. It is specifically designed for persons who do not know one chess piece from another and its approach is visual, pictorial, with photographs and diagrams. It has 221 pages, is published by Simon and Schuster and costs about $3.50. ■

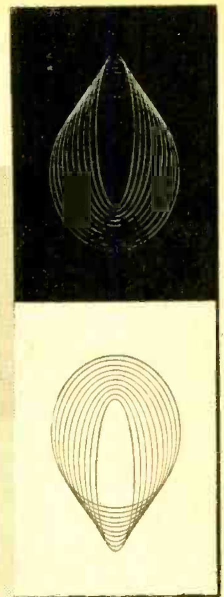
About Our Columnist. Who is John W. Collins? Well, he is a former U. S. Correspondence Champion, New York State Champion, Marshall Chess Club Champion, Hawthorne Chess Club Champion and Brooklyn Chess Club Champion. He has been secretary of the Brooklyn Chess League and the Metropolitan Chess League. He teaches the game privately and by correspondence and he has been the early teacher-mentor of U. S. Champion Bobby Fischer, Grandmasters W. Lombardy, R. Byrne and D. Byrne, Senior Master R. Weinstein and is now teaching a fourteen year old rising star, Sal Matera. He was co-reviser of Modern Chess Openings, 9th Edition, the so-called "chessplayer's bible." And currently he has (and has had for several years) columns in **Chess Review** (Postal Games and Book of the Month) and **Chess Life**, official publication of the United States Chess Federation (GAMES By USCF Members) and is a member of the Manhattan Chess Club, oldest and foremost in the country. The **Editors** of ELEMENTARY ELECTRONICS welcome John to the staff and we are privileged to have him work with us.

Cartoon by **Cork**

To have a firm foundation, build your knowledge of electronics theory with a basic building block—the atom

Electricity, Magnetism and the Atom





Prepared by the Editors of Elementary Electronics

■ One of the most thought provoking discoveries of modern physics is the fact that matter and energy are interchangeable. Centuries of scientific head-scratching about the nature of matter, the mystery of fire, and the once-terrifying crack of lightning have all come to focus on the smallest particle that is the building block of any given substance: the atom. An atom is necessarily matter and yet this atom of matter can undergo nuclear fission and release quantities of energy that are beyond the imagination. In the atom lies the secret of all phenomena. One theory of the universe, hypothesized by Georges Lemaitre, even regards the present universe as resulting from the radioactive disintegration of one primeval atom!

A Monumental Discovery. By the beginning of the 19th century, the atomic theory of matter—which actually originated in 5th century Greece when the atom was named—was firmly established. It was due primarily to the efforts of 17th century scientists who—actually working in the tradition of medieval alchemy—sought the prime constituent of all matter. Mainly through the work of John Dalton, whose investigations as to how various elements combine to form chemical compounds, it came to be regarded that *an atom* was the indivisible and indestructible unit of matter.

This viable and working view of the indestructible atom served science until 1897 when the atom itself was found to be destructible! To anyone concerned with electricity or electronics, the year 1897 is a memorable one: it was the year J. J. Thomson, the English physicist, identified and experimentally revealed the existence of the first subatomic particle—the *electron!*

The First "Electronic" Experiment. We blithely speak of electricity as the flow of electrons yet, often, we are little aware of the great body of research that went into elucidating this fundamental of basic electricity. In fact, before the discovery of the electron, convention held that the flow of electric current was in the direction that a positive charge moved. This convention of *positive current,* being the flow of positive charges and opposite to the direction of electron flow, is still found to be useful in circuit analysis and is used even today.

Thomson's experiment established that a particle much lighter than the lightest atom did indeed exist. The electron, as it was named, was the first subatomic particle to be defined.

The experiment was conducted utilizing a rudimentary version of a cathode ray tube—the modern version of which is in almost every home today in the form of the television picture tube. Before Thomson's experiment, it was discovered that when electric current was passed through a gas in a discharge tube, a beam of unknown nature traveled through the tube from the negative to positive terminal (opposite to the direction conventionally held as the direction of the flow of current).

This "cathode ray" beam also traveled in a straight line and was deflected by electric or magnetic forces applied perpendicular to the beam. What Thompson did was to use these facts to determine for one of the mysterious particles comprising the beam of cathode rays the relationship of its mass, *m*, to its electric charge, *e*. By deflecting the beam with a known electric force (Fig. 1)

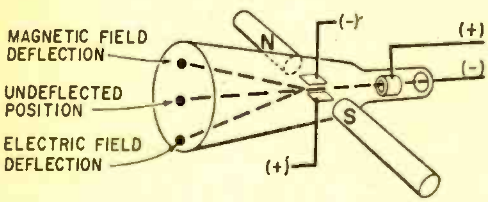


Fig. 1. Electron beam, like that in a TV picture tube (CRT), can be deflected magnetically or by an electric field. Force needed "measured" the electron.

and then measuring what magnetic force applied in the opposite direction would bring the beam back to its original undeflected position, he could determine the relationship of *e* to *m*. He established a definite value for *e/m* and thereby "discovered" the electron which, as we now know, is 1,837 times smaller in mass than the lightest atom, the hydrogen atom. It also carries the smallest charge that occurs in nature; every electric charge is actually an integral multiple of the charge of the electron.

From Minus to Plus. With the discovery of the electron, it was still over a dozen years into the 20th century before a graphic conception of the atom evolved. Since the atom is electrically neutral and electrons are negatively charged, the existence of positively charged particles was a necessity, and the existence of a *proton* was postulated. Eventually the nuclear model of the atom was evolved. Each atom was conceived to resemble a solar system in miniature. The nucleus—positively charged—is surrounded by a number of electrons revolving around it; the charges balance and the atom is electrically neutral (Fig. 2). Further research in the 20th century has gone on to reveal more elementary particles than you can shake a

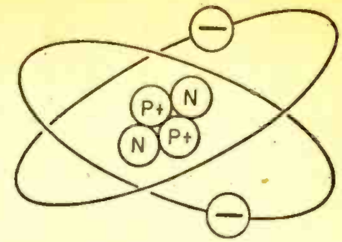


Fig. 2. Charge of each electron balances that of a proton. Other particles affect atomic mass but can be ignored in study of electronics.

stick at: neutrons, positrons, neutrinos, mesons, and more. The number continues to grow and yet the ultimate nature of matter remains a riddle. But, in a discussion of basic electricity, only the electron and proton need concern us.

Electrons in Orbit. An atom of matter has a number of electrons orbiting around its nucleus. A hydrogen atom, for example, has a single electron; carbon on the other hand has 6. These electrons are arranged in rings or shells around the central nucleus—each ring having a definite maximum capacity of electrons which it can retain. For example, in the copper atom shown in Fig. 3 the maximum number of electrons that can exist in

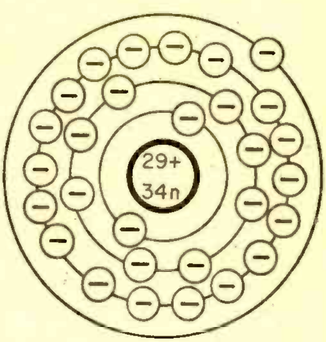


Fig. 3. The number of electrons to each ring are limited—2 in first; 8 in second; 18 for the third and a total of 32 in fourth orbital ring.

the first ring (the ring nearest the nucleus) is two. The next ring can have a maximum of eight, the third ring a maximum of 18, and the fourth ring a maximum of 32. However, the outer ring or shell of electrons for any atom cannot exceed eight electrons. However, heavier atoms may have more than four rings.

The Outer Orbit. The ring of electrons furthest from the atom's nucleus is known as the *valence ring* and the electrons orbiting in this ring are known as *valence electrons*. These valence electrons, being further from the nucleus, are not held as tightly in their orbits as electrons in the inner rings and can therefore be fairly easily dislodged by an external force such as heat, light, friction, and electrical potential. The fewer electrons in the valence ring of an atom, the less these electrons are bound to the central nucleus. As an example, the copper atom has only one electron in its valence ring. Consequently, it can be easily removed by the application of only the slightest amount of external energy. Ordinary room temperature is sufficient to dislodge large numbers of electrons from copper atoms; these electrons circulate about as free electrons. It is because of these large numbers of free electrons that copper is such a good electrical conductor. There could be no electrical or electronics industry as we know it today if it were not for the fact that electrons can fairly easily escape, or be stripped from the valence ring of certain elements.

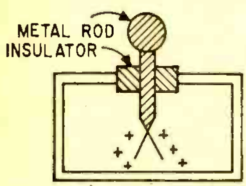


Fig. 4. Electroscope is a simple device to indicate electrical charges that are too weak to be measured with standard meters.

Electronic Charges. If an electron is stripped from an atom, the atom will assume a positive charge because the number of positively charged protons in its nucleus now exceed the number of negatively charged orbiting electrons. If, on the other hand, the atom should gain an electron, it will become negatively charged as the number of electrons now exceeds the protons in its nucleus. The atom with the deficiency of electrons is known as a *positive ion*, while an atom with a surplus of electrons is known as a *negative ion*.

Presence of an electrical charge on a body can be illustrated by use of an electroscope (Fig. 4). Two leaves of aluminum or gold foil hang from a metal rod inside a glass case so they're free from air disturbances. When the meal rod is touched by a charged body, the leaves acquire static electricity of the same polarity and, since like charges repel, they stand apart. The greater the charge, the further apart the leaves spread.

Electron Flow. When an electrical conductor is placed between these two oppositely charged bodies, free electrons are attracted by the positive body—free electrons will move through the wire. This movement of free electrons will continue only until the excess of electrons is equally divided between the two bodies. Under these conditions, the charges on both bodies will be equal and the electron flow will end.

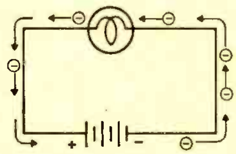


Fig. 5. Electron flow in any circuit is from negative to positive — this is opposite to current, which flows from positive toward negative terminal.

In Fig. 5 are a battery, lamp and connecting leads between the battery and lamp. In this instance, the battery serves as an electric charge pump—free electrons continually developed at its negative terminal by chemical action flow through the connecting leads and lamp back to the positive terminal of the battery by the attraction of oppositely charged bodies. The battery, connecting leads, and lamp form an electrical circuit which must be complete before the free electrons can flow from the battery's negative terminal to its positive terminal via the lamp. Thus, the battery serves as a source of potential difference or voltage by continually supplying a surplus of electrons at its negative terminal. Summing up, we can say a flow of electric current consists of the movement of electrons between two oppositely charged bodies.

We cannot progress very far into the study of electricity without first becoming familiar with the basic properties of electrical circuits. Just as we define distance in feet and inches, so do we define electrical properties in specific terms and units.

Potential. Earlier, we saw that an electric charge difference has to exist between the ends of an electrical conductor in order to cause a flow of free electrons through the conductor. This flow of electrons constitutes the electric current. The electric charge difference, or potential difference exerts a force on the flow of free electrons, forcing them through the conductor. This electric force or pressure is referred to as electromotive force, abbreviated EMF.

The greater the charge or potential difference, the greater will be the movement of free electrons (current) through the conductor as there will be more "push and pull" on the free electrons. The symbol used to designate electrical potential is the letter E which stands for electromotive force. The quantity of EMF is measured by a unit called the volt. Hence, the common name most often used in place of EMF is *voltage*.

Current Intensity. We have learned that an electric current consists of a flow of charge carrriers (generally free electrons) between two points of different electrical potential. The rate of flow of these charges determines the intensity or strength of this current flow. Current strength is expressed in units known as *amperes*. One ampere of current flows in a circuit when 6,240,000,000 electrons flow out of a negative terminal, through a conductor, and back into a positive terminal in one second. The symbol for the ampere is the letter *I* which stands for intensity.

Resistance. The flow of electric current through a conductor is caused by the movement of free electrons present in the atoms of the conductor. A bit of thought then indicates that the greater the number of free electrons present in the atoms of a particular conductor, the greater will be its electrical conductivity. Gold, silver, and copper rank as excellent electrical conductors as their atoms readily release free electrons. On the other hand, the atoms of such elements as sulphur have almost no free electrons available and they are thus very poor electrical conductors. Such materials are known as electrical insulators. Between these extremes, lie elements such as carbon whose atoms have a moderate number of free electrons available and thus are moderately good electrical conductors.

Even the best electrical conductors offer some opposition to the passage of free electrons. This opposition is called resistance. You might consider electrical resistance similar to mechanical friction. As in the case of mechanical friction, electrical resistance generates heat. When current flows through a resistance, heat is generated; the greater the current flow, the greater the heat. Also, for a given current flow, the greater the resistance, the greater the heat produced.

Electrical resistance can be both beneficial and undesirable. Toasters, electric irons, etc. all make use of the heat generated by current flowing through wire coils. Resistance is also often intentionally added to an electrical circuit to limit the flow of current. This type of resistance is generally lumped together in a single unit known as a resistor.

There are also instances where resistance is undesirable. Excessive resistance in the connecting leads of an electrical circuit can cause both heating and electrical loss. The heating, if sufficient can cause a fire hazard, particularly in house wiring, and the circuit losses are a waste of electrical power.

Electrical resistance is expressed by a unit known as the *ohm*, indicated by the letter *R*. An electrical conductor has a resistance of one ohm when an applied EMF of one volt causes a current of one ampere to flow through it.

Resistance Factors. There are other factors beside the composition of the material that determine its resistance. For example, temperature has an effect on the resistance of a conductor. As the temperature of copper increases, for example, its resistance increases. The increase in temperature causes the electrons in the outer ring of the atom to resist release to the free electron state. This increase in resistance with an increase in temperature is known as a *positive temperature coefficient*. Not all conductors show this increase in resistance with an increase in temperature; their resistance decreases with an increase in temperature. Such materials are said to have a *negative temperature coefficient*. Certain metallic alloys have been developed which exhibit a *zero temperature coefficient:* their resistance does not change with changes in temperature.

As you might suspect, the length of a conductor has an effect upon its resistance. Doubling the length of a conductor will double its resistance. By the same token, halving the length of a conductor will cut its resistance in half. Just remember that the resistance of a conductor is *directly proportional to its length*.

The cross-sectional area of a conductor also determines its resistance. As you double the cross-section of a conductor, you halve its resistance; halving its cross-section doubles its resistance. Here again, the "why" of this is pretty easy to see: there are more current carrying electrons available in a large cross-section conductor than in a small cross-section conductor of the same length. Therefore, the resistance of a conductor is *inversely proportional to its cross-sectional area*.

Circuit Relationship. Now that we have a basic understanding of voltage, current, and resistance, let's take a look at just how they

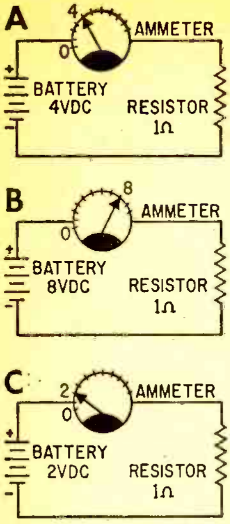


Fig. 6. In A, B and C, (above left) the value of the resistor remains constant while the supply voltage is raised and then lowered with a resulting current change.

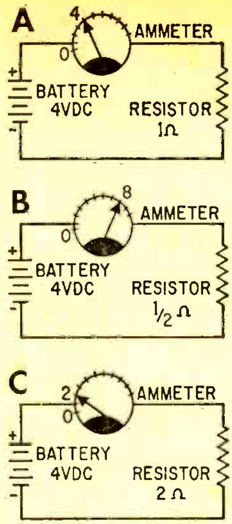


Fig. 7. Battery voltage in A, B and C (above) is held constant while resistor is halved and doubled in value. Resulting current increase, decrease are basis for Ohm's law.

interact under circuit conditions.

Fig. 6A shows a battery, ammeter (a device to indicate current strength), and resistor connected in series. Notice that the ammeter indicates that 4 amperes are flowing in the circuit.

Fig. 6B shows the identical setup with the exception that the battery voltage has now been doubled. The ammeter now shows that twice the original current, or 8 amperes, are now flowing in the circuit. Therefore, we can see that doubling the voltage applied to the circuit will double the current flowing in the circuit.

In Fig. 6C the same circuit appears again; this time, however, the battery voltage is one-half its original value. The ammeter shows that one-half of the original current or 2 amperes, are now flowing in the circuit. This shows us that halving the voltage applied to the circuit will halve the current flowing through the circuit.

All this boils down to the fact that assuming the same circuit resistance in all cases, *the current flowing in a circuit will be directly proportional to the applied voltage*—increasing as the voltage is increased, and decreasing as the applied voltage is decreased.

In Fig. 7A we again see the circuit consisting of the battery, ammeter, and resistance. Notice that the ammeter indicates that 4 amperes are flowing through the circuit.

In Fig. 7B we see that the value of resistance has been cut in half and as a result, the ammeter indicates that twice the original current, or 8 amperes, is now flowing in the circuit. This leads us to the correct assumption that for a given supply voltage, halving the circuit resistance will double the current flowing in the circuit.

Fig. 7C again shows our basic circuit, but with the resistance now doubled from its original value. The ammeter indicates that the current in the circuit is now one-half of its original value.

Summing things up: for a given supply voltage, *the current flowing in a circuit will be inversely proportional to the resistance in the circuit.*

Ohm's Law. From what you have seen so far, you are probably getting the idea that you can determine the current flowing in a circuit if you know the voltage and resistance present in the circuit, and the voltage if you know the current and resistance, or the resistance if the voltage and current are known.

All this is quite correct, and is formally stated by Ohm's Law as follows:

$$I = \frac{E}{R}$$

Where: E = voltage
I = current
R = resistance

Now, let's take a look at how this formula is used:

To find voltage:

E (voltage) = I (current) x R (resistance)

To find current . . .

$$I\ (\text{current}) = \frac{E\ (\text{voltage})}{R\ (\text{resistance})}$$

To find resistance:

$$R\ (\text{resistance}) = \frac{E\ (\text{voltage})}{I\ (\text{current})}$$

A handy way to remember Ohm's Law is by means of the triangle shown in Fig. 8. Simply cover the quantity (voltage, current, or resistance) that you want to determine, and read the correct relationship of the remaining two quantities. For example, if you

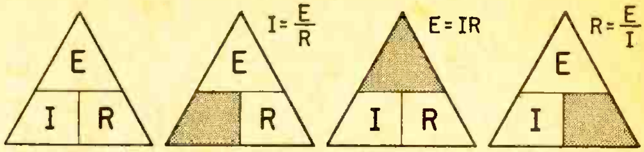


Fig. 8. Shaded portion of triangle indicates unknown quantity in the formula. Visible factors appear in their proper mathematical relation. Just fill in the known values and go on with multiplication or division.

want to know the correct current (I), put your finger over I and read $\frac{E}{R}$. Covering E or R will yield I x R or $\frac{E}{I}$, respectively.

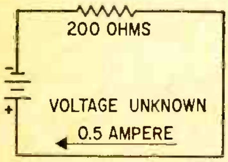


Fig. 9. Unknown quantity, voltage, found easily by applying Ohm's law. Using known factors (ohms and amperes) in a simple multiplication process the voltage is calculated.

Ohm's Law to Determine Voltage. Let's delve a bit more deeply into Ohm's law by applying it to a few cases where we want to determine the unknown voltage in an electrical circuit. Take a look at Fig. 9, which shows a simple series circuit consisting of a battery and resistor. The value of this resistor is given as 200 ohms, and 0.5 ampere of current is flowing through the circuit. We want to find the value of battery voltage. This is easily done by applying Ohm's law for voltage as follows:

$$E = I \times R$$

E (unknown voltage) = 0.5 (current in amperes) x 200 (resistance in ohms) = 100 V.

Let's go through this again, this time using a practical illustration. Fig. 10 shows a string

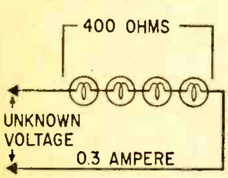


Fig. 10. Although problem looks different the basic circuit is same as that for Fig. 9. Putting triangles in Fig. 8 to use is simplest, easiest way to determine formula.

of light bulbs, the total resistance of which is 400 ohms. You find that the bulbs draw 0.3 amperes when lighted. Let's say you would like to operate this string of bulbs from the standard 120-volt house current, but you don't know the voltage rating of the individual bulbs. By using Ohm's law for voltage, you can easily determine the voltage to light the bulbs as follows: E (unknown voltage) = 0.3 (amperes) x 400 (bulb resistance) = 120 volts.

Ohm's Law to Determine Current. Now, let's take a look at a few examples of how

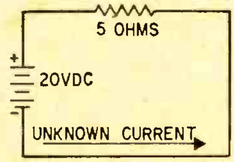


Fig. 11. Formula needed here is different since current is unknown. Just look for triangle in Fig. 8 that has I shaded and substitute values for E and R — simple division.

to determine the value of unknown current in a circuit in which both the voltage and resistance are known.

Fig. 11 shows a series circuit with a battery and resistor. The battery voltage is 20 volts DC and the value of resistance is 5 ohms. How much current is flowing through the circuit?

$$\text{Ohm's law for current } I = \frac{E}{R}$$

$$I \text{ (unknown current)} = \frac{20 \text{ (battery voltage)}}{5 \text{ (resistance in ohms)}}$$

$$I = 4 \text{ amperes}$$

Again to get a bit more practical, let's take

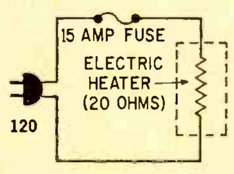


Fig. 12. Basic circuit is same as that in Fig. 11. Although three factors are given, current is unknown quantity because the problem is to decide proper rating for fuse.

a look at Fig. 12. Here we see an electric heater element connected to the 120-volt house line. We know that this particular heater element has a resistance of 20 ohms. The house current line is fused with a 15-ampere fuse. We want to know whether the heater will draw sufficient current to blow the fuse. Here's how to find this out by use of Ohm's law for current.

$$\text{I (unknown current)} = \frac{\text{120 (line voltage)}}{\text{20 (Heater resistance in ohms)}}$$

$$\text{I} = \text{6 amperes}$$

We find from the above use of Ohm's law for current that the heater draws 6 amperes, so it can be safely used on the line fused with the 15 ampere fuse. In fact, a 10 ampere fused line can also do the job.

Ohm's Law to Determine Resistance. Ohm's law for resistance enables us to determine the unknown value of resistance in a circuit. Fig. 13 again shows a simple series circuit with the battery voltage given as 20 volts and the current flowing through the circuit as 0.5 ampere. The unknown resistance value in this circuit is found as follows:

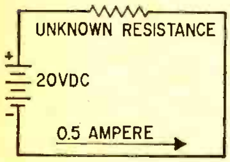


Fig. 13. Most Ohm's law problems are simple series circuits or can be reduced to simple series circuits and then solved using the formula with known values substituted.

$$\text{Ohm's law for resistance R} = \frac{E}{I}$$

$$\text{R (unknown resistance)} = \frac{\text{20 (battery voltage)}}{\text{0.5 (current in amperes)}}$$

$$\text{R} = \text{40 ohms}$$

Fig. 14 is a practical example of how to determine unknown resistance. Here, we want to operate a 6-volt light bulb from the 120-volt house line. What value of series dropping resistor do we need to drop the 120-volt house current down to 6 volts? The bulb draws 0.2 ampere.

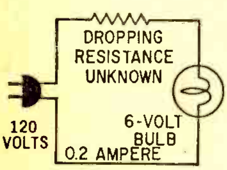


Fig. 14. This Ohm's law problem is somewhat more complex since dropping resistance must take care of voltage, from source, not needed by 6-volt bulb in circuit.

We must first determine the voltage which must be dropped across the series dropping resistor. This is done by subtracting the line voltage (120) from the bulb's voltage (6). This gives us a value of 114 volts which we use in conjunction with Ohm's law for resistance as follows:

$$\text{R (unknown resistance)} = \frac{\text{114 (voltage dropped by resistor)}}{\text{0.2 (bulb current in amperes)}}$$

$$\text{R} = \text{570 ohms}$$

Resistance in Series. Many practical electrical and electronic circuits use two or more resistances connected in series. The point to remember in this case is that the total resistance is the sum of the individual resistances. This is expressed by the formula:

$$\text{R (total resistance)} = \text{R1} + \text{R2} + \text{R3} + \text{etc.}$$

where R1, R2, R3, etc. are the individual resistances. Thus, in Fig. 15 the total of the individual resistances is R (total) = 40 + 6 + 10 + 5 = 61 ohms.

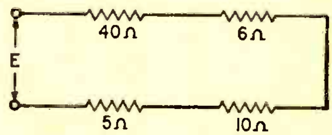


Fig. 15. Resistances in series are added. As far as voltage applied and current flow is concerned the individual resistors are only one.

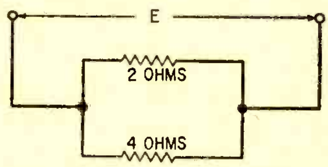


Fig. 16. Resistors in parallel are added algebraically — the result will always be a value less than that of the lowest in the circuit.

Resistances may also be connected in parallel in a circuit as in Fig. 16. In this case the current flowing in the circuit will divide between the resistances, the greater current flowing through the lowest resistance. Also, the total resistance in the circuit will always be less than the smallest resistance since the total current is greater than the current in any of the individual resistors. The formula for determining the combined resistance of the two resistors is:

$$\text{R (total)} = \frac{\text{R1} \times \text{R2}}{\text{R1} + \text{R2}}$$

Thus, in Fig. 16 the effective resistance of R1 and R2 is:

$$R\ (\text{total}) = \frac{2 \times 4}{2 + 4} = \frac{8}{6} \text{ or } 1.33 \text{ ohms.}$$

In a circuit containing more than two parallel resistors as in Fig. 17 the easiest way to determine the total circuit resistance is as follows: first, assume that a 6-volt battery is connected across the resistor network. Pick a value that will make your computations simple. Then determine the current flowing through each of the resistors using Ohm's law.

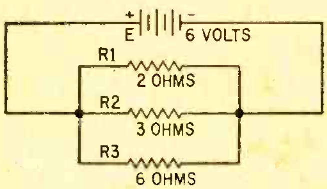


Fig. 17. Ohm's law can be used to determine the equivalent resistance of two or more resistors in parallel. Total current—then solve for ohms.

$$I = \frac{E}{R1} = \frac{6}{2} = 3 \text{ amperes}$$

$$I = \frac{E}{R2} = \frac{6}{3} = 2 \text{ amperes}$$

$$I = \frac{E}{R3} = \frac{6}{6} = 1 \text{ ampere}$$

Next, add the individual currents flowing through the circuit:

2 amperes + 3 amperes + 1 ampere

I = 6 amperes

Inserting this 6 amperes in Ohm's law, the total circuit resistance is found to be:

$$R = \frac{6}{6} = 1 \text{ ohm}$$

The combined equation for determining the total resistance of *n* number of resistances would be:

$$\frac{1}{R} = \frac{1}{R1} + \frac{1}{R2} + \frac{1}{R3} + \ldots \frac{1}{Rn}$$

Quite often an electronic circuit will contain a combination of series and parallel resistances as in Fig. 18.

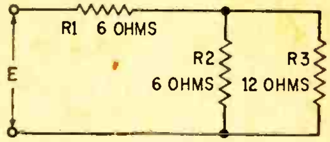


Fig. 18. Series-parallel circuit is not really difficult. Add R2 and R3 algebraically. Add effective resistance to R1 for total resistance.

To solve this type of problem, first determine the combined resistance of R2 and R3:

$$R\ (\text{total}) \frac{6 \times 12}{6 + 12} = \frac{72}{18} = 4 \text{ ohms}$$

This total value of R2 and R3 may be considered a single resistance which is in series with R1, and forms a simple series circuit. This simple series circuit is solved as follows:

R (total) = 6 + 4 or a total of 10 ohms.

Power. The amount of work done by electricity is termed the *watt* and one watt is equal to one volt multipled by one ampere. This may be expressed as: P = E x I where E = voltage in volts, I = the current in amperes. Also:

$$P = \frac{E^2}{R} \text{ and } P = I^2R$$

As an example, assume that a toaster draws 5 amperes at an applied voltage of 115 volts.

Its wattage would then be:

P = 115 x 5 or 575 watts.

Magnetism and the Electron. The atom, and a concept of its structure were a necessary preface to our discussion of basic electricity. By the same token, both are necessary to understanding basic magnetism.

As we've mentioned, electrons are in continual motion about the nucleus. The orbit is, in fact, a small loop of current and has a magnetic field that's associated with a current loop. In addition, experimental and theoretical investigation seems to indicate that the electron itself has a spin. Each electron, having its own axis, is a spinning sphere of electric charge. *Electron spin,* like the quantum and wave theories of light, is not so much a literal interpretation of a phenomenon, but a useful concept that holds water when applied to the phenomenon of magnetism.

When the electron spins, the charge that is in motion produces a magnetic field. And, to briefly state the electronic explanation of magnetism, it seems that the magnetic properties of matter can be attributed to the orbital and spinning motion of the electrons comprising the atoms of the matter.

Millennia of Magnetism. Some of the basic principles and effects of magnetism have been known for centuries. The Greeks are credited as the ones who first discovered magnetism. They noted that a certain type of rock had the ability of attracting iron. Later, the Chinese noted that an elongated piece of this rock had the useful property of always pointing in a North-South direction when suspended by a string. This was the beginning of our compass.

This strange stone which intrigued people over the centuries is actually a form of iron ore known as magnetite. Not all magnetite shows magnetic properties. Another name for the magnetic variety of magnetite is lodestone—the term lodestone being derived from two separate words, lode and stone. The term lode stands for guide, hence lodestone mean "guide stone."

All magnets, whether natural or man made, possess magnetic poles, which are commonly known as the magnet's north and south poles. As is the case of the electrical charges (which we studied earlier) between unlike magnetic poles and repulsion between like poles, it has been found that this magnetic attraction and repulsion force varies inversely as the square of the distance from the magnetic poles.

The Magnetic Field. We all know how a magnet exerts a force of attraction on a piece of magnetic material such as iron or steel. Also, when the north poles of two magnets are brought close together, they will try to repel each other, while there will be attraction between the north and south poles of two magnets. Although it is not clearly understood just what this force of magnetic attraction and repulsion is, it is convenient to visualize magnetic lines of force which extend outward from one magnetic pole to the other as illustrated in Fig. 19.

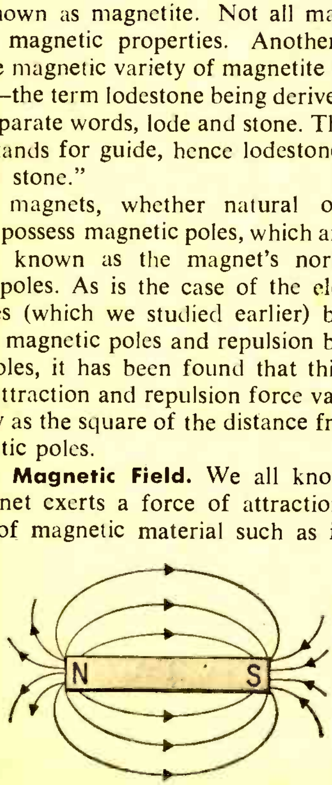


Fig. 19. Lines of force around bar magnet can be made visible by sprinkling iron filings onto white paper over magnet. Tap paper gently.

Permeability. Magnetic lines of force can pass through various materials with varying ease. Iron and steel, for example, offer little resistance to magnetic lines of force. It is because of this that these materials are so readily attracted by magnets. On the other hand, materials such as wood, aluminum and brass do not concentrate or encourage the passage of magnetic lines of force, and as a consequence are not attracted by magnets.

The amount of attraction a material offers to magnetic lines of force is known as its permeability. Iron and steel, for example, possess high permeability since they offer little resistance to magnetic lines of force. Nonmagnetic materials have low permeability. For practical purposes, we can say that reluctance is to magnetic lines of force what resistance is to an electrical current.

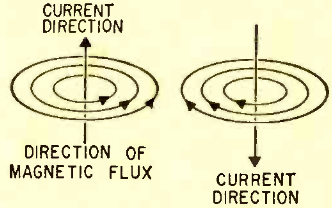


Fig. 20. Direction of flux lines is changed by direction of the current. Heavy current is needed to make flux lines visible with sprinkled filings.

Electromagnetism. Any electrical conductor through which flows an electrical current will generate a magnetic field about it which is perpendicular to its axis as shown in Fig. 20. The direction of this field is dependent upon the direction of current flow, and the magnetic field strength proportional to the current strength. If this current-carrying conductor is wound into a coil, forming a solenoid, the magnetic field will be increased by each individual turn that is added. If an iron core is inserted in this current carrying coil, the generated field will be increased still further. This is because the lines of force are concentrated within the iron core which has considerably less reluctance than the surrounding air.

The magnetizing power of a multi-turn current-carrying coil through which a core is inserted is proportional to the current flowing through the coil as well as the number of turns in the coil. The current through the coil is termed *ampere turns*. As an example, if a coil consisting of 200 turns is carrying 2 amperes, its ampere turns equal:

Ampere turns = 200 turns x 2 amperes or

400 ampere turns

Similarly a coil of 100 turns through which a current of four amperes flows also has 400 ampere turns.

Electromagnetic Induction. We saw earlier how a current carrying conductor will generate a magnetic field which is perpendicular to the conductor's axis. Conversely, a current will be induced in a conductor when the conductor is passed through a magnetic field. The strength of this induced current is proportional to both the speed at which it passes through the field and the strength of the field. One of the basic laws pertaining to electromagnetic induction is Lenz's law which states: "The magnetic action of an induced current is of such a direction as to resist the motion by which it is produced."

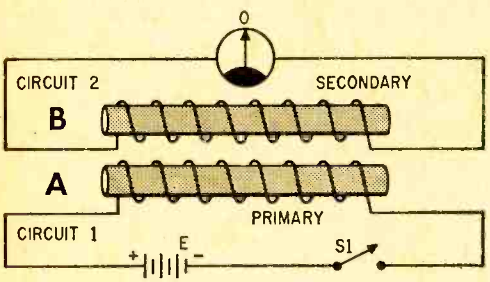


Fig. 21. Two-core transformer is inefficient since an air gap at either end does not have permeability of a ferrous metal and some flux lines do not go through core of secondary winding (B)—their effect is lost.

Fig. 21 illustrates two coils, A and B, which are placed in close proximity to each other. Coil A is connected in series with a switch and battery so that a current may be sent through it when the switch is closed, and coil B is connected with a current-indicating DC meter. When the switch is closed, current will flow through coil A, causing a magnetic field to be built up around it. In the brief instant that the field is building up to maximum, it will "cut" the turns of coil B, inducing a current in it, as indicated by a momentary flick of the indicating meter. When the switch is opened, breaking the current flow through coil A, the field around coil A will collapse, and in so doing will again induce a current in coil B. This time, however, the flow of current will be in the opposite direction. The meter will now flick in an opposite direction than it did when the switch was closed. The important thing to remember is that the conductor must be in motion with respect to the magnetic field or vice versa in order to induce a current flow. You can perform this simple experiment using two coils made of bell wire wrapped around large nails, a few dry cells in series, and a DC zero-center scale meter.

Self Induction. As mentioned a short while ago, a magnetic field is built up around a coil at the application of current through the coil. As this field is building up, its moving lines of flux will cut the turns of the coil inducing a counterelectromotive force

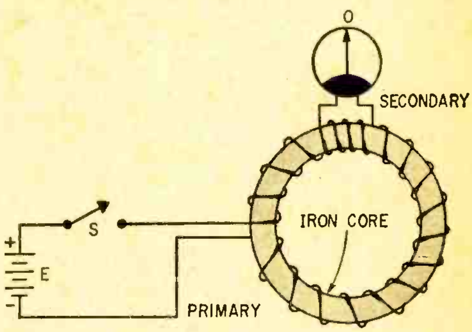


Fig. 22. Toroidal core is highly efficient but is very difficult to manufacture. Familiar C- and E-shape core has less waste and windings are slipped over the core. Efficiency is good—about 90 percent for most designs.

or counter EMF which opposes the current flowing into the coil.

The amount of counter EMF generated depends upon the rate of change in amplitude of the applied current as well as the inductance of the coil. This value of inductance is dependent upon the number of turns in the coil; a coil with many turns will have greater inductance than a coil with few turns. Also, if an iron core is inserted into the coil, the inductance of the coil will increase sharply. The unit of inductance is known as the *henry*.

The Transformer. One of the most important and widely used applications of mag-

netic induction is the transformer. Transformers find the major application in stepping up or down voltage and current in countless applications.

Fig. 22 shows the basic construction of a typical transformer. While two separate windings are shown here, some transformers can have as many as five or six windings.

A transformer consists of two or more separate windings, electrically insulated from each other. One winding, which is known as the primary winding, is fed from a source of alternating current.

The alternating currents flowing through the primary induce a current in the secondary winding by virtue of magnetic induction. The transformer core is constructed from a relatively high permeability material such as iron which readily conducts magnetic flux between the primary winding and secondary winding.

The alternating current flowing in the primary of the transformer produces a variation in the magnetic flux circulation in the transformer core which tends to oppose the current flowing in the primary winding by virtue of self-induction. The counter EMF is just about equal to the voltage applied to the primary winding when no load is connected to the transformer's secondary winding. This accounts for the fact that very little current flows through the primary winding when no load is connected to the secondary. The negligible current that does flow under this no-load condition is known as the transformer magnetizing current. As the current drawn from the secondary winding increases, the primary current will increase proportionately due to the reduction in the counter EMF developed in the primary winding of the transformer.

In any transformer the ratio of the primary to secondary voltage is equal to the ratio of the number of turns in the primary and secondary windings. This is expressed mathematically as follows:

$$\frac{Ep}{Es} = \frac{Np}{Ns}$$

where Ep = primary supply voltage
Es = voltage developed across secondary
Np = number of primary turns
Ns = number of secondary turns

The above formula assumes that there are no losses in the transformer. Actually, all transformers possess some losses which must be taken into account.

Transformer Losses. No transformer can be 100 per cent efficient due to losses in the magnetic flux coupling the primary and secondary windings, eddy current losses in the transformer core, and copper losses due to the resistance of the windings.

Loss of magnetic flux leakage occurs when *not all* the flux generated by current flowing in the primary reaches the secondary winding. The proper choice of core material and physical core design can reduce flux leakage to a negligible value.

Practical transformers have a certain amount of power loss which is due to power being absorbed in the resistance of the primary and secondary windings. This power loss, known as the copper loss, appears as heating of the primary and secondary windings.

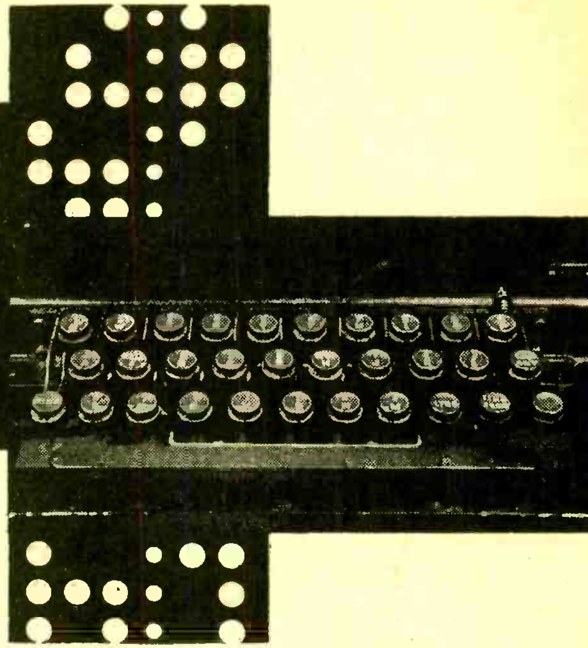
There are several forms of core loss—hysteresis and eddy current losses. Hysteresis losses are the result of the energy required to continually realign the magnetic domain of the core material. Eddy current loss results from circulating currents induced in the transformer core by current flowing in the primary winding. These eddy currents cause heating of the core.

Eddy current loss can be greatly reduced by forming the core from a stack of individual sheets, known as laminations, rather than from a single solid piece of steel. Since eddy current losses are proportional to the square of core thickness, it is easy to see that the individual thin laminations will have much less eddy current loss as compared with a single thick core.

Another factor which effects eddy current loss is the operating frequency for which the transformer is designed to operate. As the operating frequency is increased, the eddy current losses increase. It is for this reason that transformers designed to operate at radio frequencies often have air cores and are void of ferrous metals.

Theory and Practice. We've come a long way from our initial discussion of the atom and its importance for an understanding of electricity and magnetism. And there's still a long way to travel to understand all about the subatomic nucleus and its satellites and how they are being harnessed in an ever-expanding electronics technology. But, we move ahead by mixing theory with practice—so, put your new knowledge to work in a project or two! ■

Basics of RTTY



Speeds of 60 wpm are attainable, with characters typed as fast as sent out.

■ "I *read* you five by five" is a familiar phrase in Ham radio. But the only crowd who can use it literally is the one on RTTY —Ham radioteletype. These communications are by printed page, with typed-out messages you can really *read.* Instead of speaking into a mike or hitting a key, the RTTYer sits at a machine (Fig. 1) that looks like an overgrown electric typewriter. There's the usual back-and-forth rag chewing, but it's neither voice nor Morse code. In the words of the RTTYer stations "print" each other.

These are the guys responsible for funny-sounding pulses you've probably heard on CW—the ones that sound like a chirpy CW signal running at high speed. And you might have wondered how anyone could copy such fast code. No one can, of course, since the pulses are too fast for the human brain to follow. But the Ham's Teletype machine thrives on speed, and tools along at 60 words a minute.

Is high speed the reason for hams on RTTY? In most cases it is not. The main appeal of RTTY is that the field is wide open for the experimenter. It's something entirely fresh for the natural-born tinkerer. It takes a while to get used to the idea of putting oil on a piece of radio gear, but once a ham gets accustomed to this marriage of mechanics and electronics, he seldom gives it up. For the fellow who likes to turn thumb screws as well as tuning capacitors, RTTY offers a never-ending challenge. Many Hams rise to this challenge like a rocket leaving the launching pad, and devise original circuits for receiving and decoding the RTTY signal that makes the wheels go 'round.

Pulses. A Teletype machine feeds on a special diet of electrical pulses. These pulses trigger a mass of levers and gears inside the machine into motion which print letters and figures on a paper roll. As in Morse code, there is a different combination of pulses for each printed character, plus a few extras for spacing and functions such as carriage return, line feed, shifting from figures to letters, even ringing an attention-getting bell.

For each letter, figure, or machine function, there is a set of seven pulses. First is a *start* pulse which tells the machine in ef-

by Marshall Lincoln
K9KTL

fect: "There's a signal starting to come in. Hitch up gears and get ready." The last pulse is a *stop* pulse, which instructs the machine: "You're done with that letter, relax for a few milliseconds before the next one comes along."

Those five pulses between *start* and *stop* are the ones which determine which letter or figure the machine will print, as shown in Fig. 2. This is why the Teletype code used by Hams is called a *five-level code*. The intelligence-carrying job is primarily done by various combinations of five pulses. Consider it this way. Think of five zeros: 0 0 0 0 0. Each zero represents a fraction of a second, or interval of time. Let's say the signal for the letter *R* comes into the machine. Letter *R* consists of a pulse in the *second* and *fourth* intervals (with no pulse in the first, third and fifth intervals). You could represent the *R* in code like this: O X O X O. The letter *Y*, on the other hand, is just the opposite: X O X O X. So we see that different pulse and space combinations determine the character. Incidentally, letters *R* and *Y* frequently are used to test Teletype machines. They're *electrical opposites*, and make the machine reverse gears, so to speak, after each interval. This provides a good test of all vital parts in the machine.

In RTTY parlance, the presence of a pulse at the machine is a *mark* and the absence of one is a *space*. The terms are carryovers from the old days of the printing telegraph, when dots and dashes were actually printed by the receiving machines. Both mark and space are referred to as pulses, but at the machine itself a mark means pulse of current, while a space is the absence of current for a definite interval.

There are 32 possible combinations (Fig. 3) of these five mark and space pulses. They cover 26 letters of the alphabet and the mechanical machine functions already mentioned. There are no lower case letters on the machines—all letters are capitals. By pressing a *Figures* key the machine is set up to print figures (numerals) and punctuation marks. Pressing a *Letters* key gets the machine back to letters again. Many machines also have levers which shift them to printing letters when the space bar is pressed.

When Hams first started using Teletype, they simply keyed the transmitter carrier; on for mark, off for a space. This was done

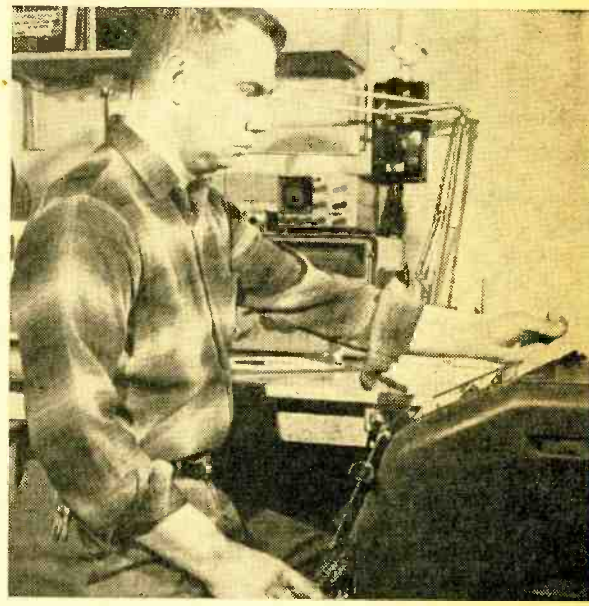


Fig. 1. Copy is actually read at this Ham shack. There are some differences in Teletype keyboard but if you can type you can transmit RTTY messages.

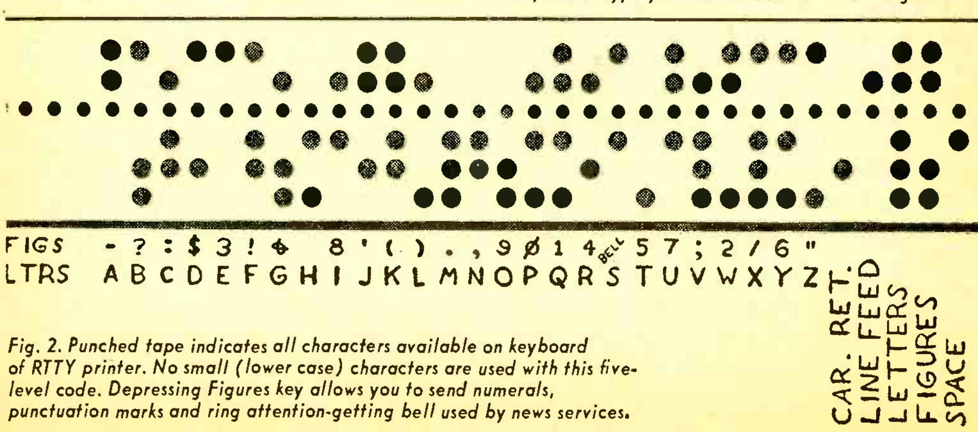
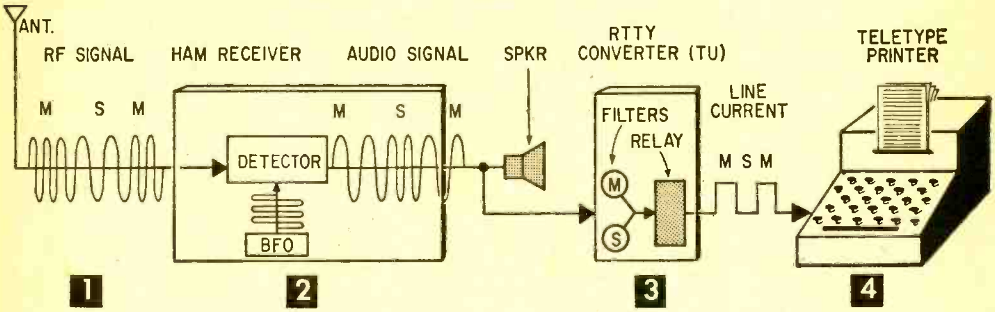


Fig. 2. Punched tape indicates all characters available on keyboard of RTTY printer. No small (lower case) characters are used with this five-level code. Depressing Figures key allows you to send numerals, punctuation marks and ring attention-getting bell used by news services.

Fig. 3. Keyboard only needs three rows of keys since the twenty-six lower-case letters of the alphabet are not used. Letters are in same positions on typewriter. Fig. 4. (below) Block diagram for RTTY receiver.



rapidly by the switching mechanism inside the machine.

The Problems. Interfering signals or noise pulses could fill in the brief interval of "dead air" when the transmitter was off during a *space*. This would make the receiving machine print garbled copy (wrong letters).

So, they tried transmitting a signal on one frequency for *mark* and on a sightly different frequency for space. It worked well, and that's the way it's done today. It's called frequency-shift keying (FSK). The transmitted carrier remains *on* continuously, but it is flipped rapidly back and forth between two adjacent frequencies. That's the rcason an RTTY signal sounds chirpy.

The FCC allows Hams up to 900 cycles of shift for RTTY work. Hams have pretty much standardized on 850 cps. This provides wide enough shift to make it fairly easy to adjust equipment, and leaves a margin for error and still stay within the legal limit. Some operators are experimenting with narrow shift, down around 170 cps or so. This requires better equipment to distinguish between the two frequencies so close together, but has the advantage of being less susceptible to interference.

Incoming. To receive an RTTY signal, a ham generally uses an ordinary communications receiver with the BFO turned *on* so

Fig. 5. Teletype tape does not usually have any printing but experienced operators often read tape perforations across width of paper tape.

the frequency shifts of the incoming signal produce a varying audio beat note in the receiver. (The overall system is in Fig. 4.) These audio notes are fed to a device variously known as a *terminal unit* (TU), *receiving converter,* or *demodulator*. Basically it contains a pair of filters tuned to two audio frequencies which are 850 cycles apart. Conventionally, these are 2975 and 2125 cps. One filter accepts the mark frequency (2125 cps), the other accepts the space frequency (2975 cps) and passes them through a stage of amplification then to a keyer tube on relay. This controls current to the Teletype machine. Current flows for *mark* and is turned off for *space*. This operates an electromagnet in the machine which, in turn, triggers a series of levers which operate type bars.

On six meters and above, Hams use a slightly different method for sending RTTY

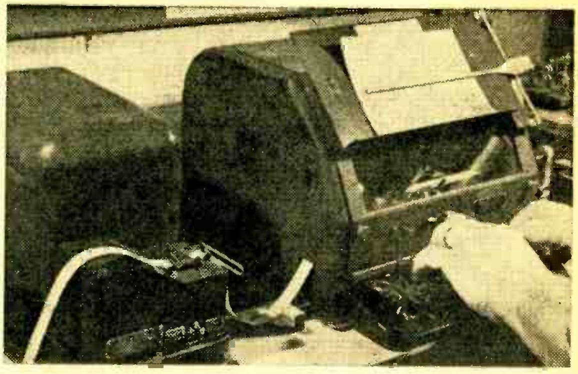


Fig. 6. Tapes can be prepared in advance and then zipped out at 60 wpm by tape distributor (to left of keyboard).

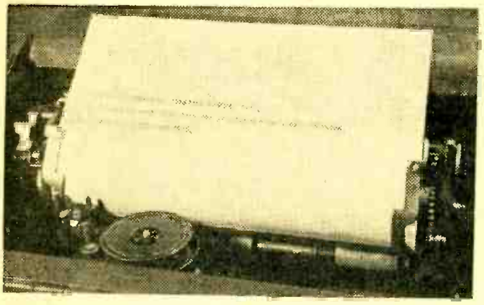


Fig. 7. Received copy rolls right out of printer that resembles typewriter. Generally special long lengths of paper are used unfolding directly from packing box into printer.

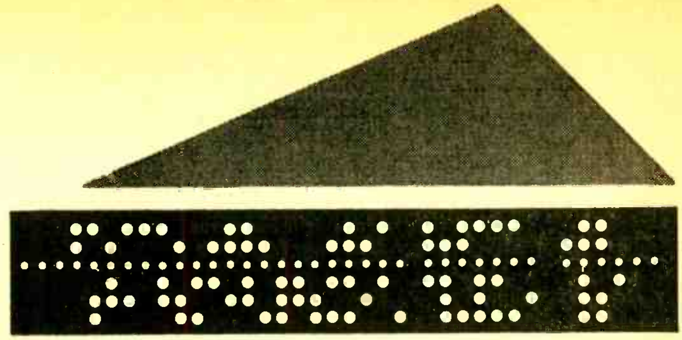
signals. Instead of shifting the carrier frequency to correspond to mark and space pulses, the steady carrier is modulated with two audio tones—one for mark, the other for space. This is known as *audio frequency shift keying* (AFSK). Converting the received tones to electrical pulses is done much the same as with FSK, except the receiver BFO does not need to be turned on. AFSK is not permitted below 50 mc, so hams on the lower frequencies must use FSK.

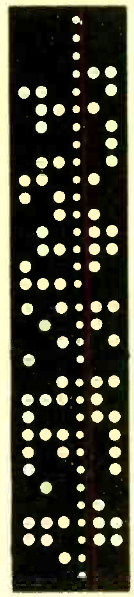
Outgoing. Transmitting Teletype signals is relatively simple. The keyboard of a Teletype machine operates a set of electrical contacts that open and close in sequence to form the mark and space pulses of the Teletype code. These contacts are connected to the transmitter VFO (in the case of FSK) or to an audio-tone generator (in the case of AFSK) which feeds its output to the transmitter. Many people are surprised to learn that a Teletype actually is two separate machines in one cabinet. Although both are driven by the same motor, the receiving and sending units are otherwise completely separate. They may be connected together electrically so the receiving unit prints what the sending unit is sending, or they may be operated independently. An operator may bang away at the keyboard, sending a message, while at the same time monitor his sending on the same machine. Or, he can receive a message on one frequency while sending a message on a different frequency—with the same machine!

A more versatile arrangement is to use a machine which punches holes in a paper tape (Fig. 5.) corresponding to mark and space pulses. This tape may then be fed through a device called a *tape distributor* which operates the transmitter the same way as a keyboard. A tape distributor (Fig. 6.) contains its own motor and a set of electrical contacts like those operated by a Teletype keyboard. As the tape is pulled across a set of sensing pins by a cog wheel, the pins (feeling holes in the tape) operate electrical contacts. They create electrical pulses identical to those produced by a Teletype keyboard. The result is shown in Fig. 7.

With this set-up, a Ham can prepare a long transmission or series of messages in advance of going on the air. Then the tape distributor can do the actual sending at a smooth, constant speed. Or, he may receive an incoming transmission on his printer while at the same time preparing his answer by punching a tape. When his turn comes to transmit, he feeds the punched tape into the tape distributor, which obediently bangs away at an impressive 60 wpm.

If the prospect of humming machinery wedded to electronic circuits looks inviting, why not look further into RTTY? Part 2 of this article tells you what you need to know for getting a rig on the air. ■





Putting RTTY in the Shack

by Len Buckwalter
K1ODH

Communicate with instant-messages. A typed sheet of copy straight from the receiver gets those cans off your ears and the pencil out of your "fist" but RTTY's hard work.

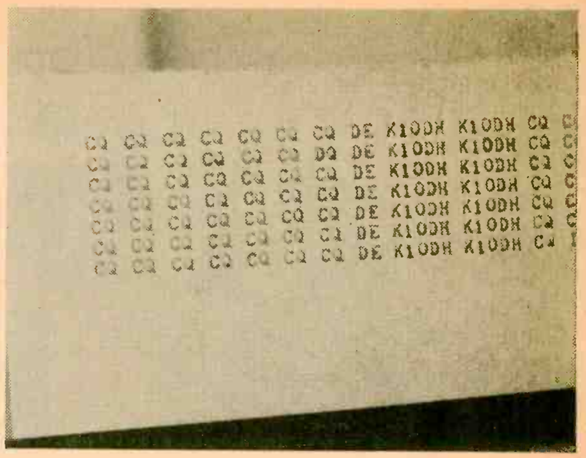
☐ You won't have to hock the family jewels or get an engineering degree to get on radio-teletype. If you're a ham with a reasonably good rig, you may already own about 75% of an RTTY station. How about the other 25%—and the myriad items you need to know about before you can hit those 32 green keys? Before considering them, here's the most important question of all.

Is It Your Cup of Tea? If the ink is barely dry on your Ham ticket, better get your kicks first on phone and CW. They provide solid operating experience needed for more sophisticated RTTY. Later, when the thrill goes out of brass pounding, and your voice grows hoarse from calling CQ, you're a candidate for QSO'ing on a teleprinter machine. As scores of once-jaded Hams will attest, it can put the sizzle back in ham radio.

Hams who won't touch a screwdriver, maybe cringe at the sight of an oil can, or can't wire an AC plug, probably won't enjoy the game. Though you need no great skill or know-how, it's an asset to enjoy fiddling and experimenting with equipment —even if you have to go by the book. Your RTTY machine will have a mass of mechanical parts going *ta-pocketa ta-pocketa,* and they need a roll-up-your-sleeves lube job at regular intervals. RTTY is for the nuts-'n-bolts man.

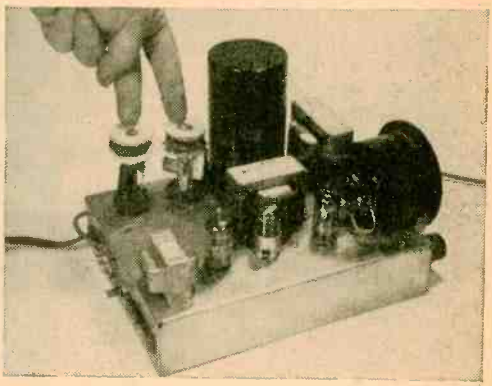
Take Stock. Some Ham RTTY rigs resemble the inside of the blockhouse at Cape Kennedy. But in the beginning there's no need for that level of complexity. Let's begin with the basic rig; a receiver and transmitter combination you might already have. There is no special circuit needed *inside* the receiver. Any reasonably good model fills the requirement. About the only type that won't give satisfactory results is the AC-DC gutless wonder that quivers as you walk across the room. The receiver must be fairly stable or you'll have to do a lot of retuning to keep the RTTY signal on the nose. But given plenty of warm-up time, a moderately priced set will stop drifting and provide the required stability. Other worthwhile receiver

e/e RTTY IN THE SHACK



A typical Ham RTTY CQ can be punched into tape. Spliced end-to-end it can be run continuously through tape keyer for calling.

Teletype machine, in front of operator (below) is used with units on shelves at rear. All that's needed is a TU converter. The Twin City converter—a 3-tube job—is shown at right.



Some of the Ham RTTY publications (right) help point up the state-of-the-art of Ham equipment and RTTY experimental units.

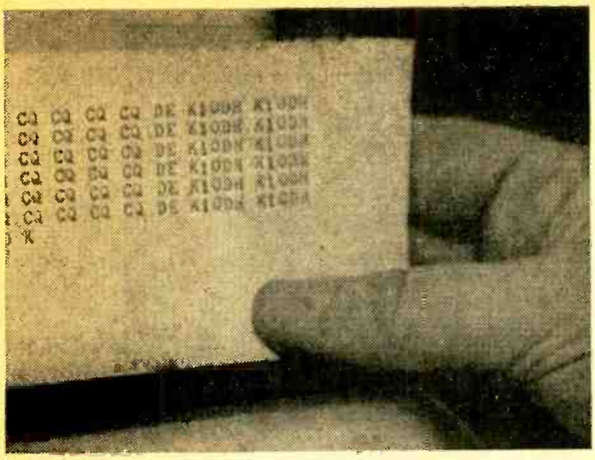
features: an easily adjusted BFO and bandspread tuning. Exceptional selectivity in the receiver is nice to have, but not imperative for the beginning RTTY'er. Chances are you'll start with standard (as opposed to narrow) shift operation where the signal is relatively wide. The only modification to the receiver in a simple system is tapping the incoming audio signal from the speaker terminals.

The frequency bands used for radioteletype correspond to those of regular phone and CW work. RTTY stations commonly use 80, 40 and 20 meters. Within each band there are RTTY frequencies where stations tend to cluster (like 3620, 7140, and 14,090 kc.). Some operators prefer VHF bands—6 and 2 meters. These are valuable for QRM-free, local contacts. Thus the regular ham rig provides the necessary frequency coverage on HF, with receiving converters added for VHF, if desired.

Transmitter requirements. No complex circuits are needed inside the transmitter, but it should have *variable-frequency oscillator* (VFO). (Crystal-controlled oscillators don't lend themselves to frequency-shift keying.) You'll have to make up a simple adapter to enable the Teletype machine to vary transmitter frequency. It helps to have a stable transmitter that won't drift and cause tuning problems for the Ham trying to copy you at the other end of the QSO.

On the matter of transmitter power, most old-timers say pour on the coal. Good advice, but you can still do plenty of operating at moderate power, especially for local rag chewing and short skip. Try to get at least 100 watts into a good antenna. At higher power there's more chance to work cross-country and occasional DX. Lower power has increased garbling, strike-overs and missed words.

Total Tab. If you own a suitable rig, con-



sider next the cost of adding RTTY. The price of a *brand new* Teletype machine is about the same as a fully equipped Volkswagen. But incredible as it may sound, fine Teletype printers—which function for both send and receive—can run under $100! The machine shown in the photos (a Model 26) cost $60. It spews out signals as well as the best of them. The secret is simply that Teletype machines are retired in sizeable numbers to make way for newer, faster machines demanded by commercial and military services. If it weren't for this cost-busting factor, RTTY and Hamming simply couldn't mix. How you can get these machines—and they are not freely available except to hams—is detailed in a moment.

After the machine, next item is the terminal unit (TU). This is the device which converts audio signals from your receiver into a form that can drive the Teletype printer. Again, the price of a commercial unit is sky high, but cost is piddling if you build the popular home-brew job known as the *Twin City* converter. As shown in the photos it's a 3-tube chassis. All new parts cost about $35, but a generous junkbox can slash that figure. We built ours for some $10 in new components.

Thus the grand total for getting on the air with a functioning RTTY rig might dip as low as $70. Sure you can get ritzy accessories, like a scope for visual tuning of the RTTY signal but it's not a beginner's necessity. (Later on you'll give up candy bars to buy one.) There's one other item—the keyer unit which enables the Teletype machine to drive your transmitter as you type. In some Ham rigs, it is done simply with the addition of a potentiometer (with instructions provided by the manufacturer) or an uncomplicated 1-tube or 1-diode circuit.

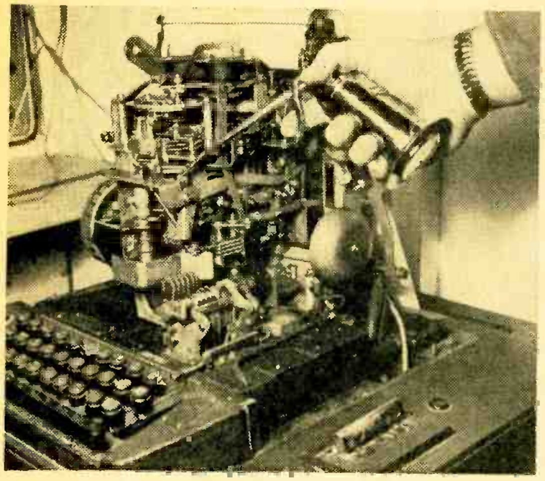
Get The Dope. Before buying any hardware consider these sources of information. They contain much valuable data on Ham RTTY:

The New RTTY Handbook by Byron H. Kretzman. Cowan Publishing Corp., 14 Vanderventer Ave., Port Washington, L.I., N. Y. 11050. $3.95. This 191-page book covers theory and practice. It contains the *Twin City* converter circuit and construction data. Listed are Hams in each of the call areas who might supply you with leads on where to purchase equipment locally.

Ham-RTTY by W2NSD/1, W4RWM. 73 Inc., Petersborough, N. H. This is another source book; 113 pages, $2.

RTTY Bulletin. This is a monthly bulletin published by the RTTY Society of Southern California, 372 West Warren Way, Arcadia, Calif. Rate is $3 per year. This publication, by the leading ham RTTY organization, is newsy journal of what's happening in RTTY; from circuits to contests, and anything else that touches the hobby. A useful feature is the *Horse Trades* column. Each month it lists a raft of RTTY equipment for sale and trade. Ads are free to members.

Copying Commercials. It might be apparent that it's possible to set up one-half of an RTTY system—the receiving end—and be able to copy commercial stations transmitting press, telegrams and other traffic. Several factors work against it. For one, these stations exist out of the regular Ham bands, although occasionally they can be pulled in when they're close to the band edges. But even if you tuned with a general-coverage receiver, where such stations



Scope (above) helps to tune RTTY signals for best, error-free copy at advanced installations. For trouble-free operation you'll have more than the usual amount of maintenance work. Regular use of the oil can, and cleaning, will be a must. Dust and lint must be removed and oil gets gummy.

abound, your machine would copy few signals. Most commercial stations have switched to newer equipment and higher speeds. The Ham system is synchronized to 60 words per minute and prints gibberish on most signals other than Ham.

Tickling The Keys. While it helps to know how to touch-type when operating a teleprinter, there's no deterrent to the hunt-'n-peck typist. Operating speed is not comparable to CW, for example, where the fast operator must slow down for the beginner. The reason is that the printer makes a typed record of an incoming transmission. If a particularly slow typist is sending, you don't even have to sit at your machine. Fill in the log, touch up a tuning knob or even leave the shack for a few minutes. The machine will clack away unattended. Then you can walk over to the machine and read the whole transmission in a minute or so.

Sometimes another operator comes tearing back at top speed like a typing champ. Don't be fooled. He may be a two-finger typist who has punched a tape during your transmission. Played back through tape equipment, it transmits at maximum speed. Although this kind of snappy operation typifies the advanced RTTY'er, manual typing skill is an advantage and it makes operating more pleasurable.

Before You Plunge. Getting a basic RTTY rig on the air is neither complex nor time-consuming. But there's an important qualification: It is definitely not like building a kit, or even a construction project like the ones in this magazine. There is no single publication in RTTY literature that takes you by the hand and tells you to *hook wire A to terminal B*. And even if you are well-stocked with diagrams, this is no guarantee that you'll wire equipment correctly.

But there's an answer. By checking through the publications listed earlier, and the Call Book, you should be able to locate an active RTTY'er in your area. If he's typical of most hams, he'll heap you with advice and helpful suggestions. When we got our machine, we puzzled for hours over some dangling leads. A phone call to an active RTTY'er in the area solved the problem in about three minutes. Of course, once you get on the air, the rig becomes a direct radio link to hundreds of fellow hams who'll lavish you with sound RTTY advice.

Meet You On The Green Keys. That's one expression you'll be seeing—and printing—if you go RTTY. Is it worth the effort and cost? Yes, if you want to get in on one of Hamdom's remaining outposts for the experimenter seeking an exciting and different mode of communication. As a bonus, you'll be able to copy news bulletins each evening from the ARRL's station W1AW. They cover everything from reports on OSCAR, the orbiting Ham satellite, to propagation reports on band conditions. And when you work other RTTY'ers around the country, you, too, can sign off with; "see you further down the page. OM." ■

Using Cross-Coupled Circuits

Cross coupling two single-stage amplifiers produces a simple multivibrator that can be used to demonstrate circuits used in all digital computers

by Jack Brayton

■ Cross-coupled circuits can add, subtract, gate, read information in or out, count, generate square waves, eliminate unwanted pulses, shift numbers left or right, store information indefinitely, and accomplish many other tasks far too numerous to list.

In addition to their wide use in computers, they're also used for timing, triggering, pulse shaping, etc. In spite of the many functions cross-coupled computer circuits can perform, they're not complicated, difficult to understand, nor expensive to build. In fact, we'll outline 3 experiments, all of which can be breadbroaded (using the same parts for each experiment and clip leads for switches) for about $4.00. Even this low figure can be cut in half if you have a 6-volt DC source and a few scrap parts.

Also, for those who want something more, plans for a complete cross-coupling demonstrator (Fig. 1) are included. This unit, which costs about $8.50, makes a good Science Fair project and includes the three basic types of cross-coupling. That is, DC (direct-current), AC (alternating-current) coupling, and a combination of AC and DC cross-coupling can be selected simply by flipping a switch. All three circuits are broadly classified under the multivibrator heading. And, although the circuits *look* similar, they're very different in the jobs they perform.

Fig. 1. Demonstration unit has three types of multivibrator circuits easily selected by a front panel 3-position switch.

CROSS-COUPLED CIRCUITS

Now, let's run through each of the experiments and discover exactly how they work and why they work that way.

DC Cross-Coupling. Fig. 2 shows the schematic used for the first experiment; a flip flop or *bi-stable* multivibrator. It consists of two DC-coupled, common-emitter amplifiers. Q1, R3, R5, and I1 form the first amplifier while Q2, R4, R6, and I2 form the second. You'll notice that the first amplifier's *output* is directly coupled (through R1) to the *input* of the second amplifier. Further, the second amplifier's *output* is directly coupled (through R2) to the first amplifier's *input.* This causes the circuit to have *two stable states*. That is, Q1 can be conducting with I1 lighted or Q2 can be conducting with I2 lighted. Thus the transistors act like simple switches for the lamps and have either a high resistance (open) or low resistance (closed) across their emitter/collector leads. The cross-coupling, as we'll show, *prevents* both transistors from conducting at the same time. To explain, let's trace the circuit's action.

When power is first applied to the circuit, one of the transistors will turn on faster than the other, which causes this transistor to conduct while the opposite transistor cuts-off. We'll assume Q1 conducts while Q2 cuts off.

When Q2 is cutoff its collector rises to −6 volts. This results from the fact that the resistance of Q2's emitter/collector junction is then much *higher* than the series circuit composed of R4 and the lamp. Thus, almost the full battery voltage appears across Q2. However, some current flows through R2, R5, and the *emitter/base* junction of Q1. This current, although *not* large enough to light I2, *is* large enough to cause Q2 to saturate. Thus, Q1's emitter/collector resistance becomes much *lower* than that of R3 and I1. This being the case, most of the battery voltage is dropped across I1 and R3. This, in turn, causes I1 to light. Q2 *cannot* conduct, under these conditions, because Q1's collector potential is at, or near, ground and hardly any current flows through R1, R6, and the emitter/base junction of Q2.

The circuit can be switched from one state to the other merely by closing the input switch to the transistor which is conducting.

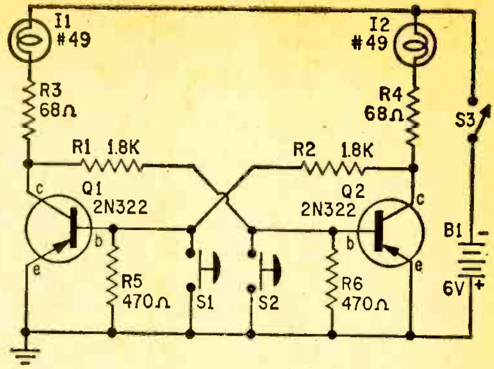
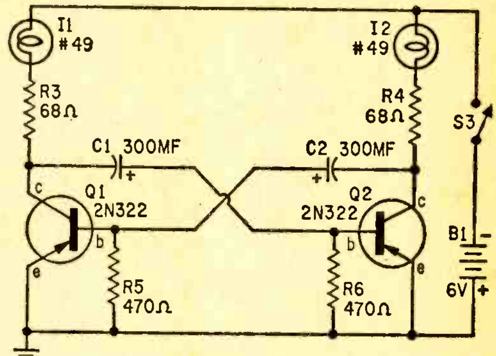


Fig. 2. DC or direct coupled bi-stable multivibrator circuit will let but one lamp light at a time. Pressing pushbutton (S1 or S2) grounds base and transistor jumps to cutoff and other transistor jumps into saturation and is held there by the high-negative bias applied to base connection.

Fig. 3. Charge and discharge of C1 and C2 cause lamps I1, I2 to blink, alternately, on and off.



For example, if I1 is lit and Q1 is conducting we would close S1. This switch momentarily shorts the current flowing through R2, R5 and the emitter/base junction of Q1 to ground. Thus, the *base* current of Q1 is *removed* and Q1 is cutoff causing its collector to go to −6 volts. Now, current can flow through R1, R6, and the base/emitter junction of Q2. Q2 saturates and its collector voltage goes toward ground potential, removing the forward base bias from Q1. Having switched states, the circuit will hold or "remember" its new state until the opposite switch (S2) is closed momentarily. This action, of course, closely resembles that of a latching relay except the circuit switches much faster, has no moving parts to wear out, and usually costs less than electromechanical relays.

AC Cross-Coupling. Fig. 3 shows the second experiment; an *astable* or *free-running* multivibrator. This circuit is similar to the first circuit except there are no input switches and the resistors (R1 and R2, of the first circuit) have been replaced by capacitors C1 and C2. This causes the circuit to *oscillate* and the lamps to blink *on* and *off* alternately. It also causes a square wave to be produced at *both* collectors. To find out how this is accomplished let's take a closer look. Again, we'll assume Q1 conducts and Q2 is cutoff when the power is first applied. Also, we'll assume C2 was previously discharged.

When Q2 is cut off its collector rises to −6 volts and, since C2 has already been discharged, it offers almost *no* resistance to current flow during the first instant. Thus C2 starts to charge through I2, R4, R5, and the emitter/base junction of Q1. This causes Q1 to saturate; its collector goes toward ground potential; and I1 lights. At the same time, C1 starts to discharge through the emitter/collector resistance of Q1 in saturation; R4, and the *back resistance* of Q2's emitter/base junction. It's important to note that C2 is *charging* and holding Q1 in saturation while C1 is *discharging* and holding Q2 cutoff. Thus, the circuit is at a standstill for a length of time determined by the charge and discharge times of C1 and C2. (This time can be altered simply by increasing or decreasing the size of these capacitors.)

When C2 has finished charging, current flow through the capacitor stops, which means Q1 is no longer forward biased. Thus, Q1 is cutoff causing I1 to go out and its collector potential to go to −6 volts. C1 having discharged—either partly or fully—starts to charge to this higher collector potential. It does this through I1, R3, R6, and the emitter/base junction of Q2. Q2, in turn, saturates causing I2 to light and its collector to go toward ground potential. Now C2 starts to discharge through Q2's emitter-collector resistance in saturation, R5 and the back resistance of Q1's base-emitter junction. Again the circuit is at a standstill until C1 and C2 have charged and discharged. Then the entire cycle repeats itself, endlessly.

Because the collector potentials are constantly changing from ground to −6, staying at −6 for a length of time, then returning to ground, a square-wave is produced at each collector.

Before we go on to the next experiment, it should be noted that C1 and C2 do not have to be the same value. Making them different will cause one lamp to stay on longer than the other. With the values shown the lamps blink *on* and *off* about twice a second.

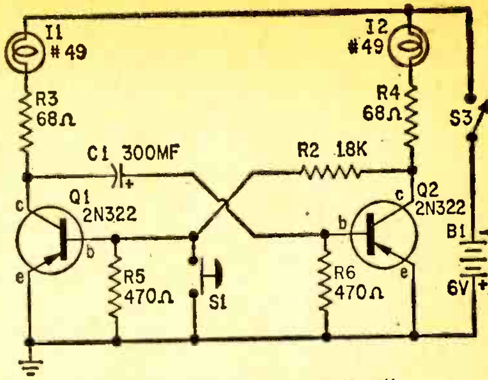


Fig. 4. Pressing S1 sends Q1 to cutoff. I2 will remain lighted until C1 charges. Both lamps will remain dark until S1 is released—then I1 will light and remain lit while S1 is open.

AC/DC Cross-Coupling. The third circuit (Fig. 4) is really a combination of the first two. That is, one AC and one DC coupled amplifier is used to form a *one-shot* or *monostable* multivibrator. The one-shot—as its name implies—provides *one* cycle for each input pulse.

When power is first applied to this circuit, I2 will *always* light for an instant because C1 allows a heavier base current to flow through Q2 than resistor R2 allows in Q1. However, I2 will not stay lit very long because as soon as C1 has charged Q2's base current drops to zero and that transistor is cutoff. This, of course, causes a heavy base current to flow through R2, R4, and the emitter-base junction of Q1. Q1 saturates; I1 lights and *stays lit,* indefinitely.

Of course, momentarily closing S1 will cause Q1 to cutoff; C1 to *charge;* Q2 to saturate; I2 to light and stay lit for as long as it takes C1 to charge. After that Q2 will cutoff and the circuit will return to its orig-

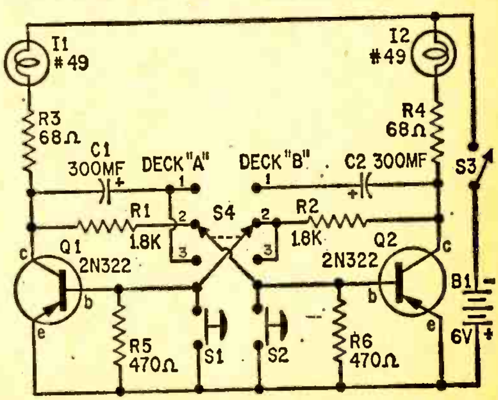


Fig. 5. Double-pole, 3-position switch changes the connections to the different circuits. For some demonstration purposes a neatly breadboarded circuit can use clip leads in place of S4.

CROSS-COUPLED CIRCUITS

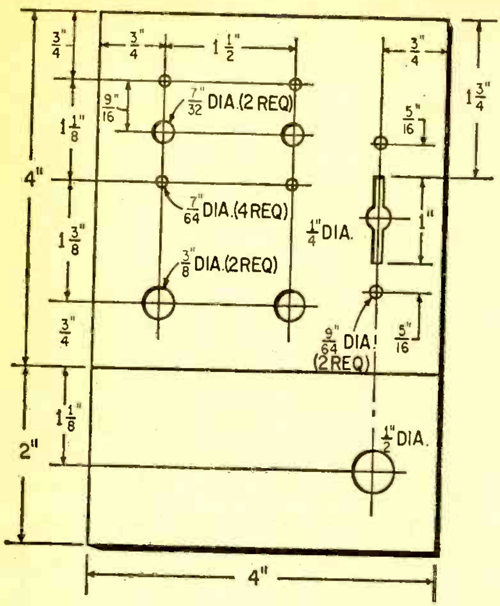


Fig. 6. Front and sloping panel layout for the cabinet calls for 4-inch width since rounded edges of some cabinets do not leave more usable width. Rubber cement or tape full-size template to panel.

inal state. Thus, as we've already mentioned, one input pulse generates one output pulse.

About The Demonstrator. Looking at the demonstrator's circuit shown in Fig. 5 we can see that it's exactly like the experiments except we've included all three types of cross coupling and provided a means of switching from one to the other. Thus, the demonstrator works similar to the experiments and its theory is identical.

Construction. Laying out the chassis is, of course, the first step and this is done according to Fig. 6. The layout should be drawn on graph paper then taped to the front panel and the hole-centers punched.

The slot for the lever switch can be easily made in the following manner. First, drill the 1/4-inch hole at the slot's center as shown. Then, using a *keyhole* hacksaw, cut the slot and file the edges smooth. Since the slot only has to be about 1/16-inch wide, very little

(Continued on page 110)

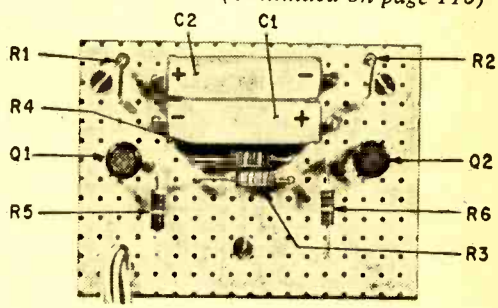


Fig. 8. Perforated phenolic board is ideal for assembling this small circuit. Wiring is not critical since feedback from stray capacitance is not likely in this low-impedance, low-frequency multivibrator circuit.

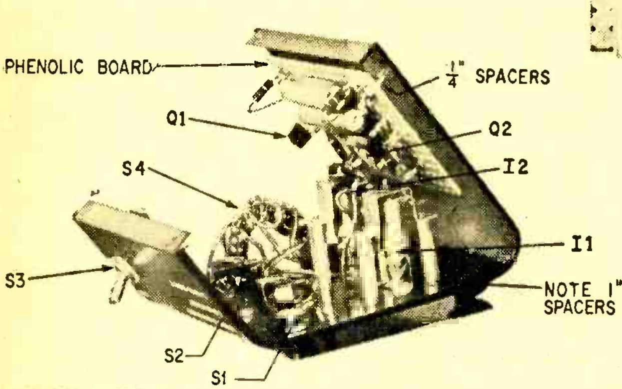
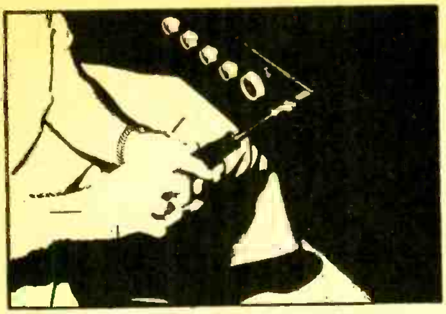
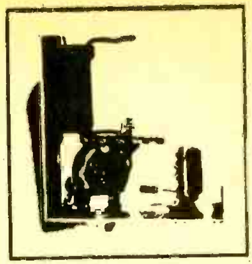
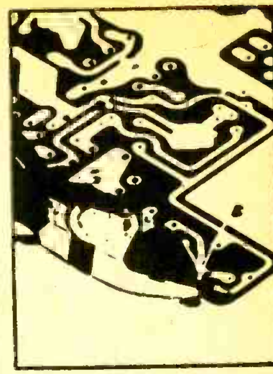


Fig. 7. With the sloping panel down, all major components are visible—none hidden. Transistor circuitry is on phenolic board with leads going to switches and lamps on panel.

PARTS LIST

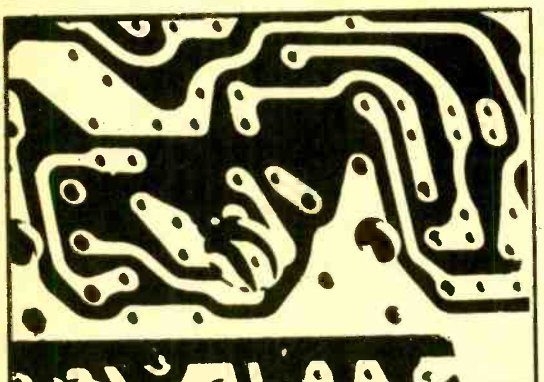
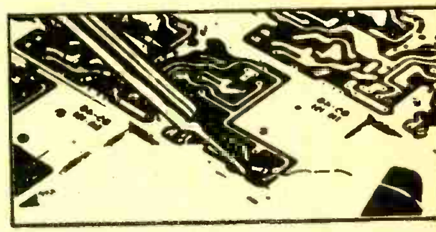
B1—6-volt battery (Burgess, Z-4 or equiv.)
C1, C2—300-mf., 6-volt electrolytic capacitor (Sprague, TE-1106 or equiv.)
I1, I2—Pilot lamp, 2.0-volt, 0.06 amp., bayonet base. (type 49 or equiv.)
Q1, Q2—pnp transistor, 2N322, 2N188A, 2N241A, 2N270, 2N404A or equiv.
R1, R2—1800-ohm, 1/2-watt resistor
R3, R4—68-ohm, 1/2-watt resistor
R5, R6—470-ohm, 1/2-watt resistor
S1, S2—S.p.s.t., momentary contact pushbutton switch (Leecraft, 7-11 or equiv.)
S3—S.p.s.t. toggle switch (Cutler-Hammer, 8280K14 or equiv.)
S4—2-pole, 3-position, positive index, lever switch (Centralab, 1454 or equiv.)
1—Battery holder (Keystone, 175 or equiv.)
2—Pilot lamp sockets (Leescraft, 7-11 or equiv.)
1—Sloping-panel utility box (4 1/2"H x 4 1/4"D x 4-3/16"W) (Premier, ACPC-1200, or equiv.)
Misc.—Perforated-phenolic board (2-7/16" x 3 3/8"); machine screws; spacers; flea clips; wire; solder, etc.

Estimated construction cost: $8.50
Estimated construction time: 2 hours


Build'em Good

by John D. Lenk

Tips on soldering and tools for good-looking electronics projects

■ Any electronics kit, built in the home workshop, can look just as professional as those factory-wired jobs. Those squared-off wiring turns and neatly positioned resistors and capacitors don't just happen by accident, though. It does take a little more effort and some know-how to keep that chassis from looking like a "ball of snakes" from which all wiring emanates.

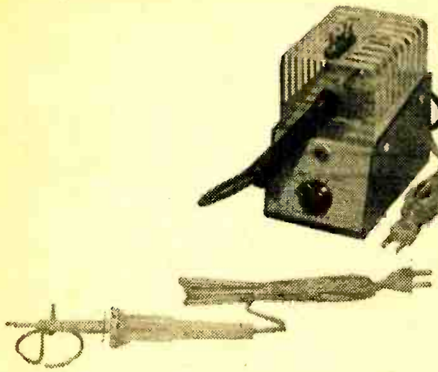
Of course we're referring to that other fellow's projects, not the ones you've built. Your kits never have panels that were scorched by hot soldering irons or scratched by a slipped screwdriver—they never look as if they were built using a blowtorch, pipe wrench and a sledge hammer. Do they?

Well, here are some tips you can pass on to those less adept constructors when they ask you for your secrets of producing finished gear (kits or home brew) that not only works well but looks good—inside.

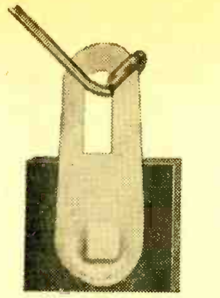
The Facts. We contacted the service representatives of various kit manufacturers to find out where most home workshop kit builders go astray. The consistent repair problems are those caused by improper work habits, incorrect use of tools, poor wiring and soldering practices and *the inability to follow instructions exactly*.

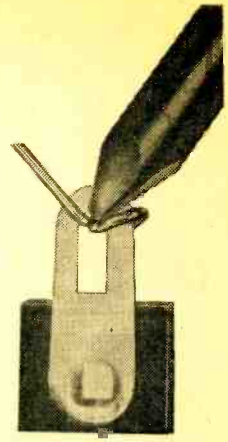
Introduction To Soldering. Before going into the practical side of electronics wiring and construction, let's go over the fundamentals of soldering.

Soft solder, which is used in all electronic construction except for a few specialized applications, is a fusible alloy, consisting essentially of tin and lead. (We could tell you in technical jargon that its purpose is to join two or more metals at temperatures below their melting point. Soft solders secure attachment by virtue of a metal solvent or intermetallic solution action that takes place



Pencil-type soldering irons are popular with numerous technicians as well as hobbyists. Temperature-selection iron is Heathkit GH-52—has 8 ranges.



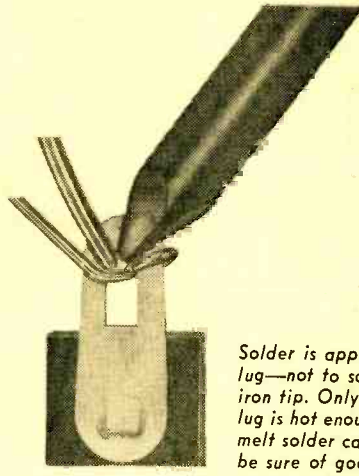


Lead is wrapped around tie-point lug (above) before applying heat to lug (right)—close to wrapped lead end.

at relatively low temperatures. But that won't help you make a better-soldered joint.) Soft solders are not to be confused with *hard solders* or *brazing alloys* whose action involves the formulation of a fusion alloy with the metal that is joined; nor are they to be confused with *welding alloys*, whose action again involves actual fusion with the respective metals. Soft solder secures attachment by dissolving a small amount of the two metals.

A soldered joint is chemical in character rather than purely physical. Therefore, the properties of a soldered joint are different from those of the original solder alone because of the soldering process. The solder is partly converted to a new and different alloy. Thus, a soldered connection is continuous in intermetal continuity while an unsoldered one is discontinuous. When two metals are soldered together, they behave like one solid metal, but when bolted, wired, or otherwise physically attached, they are still two pieces of metal, and often they are not even in direct physical contact with each other due to the extremely thin insulating film of oxide on the surfaces of one or both of the metals.

When tin is added to lead, which melts at 621°F, it lowers the melting point of lead. Also, when lead is added to tin, which melts at 450°F, it lowers the melting point of tin. The alloy of tin and lead with the lowest melting point of the combined metals is known as the *eutectic* composition. It consists of 63% tin and 37% lead, and has a sharp and distinct melting point of 361°F.

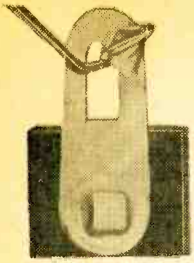


Solder is applied to lug—not to soldering iron tip. Only when lug is hot enough to melt solder can you be sure of good joint.

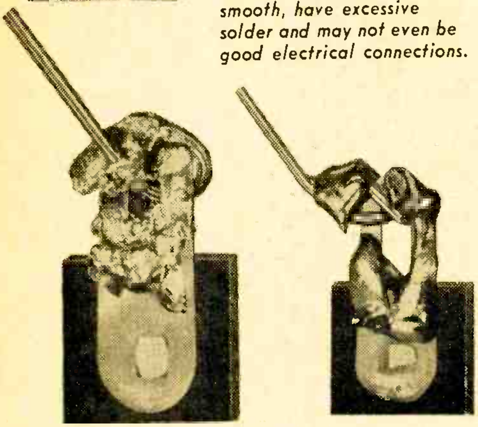
Except for this eutectic alloy, all tin-lead solders are mixtures which do not melt sharply at any one temperature, but will pass through an intermediate range of plasticity in cooling from the liquid to the solid state. Any solder containing less than 63% tin is said to be *eutectic plus lead* while a solder containing more than 63% would be *eutectic plus tin*. Both melt at a higher temperature than the eutectic composition.

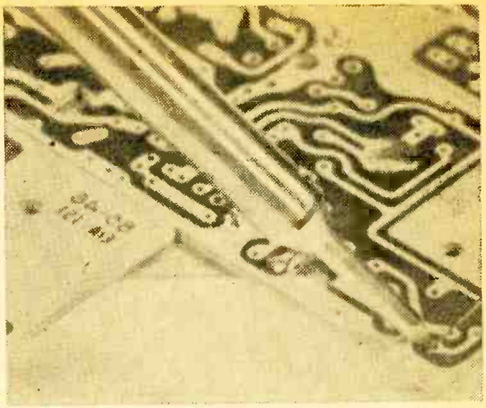
Commercial solders cover the entire range of tin-lead ratios from pure tin to pure lead. A 50/50 (50% tin, 50% lead) or a 40/60 alloy is typical for electronic solders. Most commercial solders in common use also contain impurities. In special cases, other elements are added to the solder to change its characteristics. Such elements include silver, antimony, bismuth and cadmium.

The Flux of the Matter. All common metals are covered with a non-metallic film known as an oxide, which forms an effective insulating barrier that prevents metals from touching each other. As long as this non-



Properly soldered connection (top left) uses little solder. Poorly soldered connections (below) are not smooth, have excessive solder and may not even be good electrical connections.





With printed-circuits, soldering technique is about the same. Pigtail lead is inserted and bent to a slight angle. Foil and lead are heated together. Foil, being thin, heats rapidly. Excessive heating can loosen foil from board.

metallic oxide barrier is present on the surface of metals, the metals themselves cannot make actual metal-to-metal contact, and as a result intermetallic solvent action (soldering) cannot take place.

The *soldering fluxes* remove the metallic-oxide film from the surfaces of the metals and keep it from re-forming during the soldering operation, in order that the clean free metals may make mutual metallic contact. Soldering flux has the same effect as scraping a metal just before soldering. The flux does not constitute a part of the soldered joint. After soldering, the flux residue (still retaining its quota of captured oxides) lies inert on the surface of the soldered joint.

Soldering fluxes are available as a paste which is applied to the metals just prior to soldering, or can be contained within the solder as a core. Wire solder with a flux core is the most common form of solder for electronic wiring. The paste is used primarily to *tin* or prepare the surface of a soldering-iron tip, or where a large surface must be soldered.

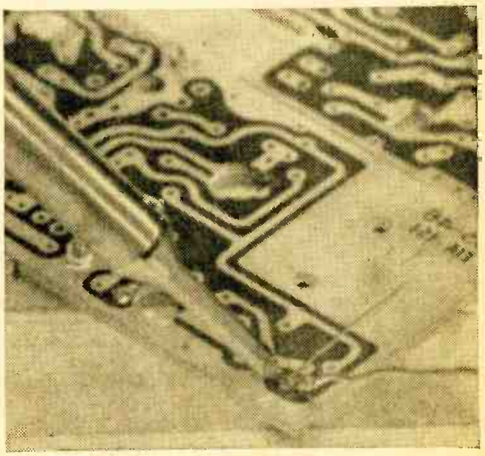
Fluxes can be divided into three general groups: (1) the chloride or acid type, (2) the organic type, and (3) the rosin or resin type.

The acid or organic types of solder are used mostly in sheet metal and plumbing work and should not be used in wiring. In fact, the kit manufacturers will void your guarantee if there is evidence of soldering with anything but rosin type solder.

The chloride or chemical acid fluxes contain a strong acid that cuts the oxides quite nicely, but the remaining acids will continue to corrode the metals after the soldering process is completed.

Organic fluxes contain mild acids that do not tend to corrode the metals. However, organic fluxes are unstable in the presence of high temperatures, and some of them leave a sticky, greasy, residue.

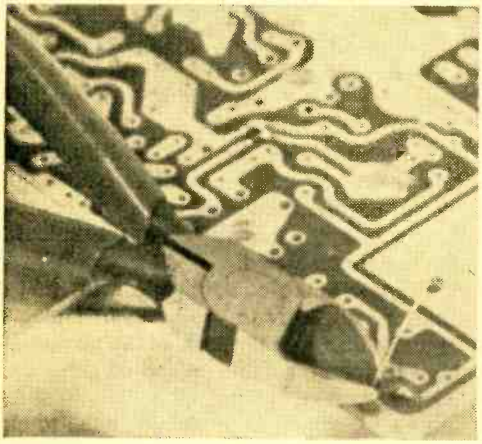
The rosin fluxes are ideally suited to electronic work for two reasons. First, the rosin will act as an acid, to cut the oxides, only when heated. The rosin returns to its nor-



Solder is applied to junction of soldering-iron tip, foil and lead. Since junction of this foil and fine wire heats rapidly, solder is applied only a fraction of a second after heat. Very-thin solder (20 gauge) is preferred by professionals.

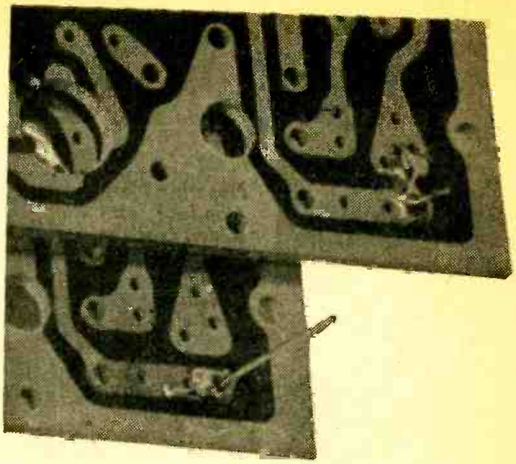
mal, non-acid, state when cool. This prevents corrosion of the metals. The other reason for the use of rosin flux is that it has a very high electrical resistance (3300 trillion ohms per cubic inch!).

Putting the Heat on. No matter what type of solder and flux is used, much of the success in soldering is dependent on heating the metals and solder. Part of the application of heat is dependent upon the soldering technique (which will be discussed later). The other part of the heat problem is selection of the soldering tool. While many tools, methods, and processes are used in industrial and commercial work, either the soldering iron or soldering gun are used almost exclusively in electronics work. Actually, the term *iron* is a hold-over from sheet metal soldering methods. The soldering tools usually have copper tips—some are plated on top of the copper to prolong the life of the tip.



After lead is soldered, clip it off close to board. It is best to insert a group of components, solder, then clip them. Doing individual components will slow down assembly considerably—but the best advice is to follow the manufacturer's instructions.

The ideal soldering tool should produce enough heat for "high-heat" soldering (like chassis solder lugs) but should not be too hot for "low-heat" soldering (like circuit board connections). A small efficient soldering iron (also called a soldering pencil) with a ⅛- to ¼-inch diameter tip is ideal for most circuit connections. Soldering irons are inexpensive and have the advantage of being hot (if they're plugged in) whenever you need them.



Poorly soldered boards are not a lost cause—they can be repaired if you work carefully. Heat, reapplied to the joint on bottom board, will flow solder properly if lead is clean. At top, excess solder can be removed with stiff brush.

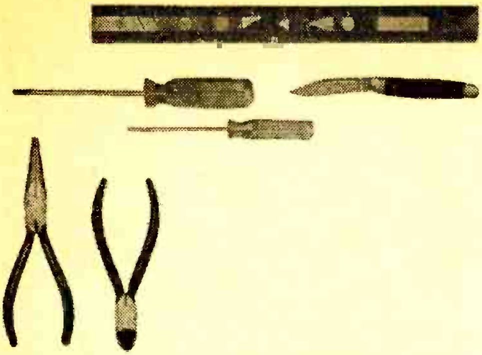
Soldering Guns. These are generally used as repair tools rather than for initial construction. This is because they develop high heat quite rapidly and cool off just as fast. This high heat will quickly melt previously soldered connections for removal of parts or wires.

Most soldering iron tips are pretinned. That is, the tip has been "wetted" with a thin film of solder. When the iron heats, the solder melts and transfers heat to the surfaces that are to be soldered. Unless you are using a plated tip, it may be necessary to retin the tip from time to time. The tinning process is similar to that of soldering. The tip (or surface that is going to make contact with the metals to be soldered) is cleaned of oxides by scraping, filing or with fluxes—then solder is applied to the cleaned tip. Once a thin film of solder is formed over the tip, excess solder is wiped off.

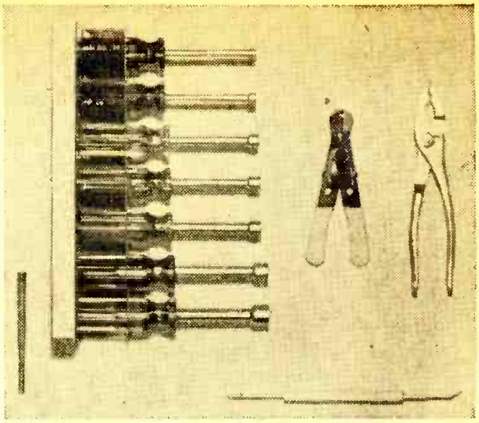
A popular misconception is that the wattage of a soldering tool is the most important characteristic to look for when considering a new purchase—it's not.

Tip Temperature. Far more important is the heat available at the working end of the soldering iron. This is directly related to the shape and size of the tip and how the heat is applied to the working end.

Different designs of the heating elements have great effect, too. Some of the 60-watt economy-type soldering irons are no hotter than the 23½-watt combination element-tip units that thread into their special handles. Probably the best example of the relation of



Most electronics kits can be built with these few hand tools and a soldering iron. Ruler, at top, is used to measure lead lengths. Small screwdriver is used mostly for tightening knob setscrews.



Soft-plastic tool (lower left) is used to start nuts in difficult places. Nutdrivers (socket wrenches) do an expert job of tightening. Wire strippers are adjustable. Slip-joint pliers are often handy, too.

design to tip temperature is the catalog data for one brand element.

When the tip and element are made in one permanent unit, the 23½ watt tip (depending upon shape) reaches a temperature of 650° to 700°F while the same wattage element with a thread-on tip is rated between 600° and 650°F. This 50°F difference can be quite important when working in an area that is cool or drafty.

Heat Transfer. Getting heat to the joint to be soldered is the most important part of the process. A clean hot iron will transfer heat the fastest. Clean does not mean *dry*—*clean* means free from oxidization and charred flux. For maximum heat transfer in the shortest possible time the tip must be *wet* with solder—this makes better contact between the tip and the joint.

To some extent a low-heat soldering iron can damage more components than a moderate-heat iron. The faster a joint heats the less time the heat has to be applied. With a sufficient heat (and soldering experience) you can solder a joint and get the soldering iron away before the heat has a chance to creep up the lead. Take a good look at that production-wired printed-circuit board — there just isn't any space to get a heat sink on the component leads. Besides, most heat damage to transistors and diodes occurs only when current is flowing through them—just make real sure that they have cooled off completely before you apply power to the circuit.

Wiring And Soldering. The service centers of kit manufacturers spend much of their time unscrambling home kit builder's butchered wiring and soldering. Except for not following instructions precisely, poor soldering is the major cause of kit failure. And it has proven by actual record that a sloppy kit-wiring job goes hand in hand with intermittent or poor performance. In any case, the poorly wired kits seem to find their way into the service shops more often. The following steps may seem quite basic, but they can't be over-emphasized:

Wiring must be mechanically secure on the terminal before applying heat or solder. Pass the wire around and through the terminal, then crimp it with needle nose or long nose pliers. Clip off any excess lead length. Make certain not to drop the wire bits back into the chassis. Small lengths of wire make excellent shorts between power leads and ground.

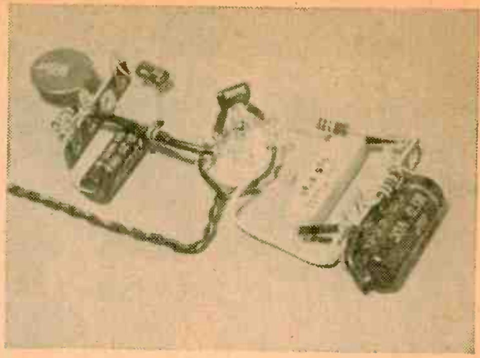
Apply heat to the terminal, not just to the wire. The soldering-iron tip should be placed on the joint so that heat will be transferred through the terminal to the wire. Use the correct amount of heat. Too little heat can cause a cold-solder joint (poor electrical contact), and will cause the solder to appear dull or crumbly after it has cooled. The correct amount of heat produces a bright solder connection. Naturally, too much heat, applied too long, will damage surrounding parts.

Some solder must be applied to the iron—too much can run into the terminal before it's properly heated. This can cause either poor electrical connection, or a cold-solder joint, or both. It goes without saying that you must use a good grade of rosin core. (To remove excess flux clean the connection with a small stiff-bristle brush dipped in a non-inflammable solvent, immediately after the connection has cooled.)

Once you have mastered the basic solder-

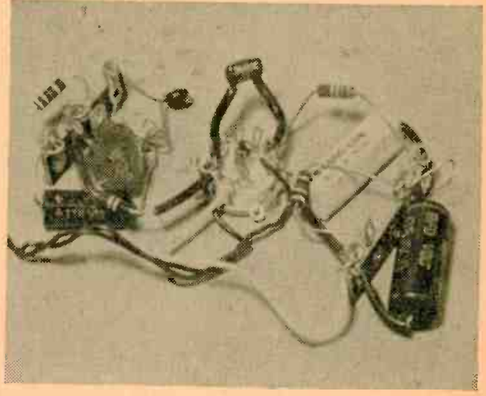
Carefully checked and placed kit components are easy to find and less likely to be lost or damaged. Cabinet, dial parts and knobs are left wrapped until all other work is finished—this prevents scratches.

Illustrations courtesy of Heath Co.



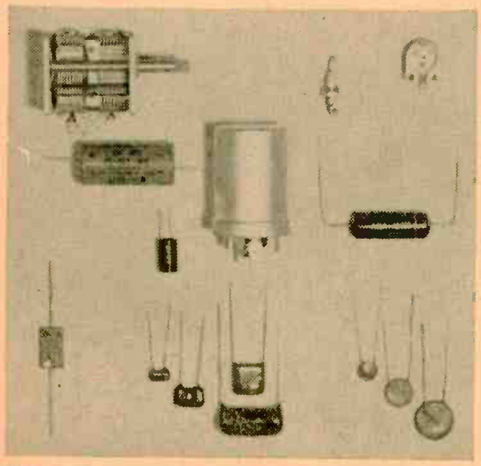
Resistors and capacitors above are neatly positioned. Often this is not practical in high-frequency work where leads must be kept as short as possible or cut to an exact, specified length to prevent trouble.

Jumble of parts (below) looks like someone dropped a handful out of a bag. Excessive lead lengths help create short circuits and often break easily from vibration. There is no excuse for sloppiness.



ing theory and technique, you are well on the way to becoming a good craftsman in the art of electronic construction. Here are some additional tips that should make life a lot easier on your next construction job.

Follow Instructions. This is one rule that those experienced in electronics (engineers, technicians and old-time Hams) often break. They often start at Step 15 or so, instead of Step 1. The kit manufacturers go to great lengths to prepare the instruction manuals so that all parts would be mounted and wired

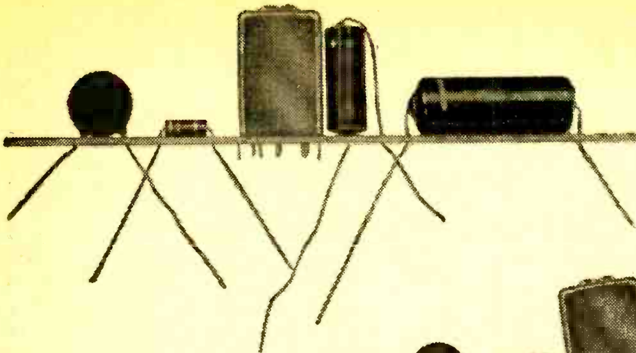


Some of the many types, shapes and styles of commonly used capacitors. Individual units are described or illustrated by kit manufacturers to prevent the mistakes possible by selecting wrong unit.

in a specific order. (The same is true of many construction articles found in magazines.) By not following this order, you find that some particular part will not quite fit as indicated in the instructions. So you stick it in at the next best spot. The kit may work that way, but the net result is a jumble of parts that mark the unit as home-made.

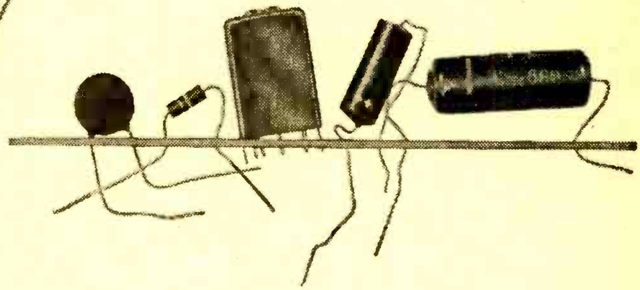
Have A Place For Tools. Select all of the tools you will need before you start. Lay them out in a readily accessible spot on the work bench (unless you have a peg board or rack for them). Do not mix tools in with the kit parts. Once you have used a particular tool, lay it back down (or hang it up) in the same place. This will not only make life easier, but it will prevent a kit part from being scraped by a screwdriver blade.

Protecting Parts. Don't dump all of the parts into one big box. After you have checked parts against the packing list, set aside those that will not be used right away—remove them from the work area. Group all



WRONG! Sloppy work (below) will give a lot of heartache. Shorts and intermittent operation will give poor results that are often blamed on kit manufacturer since constructor will seldom admit to faults being in work.

Side view of printed-circuit board (above) shows IF transformer, resistor and capacitors properly inserted. Leads are bent slightly to prevent components from falling out before soldering. Solder—then trim leads.



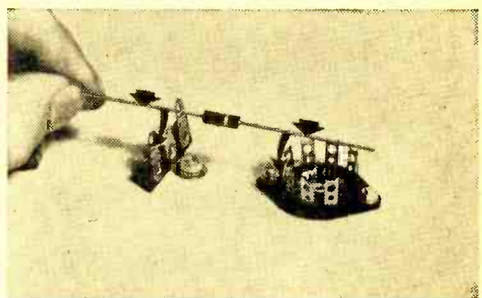
of the remaining parts by type (resistor, capacitor, etc.) Note the recommended method of using the edges of a corrugated carton (shown in photo) for parts storage during assembly.

Make certain that you know the electrical values of all parts. This is necessary even with kit parts, but is especially important with home-brew construction.

Resistor Values. Resistors are identified as to value and tolerance by color-code bands. Kit instructions usually explain the color-code system. Sometimes, however, the bands are not clear, or have been rubbed off (or you might even be color blind without knowing it). To better learn the color-code check all resistors with an ohmmeter. If you plan on much electronics building in the future, you will find that an ohmmeter (combined with a volt and milliammeter—a multitester or VOM) is a handy instrument to have, and well worth the small investment.

Fixed capacitors may be identified as to value by a color code similar to that used for resistors although most capacitors are stamped as to value and tolerance. If these markings are not clear, it will be necessary to check the capacitor on a capacitance bridge. Once identified, the capacitors should be marked—with a pen, grease pencil or on a tab of adhesive-backed tape.

Check for Polarity. Electrolytic capacitor leads are marked as to polarity (+ or −). Unlike most other types of capacitors, the leads of an electrolytic *must be* connected as indicated in the instructions. If not, the equipment will not operate properly, and the capacitor will most likely be damaged.



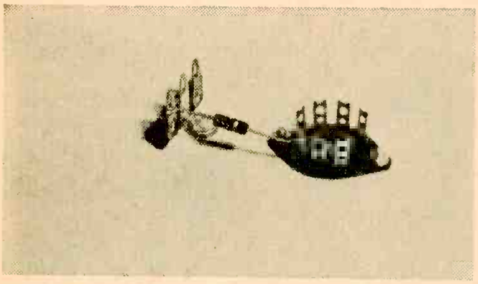
Pigtail leads are cut at short arrows. Long arrows indicate distance between terminal lugs. Allow some lead length for dressing components for neater layout. Use sleeving or spaghetti where needed.

Batteries are clearly marked as to polarity, too. However, instructions sometimes require that you connect leads to battery terminals and then route the leads to other connections. This can cause confusion if the leads are not tagged (at the open end) when first connected to the battery. A small strip of masking tape makes a good tag since it can be removed easily once the lead is soldered in place.

The Outside. Since a finished project is going to become part of *your* home decorations, its outward appearance is just as important as proper operation. That quality look can be achieved, or preserved by using a little extra care during assembly.

The outside parts (panels, cases, etc.) of kits are usually given extra protection when packed for shipment. Since these parts are not required until the last steps of assembly, they should not be unwrapped and left exposed to hot soldering irons and sharp tools. Leave such parts in their wrappings, and store them away from the working area.

Use the correct mounting hardware, and in the correct assembly order! Although this may seem obvious it's often overlooked and it is usually not spelled out in magazine construction articles (they assume that you will know the right way to do it!). Properly prepared kit instructions call for a flat washer under the attaching nut of panel-mounted controls. Lockwashers, if any, are placed on the control-shaft bushing *behind the panel.* If a lockwasher is used outside, its prongs can crack, gouge or otherwise scar finished surfaces.

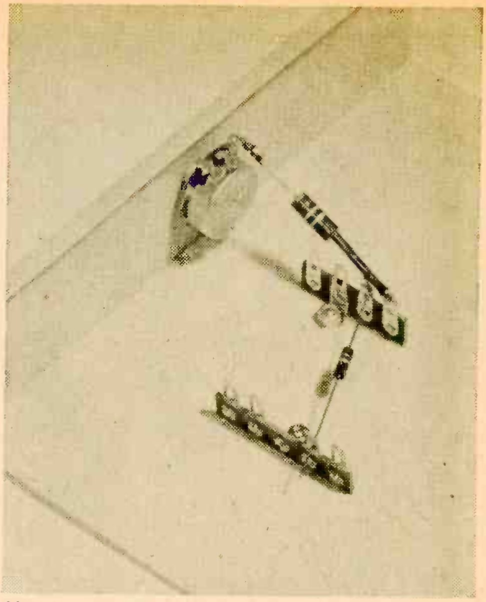


Leads are bent slightly to keep component body perpendicular to tie strip. Lead to tie-strip lug is wrapped—lead to smaller tube-socket lug is not. Close spacing makes shorts more likely.

Never use pliers to tighten control mounting nuts against the panel! This is a very common fault, and even the old timers are guilty. It's quite human to get used to a particular tool, and use this tool for everything. Unfortunately, pliers were not designed to tighten nuts. One slip, and you'll have a gouge or scratch that can't be covered up easily. And if it happens to be the front panel you'll have a permanent record right out where everyone can see it.

A *socket wrench* of the correct size should be used to tighten nuts, both inside and out. But it is of particular importance for nuts which tighten against the outside panels. Do not over-tighten nuts, and do not press on the socket wrench, scraping against the panel while turning.

Although few people are ever going to look inside your kit or other construction project, the mark of a good craftsman is neat work—both where it does and *does not* show.



Sleeving or spaghetti is used on one lead to prevent its touching other tie-strip lug. Where practical, dress leads to prevent soldering-iron damage that can occur if it's ever necessary to replace part.

Signal-carrying leads should be as short and direct as possible. Power leads, both AC and DC, can be squared off and kept away from low-level signal points.

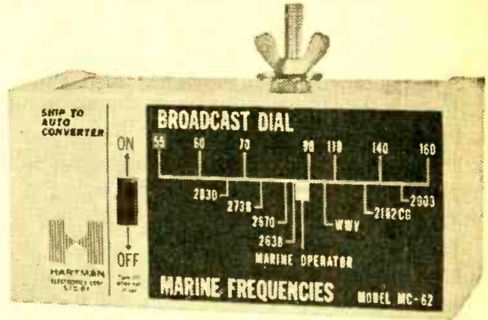
Besides, proper placement of parts and wire routing can improve performance. Improperly routed wires can cause hum pickup and signal loss.

Kit instructions are usually quite specific on the method of mounting components. They usually caution you to make sure the

(Continued on page 112)

e/e COMMUNICATIONS

HARTMAN MODEL MC-62 SW/Solid-State Ship-to-Auto Converter



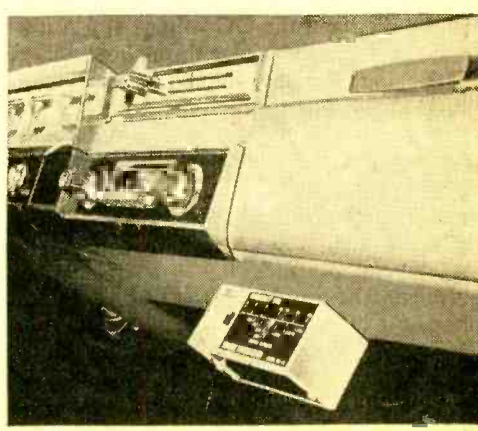
■ For no other reason—other than it's logical—one would assume that what takes place on the marine frequencies is of interest only to someone on a boat. However, this is not always the case. Just as SWL's (short-wave listeners) like to hear what's going on in the world, boat enthusiasts like to know what's going on even when they're not cutting a wake through King Neptune's domain. Many times a lot of aimless preparation and sailing is saved by hearing the marine-band chit-chat—about good fishing grounds, choppy seas, or a bunch of juvenile delinquents with a 100-hp. motor on the back of a rowboat—while driving to the boat yard.

For just this purpose (eavesdropping on the marine band), Hartman, a manufacturer of marine radiotelephones, makes available a Ship-to-Auto Converter Model MC-62.

The MC-62, priced at $19.95, is a solid-state device which converts a standard AM auto radio into a marine-band receiver. It is powered by a built-in 9-volt battery, so it can be used with *any* auto radio (tube or solid-state) and with any auto battery voltage or polarity. Other than the antenna connection, the MC-62 requires no direct connection to the radio or the auto's electrical system.

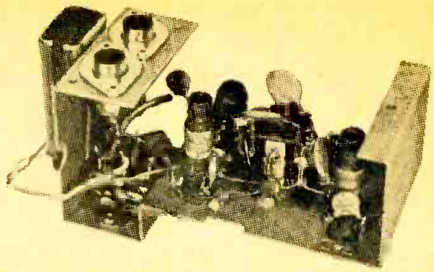
Stow It. The Hartman MC-62 mounts under the dash with a single screw which is factory attached to the cabinet. To use it, you simply unplug the antenna cable from the radio and insert it into the matching antenna jack on the rear of the MC-62. Then you connect a supplied cable between the MC-62's output jack and the auto radio's antenna jack. Finally, you adjust the radio's antenna trimmer (an accessible user adjustment) for maximum sensitivity. The power switch determines whether the converter or the antenna is connected to the radio. (The converter does not interfere with normal radio reception.)

Unlike many converters, the Hartman MC-62 is not tunable: the AM radio is used to tune the marine band. The MC-62 is a broadband device with its oscillator frequency fixed at 3.5 mc. Marine-band frequencies beating against the 3.5-mc. local oscillator produce a difference frequency which falls in the AM broadcast band. For example, WWV at 2.5 mc. beating 3.5 mc. has a difference of 1,000 kc. Therefore, if the user tunes the auto radio to 1,000 kc. he will hear WWV (which originally started out at 2.5 mc.). Similarly, any signal on the marine band between 2 mc. and 3 mc. will, by beating against the 3.5 mc. oscillator, appear at a standard broadcast frequency.



Mounted under the dashboard with a single wingnut the Hartman MC-62 can be installed by anyone. Only wire connections it requires are for the antenna.

e/e SHIP-TO-AUTO CONVERTER



Readily available transistor-radio battery powers the solid-state circuitry of the Hartman MC-62 converter. Jacks are for auto-radio antenna and jumper to radio.

The MC-62 has a front panel chart (made to look like a slide-rule dial) which lists the common marine frequencies—including the marine operator—at their broadcast-band dial settings. For example, if you were interested in hearing 2830 kc., you would check the chart and determine that it falls between 60 (600 kc.) and 70 (700 kc.) on the AM radio dial. Tuning the radio to this setting would bring in 2830 kc.

Performance. The Hartman MC-62 did exactly what it's supposed to do. We picked up the marine band with average sensitivity (comparable to inexpensive SW receivers). There was no noticeable leakthrough of broadcast signals. Though atmospheric interstation noise was somewhat high, this is true of any receiver not equipped with a noise limiter (a limiter can always be added to the auto radio).

Our unit pulled exactly 0.4 ma. from its battery, indicating that the battery should last its normal shelf life of 6 to 12 months even with frequent use.

The MC-62 cannot be used to convert a *table radio* (or any loop antenna equipped radio) to the marine band, as just the shortest exposed antenna lead will result in severe broadcast signal leakthrough. The STAC requires the complete antenna system shielding common to auto radios.

For additional information write to *Hartman Marine Electronics Corp.*, 30-30 Northern Blvd., Long Island City, New York 11101. While you are at it, ask them to send information and specifications on their complete line of converters. ■

BLOCK THAT LEAK

■ Checking the DC resistance of a capacitor using the high-ohms range of a VTVM is often unrevealing due to the low voltages used in the meter circuit. The DC resistance may be unacceptably low when tested at high voltages.

Coupling and bypass capacitors are easily checked for leakage using a DC voltage range.

In the diagram, the DC voltage appearing across *Rg* is due to leakage through coupling (or blocking) capacitor *C* and any grid current that may flow through the grid resistor.

Remove V2 to prevent grid current and measure the voltage across *Rg* using a low DC range of the VTVM.

For a more stringent leakage test disconnect *C* from *Rg* and connect the VTVM to the free end of *C*. You can calculate the equivalent DC resistance *(Rc)* of *C* at test voltage *Va*, by formula:

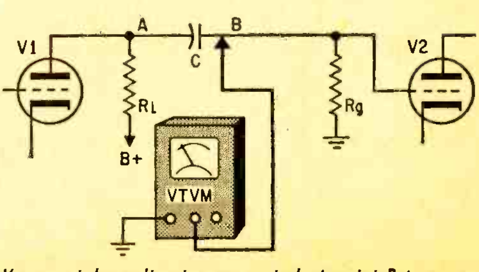
$$Rc = Rm \frac{Va - Vb}{Vb}$$

Where *Rm* equals the input resistance of the VTVM and *Va* and *Vb* are the measured DC voltages at points A and B.

Reject capacitors giving erratic readings, as these introduce noise and instability into the next stage.

Coupling or blocking capacitors in TV horizontal and vertical oscillator and output stages, video output, DC restorer and sync stages produce a host of troubles when leakage is erratic or high.

Consider its function in the circuit before you reject a capacitor. For example, paper and ceramic bypass capacitors shunted across relatively low-value cathode resistors need not meet the very-low leakage needed for a blocking use. ■



Vacuum-tube voltmeter connected at point B to measure DC voltage due to leakage through capacitor C.

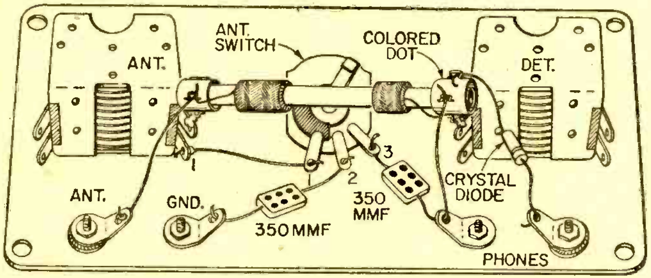
Breaking the Crystal Barrier

Simple 1-transistor amplifier boosts the weak audio output.

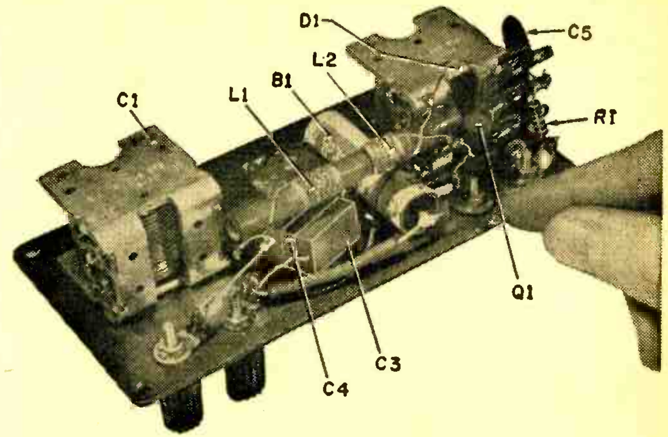
by Robert E. Kelland

■ Heathkits' popular crystal radio, the CR1, has probably been a major contributing factor in getting many people initiated into the field of electronics. The radio has excellent selectivity, but its sensitivity, like most all crystal sets, leaves much to be desired. The addition of a single stage transistor amplifier to the radio will increase the volume of weak stations and will enable you to "operate" with a shorter antenna. Full details for making the modification are given in this article.

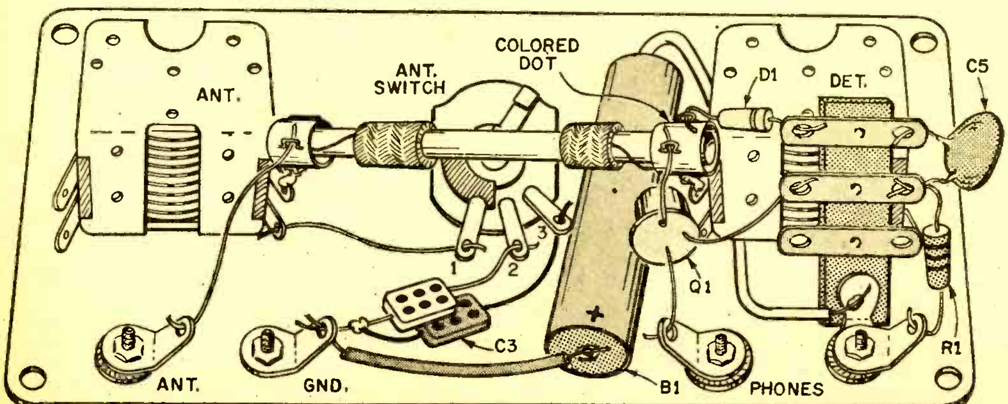
Only a few inexpensive electronics parts



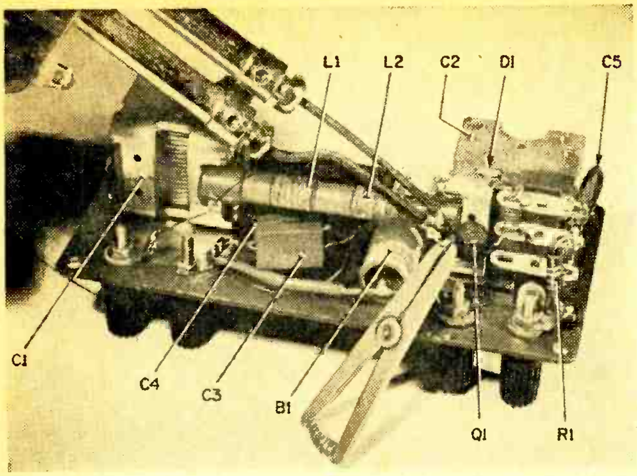
Original layout of Heath CR1 Crystal Detector Radio shows connections of the few components needed for reception of strong signals from the radio broadcast stations—a good antenna is a very helpful item.



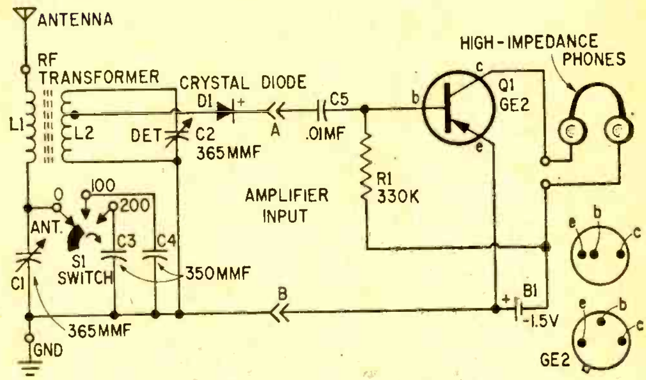
The completely wired conversion (above) shows how added components fit easily into spaces between original components. Penlight cell is largest single item to be added to original layout. Finger points to added insulated washer.



Pictorial diagram (left) shows new connections. Added, or repositioned, components are shaded to make them more outstanding. Small dry cell is held in position by heavy-gauge wire to GND, and PHONES terminal with added tie or terminal strip. Wire between GND terminal and emitter connection on coil lug is not shown.



Soldering gun is heating coil lug. Emitter lead has a heat sink to prevent overheating junction inside transistor even though lead is special low-heat-conductance alloy.



Complete circuit of modified Heath CR-1 kit. Crystal-type phones can be used across points A and B but phones of 2000 to 5000-ohms resistance are required for collector circuit.

(see parts list) are all that's needed to make the modification. No chassis drilling or cutting is required, so it shouldn't take the most wary experimenter any more than a couple of hours to complete the job. The exterior appearance of the radio is not changed in any way as all new parts mount neatly inside the case.

The modified schematic is shown above; pictorial diagram shows arrangement of parts. As you can see from the photos and pictorial a few of the existing components must be shifted around to make room for connecting the new ones.

First move the grounded end of capacitor C4 from the grounded *phones* jack over to the ground lug of the *Gnd* jack. The grounded end of L2 is shifted at the same time to the same lug. Crystal diode D1 is unsoldered from the *Phones* jack lug and left free until the terminal strip is mounted.

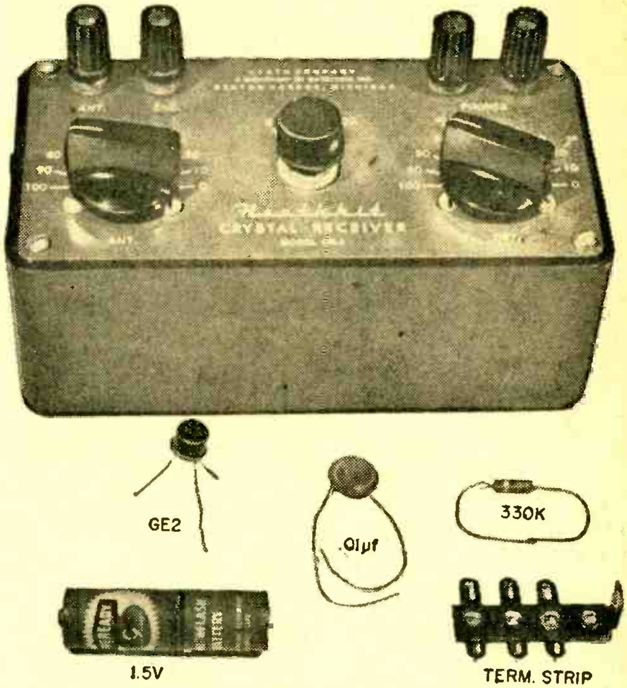
The grounded *Phones* jack and its associated soldering lug must be *insulated* from ground. This is the most important step. However, this is an easy task, as you follow the same procedure used to insulate the other jack when you first constructed the Heath CR1, that is, you mount a flat insulating washer between the chassis and the lug and secure the assembly with the nut. An insulating washer is already provided on the top side of the chassis. Make sure the jack and lug are insulated from the chassis. (You can test with an ohmmeter—meter prods placed between the lug and ground should give an infinite-resistance reading on the meter.)

The three-tier upright terminal strip is mounted next. Remove the retaining nut

PARTS LIST

B1—1.5-volt dry cell (AA-size penlight cell)
C5—.01-mf. disc capacitor
Q1—Transistor, p-n-p audio (General Electric GE2, 2N107, 2N241A, 2N404, 2N525A or equiv.)
R1—330,000-ohm, ½-watt resistor
Misc.—Terminal strip; #6 flat fiber washer, wire, solder, etc.

Estimated construction cost: $2.00
Estimated construction time: 1 hour



Original Heathkit CR-1 Crystal Receiver will not look any different after the parts in front of it are wired into the existing circuitry. All parts are shown except insulated washer and the few short lengths of wire needed.

from the second phones job (which is already insulated from ground) and mount the terminal strip between the soldering lug and the fiber washer. The lower lug on the terminal strip may be removed as it is not used in this modification.

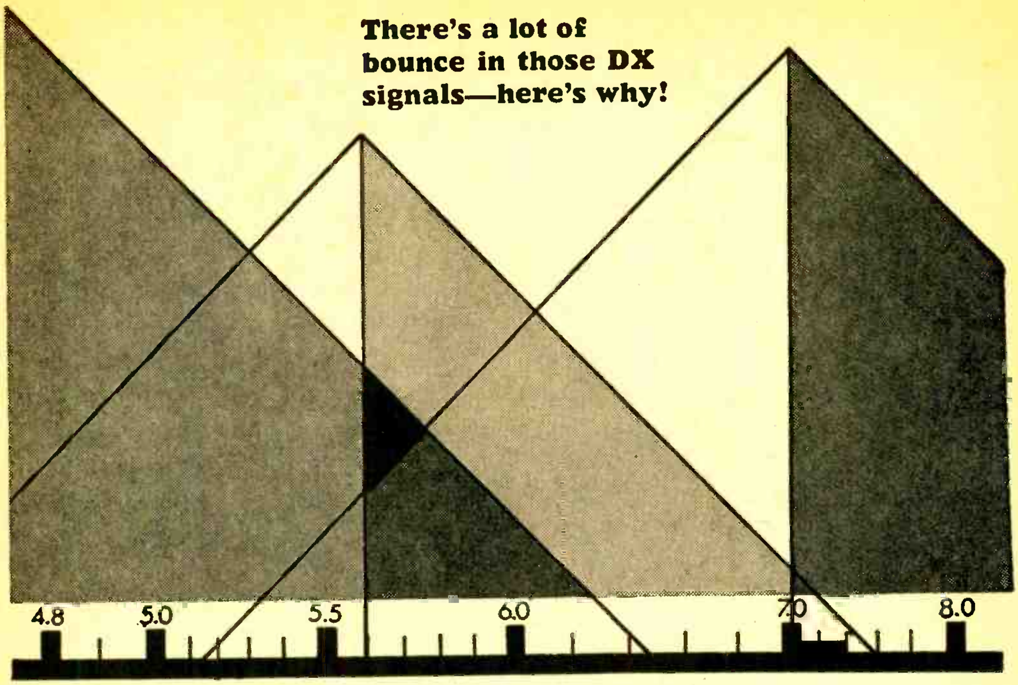
The AA penlight cell is soldered into the circuit and is supported by a piece of heavy copper wire. There's plenty of room to mount a battery holder, but this will mean drilling mounting holes. Besides, when the battery is expended it is only necessary to unsolder it and solder in a fresh one. When soldering in the battery you will find it easier if you first clean the ends of the battery with sandpaper or steel wool.

You can now start soldering in the other parts. The main thing to be careful with here is the transistor and diode; use a heat sink to prevent any damage to them. Follow the pictorial and photos and the job should be finished in short time.

Put the radio back in the case, attach the antenna and phones. You'll be receiving stations with much more volume—you may even hear some new ones. To turn the radio *off* remove one of the headphone pin tips; a separate switch thus won't be needed.

Power switch is not needed. Transistor draws little current and disconnecting headphones opens the circuit preventing all current drain from single penlight cell that is sole source of power.

Of course this amplifier can be added to any crystal-radio circuit, like that sold by Allied Radio as catalog number 85U024-AMW or to your favorite home-brew set. Just connect the amplifier input (points A and B) to the earphone connections and tune the set the way you always have. Good listening! ■



There's a lot of bounce in those DX signals—here's why!

The Angles On DX

by C. M. Stanbury II

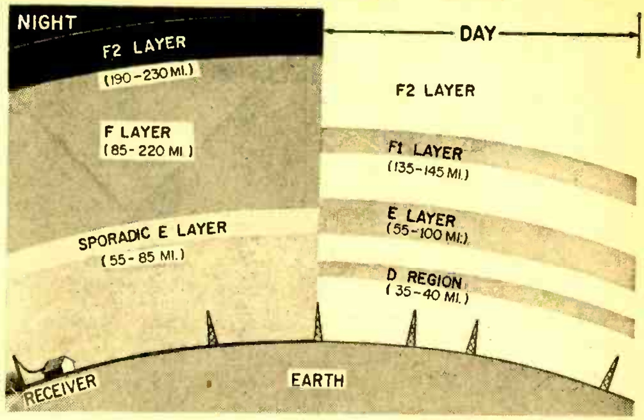
☐ Originally DX simply meant distance and even today, when DX now means rare or unusual reception, distance is still an important factor. "Of course!" you say. But it's not quite that simple. For example, below 7 mc. a radio station 2500 miles away can be easier to log than one which is 1900 miles away. No, to cope with distance, a straight line approach won't do. You must play the *angles*.

But let's start at the beginning and that beginning is the ionosphere, the four layers of ionized gasses which surround the earth. As many of our readers already know, it is these layers which reflect radio waves back to, and around the curvature of, the earth. If it were not for the ionosphere, there would be no radio reception beyond the horizon. A more detailed picture of the ionosphere layers above the earth appears in the illustrations.

It should be noted that every time a radio wave tangles with the ionosphere, it's not only reflected (at least we hope it's reflected) but also weakened. (Technically, the signal

(Continued Overleaf)

ANGLES ON DX



Roughly these are the positions of the layers during the day and at night—they are not to scale. F layer is low during the day and rises at night. E layer does not always exist in a given area. Bends or ripples in the layer act like curved mirrors to concentrate or spread reflected signals.

layer—anyhow the received signal is weakened when it tangles with the ionosphere.) Therefore, when transmitting from one point on the earth to another, the signal should strike the ionosphere as few times as possible. Or, putting it another way, there should be a minimum of hops or reflections.

For geometric reasons, due to the height of the reflective layers and the earth's curvature, the maximum single-hop distance is about 1900 miles. On the basis of this (ignoring the antenna height and averaging the layer height), radio stations of the same effective radiated power (e.r.p.) that are located between 1500 and 1800 miles away should be received with about the same signal strength but a transmitter of the same e.r.p. 2000 miles away (beyond the 1-hop limit) will be noticeably weaker as are stations less than the 1500-mile distance that cannot be received by a direct or *ground-wave* signal. Therefore a station outside the 1-hop area is an even better DX plum; for this station will be a rare one in your area.

All Hopped Up. This 1500 to 1800-mile distance figure is for reception via the F layer at night. This is the only layer which *regularly* affects reception during the hours of darkness. During the daytime there are actually two F layers (F1 and F2) and, even more important, an E layer.

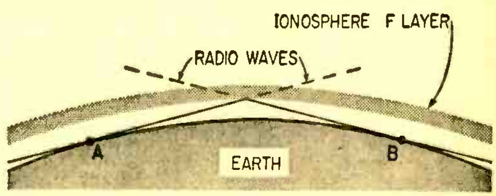
If radio wave reflection takes place via the E layer, maximum hop distance is only 900 miles. Under certain abnormal conditions the E layer does not dissolve with the coming of night. Such a *sporadic E layer* is even capable of reflecting VHF signals. Thus, 900 miles can also be considered a step on the DX ladder—for VHF.

The Angle. Both our barriers of 900 and 1800 miles are based on an *angle of arrival* of 5 degrees above the horizon. The *longer* the hop the *smaller the angle of signal* ar-

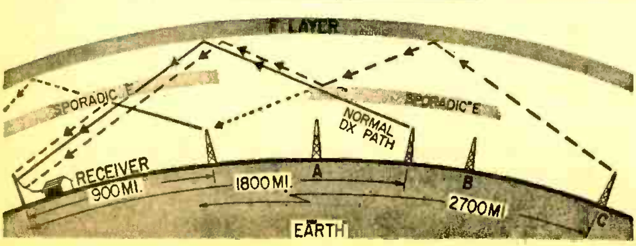
(Continued on page 114)

Angles of Arrival Via the F layer

Angle (deg.)	Hop Length (miles)	Angle (deg.)	Hop Length (miles)
5°	1900	8°	1575
6°	1772	9°	1500
7°	1650	10°	1400



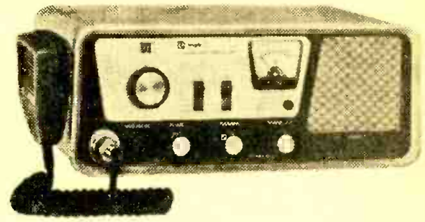
This drawing is nearer to scale. At too sharp an angle the radio waves pass through layer—too shallow angle and reflections do not return to earth.



Although it's not to scale this will give you an idea how waves can bounce from either side of ionized layers for DX.

e/e COMMUNICATIONS

KNIGHT-KIT SAFARI I. 23-Channel, 5-Watt CB Transceiver



■ While Knight-Kit's Safari I (Allied Radio) CB Transceiver is another of the so-called *high-performance* rigs, for a change, *high-performance* really refers to performance in measurable terms, rather than a slew of generally unneeded features and fancy chrome plating, for the Safari I includes not a single useless feature; every single feature contributes directly towards better communications.

What's in the Box. The Safari I is frequency synthesized to cover all 23 channels on a single selector switch. While frequency synthesis does not mean one iota of better performance, it does, because fewer crystal are needed for complete coverage, result in considerably reduced cost. Naturally, the receiver uses double conversion with two stages of 455 kc. IF amplification. A front panel ANL (automatic noise limiter) on-off switch is provided as well as a PA (public address) on-off switch which allows the transceiver to be used as a PA amplifier. A terminal strip is provided on the rear apron for the external speaker. The S-meter doubles as a relative RF output meter when the transceiver is switched to the transmit mode.

To insure reception of received stations which may be off the center channel frequency, a front panel control allows the receiver to be tuned ± 1 kc. off-channel.

Wired In Quality. Most of the *extras* have gone into the transmitter, in fact, into the modulation. The mike is a rather good quality noise-cancelling type. A front panel microphone gain control is provided which adjusts the microphone sensitivity from full *off* to at least twice as sensitive as the average transceiver.

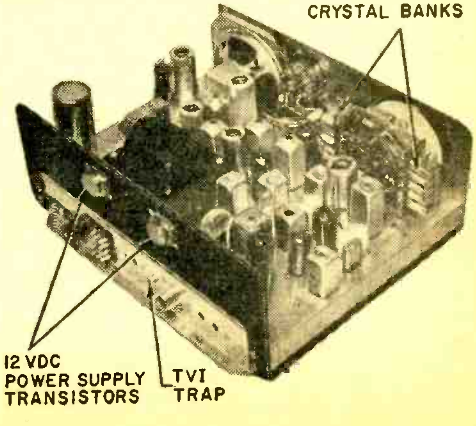
In short, whether you roar like a lion or squeek like a mouse you can tailor the mike gain to your specific need.

Two modulation indicators are provided, and unlike other *modulation indicators* which simply flicker to indicate you're talking, the Safari I's indicators are *calibrated*. The *Normal* modulation indicator goes on only when the percent modulation reaches 50%. A red *Overmodulation* lamp flickers only when the percent modulation exceeds 85%. (For all practical purposes 85% modulation equals 100%.) Maximum *undistorted* modulation is obtained if the mike gain control is adjusted so the 50% lamp is on most of the time while the 85% lamp flickers occasionally.

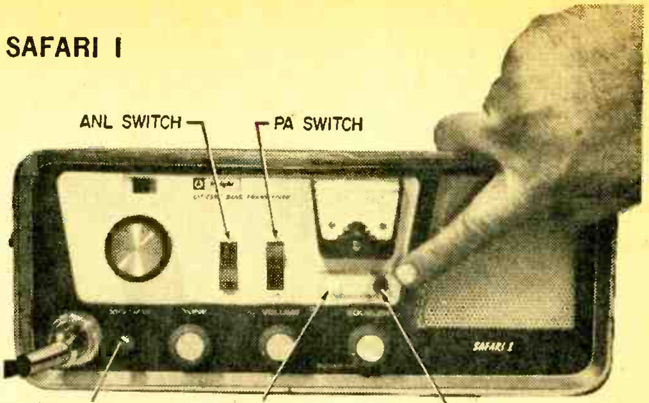
To avoid sideband-splatter and its interference, caused by overmodulation (in excess of 100%), the modulator limits the percent modulation to slightly less than 100% regardless of the sound level into the mike or the setting of the microphone gain control.

Performance. While anyone can build-in the features required for high-performance, it's another thing to actually get it. But the Safari I actually delivers all the performance built into it.

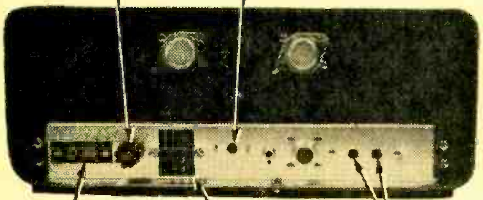
Transistors on back panel are for the DC power supply—no vibrator is used. TVI trap will make operator popular with local TV set owners.



e/e KNIGHT-KIT SAFARI I



Finger points to calibrated overmodulation lamp which indicates when modulation peaks exceed 85 per cent. Control to the right of the microphone connector adjusts mike gain from full on to full off.



Terminal strip at extreme left is the remote speaker output. Transmitter is tuned by adjusting two pi-network capacitors through holes at right. Power plug permits rapid conversion from 12-volt DC to 115-volt AC.

Measured input sensitivity for a 10 db signal + noise to noise ratio (a much tougher test than just signal to noise or *usable sensitivity*) was 0.65 microvolts at the antenna terminals (anything lower will pick up Mars' probes). Adjacent channel rejection *through the front end* was −42 db on both sides of center channel—better than the Knight specs and indicating a good, balanced IF amplifier design. Image rejection, again better than Knight's specs, was −53 db. AGC action, indicating the difference in output level, for a change in input signal of 54 db—representing an increase of signal strength from 2 to 10,000 microvolts—was 11 db. (In practical terms meaning that if you have the gain cranked open to hear a weak signal you won't be blasted out of your seat if a very strong signal comes on the monitored channel.)

RF output into 50 ohms was 2.4 watts; the transmitter's pi-net tuning controls are on the rear apron. Modulation was exceptionally clean with no trace of distortion (on an oscilloscope) up to the test value of 85% modulation.

Summing up Performance. As you can see, not only is the Safari I's performance good (if not outstanding, but in almost all instances Knight's claims are pessimistic, and our test unit actually *outperformed* the specs. The only negative aspect we could find was a slight residual loudspeaker hum (but no modulation hum); though not unusually high, it can be somewhat distracting in a very quiet room. However, once a signal breaks the squelch the hum is "buried" under the received signal.

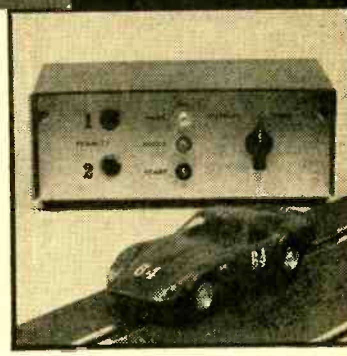
Construction. Instead of commenting on the construction we'll report on an unusual "test." The unit was severely damaged in transit from workbench to test lab, and the entire panel was stove in. Even with a hammer we could not straighten the panel or the speaker mounting to original form without leaving a few scars and scratches. Yet this is the same unit that delivered the performance given above. (We can't think of a better testimonial.)

What you get. The Safari I is supplied with 23 channel coverage and both the AC and DC cables. (The 12 VDC supply is solid-state, no vibrator.) Also a gimbal bracket for mobile mounting or tilted base mounting. It is priced at $129.95 in kit form. For additional information, write to Allied Radio, Dept. 20EE, Chicago, Illinois, 60680. ■

SCR Slot-Car Starter

by Herbert Friedman

This electronic referee will settle your Slot-Car race starting disputes as quick as a wink



A SURE WAY to create an argument is to call out *Ready, Set, Go* when starting a race. First thing you know someone yells "You fudged"; another claims you didn't start the stopwatch in time, or someone—to be polite—will say, "I didn't hear you say *go*." And if you do any serious slot-car racing, where a split second makes the difference between winning and losing, you know that every race leads to an argument. But all the arguments are really unnecessary if you steal a trick from the commercial drag strips and use a *starter*—in this instance RADIO-TV EXPERIMENTER's SCR Slot-Car Starter—to start your slot races.

The SCR Slot-Car Starter is an automatic device that signals when the race begins. If anyone "jumps the gun" a *penalty light* goes on to indicate that someone has cheated. The exact penalty should be settled before the racing begins. Either the culprit can be banned from the track (rather severe penalty), can be fined one lap, or can be penalized one or more car lengths for the next race. To avoid disagreements over whether the *Start* signal is early or late the entire control—from *Start* signal to penalty light—is automatic. When S2 is set to the *Time* position the *Mark* light goes on. After about 2 seconds the *Ready* light goes on; and finally, after another 3 seconds or so the *Go* light illuminates. If any car attempts to roll before the *Go* light a *Penalty* light goes on indicating which track jumped the gun. At the instant the *Go* light flashes on the penalty circuits are locked out. In short, there is no more room for human error. If you get a *Penalty* light you cheated—it's that positive.

To avoid having the slot racers anticipate the timing of the *Start* light the time sequence between *Mark* and *Ready* is shorter than between *Ready* and *Go*. The slight hesitation before the *Go* light goes on is deliberate, so don't attempt to change the timing circuits so *Ready* and *Go* have the same delay. Many is the racer who is going to mentally time the *Go* signal only to find he's earned a penalty.

The unit shown will accommodate any slot track using a 10- to 18-volt power supply. If your track uses a track voltage lower than 10 volts simply change K2 and K3 to their 6 volt equivalents and substitute 6 volt lamps for I4 and I5.

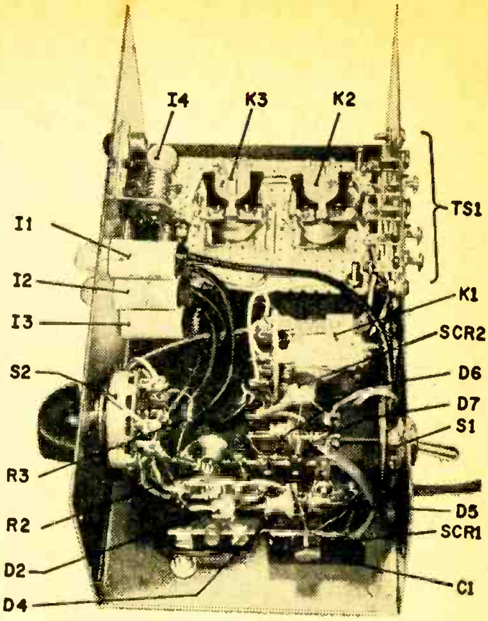
Construction. Note that there is no common connection to the metal cabinet. For maximum safety, since the circuit is connected directly to the AC main, be absolutely certain no wire or component touches the metal cabinet.

The unit shown is built in a Bud SC-2132 Cowl Type Minibox, which, like all other components used in this project, is standard stock from Allied Radio. Since parts layout is not critical any other type of housing can be substituted.

D.p.d.t. relay K1 may be rated either 115 VAC or 115 VDC, whatever you have or can get. If you use the DC relay, diode D8 must be used; if you use a 115-VAC relay, eliminate D8. Diode D8, like diodes D1 to D7, can be the cheapest diodes you can get—as long as they are rated a minimum of 200 PIV at 400 milliamperes.

Relays K2 and K3 are the 12-volt DC models for slot tracks having a 10- to 18-volt DC power supply; use their 6 volt equivalents if the track uses 10 volts or less. Either way, a Potter & Brumfield (P & B) type RS5D relay is used, and since their wiper contact is common to the mounting frame they must be insulated from the cabinet. Mount the relays on a piece of perforated wiring board, as shown, then mount the board in the cabinet with ¼-inch insulating spacers between the board and the cabinet at each mounting screw.

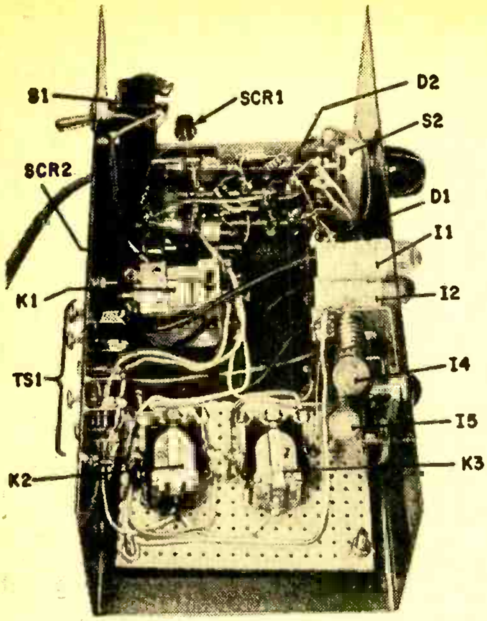
Neon pilot assemblies I1, I2 and I3 are



Only K2 and K3 are mounted on the perforated phenolic. Other components are wired to terminal strips attached to base of metal cabinet with machine screws. Additional perforated-phenolic board can be used to hold the resistors, capacitors, diodes and SCRs wired to terminals inserted in the perforations. Other-end view of the completely wired Starter (above, right) shows rest of components. Both I4 and I5 should be positioned so that filament of lamp is centered on pilot jewel.

PARTS LIST

C1—2 mf., 450-WVDC electrolytic capacitor
C2—4 mf., 150-WVDC electrolytic capacitor
D1-D8—400 ma., 200 PRV (PIV) or higher rating rectifier diode
I1, I2, I3—Neon pilot lamp (see text) (*Snaplight*, Allied Radio 7U758 or equiv.)
I4, I5—12-volt pilot lamp (type 1487, 1815)
K1—D.p.d.t., 115-vac relay (*Knight*, Allied Radio 74U657 or equiv., see text)
K2, K3—S.p.d.t., 12-vdc relays (*Potter & Brumfield* RS5D, Allied Radio 75U504 or equiv., see text)
R1—100-ohm, ½-watt resistor
R2—330,000-ohm, ½-watt resistor
R3—220,000-ohm, ½-watt resistor
R4, R5—1,000,000-ohm, ½-watt resistor
S1—S.p.s.t. toggle switch
S2—4 p.d.t. rotary switch (*Mallory* 3242J or equiv.)
SCR1, SCR2—Silicon controlled rectifier C6B (*General Electric*)
TS1—4 or 5 terminal (screw type) barrier strip
1—3 x 8 x 6-inch cowl-type chassis box (*Bud* SC-2132 or equiv.)
Misc.—Pilot lamp assemblies; perforated phenolic board; terminal strips; assembly hardware; wire; solder; etc.
Estimated Construction Cost: $18.00
Estimated Construction Time: 6 hours



shown in a box in the schematic diagram because they come with built-in current limiting resistors. If you attempt to cut costs by using standard NE-2 lamps, make certain you connect a 100,000-ohm series resistor.

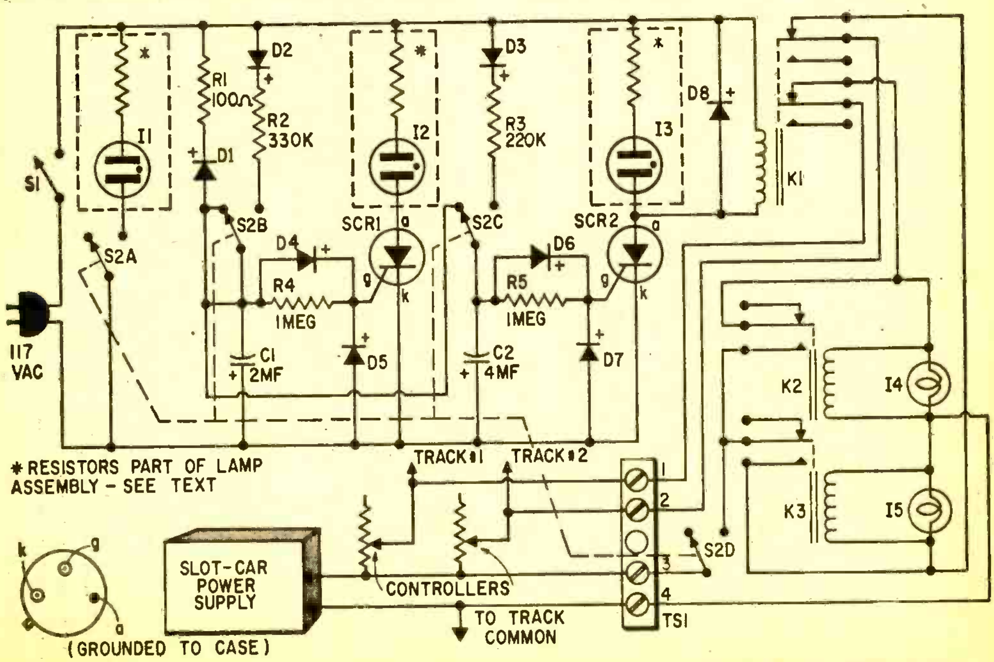
Switch S2 is a 4.p.d.t. rotary—do not substitute two separate D.p.d.t. switches as all circuits must be activated simultaneously. Note the connections carefully; all circuits shown in the schematic are in the *Standby* position. For clarification, to avoid wiring errors: S2A turns on the *Mark* light while S2B and S2C activates the *Ready* and *Go* timing circuits (do not attempt to save on a switch by connecting the S2B and S2C circuits together; it won't work). S2D closes the penalty circuit and then clears the *Penalty* lights when S2 is reset to *Standby*.

The penalty lights, I4 and I5, are 12-volt types for tracks using 10- to 18-volts and the 6-volt type for tracks using under 10 volts. Whether they are screw or bayonet base doesn't matter as long as they match the lampholder. However, in the 12-volt type it is easier to obtain a bayonet base, so figure this in when ordering the parts.

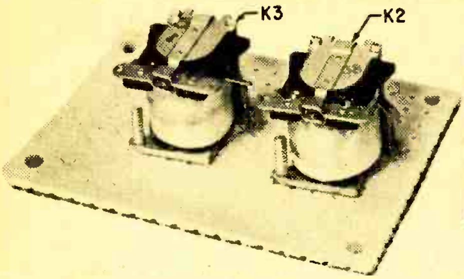
The connections shown to terminal strip TS1 are only for clarification. The exact layout of the TS1 connections will be determined by what is most convenient for your track layout.

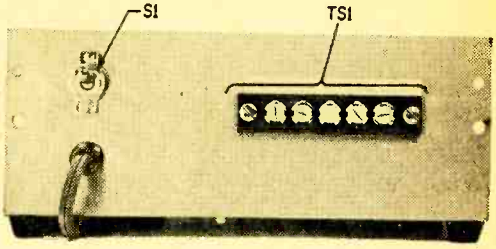
To avoid soldering-heat damage make certain you use a heat sink when soldering to the diodes and SCRs.

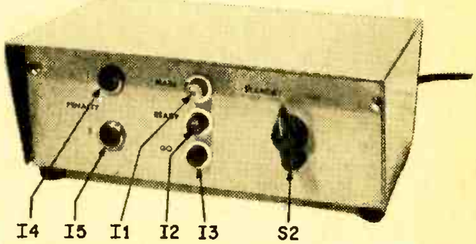
Connecting to the Track. First, note that at TS1 the two main leads from the slot car power supply are labeled *A* and *B*; this is for wiring reference only and has no relationship to the actual polarity of the power supply. The *B* connection is that power supply terminal connected to the common track connection—whether it is actually positive or negative doesn't matter; you are only



Lead connected to 3 on TS1 is A lead—B lead connects to 4. Relays isolate track from SCR circuitry.







Relays K2 and K3 are mounted on perforated phenolic because frame is electrically connected to the movable contact on the armature.

Rear view (top, right) shows location of power on-off switch and terminal strip TS1. S1 could be installed on front panel.

Front-panel layout (right) is uncluttered. S1 could be mounted to the right of S2.

concerned with that it goes directly to the tracks (one leg of track #1 and one leg of track #2). The A connection is whatever power supply terminal is connected to the controllers. The controller connection, TS1 terminals 1 and 2, are connected after the controllers *where they are attached to the track* (generally at the track connecting block); *do not cut into the controller wiring.*

The connections from TS1 terminals 3 and 4 go directly to the slot-car power supply.

Checkout. Set power switch S1 to *Off*, S2 to *Standby* (the position where S2A is on the unused terminal) and plug *PL1* into the AC outlet; then turn S1 *On*. After a few seconds turn S2 to *Time*. The instant S2 is closed I1 should light; after a couple of seconds I2 should light; and after another three seconds or so, I3. If all three lights go *on* at once check for a wiring error, particularly reversed polarity on diodes D4 and D6. If I3 lights before I2 either C1 and C2 are interchanged or R4 and R5 are interchanged; or, you have reversed the I2 and I3 mounting positions.

If I2 and I3 don't light, in addition to the usual problems of wiring errors or defective SCRs, check that C1 and C2 are installed with the correct polarity—the *positive* capacitor terminals to the common buss. If the three neon lamps operate correctly connect the slot starter to the tracks and perform the following tests.

Set S2 to *Standby* for a few seconds then flip it to *Time*. After I2, the *Ready* light, goes on, but before I3, operate both track controllers; if the unit is wired correctly both penalty lights should go *on* and then *stay on* even after I3 lights and the controllers are released. If the *Penalty* lights fail to latch, that is, if they go out after I3 lights or after the controllers are released, check the connections to K2 and K3's wiper contacts. If the *Penalty* lights fail to go *on* under any condition check that K1's contacts are *normally closed* until I3 lights.

If both *Penalty* lights operate properly reset S2 to *Standby* for a few seconds then set S2 to *Time*. After the *Go* light, I3, goes *on*, operate the controllers. If the unit is wired correctly neither *Penalty* light should go *on*. If the *Penalty* lights go *on* when the controllers are triggered after the *Go* light, I3, goes *on*, check that K1 is operating in step with I3—the contacts should open when I3 lights.

The Race Is On. Turn power switch S1 *On* and set S2 to *Standby*—thereby clearing all lights. When you're ready to race flip S2 to *Time*. When *Go* light I3 goes *on* it's down on the controllers. If anyone jumps the gun—if they start before the go signal—their respective *Penalty* light will flash *on*; and regardless how loud they shout the *slot starter* doesn't lie—if they get a penalty light they cheated. ■

Go mobile with your hi-fi. Once this unit is on wheels you can listen to your favorite discs in comfort, anywhere, anytime, without disturbing anyone!

The Stereophone Server

by Art Trauffer

■ You'd like to relax and enjoy your favorite stereo and mono discs, but it's getting late and your neighbors have retired? Just roll the Stereo Server over to your easy chair or bed, and serve yourself some stereo at it's best, and without disturbing anybody! This feature makes it ideal for use in hospitals, libraries, record shops, radio stations, and in similar situations.

It's nice to have everything in one package and ready to use where and when you want it. No need to rig up your stationary hi-fi sound system for headphone use, and use a lot of power just to drive the phones.

As shown in the illustrations, the Server is simply a wheeled cart with a push-handle. The turntable and stereo pickup go on top; the stereo headphone amplifier goes on the shelf; and the records and headphones go in the large partitioned space in the bottom. The back of the record space is closed to help keep out dust, but the back of the amplifier space is left open to make it easier to make the rear-panel connections.

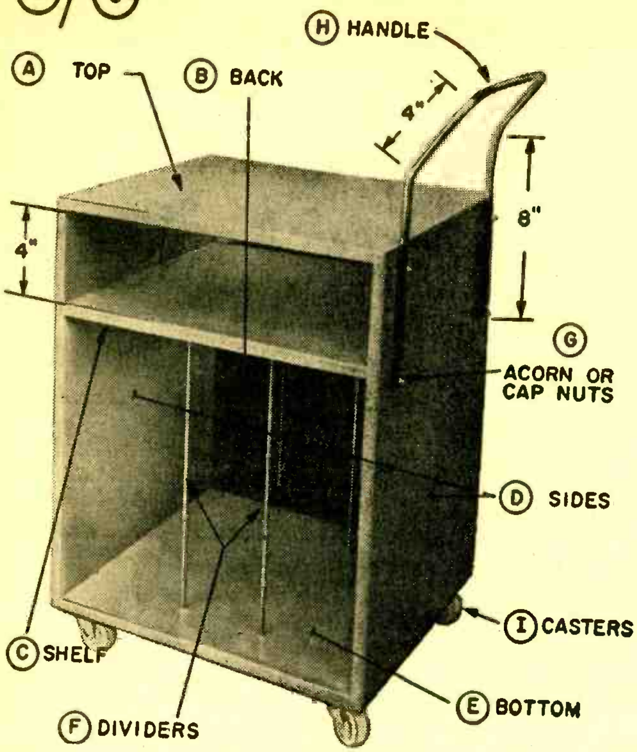
Construction. The Server in the photograph is 18½ inches high, 15 inches wide, and 12½ inches deep. The amplifier shelf is 4 inches below the top, and the balance of the space below easily takes 12 inch LP's in their record jackets. But you may want to alter some of these measurements to fit your own equipment.

Lumber used for the server is 5-ply plywood ½-inch thick. Cut to size and sanded, it was put together with small finishing nails and good quality hide glue. The nail heads were sunk below the surface and the holes filled. The assembly was sanded overall, dusted thoroughly, and sprayed with several coats of thinned light-brown lacquer.

Partitions for the record cabinet are four 3/16-inch diameter metal rods about 14 inches long, mounted as shown. Space the rods two in front, and two in back, as shown.

The push-handle is a 33-inch length of ⅜-inch OD aluminum tubing bent and screw-fastened to the side of the cart. If you make large, round bends in the aluminum tubing it will not flatten at the bends as it will if you try to make sharp, square bends. The aluminum tubing can be polished and given a coat of clear lacquer so it doesn't blacken your hands when handled.

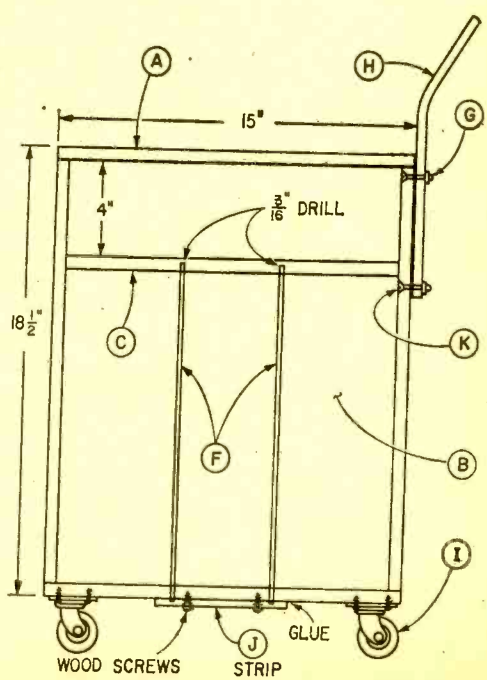
Four ballbearing swivel casters are at-e/e



STEREO SERVER

You don't have to be an expert cabinetmaker to put this simple unit together—it's little more than a crate with a shelf and a few rods for supporting the records. If the cabinetry is beyond your shop facilities some lumber dealers will cut stock to size for a small fee. You might also find an unpainted nighttable or telephone stand of suitable dimensions.

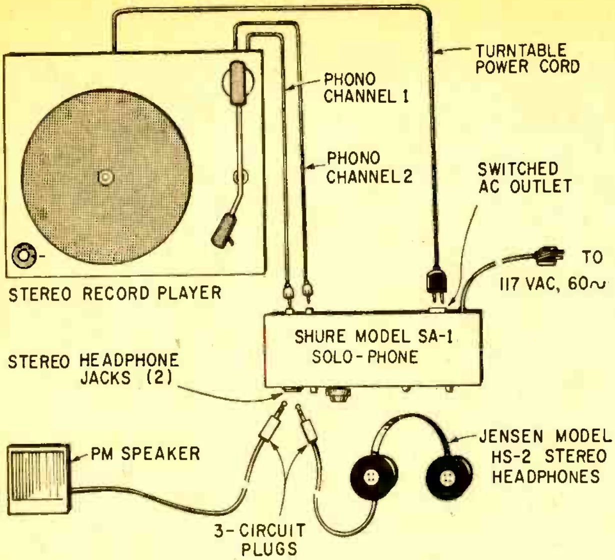
Plan shows simplicity of the construction. Casters should be 2½ to 3-inch tea-wagon type if you have to roll Server over carpeting, or use outdoors on a patio. Largest wheels roll best and are less likely to bind or jam against small objects.



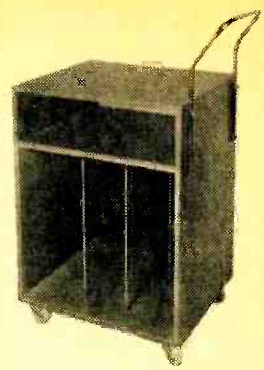
PARTS LIST

TOP—15 x 12½ x ½-inch 5-ply veneer
BACK—15 x 14 x ⅛-inch pressed hardboard
SHELF—12½ x 14 x ½-inch 5-ply veneer
SIDE—17½ x 12½ x ½-inch 5-ply veneer (2 required)
BOTTOM—15 x 12½ x ½-inch 5-ply veneer
DIVIDERS—14 x 3/16-inch rod (4 required)
HARDWARE—Acorn or cap nut, 1-inch flathead machine screw, 6-32 thread (4 required)
HANDLE—33 x ⅜-inch OD aluminum tubing (to be bent as shown)
CASTERS—2-inch wheel surface mount (4 required)
STRIP—6 x 1 x ⅛-inch hardboard

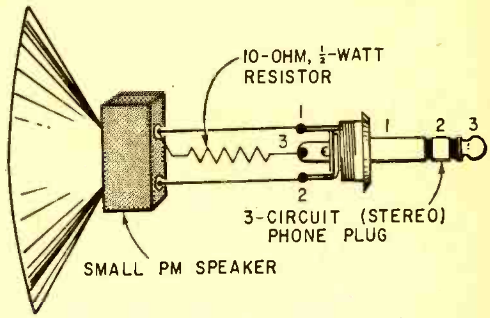
Misc.—Glue, finishing nails, wood screws, sandpaper, wood filler and finish coat (stain, varnish, enamel or lacquer).



Connections for the author's hi-fi equipment consist of inserting plugs into the appropriate jacks. Other hi-fi equipment will have similar connections that are generally outlined in the manual supplied with the instrument.



Completed Stereophone Server is ready for the hi-fi equipment. If a vacuum-tube amplifier is used make sure there is enough ventilation —leave back of shelf open or drill holes.



Connecting speaker to 3-contact plug is simple. An additional speaker can be used in place of the 10-ohm resistor if you want to hear both stereo channels—use separate cabinets for stereo.

tached to the bottom, using four ⅜-inch long round-head wood screws for each caster. For heavy duty, use flat-head machine screws—heads flush; nuts on bottom.

The back of the record cabinet is covered with a 15 by 14 by ⅛-inch sheet of pressed wood. This can be screw-fastened, or glued and tacked.

The connection diagram shows how the author's hi-fi system is hooked up in the Server cart.

Speakers. While the *20 milliwatts per channel* isn't going to break any leases you can use it to drive speakers just as easily as you drive the earphones. A pair of good quality, high-efficiency speakers will give you good listening in a quiet room.

One 3-circuit (stereo) phone plug can be used for the stereo speakers. One lead from each of the speakers is connected to terminal 1 of the plug. The other lead of one speaker goes to terminal 2 and the second lead of the second speaker goes to terminal 3 of the stereo plug.

Even if you don't want to go in for a stereo speaker set up, a small monitor speaker comes in handy at times. Just mount a 3-inch PM speaker in a small plastic, wood, or metal box, and wire the speaker to a 3-circuit (stereo) phone plug. Since this is a single speaker plugged into a 2-channel stereo output jack, it might be well to use a load resistor in the unused channel, as shown. The 10-ohm, ½-watt resistor can be wired into the circuit inside the speaker box. Use light-weight flexible 3-conductor cable to wire the speaker and resistor to the phone plug, as shown. If the shell of the plug is large, the resistor can go inside.

Well, there's the idea. Now some of you expert woodworkers, with small children in the house, might want to add hinged doors to the front and a hinged cover on top—to keep out dust and the little tots' inquisitive fingers. Or you can simply cover the turntable and pickup arm with thin plastic sheeting when the Server is not in use. Good listening! ■

SUITCASE WORKSHOP

By Charles Green W3IKH

A shop you can set up anywhere—in a motel room, while traveling, or a small apartment.

■ Nowadays most people seem to be on the go. Traveling is part of many jobs and those of you who relax by building some electronic project leave this form of recreation at home. Since everything else has become compact, why not a compact workshop, too? Just pack everything into an inexpensive suitcase.

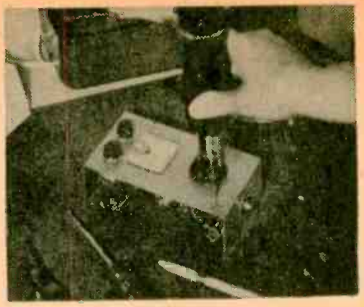
How can a complete electronics workshop fit into a suitcase with space for storing the construction project? The trick is in the selection of tools for the project construction. Since the project can be broken down into three stages of construction—chassis fabrication, the wiring, the testing—tools and materials can be separated into three packages.

Here, three metal boxes, sold as *cash boxes*, fit neatly into a large suitcase. A cardboard box is used to fill in the remainder of the space. Use this space for a small folding high-intensity lamp, the construction project and a short electrical extension cord.

A section of hardboard is cut to fit in the lid of the suitcase. The hardboard is a work area and a divider for the suitcase to provide additional storage space in the lid. Here you can store your manuals, a few scraps of perforated phenolic board and some sheet aluminum.

Don't just rush out and buy the first things you see. Check what you have, and leave room for the things you plan to get. Check what is available in the stores and make a few measurements of the tool, file card and tackle boxes you see. Planning will get more into the space you have. ■

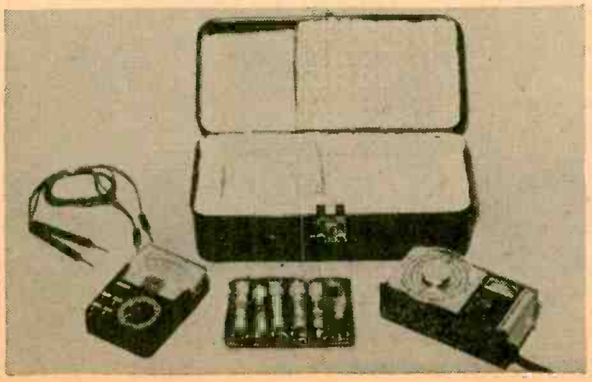
Cash boxes are used instead of adding compartments to suitcase. Label boxes or buy different colored boxes.

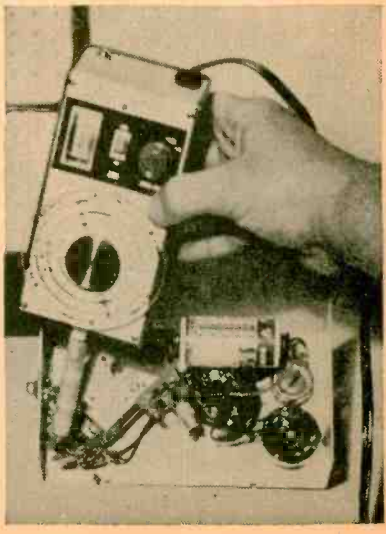


High-speed hand grinder drills (above), routs as well as grinds metal, plastic and wood. Delicate bits and burrs can be protected in plastic box. Many of the tools (left) are unnecessary for "breadboarding" experimental circuits.

Supply of hardware (left) is a must. Rubberbands around boxes will prevent accidents. A thin sheet of sponge-like foam in the cover will keep washers and lugs from adjoining compartments when you are traveling. Typewriter-ribbon spools and boxes can be used for wire, tape and solder.

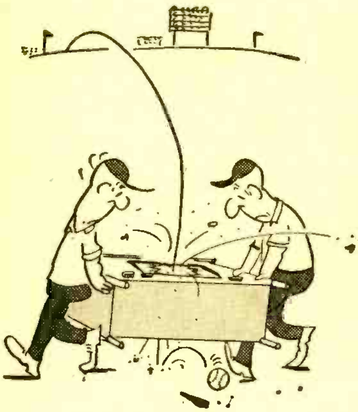
Sponge-like foam pads box (below) to protect compact multimeter and grid-dip oscillator during travel. GDO is useful as a wide-range signal generator (left) and, with adaptors, can be used to measure inductance and capacitance. If VOM doesn't have an off or transit position set selector to lowest current range and put a shorting jumper across input jacks to protect meter.



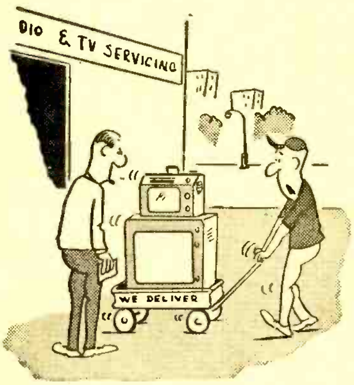


TV on the go

by **Harold E. Holland**

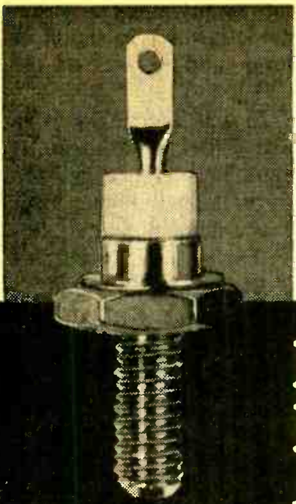


Jack up the truck? Gee, boss, I thought you said, "*back* up the truck! !"



"Seriously, boss, isn't it time you considered a truck for this sort of thing?"

"Now don't get all upset, boss, this is my own set."



Making Zener Diodes Work

by Len Buckwalter
K1ODH/KBA4480

Zener diodes do their job at the low voltages—where gaseous reference diodes are useless.

■ The Zener diode—solid state's answer to the voltage regulator tube—can work miracles in experimenter circuits. It'll pin down a swaying supply voltage that's causing drift in an oscillator, or neatly string out voltages in a power supply. These are just a few applications of the versatile Zener, whose circuit simplicity and wide range of voltage ratings put the old tube regulator to shame.

Like any simple component that performs a sophisticated job, the Zener must be fitted carefully into the circuit. There are several calculations to be sure, but you won't need a slide rule to do them. Before considering the steps, here's a fast refresher on what the Zener does.

The Beneficial Breakdown. Zeners are similar to conventional diodes; they pass current in only one direction. When the diode's polarity is matched to that of the circuit, current flows pretty much as though the diode weren't there. But reverse the diode in the circuit and it looks like a high resistance. Little circuit current squeezes through.

Let's leave the diode connected in that reverse, or high-resistance direction—and raise circuit voltage. At some point during voltage increase, the diode breaks down—not in a puff of smoke—but electrically. Current shoots up fast as resistance drops to nearly nil. This effect, created by a process of electron multiplication in the semiconductor material, is called the *breakdown, avalanche*

e/e ZENER DIODES WORK

or *Zener voltage*. And it happens to all diodes, regardless of type, at a particular value of reverse voltage. But the Zener is no ordinary diode. Due to careful manufacturing techniques, it goes through the breakdown phase far more sharply than run-of-the-mill diodes. It functions more nearly like a switch. Now to put the Zener in a circuit that not only prevents excessive reverse current—and possible burn-out—but one that provides voltage-regulator action.

Shown in Fig. 1 is one of the most im-

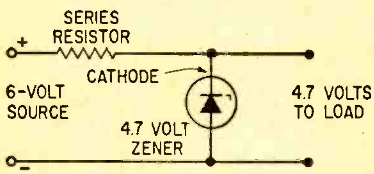


Fig. 1. Current drawn by Zener diode drops voltage from 6-volt source to rated value of diode. Improper design can ruin diode if load is disconnected when power remains on at source.

portant Zener circuits you'll use. It's the shunt regulator, a nifty way to tame or drop voltage to some value required by a transistor radio, a test instrument or some other project that misbehaves with varying voltage. Here we're assuming that the supply is the 6-volt source, and the device (load) to be powered operates on steady 4 volts.

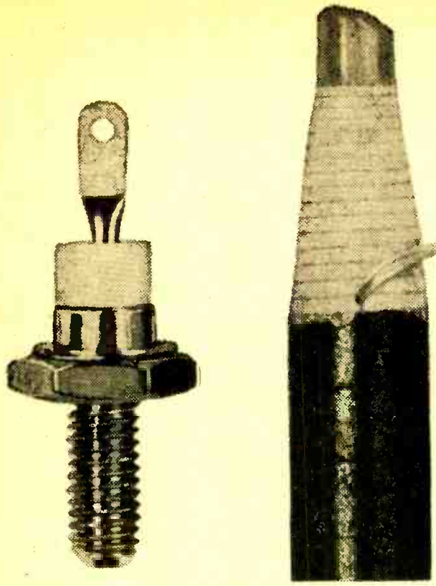
The first choice of components is simple; it's the 4.7-volt rating for the Zener diode. This is chosen to agree with the voltage you wish to apply to the device. Since Zeners are not available in every possible voltage rating, you'll have to pick one that most closely approximates the desired load voltage. You'll find, however, that most electronic devices can function at voltages within 20% of their specified value. Thus the load in Fig. 1 may actually require 4 volts, but can function at 4.7. It's usually voltage *variation* that causes trouble. Let's examine how the Zener operates in the shunt regulator of Fig. 1.

A Shunt Regulator. For one, we see that the diode is wired into the circuit in a reverse direction; if you look at the Zener symbol, you'll note that the *bar*, representing the cathode (−), is connected to the positive leg of the circuit. (Some Zener diodes are marked with this symbol, others identify the cathode by a rim, or hex nut.) Also apparent is that the diode is wired in shunt, or parallel, across the + and − legs of the power source.

If the circuit of Fig. 1 is considered to be in operation, the Zener is now in its breakdown condition. This is because the 6-volt power supply voltage is higher than 4.7 volts. But for the system to operate, another component is brought into play. It's the series resistor. As the Zener conducts reverse current, it is pulling that current through the resistor. And as Ohm's Law dictates, current through a resistor means a voltage drop occurs across that resistor. This is how the 6-volt supply is cut down to size. What's more, if any up or down shifts occur in the supply voltage, the Zener automatically applies a correction. It happens this way: If the supply suddenly rises to 7 volts, additional current flows through the Zener. This, in turn, raises the voltage drop across the series resistor. That extra volt is dropped by the resistor and never reaches the load. Conversely, a dropping of supply voltage also tends to be equalized by the Zener. The diode pulls less current through the resistor, thereby lowering its voltage drop. Thus the system provides regulation. Large fluctuations, as might occur in the electrical system of a car, are neatly smoothed before application to the load. Hi-fi manufacturers of solid-state tuners use a similar Zener arrangement to keep transistors from drifting with line voltage changes.

We've seen that the series resistor plays an important role in smoothing out voltage. But it supplies another important function. It limits the maximum current that may flow through the Zener. As with resistors, transformers and other components, a Zener has a maximum wattage rating that is not to be exceeded. Otherwise its silicon material will heat excessively. This calls for some calculation.

Figuring Circuit Values. Let's determine the rating of the series resistor. Before its value in ohms can be selected, you'll have to get out the multimeter and run some measurements on both the power source and the load, or device, you wish to power. Let's say you have a small transistor transmitter or handie-talkie that works on a 9-volt battery. You want to operate it in your 12-volt automobile using the car's battery. This is a fine application for the Zener. For not only will it help reduce car's battery voltage to the right value, but will iron it out.



Larger-wattage Zener diode can be mounted on chassis or proper heat sink. This oversized view shows Zener to be identical to conventional diodes. Low-wattage units have pigtail leads.

First measure the power source. Since it's the car's electrical system, run a voltage check on any 12-volt lead. You'll find that if you race the engine, voltage can soar up to 15 volts. This figure, the highest possible supply voltage, we'll call V_{IN}—for input voltage. It is the *unregulated* source.

Next value is V_Z—the Zener voltage. As mentioned earlier, the diode's voltage rating is selected to match that of the load. Since we need 9 volts, in this case, we could select the closest standard Zener value of 9.1 (actual examples would be a Motorola 1M9.Z or IR 1N3019). The power rating of the Zener, in watts, is shown in a moment.

Now to find out the amount of current consumed by the load—another job for the multimeter. In the transistor radio, this is simply done by operating the set on its regular battery and disconnecting one battery clip. Insert the meter probes (with meter set to read ma.) at the break. The radio will play and you'll see current consumption. Try all operating conditions—like changing the volume control setting—and observe the *least amount* of current drawn by the radio. We'll assume that it is 20 ma. That number, written as amperes (.02 A) is I_L, or load current.

What this whole procedure is leading to is a set of operating conditions for the regulator that produces the greatest stress for the Zener. Once they are known, it's an easy matter to design into the circuit an ample safety margin and avoid burnout.

The final figure we'll need is I_Z—or Zener current. It is recommended that a Zener be operated at no more than about 20% of its maximum rated current. If we consult the spec sheets and select a 9.1-volt Zener diode rated at 1 watt, the maximum current rating might be stated as 90 ma. This figure is divided by five to determine Zener current in the practical circuit. This gives an I_Z of 18 ma.

Figuring the Formula. Once you've determined each of these circuit values it's possible to plug the numbers into a formula and come up with the required series resistance. Let's continue with our example, whose values are shown in Fig. 2.

The formula: $R_S = \dfrac{V_{IN} - V_Z}{I_Z + I_L}$

Inserting the values:

$$R_S = \frac{15 - 9.1}{.018 + .02} = \frac{5.9}{.038} = 150$$

The answer, 150, is the series resistance R_S in ohms. By coincidence, this is a standard resistance value. In other cases, use the nearest value.

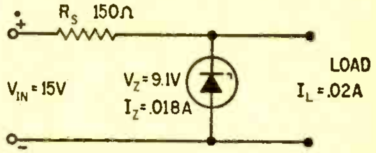


Fig. 2. Calculations for Zener-regulated 9-volt battery substitute operated from 12-to-15 volt DC automotive electrical system. Current drawn by Zener will vary with input voltage and load.

From the same formula, resistor wattage is also calculated. Just multiply top and bottom figures of the formula, which are resistor voltage and current: 5.9 × .038 = .22 watt. Double the wattage to .44 for safety and use a .5—a standard half-watt resistor of 150 ohms.

Circuit Features. This, then, is the basic shunt regulator. It will automatically keep voltage to the radio at a constant, correct value regardless of car speed. By using this approach you can design the Zener into other applications for the control and regulation of other DC-supply voltages. There are, however, certain features of the shunt design which should be considered.

In general, the shunt circuit is used where a fairly large voltage drop is needed between source and load. Also, the shunt arrangement regulates not only during shifting *supply* voltages, but changing *load* current, such as occurs in the transistor radio.

e/e ZENER DIODES WORK

In Series. Another Zener circuit is the series type, shown in Fig. 3. This system, however, is limited. Since the Zener must handle both resistor and load currents, the diode's wattage rating can run to high, impractical values. Also, the series circuit regulates only the effects of changing load current, and can't smooth out power supply fluctuations. It may be found useful, however, where voltage difference between supply and load are small (as illustrated in Fig. 3) and the supply voltage is constant.

PARTS LIST

C1—30-mf., 150-volt electrolytic capacitor
C1—50-mf., 150-volt electrolytic capacitor
D1—100-ma., 300-prv (piv) silicon diode
L1—9-henry, 50-ma filter choke
R1—47-ohms, ½-watt resistor
R_s—see text
S1—S.p.s.t. on-off switch
T1—117-volt primary, 125-volt, 50-ma secondary power transformer
Z1—27-volt Zener diode, 1N1781 or equiv.
Z2—22-volt Zener diode, 1N1779 or equiv.
Z3—18-volt Zener diode, 1N1777 or equiv.
Z4—12-volt Zener diode, 1N1773 or equiv.
Z5—9.1-volt Zener diode, 1N1770 or equiv.
Z6—6.8-volt Zener diode, 1N1767 or equiv.

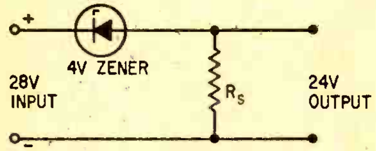


Fig. 3. Series-connected Zener diode will provide a constant voltage drop. If voltage goes to 29 volts, voltage across output will rise to 25. Circuit has many limitations—seldom used.

Handy Power Supply. Here is a versatile source of power for the experimenter. Based on Zener diodes it provides a number of useful functions around the workbench. Not only will it act as a voltage reference for checking calibration of a meter, but can supply a large number of regulated-DC voltages for powering small transistor projects. We'll give a basic circuit here, but you can easily vary it to suit a particular need.

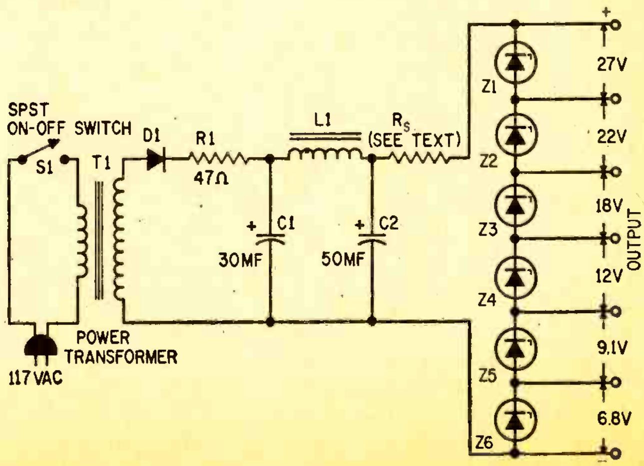
The complete supply appears in Fig. 4. The section on the left is a conventional half-wave transformer supply operated from AC line voltage. Suitable values are shown next to each component. Ratings for the silicon diode are minimum and you can use a larger (and more common) unit. The capacitors may be one dual-section electrolytic, the kind usually sold for replacement.

The output of the supply utilizes a group of six Zener diodes connected in series across the DC output of the supply. Although output voltage from supply is over 100 volts DC, each diode will display its own Zener voltage across its terminals. Not only can you obtain six different output voltages, but various combinations.

By connecting across the terminals of any single diode you'll obtain its specified Zener voltage. Hook across two or more Zeners and you'll get the additive voltage among them. For example, hook to the top of Z2 and the bottom of Z3 and you'll obtain 40 volts. Thus there is a remarkable number of voltage possibilities—plus the full output of the supply. Note that in hooking across any Zener or combination, the positive side of the circuit is the upper connection; the negative is the lower terminal.

We've shown a typical assortment of Zen-
(Continued on page 110)

Fig. 4. Diodes can be wired in any order that gives the greatest number of usable voltages for your use. Additional diodes can be added as long as DC across circuit is increased in like amount.



Expensive chemicals and elaborate equipment are not always needed for many electroplating jobs

■ Most of the articles dealing with electroplating will tell you to go to the drugstore, or some chemical supply house, to purchase chemicals to use in the electro-bath; not so with this type. You need only tap water, sugar, and a pinch of salt, and the results are comparatively good, especially for small articles found around the house or workshop. This type of plating will probably intrigue the *do-it-yourselfer,* if for no other reason than its sheer simplicity.

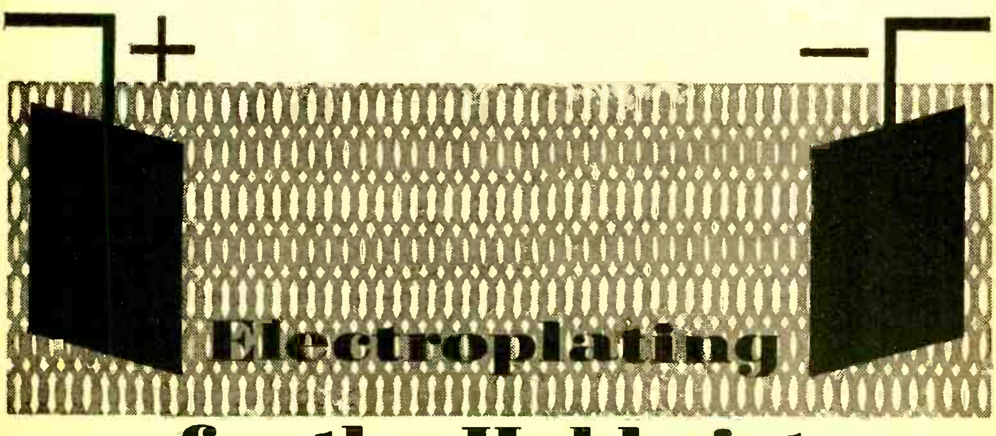
Almost any type of plating, within reason, can be done this way: copper on iron or brass; silver on brass or copper; gold on copper or brass; and yes, even stainless steel on brass or copper. The nicest part of it is that you can steal the metal to be deposited from discarded objects around the home or workshop. For example, if the distaff side of the family should become tired of the color of her earrings, why not plate them with a coating of stainless steel which is not unlike that of silver? Or, if you should have some gold plated objects no longer useful, why not give the earrings a plating of gold?

To start, select a small drinking glass or any similar vessel and heat it to a point where it becomes uncomfortable to hold. Fill the glass half full with warm water. Pour in a teaspoonful of sugar and stir. Insert into the liquid the metal you wish to plate. For example, say you want to do copper plating. Then, the positive electrode will be some form of discarded copper, and the negative electrode will be the object you wish to plate.

Connect these to one of the circuits given. Be sure to observe the proper diode polarity. After all connections have been made, drop a pinch of table salt into the warm water. Wait for about ten seconds and observe the light bulb. If after ten seconds there is no glow, drop another pinch of salt into the solution. Continue until you observe even the faintest glow. Cover the solution with a cardboard to prevent the bursting bubbles from splashing. Let the plating continue for a while, checking it periodically. Always disconnect the power when you do your checking. In less than an hour you should observe a deposit building up along with a discoloration of the electrolyte—in this case, a light blue.

Using the same circuit and a new solution, you can plate with almost any discarded metal. The object to be plated will always be the negative connection. The author used gold from an old watch case to plate a set of earrings, stainless steel from an old knife to plate some Fahnestock clips, and silver from a discarded spoon to plate some electrical-contact points.

The obvious advantage of this type of plating is that special chemicals are not re-



for the Hobbyist

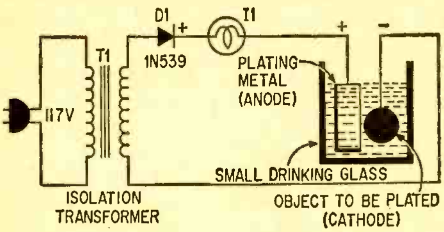
by Martin H. Patrick

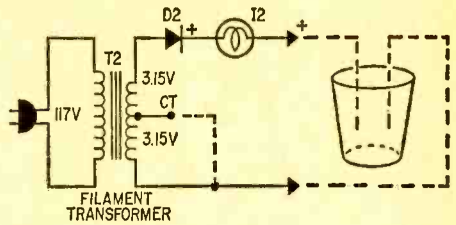
quired and that the same basic procedure is followed with all metals.

The quality of the electroplating depends directly on the preparation of the object to be plated. The object *must* be thoroughly cleaned of grease and oil, and if a shining result is desired, it is necessary that the object be buffed and polished before plating. If objects made of iron fail to take a plating, try copper plating it first. Then follow by plating with first selected plating metal. ■

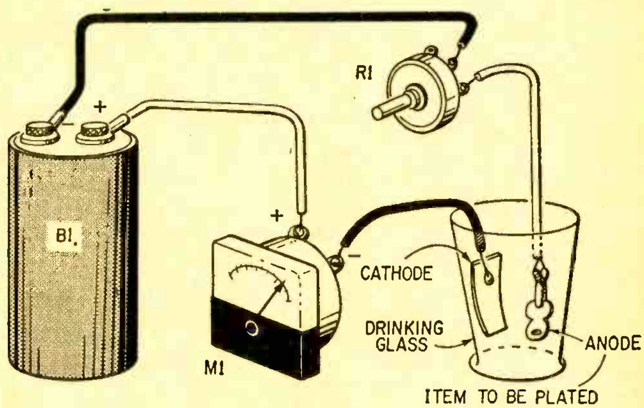
PARTS LIST

B1, B2—1.5-volt dry cell (Number 6)
D1—750-ma, 300 PRV (PIV) or higher rating silicon diode (1N539, 1N1489, 1N1763 or equiv.)
D2—750-ma, 50 PRV (PIV) or higher rating silicon diode (1N536 or equiv.)
I1—15 to 50-watt, 110 to 125-volt light bulb
I2—250-ma, 6 to 8-volt pilot lamp (type 44, 46 or equiv.)
M1—0 to 1-amp DC panel meter
R1—15-ohm, 25-watt rheostat
T1—117-VAC to 117-VAC isolation transformer (Lafayette 33R7502 or equiv.)
T2—6.3-V, 1-amp centertapped filament transformer, any inexpensive unit will do
Misc.—Socket, clips, wire, scraps of precious and semiprecious metals, water, salt, etc.

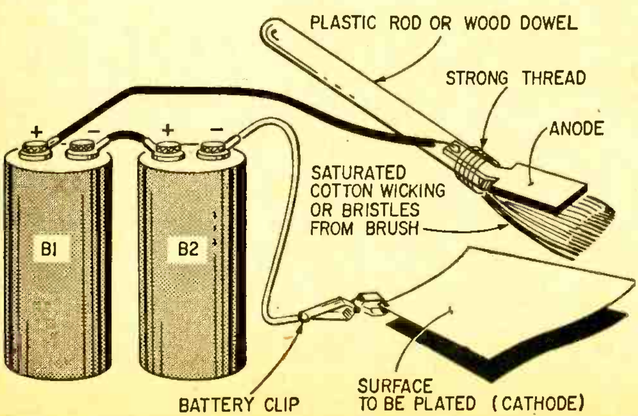




Even using a 1:1 isolation transformer does not make the circuit above safe—117 volts is quite a jolt even when current is limited by I1. Without T1 it is really a death trap—don't eliminate T1. Setup with T2 is quite safe. The lamp (I2) limits current to protect the transformer, and whether the full 6.3 volts or the center-tap value of 3.15 volts is used, touching the bared wires produces little more than a strong tingle.

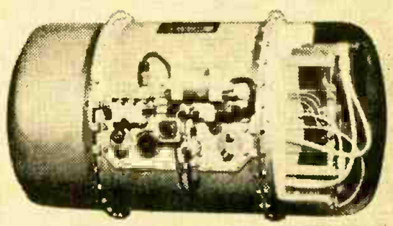


Dry cells are safe, too. For extensive electroplating use large cells (or filament transformer circuit at top). For one small job you can use the penlight types of cells. Electroplating requires current—the larger the surface the greater the current needed. Too little current increases the time required while too much current causes excessive bubbling at immersed electrodes.



Those Fabulous Fuel Cells

Reverse electrolysis generates the power instantaneously— as long as fuel and oxidizer are supplied to cells. No moving parts to wear out—silent operation that provides pure water as a waste by-product. And it's 80% efficient.



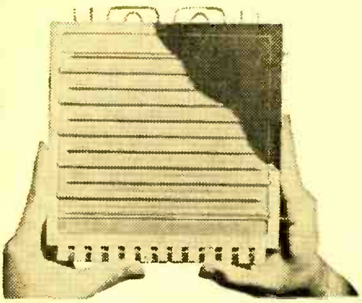
by Len Buckwalter

Any high school science student can probably tick off a half-dozen ways for producing electricity. There's the spinning coil inside a magnetic field (generator), chemicals reacting in a container (battery), heating metals (thermoelectricity), friction (static electricity), squeezing a crystal (piezoelectric) or light waves on semiconductors (photoelectric).

Now There's A New Way. It's the fuel cell; a compact package that surrenders more electricity per pound than any other source—except nuclear energy. So promising is this neat electrical device that researchers have already racked up some remarkable successes. Chrysler Motors can point to a model automobile that's buzzed around a test track with an engine that neither growls nor spits exhaust. Power is by fuel cell and electric motor.

Allis-Chalmers won a place in history

e/e FABULOUS FUEL CELLS



Cutaway view of General Electric fuel cell shows ribbed current carrier, hydrogen inlet and purge tubes. Cell is about 7 x 8 inches—96 cells are in a battery.

when its full-size tractor, power by fuel cells, wound up in the Smithsonian Institution. Even now, the military services use them to power small field-type radar sets. Gone is the gas-engine generator whose noise might warn a nearby enemy.

But the most dramatic use of the new power source is in space. Those weeks-long Gemini flights just couldn't have been made without the light weight and efficiency made possible by fuel cells.

Reversed. If you've ever seen the classic experiment in chemistry—the electrolysis of water—you witnessed the operation of a fuel cell, but exactly in reverse. This is the demonstration that proves water is actually made of the gasses hydrogen and oxygen. To conduct the experiment, a current of electricity is passed through water. As water molecules (H_2O) absorb energy, they split apart into component parts. The wet stuff disappears and two gasses are created.

Reverse That Process. Begin with the gasses hydrogen and oxygen, cause them to combine, and they'll not only form water, but release electrical energy as well. That's the heart of the fuel cell and, in fact, many practical fuel cells do just that. There are, to be sure, some exotic chemical techniques to aid the process. Catalysts (platinum for example) must coax the gases into combining. And special membranes keep the reacting agents free of contamination.

The excellence of the fuel cell lies in its ability to convert energy—chemical to electrical—in a surprisingly direct manner. Far cry from the traditional method of power generation; say, burning coal to produce steam, to spin a turbine, to turn a generator, and so on. Although we get much electrical power this way, efficiency is a meager 40%. Fuel cells, on the other hand, reach up in the 80% efficiency region. But before you call your utility company and have the house current turned off, look at costs. Fuel cells produce a huge number of watts-per-pound, but cost is still prohibitive for residential or commercial use. If your monthly electric bill is now $10, it would skyrocket to about $100 if fuel cells ran lights, TV and other household appliances. But in military and space applications, performance, not cost, is the boss. In one case, a 55-pound fuel cell eliminated 1000 pounds of ordinary storage batteries (like the one in your car). This is a bonanza for rocket-powered vehicles where weight is reckoned by the ounce.

It might seem the fuel cell bears some resemblance to any ordinary battery. It does up to a point. Both fuel cell and battery are fundamentally devices which depend on chemical reactions to obtain electrical power. But here the similarity ends. A conventional battery is considered a *storage* medium of energy. It is limited by the extent of its primary charge or by frequent recharging. But fuel cells continue to operate so long as fuel and oxidizer (hydrogen and oxygen, for example) are fed in from an external source. Another big difference is that materials which make up the fuel cell do not change as they process fuel into electricity. What's more, a by-product of fuel-cell opera-

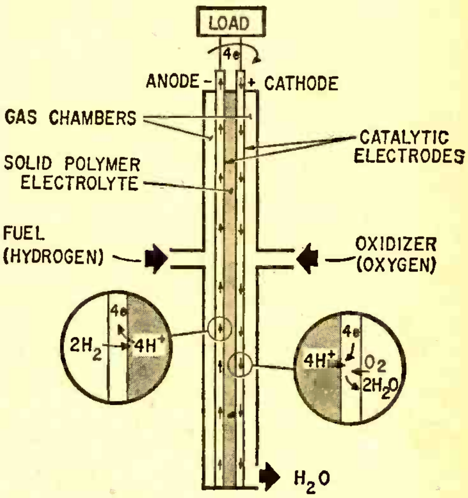
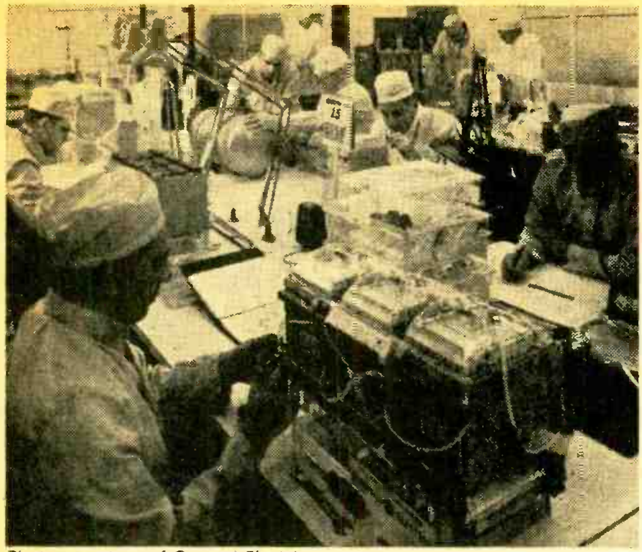


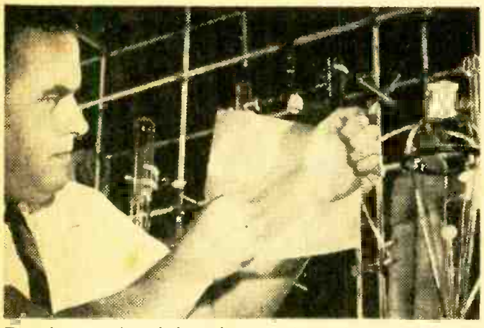
Fig. 1. Simplified diagram of fuel cell indicates fuel and oxidizer inlets, gas chambers, electrolyte and the catalytic electrodes. Inset circles diagram action that produces electricity, a pure-water by-product.



Clean-room assembly of fuel-cell batteries rivals cleanliness of hospital operating room at General Electric's Direct Energy Conversion Operation at Lynn, Mass.

Cutaway mockup of Gemini fuel-cell battery is displayed by Roy Mushrush, Manager of General Electric's Direct Energy Conversion Operation. One fuel-cell stack is held in his right hand.

Photos courtesy of General Electric



Toughness of solid polymer electrolyte is demonstrated by Dr. Russell Hodgdon of General Electric's Fuel Cell Laboratory. New electrolyte, developed by GE, has increased cell life expectancy four times.

tion is water, suitable for drinking or cooling.

Here's How. Fuel cell operation is illustrated in Fig. 1. The cell consists of a number of basic elements: *anode* and *cathode*, an *electrolyte* to act as a transportation medium between electrodes and the fuel *oxidizer*. Note that the two gasses are seen entering the center portion of the cell. Near the lower left of the drawing is a blow-up of what happens when hydrogen gas ($2H_2$) reaches the anode. The reaction causes the gas moleclue to surrender electrons. These negative charges (−) travel upward and constitute the electric current flow to the load (which might be a lamp, radio, etc.) As hydrogen supplies electrons to the load, it becomes ionized ($4H+$) and travels into the electrolyte solution between the electrodes. Hydrogen ions reach the cathode where they combine with electrons returning from the load, and ogygen entering the fuel cell. The inset at lower right illustrates the chemicals combining, which produces water. Note that H_2O (water) drains from the bottom right.

A valuable feature of the cell, in addition to high efficiency or watts-per-pound, is that it's "self-throttling." It consumes fuel only as required. Power can be switched off instantly by opening the load circuit. This stops the chemical reaction.

As in conventional battery systems, the fuel-cell type consists of a cell which is usually combined in series or parallel to obtain voltage or current (or both). An operational cell made by GE, for example, typically produces rather low voltage, somewhat less than one volt. Wattage depends on the surface area of the cell and may be up to 75 watts per square foot. Several of these cells are connected in series to form a module or battery of approximately 30 volts output. Three such modules can then be placed in parallel for high-current output. The final package is then termed a *fuel-cell battery*. Performance ratings of a one-thousand watt unit, used in spacecraft, is shown in Fig. 2. It may be seen that as the current drain (amps) rises, the output voltage of the battery drops slightly, but remains in the 30-volt region.

More complete specifications for this fuel-cell battery, and a smaller version, rated at

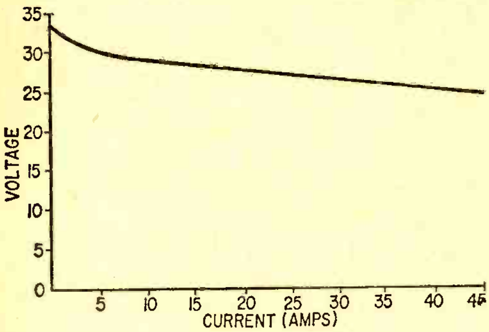


Fig. 2. Voltage-current curve of typical fuel-cell battery. A few calculations will show that battery's internal resistance is less than 0.2 ohm.

350 watts, are given in the table. You can see, for example, that to produce one thousand watts for one hour, the 1-KW unit requires about .1 pounds of hydrogen; and .8 pounds of oxygen.

The Future. Today's techniques of fuel-cell operation are by no means final. There are plenty of other experimental approaches. One is the hydrocarbon concept. Instead of gases, tanks are filled with common hydrocarbons, like gasoline, or kerosene. Then, acting like a miniature chemical plant, the hydrocarbon fuel is split into gases which enter the cell and generate electricity. Only problem here is that plenty of heat is needed to convert the hydrocarbon fuel into gas form. Yet there is hope; primitive models using this principle needed some 1000 degrees F, but recent versions can do it at 150 degrees F. If the scientists ever do it at room temperature, it could rock our concept of how to propel the family car.

Experts in the field won't name the day they'll start production, but they've already stroked in outline designs of a fuel-cell powered car. For one, the efficiency of such a vehicle would be about three times higher than that of the present automobile power plant. They envision small electric motors mounted in each of the car's wheels, with electrical power generated by fuel cells. This does away with bulky transmission, radiator and big engine compartment. Air pollution problems simply don't exist—the exhaust is water! Even the car's braking system is radically changed—to a type now used on both trains and tape recorders. It's called electrodynamic; the spinning car wheels ro-

(Continued on page 111)

TYPICAL FUEL CELL CHARACTERISTICS

1 KW FUEL CELL BATTERY	350 W FUEL CELL BATTERY
Contains 3 modules of 32 fuel cells, pressure regulators and sensors, product water separator.	Contains one 32-cell module with pressure regulators and sensors, product water separator.
Fuel: Hydrogen, approx. 0.1 lbs/kwhr	**Fuel:** Hydrogen, approx. 0.1 lbs./kwhr.
Oxidant: Oxygen, approx. 0.8 lbs/kwhr	**Oxidant:** Oxygen, approx. 0.3 lbs./kwhr.
Output: 1 kw peak	**Output:** 350w peak.
By-product: Water, approx. 1 pint/kwhr	**By-product:** Water, approx. 1 pint/kwhr.
Weight: 70 lbs. approx.	**Weight:** 35 lbs. approx.
Size: 12.5" dia., 25" long	**Size:** 14" dia., 16.5" long.
Cooling need: Liquid coolant. Temperature at inlet: 40°-100°, 75° avg. Higher temperatures tolerated for brief periods.	**Cooling need:** Liquid coolant. Temperature at inlet 40°-100°, 75° avg. Higher temperatures tolerated for brief periods.
Efficiency: 50%-60%	**Efficiency:** 50%-60%

You don't need any special powers to operate this switch. Touch it with your finger, elbow or even with the back of your hand.

SCR Touch-Control Switch

by Lester Escargot

■ Most science-fiction super heroes have the power of the universe at their fingertips: they simply point and buildings collapse, the sun darkens, and the vilest of enemies are banished to the sixth dimension. You've got power in your fingertips, too; not enough to destroy buildings, or get scantily-clad girls to throw themselves at your feet, but enough to forever eliminate turning knobs, throwing switches, and even fumbling in the dark for the light switch.

Yes, the power is there—it's the residual AC voltage picked up by your body from the power lines in the immediate vicinity; just concentrate the power to your index finger, say the magic word "Zotz," and *voila,* you can turn anything *on* or *off* by just pointing your finger. Got a ham rig? Just touch the mike stand and the transmit relays snap to attention. Fumble for the keyhole after a few slurps of the sauce? Just put some tinfoil alongside the door and your index finger will *turn on* the porch lights until you enter. Use CB? Just point your finger when you're ready to talk and you're *on-the-air.* In fact, you can control anything that goes *on* and *off* by just pointing your finger.

Of course, some of us haven't yet mastered the art of concentrating power to the finger, so you'll have to use a *finger-power concentrating amplifier,* otherwise known as a Touch To-Operate SCR Load Control, (which we will naturally refer to henceforth as the SCR Control.)

What Is It? The basic SCR Control—courtesy of General Electric—is shown in Fig. 1. C2 is a fixed capacitor of approximately 25 mmf. and C1 supposedly represents the capacitance of the body to ground. When a finger is touched to point X the body completes the capacitive voltage divider across the AC power line, C2 starts to charge, and when C2's charge reaches the ionization voltage of neon lamp NL1, the lamp conducts, C2 discharges into the SCR gate, the SCR is triggered (conducts) and power is applied to the load. The SCR will conduct as long as the finger (or hand, or any part of the body) contacts point X.

If the load is a 117-VAC relay the relay will operate in step with bodily contact to point X. If the load is a lamp it will go *on*

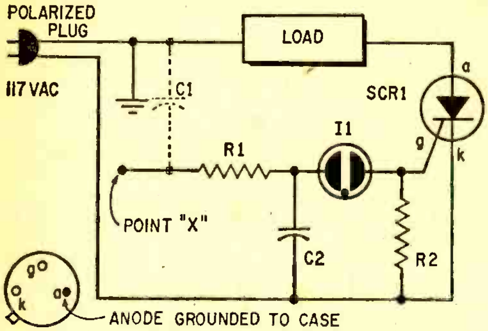


Fig. 1. C1 is capacitance between human body and earth ground. If direct contact to point "X" is possible T1 (below) must be used in circuit.

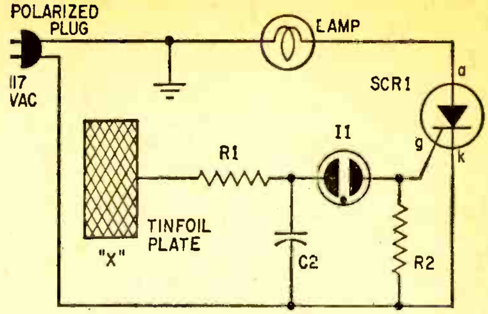
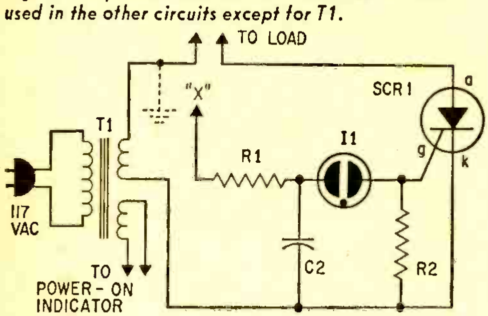
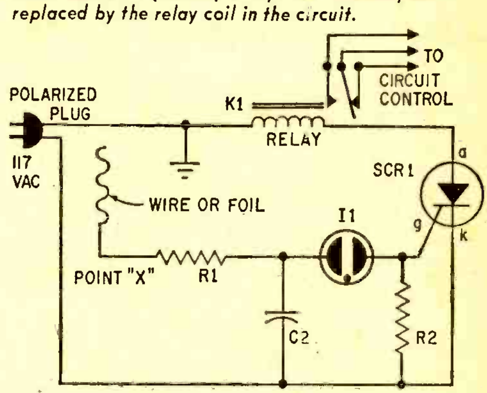


Fig. 2. With aluminum or tinfoil plate attached to the inside of a showcase this circuit is quite safe, for use without transformer T1. Linecord plug polarity is still important for the operation of the circuit. Showcase glass acts as dielectric of capacitor—foil is one electrode and body capacitance (C1 in Fig. 1) completes circuit to ground. Circuit 2B (below) is more-or-less identical to 2A (above) except that the lamp is replaced by the relay coil in the circuit.

Fig. 3. Components used here are identical to those used in the other circuits except for T1.





and *off* with point X. If an impulse relay is used as the load a touch to point X will turn the relay *on*, and it will stay *on* until a second pulse is applied through contact to point X.

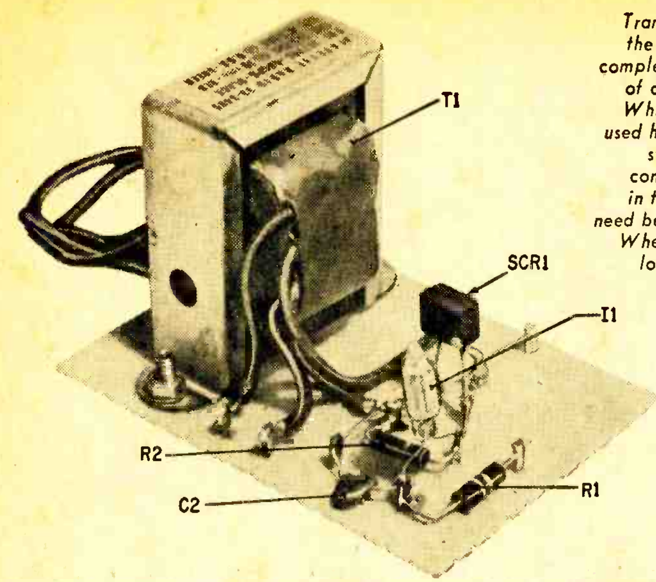
Where to Use It. Fig. 2 suggests possible applications of the touch control. Fig. 2A is an SCR substitute for the old capacitance-operated relay (which used an RF oscillator and cost at least 5 times the price of SCR control). The load in this instance is a porch light, and point X, as shown in the photographs, is connected to a large strip of aluminum foil tacked to the doorframe opposite the doorlock. As you reach for the keyhole at night your hand will brush the foil, tripping the SCR and turning *on* the porch light until you enter.

Fig. 2B is a touch-to-talk circuit. It could be used by Hams and CB'ers. Relay K1 controls the transmitter or transceiver's push-to-talk (PTT) circuits—either relay or electronic switching. A little metal foil can be cemented to the mike base or a length of bare wire can be stapled to the edge of the operating desk and connected to point X. Whenever the foil or wire is touched the rig switches to *transmit*; when the hand is removed the rig switches back to receiving.

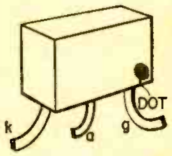
For latching control, simply use the circuit shown in Fig. 2B but substitute an impulse relay for K1. An impulse relay "trips" and stays tripped until a second pulse is applied. To trip the impulse control you'd simply touch the wire or foil connected to point X and *then remove your hand*. The single pulse will cause the impulse to close. To open the relay you'd touch point X again.

While the SCR results in DC flowing through the load, you can use an AC relay of the same voltage rating. If the input voltage is 117 VAC the relay can be rated 117 VAC or 117 VDC. If there is severe *chatter* when using an AC relay connect a 400 PIV, 500 ma. silicon rectifier across the load with the anode connected to the SCR side of the load.

Careful! As you probably have noticed the G.E. circuit can be a death trap as you must be absolutely certain the ground side



Transformer T1 is the largest item in the SCR Touch-Control Switch. The completed unit (left) shows the layout of components, which is not critical. While perforated-phenolic board is used here the layout could be on plain stock and holes drilled to suit the components. Flea clips are inserted in the perforations—only holes that need be drilled are for the transformer. When connecting the SCR be sure to locate the proper leads in relation to the dot on the molded case.



PARTS LIST FOR SCR TOUCH-CONTROL SWITCH

C1—25-mmf., 500-VDC disc capacitor
I1—Neon Lamp, NE-83 or NE-2H (see text)
R1—100,000-ohm, ½-watt resistor
R2—5600-ohm, ½-watt resistor
SCR1—Silicon controlled rectifier, C6B or C601B (G.E.)
T1—Transformer (see text)
Misc.—Perforated board, flea clips, etc.
Estimated construction cost: $5.00
Estimated construction time: 1 hour

of the AC line is connected to the grounded side of the SCR control. If you put a non-polarized plug on the SCR control you may go before the fuse. For maximum safety, use an isolation transformer as shown in Fig. 3. And it is not necessary to ground the line at the load. The voltage picked up by the body is sufficient to trip the SCR without the ground connection. A typical SCR control is shown assembled on a section of perforated board in the photo above.

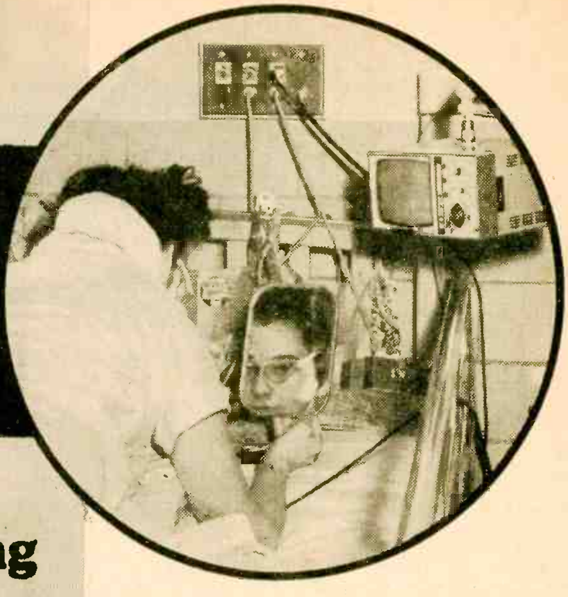
The SCR control shown is a light-duty model. Transformer T1 is a standard power transformer with 6.3 volt at .6 amp and 125 volt at 15 ma. secondaries. While 15 ma. will certainly not light a lamp it is sufficient to trip a sensitive AC relay—the 6.3-volt output is used to power a pilot lamp. Naturally, T1 must be able to handle the load, and since isolation transformers of any substantial rating can be expensive, you could use a pair of heavy-current surplus filament transformers back to back. (In a sense the SCR control is experimental, so do as you please.) If you want to control a heavy load such as a 500-watt bulb it's best to have a light duty SCR control with a sensitive relay for the load—then have the relay turn the lamp *on* and *off*.

A sensitive SCR is needed, otherwise the "power in your body" is not going to trip the gate. The SCR to use is the General Electric type C6B or C601B. Both models handle up to 0.6 amperes without a heat sink, the difference being the C6B has leads while the C601B has tabs (for perf-board and printed circuit mounting). *Do not substitute the G.E. experimenter SCR,* the X5—*its voltage rating is only 50 volts.*

Neon Lamp I1 should be the NE-83, a special neon made for use in the dark (no light). If you cannot obtain the NE-83 the more or less standard NE-2H can be substituted though there may be a slight loss in sensitivity if the SCR control is placed in a cabinet (dark).

If you experiment with the circuit, and you should as that's what it's for, you'll discover you can get astounding sensitivity if your finger is placed at the junction of R1 and C2 instead of at point X. Don't do it as a matter of course. R1 is a protection device that isolates you from the AC line should C2 or I1 fail; it also keeps you isolated from the SCR gate.

We've shown just a few uses for SCR Touch Control; we'd like to see what ideas you readers out there in magazine land can develop. If it works well and is *safe,* how about scratching it out and passing it along?■



TV Schooling for Hospitalized Students

Television can be more than cowboys, comedy and commercials. As the shut-in's window-on-the-world it can prevent boredom or help continue education.

■ Young school-age patients at the Massachusetts Hospital school, Canton, Mass., don't fall behind in their school work. They attend classes without leaving their beds—thanks to a closed-circuit television (CCTV) system.

The hospital school is world famous for the treatment and education of handicapped children. It now accommodates about 150 children but capacity will be 230—after the completion of the building addition.

If they're able, young patients attend classroom sessions. However, many are confined to the hospital beds for lengths of time varying from a few days to months. Prior to installation of CCTV, bed students averaged 20 minutes of individual tutoring each day. These youngsters still receive tutoring, but they also share the educational climate of the classroom with their fellow hospitalized students.

A standard curriculum, in grades 1 to 12, is offered at the school. Any student, whether he's in bed or in the hospital classroom, may take advantage of any course taught. CCTV cameras scan classroom sessions and relay them to bedside TV receivers. A two-way communications system between teacher and the bed-student and the bed-student and the classroom lets anyone ask or answer questions, at any point in the lesson, just as though the patient was present in the classroom.

Recorded Material. Much of the material

Classroom (above) does not have hospital atmosphere. Teacher Eleanor Woods prepares to playback previously recorded material for bedridden and classroom students alike. Science teacher, Donald Gay (top left) points out parts of the human anatomy to classroom students—those in bed view scene with help of CCTV camera on wall, at top center, which scans classroom activity.

Key elements in this 16-channel system are two 90-pound Ampex Videotape recorders. Equipment used to transmit motion-picture film and slides, as well as monitoring equipment are packed into control room shown at left. Recording tape is on wide reels.

has been previously recorded on Ampex Videotape television recorders for showing at class time. As the teacher wishes, she may show students a lecture (recorded months ago and many miles away) by an expert on a particular subject, an experiment performed in the laboratory class hours before, or any other presentation.

According to Dr. Margaret Brayton, the Director of Education at Massachusetts Hospital School, "The Videotape recorders are expected to play an important part in the school's new educational system. For instance, cost might prohibit bringing an outstanding lecturer here from the West Coast. By recording the lecture on video tape and having that shipped to the school, our students will have the benefit of an educational experience otherwise unavailable."

Ampex Corporation's Videotape recorders are key elements in many CCTV systems—preserving moving pictures on magnetic tape much as sound is recorded. A 90-pound portable recorder, used at the Massachusetts Hospital School is a direct descendent of larger models used to record network TV.

Dr. Brayton added. "You don't mind spending time and energy on a project if you know it won't be lost as soon as it's presented. With our television tape recorders we can play back a recorded presentation as many times as we desire. The original value of the presentation is expanded many times."

Massachusetts Hospital School's $170,000 CCTV system was engineered and installed by Lake Systems Corporation, Watertown, Mass. The system permits 16 channels to be telecast to individual bedside receivers throughout the hospital area. Also, as soon as the day's schooling is completed, commercial off-the-air TV programs are available on the same receivers. ■

Calibrated Attenuator

by
James A. Fred

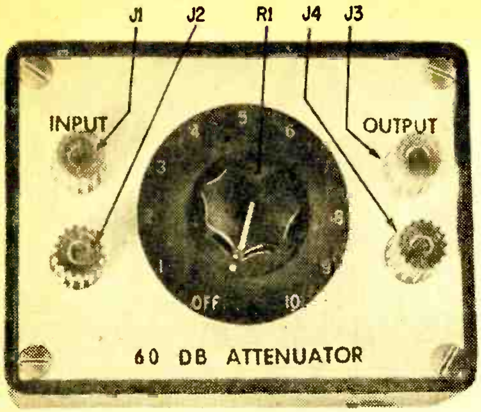
A fortune is not needed to have a calibrated control instead of a plain volume control on your amplifiers, recorders and hi-fi equipment units. Circuit changes are slight—only a small resistance has to be added to the layout to make calibration easy.

■ When we turn the knob on the volume control of a radio, TV set or hi-fi amplifier little do we realize the care that has gone into the selection and design of this component. When choosing the value and taper of the control the design engineer must decide what volume of sound he wants for each degree of control rotation. The process of making the sound softer is called *attenuation*.

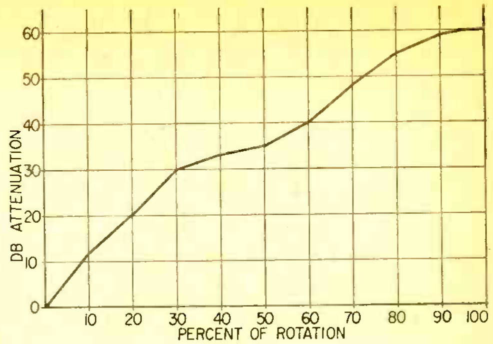
A modern American dictionary defines attenuation as, "1. to make or become thin, 2. to weaken." So in technical language we attenuate a signal when we make it weaker.

We hope to fill a twofold purpose: 1, to show the relationship between the resistance taper of a variable resistor and its attenuation curve, and 2, to show how to design a control for any desired amount of attenuation and to build a 60-db attenuator using the principles discussed.

Before we go into the actual design of an attenuator let us first find out something about variable resistors. If you consult cata-

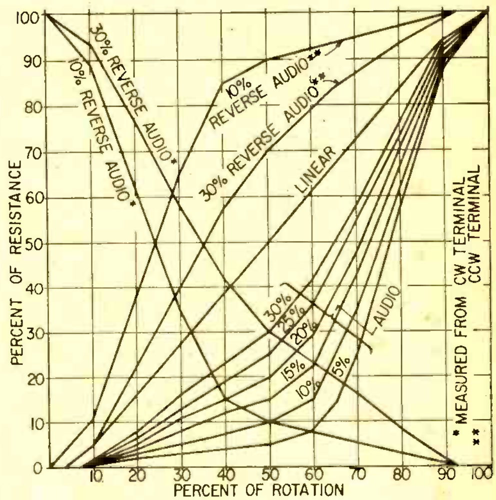


Front panel (above) shows all components except R2 which is mounted on R1's terminals inside case.



Characteristic curve (above) will vary from one control to another depending on quality.

Reverse resistance (below), measured from CW terminal is mirror image of curve of normal control—measured from CCW lug, curve is pivoted top-to-bottom.

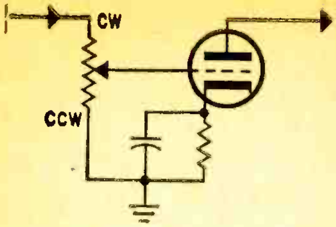


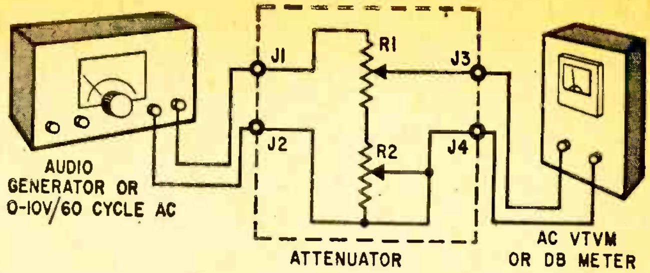
logues of such variable-resistor manufacturers as Centralab, Clarostat, and Mallory you will find two terms used to describe variable-resistor characteristics. One term is *overall resistance* and the other is *taper*. Overall resistance means just what it says, while the taper indicates how the resistance varies with rotation. For example, some variable resistors may have only half the resistance in the circuit when turned 80% of the way on (clockwise), and compress the other half of the resistance into the last 20% of rotation. If the resistance varies directly with rotation (25% of the rotation equals 25% resistance, 50% rotation equals 50% resistance, etc.) the manufacturer calls it a *linear taper* or simply *linear*.

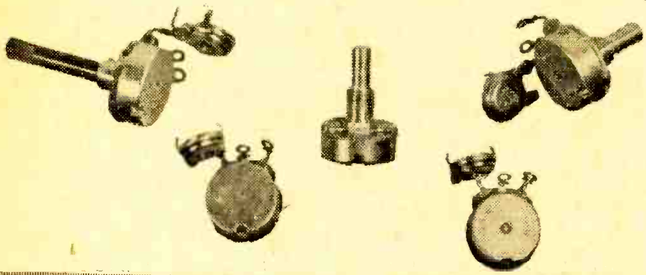
Volume control characteristic curves are usually drawn showing percent of resistance versus percent of rotation. This allows for quickly comparing one control against another without regard for resistance. The taper is usually specified as being a certain percentage of resistance at 50% of rotation, so 5 percent of resistance at 50% of rotation is usually referred to as a 5% taper. Of course each manufacturer has his own identifying symbols for his own tapers. A cross reference of tapers and designations for three companies are listed in the table titled "Resistance Tapers."

Two variations of the term that you will find in catalogs are *left-hand* and *right-hand tapers*. If you hold a variable resistor with the end of the shaft facing you and the terminals down, the left-hand terminal will be the counter-clockwise (CCW) terminal and the right-hand terminal will be the clockwise (CW) terminal. Normally when the contact arm (in the variable control) is at the CCW terminal you think of the control as being *off*, and when the contact arm is at the CW terminal you think of the control as being full *on*. Left-hand tapers are most commonly used in electronic equipment.

Design An Attenuator. Now that we have learned about controls in general let us use this knowledge to design and build a simple attenuator. This attenuator is basically a potentiometer connected to the grid circuit of a tube. Actually a potentiometer or variable resistor can be used in many circuits. To be most effective the resistance of the variable control should be nearly the same as the impedance of circuit to which it is connected. In other words if you were building a grid-circuit attenuator the resistance would be







Internal wiring of attenuator (above) is contained within the dotted lines. Connections to equipment shows calibration setup. Some of the controls tested are shown at left with screwdriver-adjusted resistor connected to potentiometer lugs. Typical volume-control circuit, used in most inexpensive radios, is shown at upper left.

PARTS LIST FOR 60-DB ATTENUATOR

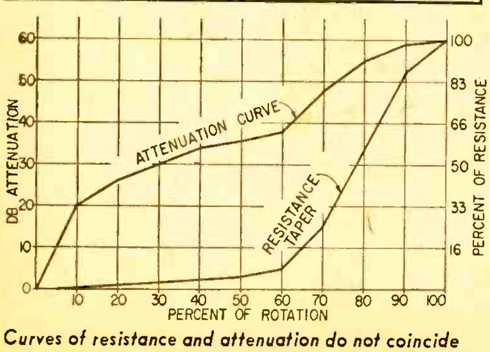
J1, J3—Red 5-way binding post (Lafayette 99G6233)
J2, J4—Black 5-way binding post (Lafayette 99G6233)
R1—1-meg potentiometer (Centralab C2; Mallory M201; Clarostat Y)
R2—Trimmer resistor (Mallory MTC—see text)
1—Plastic box (Harry Davis Molding Co., type 220; Newark Electronics Corp., 26F145)
1—Knob (Mallory 368-1)
1—Dial plate (Mallory 390)
Misc.—Sheet aluminum for box cover, wire, solder, etc.
Estimated construction cost: $4.00
Estimated construction time: 1 hour

RESISTANCE TAPERS

General Description	Centralab	Clarostat	Mallory Dist. Co.	Mallory Conts. Co.
Linear	C-1	S	4	M-101
5% Audio		Y		M-201
10% Audio	C-2	Z	1	M-204
15% Audio				M-205
20% Audio	C-4	W		M-206
25% Audio				M-207
30% Audio				M-208
40% Audio	C-6			
Right hand 30% Audio		T		Reverse M-208
Right hand 20% Audio	C-5	V		Reverse M-206
Right hand 10% Audio	C-3		2	Reverse M-204

ABBREVIATED TABLE OF RATIOS

Resistance Ratio	db Voltage Ratio	Resistance Ratio	db Voltage Ratio
1.0	0	8.0	18.06
2.0	6.02	9.0	19.08
3.0	9.54	10	20.00
4.0	12.04	100	40.00
5.0	13.97	1000	60.00
6.0	15.56	10000	80.00
7.0	16.90		



Curves of resistance and attenuation do not coincide except at minimum and maximum points on graph.

very high, while if the attenuator were used in a speaker circuit its resistance would be very low.

A Ratio. The total attenuation of a variable resistor is determined by the ratio of the residual resistance at the CCW end (which is the minimum resistance of the control) and its total overall resistance. In other words a one-megohm variable control with a minimum resistance of 1000 ohms would have a ratio of 1000 to 1. By consulting the voltage-ratio column of a standard db chart you would find that a ratio of 1000 is equal to 60 db.

(You may have some objections to the above statement because we are converting a resistance ratio to decibels. This method is perfectly logical and has been confirmed experimentally.)

Due to manufacturing processes all variable resistors have wide variations in actual resistance values. The most common resistance tolerance is ±30%, while ±20% is often used, but ±10% is available only on special order. The only way to design an attenuator for an exact amount of attenuation is to look up the voltage ratio for the db attenuation you want. Then carefully measure the resistance of the control you intend to use and divide by the voltage ratio previously used. This answer will tell you the CCW end resistance needed. If the measured end (residual) resistance is less than that needed you can add a trimmer resistor to make up the difference. Adjust the trimmer until the CCW end resistance is correct. The circuit diagram will help you here. Refer to it on the page opposite.

Any technician or experimenter can use the methods outlined in this article to make attenuators of any desired resistance or range. By using the following example you can get a better idea of what we mean. The photograph shows a plug-in 60-db attenuator built and used by the author in experimental audio work. A dial plate allows the control to be set for each 10% of rotation and a calibration chart supplies the amount of attenuation. A 0-10-volt AC voltage source is needed for calibration as shown in the circuit diagram.

This supply can consist of a 12-volt filament transformer in series with a variable-voltage transformer or, in a pinch, a tube tester could be used to supply the necessary voltages for the setup.

The control used measures 1,113,000 ohms overall, so a trimmer resistor was added, in series, to adjust the CCW-end residual resistance to 1,113 ohms. The control has a 5% audio taper and by looking at the graph titled "1 megohm, 5% Audio Taper Carbon Control" you can see both the resistance and attenuation curves. The attenuation curve is far from linear. By measuring all the controls shown in the photograph we were able to determine that a 2½% audio taper would give a nearly linear attenuation curve.

The parts needed to make the attenuator shown are in the parts list. The suggested variable resistors specified will give nearly linear attenuation curves. This small device can be used in the circuit shown for the grid potentiometer attenuator. It can be used between the output of an audio signal and an audio amplifier when plotting a response curve.

Note! *Potentiometer, variable resistor,* and *variable control* all mean the same thing and are used interchangeably. So don't do any betting about which is right! ■

SPEEDY READIN'

■ The National Cash Register Co., a major producer of computer systems, makes a high-speed unit that prints 1,000 lines (of 120 characters each), in a minute—starting and stopping the paper at least 1,000 times a minute. Otherwise the lines of characters being printed would be blurred, unreadable smudges.

Special silicon-alloy steels from Allegheny Ludlum Steel Corp., Pittsburgh, Pa., are used in parts of the drive units that bring paper tape to a halt for the fraction of a moment needed to read the tape or print the answer.

Computers can deposit worker's pay directly to their bank accounts, eliminating payday lineups and individual distribution of checks at the plant. Think what would happen if the computer information were not legibly printed so it could be understood. Chaos would occur if the tapes and papers that whirl through printer and reader systems were not accurately controlled—and NCR engineers say still higher speed is needed to record and recall information to reduce computer-services costs. ■

The tape in the NCR computer unit is read at a rate of 1,000 lines per minute. High-speed is made possible by special silicon-alloy steels made for the electrical and electronics industries. These special "electrical" steels are used in clutch plates and brake shoes requiring high performance and exceptional wear resistance.

FCC Q & A

Using questions typical of the type asked for all FCC exams (commercial or amateur) you can prepare yourself for that big day.

by Carl L. Henry

■ Here we are going to discuss questions you will encounter on tests for all classes of FCC operator's licenses, whether amateur or commercial. The questions will be *of the type* asked by the FCC on its exams; the answers will be in depth. Rather than the conventional type of question and answer, we intend to cover each subject with answers that will help you to learn the subject fully.

For a beginning we are going to discuss FCC questions covering the single most important part of the transmitter, the oscillator. It is evident that the frequency determining element of a transmitter is its most important section, since without accurate frequency control communications would be at best intermittent and at worst impossible. Most questions asked on the FCC exams, about oscillators, are concerned with testing: 1. do you know what an oscillator is? And: 2. do you know how to keep it on frequency?

The new terms Hertz (Hz), KiloHertz (KHz), and MegaHertz (MHz) are given after the long-used terms cycle-per-second (cps), kilocycle-per-second (kc), and megacycle-per-second (mc) to familiarize you with them.

Q. What is the relationship between frequency and wavelength?

A. Frequency, in cps (Hertz) = 300,000,000/wavelength (in meters), or frequency, in mc (MHz) = *300*/wavelength (in meters). This is a simple relationship that you should memorize. The second formula is the one to remember. You will use this most, and the other can be developed from it. As a further aid to memory, recall 30 mc (MHz) equals 10 meters, or 300 mc equals 1 meter.

Q. Why should an oscillator, in a typical transmitter, have a separate plate-supply?

A. Using a common plate-voltage supply in a transmitter can cause frequency modulation of the oscillator. Variations in the plate voltage, due to variable loading (current drawn) on the power supply by the final amplifier. This does not mean that an entirely separate power supply must be used, just that the section supplying the oscillator should be isolated from the balance of the supply by a regulator. This can be a tube, such as an 0D3. In this manner the voltage variations (due to the loading on the supply) will not be reflected to the oscillator.

Q. Draw a diagram of a crystal-controlled oscillator.

A. Study Fig. 1 carefully. Generally on questions such as this a diagram will be given that is incorrect, and you must correct it. This circuit may be redrawn several ways, but basically the plate (and screen if it is a pentode) must be connected to the B+, the cathode to the B− or ground; and the crystal either as shown, grid to ground, or for a Pierce circuit, grid to plate. There must be a plate load, either a resistor, a choke, or a tuned circuit. An important point to remember about crystal oscillators is that this is the only type of oscillator for a Novice.

Q. A crystal for the 80-meter band is specified to be within 0.05% of its stated frequency. What is the lowest frequency you should order to stay within the lower limit of the band, allowing an additional 1.0 kc (KHz) for temperature and circuit parameter variations; assuming you wish to operate just inside the band at this lower limit.

A. A simple formula to solve this problem is:

$$\frac{\textit{frequency (lower band limit)}}{1 - \textit{crystal tolerance}} + 1.0 \text{ kc (KHz)}$$

Using this formula:

$$\frac{3500 \text{ kc (KHz)}}{1 - 0.0005} + 1.0 \text{ kc}$$
$$= 3501.6 + 1 \text{ or } 3502.6 \text{ kc (KHz)}$$

If the question is specified to the nearest kc (KHz), the answer would be 3503 kc. If the answer had been 3502.4 kc to the nearest kc, the answer would still be 3503 kc. Since the FCC expects any operator to err toward the direction of maximum safety.

Q. A 3800 kc (KHz) low-drift crystal having a negative temperature coefficient of 5 cps (Hz) per mc (MHz) per degree Centigrade is started in operation at 40-degrees Centigrade. If the relationship is linear, what will the frequency of the crystal be at 65 degrees?

A. Negative temperature coefficient means that the crystal will shift down in frequency

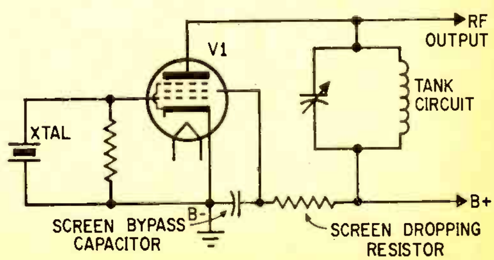


Fig. 1. Diagram of a crystal-controlled oscillator.

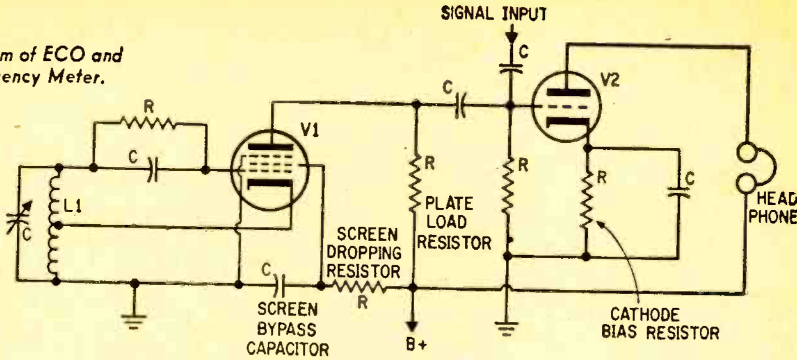


Fig. 2. Basic diagram of ECO and AM detector Frequency Meter.

with increasing temperature. Here it is specified as 5 cps/mc/degree. The temperature change is 25 degrees, so the frequency shift is: $-5 \times 25 \times 3.8$ mc, or -475 cps (Hz). So if the relationship is linear, the new frequency will be 3799.525 kc (KHz).

Q. Draw a schematic of a simple heterodyne frequency meter with provision for monitoring transmitter output.

A. The circuit in Fig. 2 is of an electron-coupled oscillator. The frequency of the oscillator is determined by the parallel LC network in its grid circuit. (These components must be selected for high stability for use in a frequency meter.) The output of V1 (the ECO) is coupled to the input of V2, the second stage, which is an AM detector. The signal to be measured is also coupled to V2's input, and the beat between the ECO and the frequency being measured is heard in the earphone. The ECO is adjusted for zero beat with the transmitter's frequency, and the accurately measured frequency is read off the ECO dial. Transmitter output (modulation) can also be monitored by V2, which is then acting only as an AM detector.

Q. What device is used to derive a 10-kc signal from a 100-kc oscillator?

A. The device is called a frequency divider. (See Fig. 3.) This is a type of multivibrator (RC oscillator) that will lock-in on a submultiple of an input signal supplied to it. The values of resistance and capacitance are calculated to cause oscillation at the desired frequency. A known-accurate signal is then applied to one of the grids at some multiple of the desired output, in this case 100 kc (or KHz). If the input signal amplitude is great enough the output signal will lock-in with the input at some submultiple, and this output signal will have the same percentage of accuracy as the input signal.

Q. Draw a schematic of a basic multivibrator.

A. See Fig. 3. The test will have a diagram such as either of these, with something missing or drawn incorrectly. Study the schematics carefully. Both circuits are identical and both methods of drawing are correct—either may be used.

Q. For maximum stability, how should the tuned circuit of a crystal be tuned?

A. At the exact plate-current dip point, or resonance, the oscillator will be critical, and slight circuit changes may cause it to stop oscillating. If the tuned circuit is adjusted

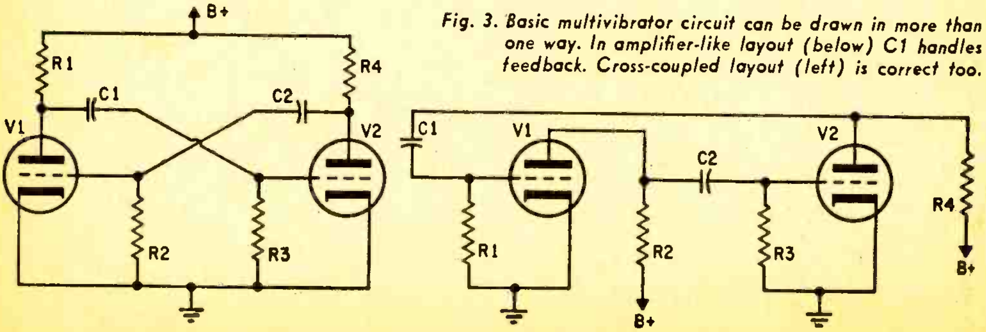


Fig. 3. Basic multivibrator circuit can be drawn in more than one way. In amplifier-like layout (below) C1 handles feedback. Cross-coupled layout (left) is correct too.

to slightly above the resonant frequency, this instability will be reduced or prevented.

Q. What advantage has a mercury thermostat (used for temperature-controlled crystals) compared to a bimetallic thermostat?
A. Mercury contacts are not subject to pitting or corrosion.

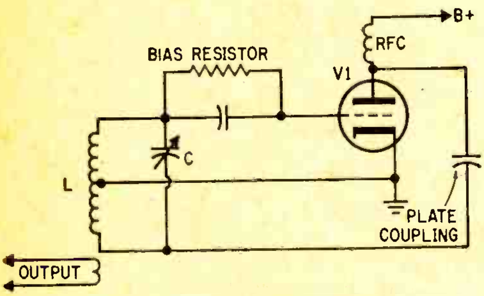


Fig. 4. Hartley oscillator has tapped coil for feedback voltage divider. Remember H for Hartley, and H for Henry (unit of inductance in a coil).

Q. Draw a diagram of a Hartley and a Colpitts oscillator.
A. The Hartley oscillator is given in Fig. 4—the Colpitts in Fig. 5. These are shunt fed oscillators. The diagrams on the test may be either shunt or series fed. The tube may be a triode or a pentode ECO.

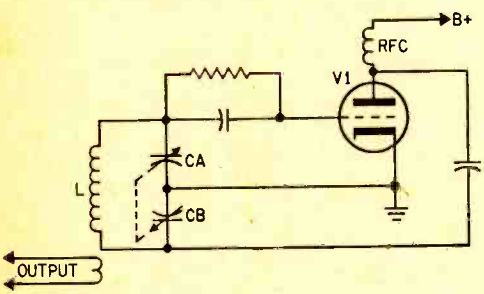


Fig. 5. Colpitts oscillator has series capacitors in feedback voltage divider. Remember C for Colpitts, and C for Capacitor and you can't go wrong.

Q. What precautions should be taken to prevent a crystal from oscillating at a frequency other than its fundamental?
A. 1. Use a buffer amplifier between the oscillator and its load.
2. Regulate the plate voltage supplied to the oscillator.
3. Keep the temperature of the crystal constant.
4. Keep feedback in the oscillator to the minimum needed to maintain oscillations.
5. Keep all parts of the oscillator mechanically rigid.

Q. At what frequency will an X-cut, 600-kc (KHz) crystal oscillate when it has been calibrated at 50-degrees Centigrade, has a temperature coefficient of −20 parts per million per degree, and its temperature has been raised to 60-degrees Centigrade?
A. It will oscillate at 599.88 kc (KHz). The temperature coefficient is −20 cps (Hz) per mc (MHz) per degree. It will shift −200 cps per mc, or $-200 \times 0.6 = -120$ cps. Subtract this from the original frequency.

Q. What are the operating characteristics of the electron-coupled oscillator?
A. The electron-coupled oscillator has its input (or grid) circuitry buffered from the variations in load which occur in the output (plate) circuitry—a tube with a screen *and* suppressor grid is used. Interaction from output to input circuitry occurs through the grid-to-plate capacitance of the tube. The addition of the other grids substantially reduces this capacitance. Hence the stability of the ECO is better than other types of LC oscillators, but it still has less stability than a crystal oscillator.

Q. Using a frequency meter known to have a possible error of 0.1%, what is the highest frequency on the 3500-4000 kc band to which an amateur transmitter can be safely set?
A. The same simple formula that we used on the crystal band-edge problem can be used here:

$$\text{frequency (indicated by meter)} = 4000/1 + 0.001$$

or for the low end of the band:

$$\text{frequency (indicated by meter)} = 3500/1 - 0.001$$

Do not add an error factor of 1.0 this time since it was not specified.

Q. Why are quartz crystals sometimes operated in temperature controlled ovens?
A. Since the frequency of crystals vary with temperature, the crystal temperature is kept constant by enclosing the crystal in an insulated box (called an oven) which contains a heater and a preset thermostat. Ovens are usually purchased with the controlled temperature specified. Usual practice is to keep the crystal temperature above the highest possible ambient temperature that the unit will encounter, in order to give the oven thermostat a good control margin.

e/e FCC Q&A

Q. What procedure should be followed if it becomes necessary to replace the tube in a heterodyne frequency meter?

A. Changing any of the oscillator components will affect the calibration. It should be checked and recalibrated if necessary.

Q. Explain, in detail, how oscillator frequency is measured, using a secondary frequency standard.

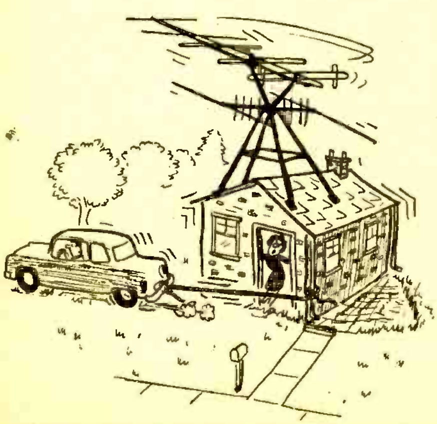
A. The first step is to verify the accuracy of the secondary standard. Tune in one of the standard-frequency station on a receiver, and loosely couple the secondary standard to the receiver antenna. When the transmitted modulation goes off the carrier zero-beat the secondary standard against the carrier. When the modulation returns, you will hear a flutter as the secondary standard beats with the modulated carrier. Slightly adjust the secondary standard until the flutter is as slow as possible. (In some cases, an oscilloscope can be used to see the beat directly.) Now zero beat the secondary standard with the oscillator's frequency, following the manufacturer's instruction for using the secondary standard. Use an oscilloscope to obtain an exact zero-beat at the output of the mixer in the secondary standard. If interpolation is necessary, such as when the secondary standard is crystal controlled and not variable, feed the output of the mixer into the vertical input of an oscilloscope. Connect an accurate audio oscillator to the other horizontal input of the oscilloscope, and adjust the oscillator to get a known ratio Lissajous pattern on the screen. Add this interpolated frequency to the known frequency of the crystal. Using this method it is necessary to have a rough idea of the oscillator frequency before making the measurement. ■

It's a Woman's World?

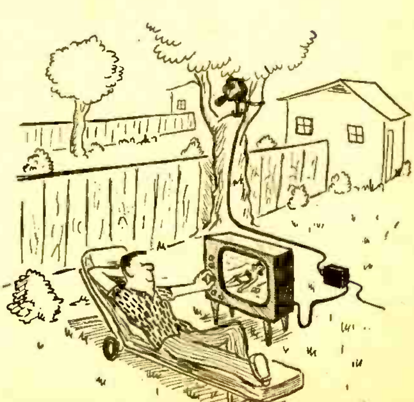
by

Jack Schmidt

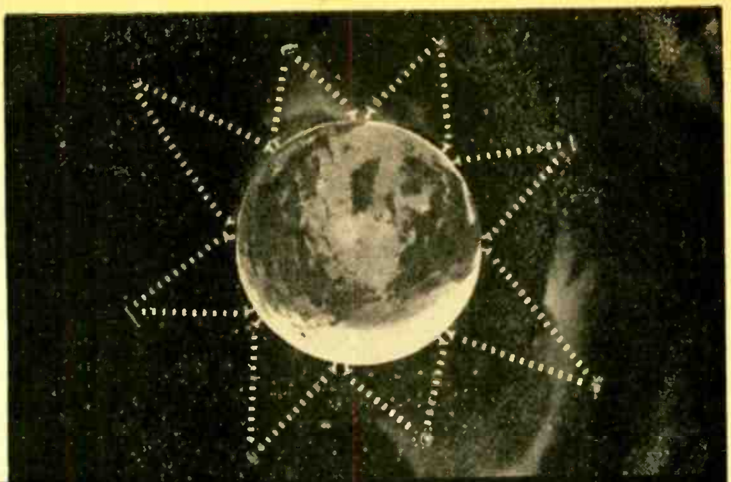
". . . and where did you get that kit?"



"OK, you can get the antenna rotor. . . ."



Civilian plans for this SATCOM network are still up in the air but easily set up units do promise better education for under-developed areas around the world.



Network on the Prowl

by K.C. Kirkbride

■ Was a day when you could build a radio network and it would stay put. But that day, alas, is now part of a dim and mildewed past. For the new mode in networks is the portable look. A network with transmitting and receiving terminals that can be folded up like a tinker toy, loaded on a plane, flown half way round the world, unloaded, reassembled, and put back in business within 48 hours.

Come Fall of this year, a fleet of communication satellites will be launched into space by the United States Army. These—the first world-wide satellite communications—will relay radio, teletype messages, and facsimile photographs to portable terminals spotted round the world. And each portable rigged to transmit and receive over four voice channels, four teletype channels at the same time.

Designed and built by Hughes Aircraft Corporation, the new type network is in the Army now, but when it changes to civvies, it might well do its bit to aid the world. For its principles converted to telecasting might prove the missing link in finishing the needed world-television network.

For when SYNCOM became operational, international television was feasible technically. But there was an important handicap. One of the major motives in creating such a network would be the intention to telecast education to peoples in hungry areas of the world, to help people help themselves.

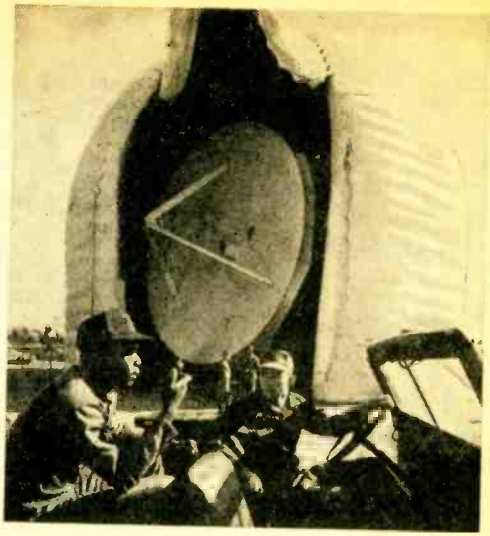
For the screen could teach people to read, write, and use simple tools in areas where illiteracy breeds poverty. It could show the people how to increase the yield from the land, multiply their food supply to help meet multiplying population needs.

But one thing lacking was the means to place receivers in the backward areas, areas handicapped by insufficient power supply, and limited or non-existent transportation facilities. Once this portable "network" design could be transferred to transmitting the television picture, portable receiving stations, transported by plane, could reach these remote areas.

Until we can see a portable television network, the new restless network will have to win its stripes as the first world satellite communications network, limited now to military use but promising all sorts of implications in the future.

How the idea was conceived. It happened like this: With today's constantly changing political, economic and military climates, communications can no longer stay static.

One day a transmitting-receiving "station" may be needed in Alaska. A few weeks later, one may be necessary in a remote spot in Africa, or in the Far East. A few months



Cocoon-like radome, with one section peeled open, houses ground-link terminal of SATCOM net.

Technicians, dangling in bosun chairs (left), are dwarfed by 40-foot diameter parabolic antenna. Air-transportable terminal is set up in 48 hours.

later, none of these terminals may have any use at all in their areas. But the Army cannot travel around the world, building and then abandoning transmitting-receiving stations. The only practical solution: a portable broadcasting network.

Hughes built a terminal station consisting of a 40-foot diameter parabolic antenna, the largest of its kind in the world. Each antenna is protected from hostile weather conditions by a dual-wall inflatable radome 58 feet in height. In operation, each antenna can withstand winds of 60 mph; when not in operation, it can withstand winds of 120 mph.

Three thirty-foot mobile vans service each terminal, and three 100 kva Diesel generators supply power. An operations van carries control console and electronic equipment. A cargo van, the radome and reflector; the maintenance van, spare parts and test equipment.

One terminal is ready, built at Helemano, Hawaii, 20 miles north of Honolulu. This one will broadcast between Hawaii, and the United States, serve as relay to and from terminals spotted through the Western Pacific.

Another portable—also in the Army, and also a brainchild of Hughes Aircraft—doesn't need a plane to get around. It travels on the back of a soldier, has 10,000 voice channels, and can strut its stuff in the densest jungle.

Called "Manpack," it is transistorized, weighs a neat 29 pounds with wet cells, is 18 inches high, 12 inches wide, and 3¾ inches thick. The solid state pack has a 2 to 12 megacycle range, its channels offering a frequency flexibility meant to confuse any jamming enemy.

The portable's high frequency signals reflect from the ionosphere, to give longer range than line-of-sight, so that its HF signals are effective in the most difficult mountain or jungle country where very high or ultra-high signals would fail. Reason for its plus portability is it can run on ordinary flashlight type dry cell batteries or on wet-cell batteries.

According to field tests, its influence reaches far. Not around the world as the portable network will, but one test broadcast succeeded between points 500 miles apart. And Senior Vice-President of Hughes Aircraft, C. Harper Brubaker, says, "We even have received clear transmission at our Fullerton (California) facility from a 'Manpack' broadcasting from more than 7500 miles away."

When this distance "Manpack" and the traveling network turn civilian, will we see a world-wide satellite network that will relegate our presentday stay-at-homes to an antiquated past? A network that will broadcast from the most remote areas, hop around the world at will. ■

■ Here we are again with a report on the most interesting aspect of short wave listening, the "utility" stations. This includes all radio transmitters with the exception of broadcast stations and Hams.

Just for kicks this month, let's look at some of the more interesting stations operated by U.S. and Canadian federal and state governments.

For instance, there's a "mystery" net of government stations which we keep hearing on 5422.5 kc. Calls are KAE310 (in New York), KAE311 (Boston), KAE312 (Miami), and others in San Juan, San Francisco, Honolulu, Seattle, San Diego, Chicago, New Orleans. See if you can figure out who operates this net. We know that it's the government, but which agency?

NBS. Do your friends have QSL cards from the National Bureau of Standards station WWV? You can send them into tailspin by betting that you know NBS (National Bureau of Standards) stations which they can't name. First they'll say WWVH (Hawaii), then WWVB and WWVL (Colorado). You'll still be two up on them. It's never before appeared in print, and it isn't generally known, but the NBS operates stations KGD28 (7975 kc) and KGD29 (10687.5 kc) in Sterling, Va. These aren't WWV-type stations, but regular 2-way 'phone stations used to communicate with the NBS office in Boulder, Colorado. Another little-known NBS station is KQ2XAU (6080 kc) in Cincinnati, Ohio. Lord knows why the station exists, but they can often be heard with a "dead carrier" on the frequency when it isn't being used by the Voice of America station in Bethany, Ohio. The callsign, KQ2XAU, is sent each half hour in CW. They run 1,000 watts into a vertical antenna. A QSL can be obtained by sending a detailed reception report to the National Bureau of Standards in Cincinnati.

The Canadian Government has a well known "time" station which sends out a nifty QSL. Station is CHU which operates on a 24-hour basis as follows 3330 kc (300 watts), 7335 kc (3 kw.), and 14670 (300 watts). Their time signals consist of a series of CW dots, with voice announcements each 5 minutes. Send your reports to: Station CHU, Dominion Observatory, Department of Mines and Technical Surveys, Ottawa, Ontario.

Weather. Stations of the United States Weather Bureau offer interesting listening, especially during the hurricane season. The hurricane net operates on 2776 and 6977.5 kc and is really in full swing when the big-blow is at its height. Listen for these stations:

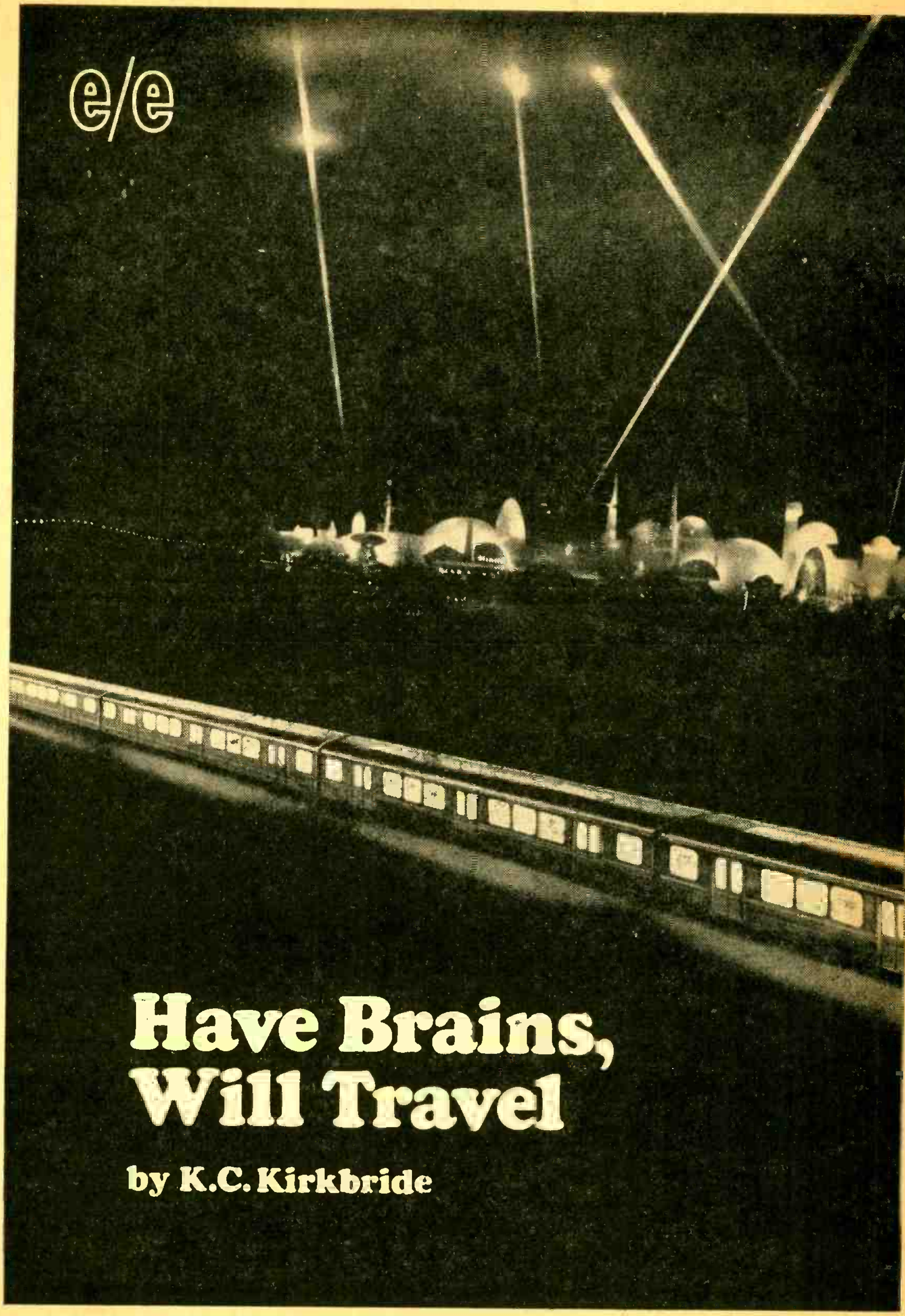
KAE46	Athens, Ga.
KAE51	Nantucket, Mass.
KEB86	Cape Hatteras, N. C.
KEB87	Cape Hatteras, N. C.
KGD64	Athens, Ga.
KGD68	New Orleans, La.
KGD72	Washington, D. C.
KID75	Nantucket, Mass.
KOE26	New Orleans, La.
KC6222	Mobile Station #2

There are plenty of other Weather Bureau stations besides this particular net, but they aren't reported as frequently.

Right after a hurricane or any other major emergency, you can dig the sounds of the massive Civil Air Patrol radio network. The CAP stations may be heard on 2374, 4467.5, 4507.5, 4585, and 26620 kc. Most of the time the stations use "tactical" (name) calls such as "Yellow Jacket 205," "Beaver Bird

(Continued on page 107)

Nifty QSL from Canadian "time" station isn't hard to get if you're set up in a good reception area.



Have Brains, Will Travel

by K.C. Kirkbride

Electronic "brains" make the split-second decisions for these high-speed passenger trains for Canada.

■ For the first time in the long history of transportation, we will apply "brains" to running our railroads. For a new pushbutton train, the first of its kind, a train that will first a series of new-era models, will soon make its debut.

When the World Exhibition in Montreal, Canada, opens next year, a sleek, new six-car automated passenger train, named Expo Express, will pick up visitors at the Mackay Pier in Montreal Harbor, speed them by "brainpower" to the Fair site on an island in the St. Lawrence River.

A streamlined job that will carry as many as 30,000 passengers an hour, it will run on electronic judgment and power 99-44/100's of its time, relying on the more fallible human variety for the remaining fraction.

The Thinking Man's Train. To get low-down details on this exciting new train trend, we went to VIPs in the Union Switch and Signal Division of the Westinghouse Air Brake Company, pappa-creator of the new train. And we were told the master key to the eight-car Montreal model will combine electronic with human brain at the main control center.

A key dispatcher, or supervisor, will pushbutton the system of eight trains at the Fair from a computer console. A huge illuminated map hanging high on the center wall will show where each train is at each second, show its direction, destination and speed.

When the dispatcher sees Train A should head for location B, he will press a button that will light a sign standing on the platform next to the train signalled. The attendant in the train's cabin will watch for this go-ahead, let passengers board, close the elevator-type doors automatically, then push still another button.

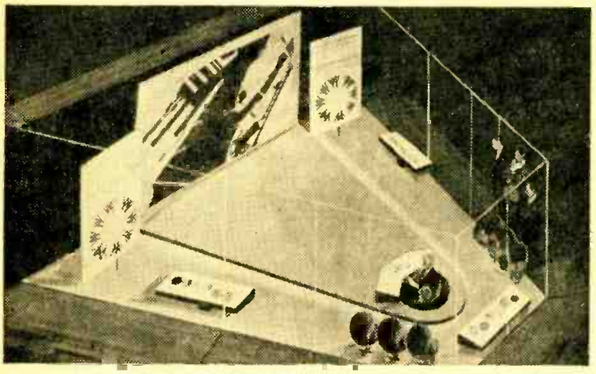
In response to this signal, wayside transmitters will send low-voltage, audio-frequency impulses down the uninsulated steel rails. Impulses will be picked up inductively from the rails by electronic hardware inside the train, automatically controlling start, speed and stop when preset destination is reached.

The on-train mechanism that controls propulsion power and brakes the train is a servo-mechanism, a velocity control programmer answering commands from cab, speed and wayside control. The attendant inside his cab can watch speed on an indicator panel, check with the main console center through a voice-communication set-up.

At the end of each system at the Fair, there

e/e HAVE BRAINS

Carryphone, a 2-way radio unit to be used for communications between dispatcher, station areas and train personnel.



An artist's overall view of the WABCO transit control center. A small control console (lower right) faces the large map display of the transit system. New information is indicated automatically. Position and speed of all trains can be seen and changes made by pushbutton.

will be track stub-end terminals with diamond cross-over, switch-over set-ups. Interlocking will also be automatically controlled so that trains will have their chosen station berths as they move into terminal, the switches positioned automatically for in-and-out moving. This speedy system, WABCO experts believe, will accommodate the most passengers in the shortest period of time, dispatching a train every 150 seconds.

The Weak Link—Man! Though Westinghouse Air Brake engineers claim they can fully automate their wonder train now, they have, in this generation stage, resorted in a moment of temporary weakness, to limited human assistance. For each attendant is trained to take over manually in case of what WABCO calls "abnormal" electronic behavior assuring a "fail-safe" system for passengers.

But while Expo will be faster, safer and miles ahead of the chugging furnace that first panted across the continent in the eighties, its sophisticated ways will only forerunner "brainy" jobs we'll see in the future.

Things to Come. Next on the passenger list, according to U. S. Department of Commerce sources, will be a fully-automated whippet, absorbing many Expo tricks, that will race across the country at speeds of 200 miles an hour and *up*. To travel such fantastic speeds, railroaders feel automatic switch-over is a "must." The human brain just can't think fast enough to guide a train that determined. Only the electronic quiz-kid can catch hep when serious problems arise such as passenger jam-ups during storm-time, or after a major sports event, or measuring distances between the speed demons, or stopping the racers without lurch when destination is reached.

Too, with multiplied populations in offing within the next few years, creating megalopolitan areas where cities will blend into cities from Boston to Washington, automatic rendezvous will be needed. An express may rendezvous often with spur trains moving in on the main trunk line, or link with other expresses, or switch to a separate track to avoid a local.

To achieve such high-paced juggling, train technicians say they intend to borrow from space technology, adopt techniques learned in the Gemini rendezvous program. Then smaller-branch train-sections can link up with mainliners regardless of pace. Though train experts expect linking trains may well prove more difficult than space maneuvers. For a Gemini rendezvous is but a single maneuver while an automated high-speed train system will need make flawless rendezvous many times in 24 hours, regardless of atmospheric conditions.

But when space technology does rendezvous with automated Expo systems, we will see fantastic speed-up in service that will make today's train as past-tense as the horse-and-buggy. And while no one really expects a future train to travel the speed of sound, we can happily promise models that will attend the funeral of the old black monster we know today.

And we predict it won't be two-three decades before today's archaic beast will only be seen under the shed of a museum. While a new robot-run fellow will race across the country, run by pushbutton, one that will always keep its electronic head. ■

MAD ABOUT MOD

A tiny solid-state device that virtually eliminates heat problems in microwave communications systems has been developed by Sylvania Electric Products Inc. The device, a MOD (Microwave Oscillating Diode), smaller than a shirt button, will give engineers considerable latitude in designing and packaging short-range, low-power microwave radar systems that can be used by astronauts during "docking" of space ships at satellite stations. The MOD also could be applied in automobile and boat collision-control units; missile radar systems and for transmitting television signals between orbiting spacecraft.

The experimental system's low-power microwave beam is generated by a tiny solid-state device which is powered by a standard 30-volt battery. Together, they represent approximately 1/50th the weight of comparable equipment presently used to produce a microwave signal in commercially available systems. The laboratory model was designed by General Telephone & Electronics Laboratories Incorporated. ■

DX Central Reporting

Continued from page 103

23," "Star Fish 57," etc. There are probably thousands of stations in operation on these frequencies and you can make an entire DX career out of listening to the CAP alone.

To the Rescue. The Royal Canadian Mounted Police do quite a bit more than chase Snideley Whiplash, you can even listen to Dudley Doright (ta-tahhhh!!!) and his friends conducting "Mountie" communications on a number of frequencies. Most frequently heard "Mountie" stations seem to be reported on 4785 and 4895 kc. Most stations heard are in the western provinces.

Getting Out. Getting away from the continental United States, the U. S. Navy operates station NGD at McMurdo Sound, Antarctica. They were recently reported on 13874 kc around 0610 GMT working New Zealand.

Another military station at a distant "rare" location would be ABK in the Marshall Islands. Operated by the U.S. Army, they are being reported on 9910 kc (0730 GMT), 13570 kc (0538 GMT), 16370 kc (0420 GMT), and 17690 kc (0055 GMT). You can take a whack at getting a QSL, but there aren't any guarantees about getting one. Try: Chief Operator, Station ABK, United States Army, Eniwetok, Marshall Islands.

We are looking forward to receiving reports from our readers concerning reception of "utility" stations on either 'phone, SSB, or CW. Please include the callsign, frequency (or approximate frequency), time (in GMT), etc. You might even send along a photo of your SWL shack. Who knows, you might even become immortalized in our pages. ■

Traffic a Go Go

Continued from page 18

turned off or the cartridge is removed.

What's Available? There are already over 20 makes on the market today with new units popping up like dandelions. They vary from the simple, early non-stereo 4-track hang-on models, which cost approximately $60 installed, to recent 8-track hang-on types offered at prices up to $155 installed. Factory-installed cartridge tape players are available in certain cars for about $130—get the exact price from your new-car dealer.

Tape cartridges have a bright future. Public acceptance with its mass purchasing has lowered the unit cost for cartridges to a level which is competitive with LP's. The demand for home units is on the increase—more and more tape cartridges will be made, lowering the price to where the LP will give ground and eventually yield to the magnetic audio tape. ■

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☆**5.** Unusual scientific, optical and mathematical values. That's what *Edmund Scientific* has. War surplus equipment as well as many other hard-to-get items are included in this new 148-page catalog.

☆**106.** With 70 million TV's and 240 million radios somebody somewhere will need a vacuum tube replacement at the rate of one a second! Get *Universal Tube Co.'s* Troubleshooting Chart and facts on their $1 flat rate per tube.

7. Whether you buy surplus or new, you will be interested in *Fair Radio Sales Co.'s* latest catalog—chuck full of buys for every experimenter.

8. Want a colorful catalog of goodies? *John Meshna, Jr.* has one that covers everything from assemblies to zener diodes. Listed are government surplus radio, radar, parts, etc. All at unbelievable prices.

10. *Burstein-Applebee* offers a new giant catalog containing 100's of big pages crammed with savings including hundreds of bargains on hi-fi kits, power tools, tubes, and parts.

11. Now available from *EDI (Electronic Distributors, Inc.)* a catalog containing hundreds of electronic items. *EDI* will be happy to place you on their mailing list.

12. VHF listeners will want the latest catalog from *Kuhn Electronics*. All types and forms of complete receivers and converters.

☆**23.** No electronics bargain hunter should be caught without the latest copy of *Radio Shack's* catalog. Some equipment and kit offers are so low, they look like misprints. Buying is believing.

6. Bargains galore, that's what's in store! *Poly-Paks Co.* will send you their latest eight-page flyer listing the latest in merchandise available, including a giant $1 special sale.

25. Unusual surplus and new equipment/parts are priced "way down" in a 32-page flyer from *Edlie Electronics*. Get one.

HI-FI/AUDIO

15. A name well-known in audio circles is *Acoustic Research*. Here's its booklet on the famous AR speakers and the new AR turntable.

16. *Garrard* has prepared a 32-page booklet on its full line of automatic turntables including the Lab 80, the first automatic transcription turntable. Accessories are detailed too.

17. Build your own bass reflex enclosures from fool-proof plans offered by *Electro-Voice*. At the same time get the specs on *EV's* solid-state hi-fi line—a new pace setter for the audio industry.

19. *Empire Scientific's* new 8-page, full color catalog is now available to our readers. Don't miss the sparkling decorating-with-sound ideas. Just circle #19.

22. A wide variety of loudspeakers and enclosures from *Utah Electronics* lists sizes shapes and prices. All types are covered in this heavily illustrated brochure.

24. Need a hi-fi or PA mike? *University Sound* has an interesting microphone booklet audio fans should read before making a purchase.

26. Always a leader, *H. H. Scott* introduces a new concept in stereo console catalogs. "At Home With Stereo" the 1966 guide, offers decorating ideas, a complete explanation of the more technical aspects of stereo consoles, and, of course, the complete new line of *Scott* consoles.

27. An assortment of high fidelity components and cabinets are described in the *Sherwood* brochure. The cabinets can almost be designed to your requirements, as they use modules.

95. Confused about stereo? Want to beat the high cost of hi-fi without compromising on the results? Then you need the new 24-page catalog by *Jensen Manufacturing*.

99. Interested in learning about amplifier specifications as well as what's available in kit and wired form from *Acoustech?* Then get your copy of *Acoustech's* 8-page colorful brochure.

TAPE RECORDERS AND TAPE

31. All the facts about *Concord Electronics Corp.* tape recorders are yours for the asking in a free booklet. Portable battery operated to four-track, fully transistorized stereos cover every recording need.

32. "Everybody's Tape Recording Handbook" is the title of a booklet that *Sarkes-Tarzian* will send you. It's 24-pages jam-packed with info for the home recording enthusiast. Includes a valuable table of recording times for various tapes.

33. Become the first to learn about *Norelco's* complete Carry-Corder 150 portable tape recorder outfit. Four-color booklet describes this new cartridge-tape unit.

35. If you are a serious tape audiophile, you will be interested in the new *Viking of Minneapolis* line—they carry both reel and cartridge recorders you should know about.

91. Sound begins and ends with a *Uher* tape recorder. Write for this new 20 page catalog showing the entire line of *Uher* recorders and accessories. How to synchronize your slide projector, execute sound on sound, and many other exclusive features.

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76. A new voice-activated tape recorder switch is now available from *Kinematix*. Send for information on this and other exciting products.

39. A 12-page catalog describing the audio accessories that make hi-fi living a bit easier is yours from *Switchcraft, Inc.* The cables, mike mixers, and junctions are essentials!

98. Swinging to hi-fi stereo headsets? Then get your copy of *Superex Electronics'* 16-page catalog featuring a large selection of quality headsets.

104. You can't hear FM stereo unless your FM antenna can pull 'em in. Learn more and discover what's available from *Finco's* 6-pager "Third Dimensional Sound."

KITS

☆**41.** Here's a firm that makes everything from TV kits to a complete line of test equipment. *Conar* would like to send you their latest catalog—just ask for it.

☆**42.** Here's a colorful 108-page catalog containing a wide assortment of electronic kits. You'll find something for any interest, any budget. And *Heath Co.* will happily send you a copy.

☆**44.** A new short-form catalog (pocket size) is yours for the asking from *EICO*. Includes hi-fi, test gear, CB rigs and amateur equipment—many kits are solid-state projects.

AMATEUR RADIO

46. A long-time builder of ham equipment, *Hallicrafters* will send you lots of info on the ham, CB and commercial radio-equipment.

CB—BUSINESS RADIO SHORT-WAVE RADIO

48. *Hy-Gain's* new CB antenna catalog is packed full of useful information and product data that every CB'er should know about. Get a copy.

107. Get with the mobile set with *Tram's* XL'100. The new Titan CB base station, another *Tram* great, is worth knowing about. Get complete specifications plus facts on other accessories.

49. Want to see the latest in communication receivers? *National Radio Co.* puts out a line of mighty fine ones and their catalog will tell you all about them.

50. Are you getting all you can from your Citizens Band radio equipment? *Amphenol Cadre Industries* has a booklet that answers lots of the questions you may have.

100. You can get increased CB range and clarity using the "Cobra" transceiver with speech compressor—receiver sensitivity is excellent. Catalog sheet will be mailed by *B&K Division* of *Dynascan Corporation.*

54. A catalog for CB'ers, hams and experimenters, with outstanding values. Terrific buys on *Grove Electronics'* antennas, mikes and accessories.

☆**90.** If two-way radio is your meat, send for *Pearce-Simpson's* new booklet! Its 18 pages cover equipment selection, license application, principles of two-way communications, reception, and installation.

☆**93.** *Heath Co.* has a new 23-channel all-transistor 5-watt CB rig at the lowest cost on the market, plus a full line of CB gear. See their new 10-band AM/FM/Shortwave portable and line of shortwave radios. #93 on the coupon.

96. If a rugged low-cost business/industrial two-way radio is what you've been looking for. Be sure to send for the brochure on *E. F. Johnson Co.'s* brand new Messenger "202."

101. If it's a CB product, chances are *International Crystal* has it listed in their colorful catalog. Whether kit or wired, accessory or test gear, this CB oriented company can be relied on to fill the bill.

102. *Sentry Mfg. Co.* has some interesting poop sheets on speech clippers, converters, talk power kits and the like for interested CB'ers, hams and SWL'ers, too.

103. *Squire-Sanders* would like you to know about their CB transceivers, the "23'er" and the new "SSS." Also, CB accessories that add versatility to their 5-watters.

SCHOOLS AND EDUCATIONAL

☆**3.** Get all the facts on *Progressive Edu-Kits* Home Radio Course. Build 20 radio and electronic circuits—parts and instructions come with course.

105. Get the low-down on the latest in educational electronic kits from *Trans-Tek.* Build light dimmers, amplifiers, metronomes, and many more. *Trans-Tek* helps you to learn while building.

56. *Bailey Institute of Technology* offers courses in electronics, basic electricity and drafting as well as refrigeration. More information in their informative pamphlet.

59. For a complete rundown on curriculum, lesson outlines, and full details from a leading electronic school, ask for this brochure from the *Indiana Home Study Institute.*

☆**61.** *ICS (International Correspondence Schools)* offers 236 courses including many in the fields of radio, TV, and electronics. Send for free booklet "It's Your Future."

74. How to get an F.C.C. license, plus a description of the complete electronic courses offered by *Cleveland Institute of Electronics* are in their free catalog.

94. *Intercontinental Electronics School* offers three great courses: stereo radio & electronics; basic electricity; transistors. They are all described in *Inesco's* 1966, 16-page booklet.

TOOLS

☆**78.** A dozen tools for dozens of jobs in *Xcelite's* 99PS-50 hip pocket set. Contains plastic handle and interchangeable blades: 7 nutdrivers, 2 regular and 2 Phillips screwdrivers plus 4-inch extension. *Xcelite's* Form S1065 explains all.

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66. Try instant lettering to mark control panels and component parts. *Datak's* booklets and sample show this easy dry transfer method.

64. If you can use 117-volts, 60-cycle power where no power is available, the *Terado Corp.* Trav-Electric 50-160 is for you. Specifications are for the asking.

67. "Get the most measurement value per dollar," says *Electronics Measurements Corp.* Send for their catalog and find out how!

92. How about installing a transistorized electronic ignition system in your current car? *AEC Laboratories* will mail their brochure giving you specifications, schematics.

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☆**70.** *Heath Co.* now has a 19" and 25" rectangular-tube color TV kit in addition to their highly successful 21" model. Both sets can be installed in a wall or cabinet: both are money-saving musts!

73. Attention, TV servicemen! *Barry Electronics* "Green Sheet" lists many TV tube, parts, and equipment buys worth while examining. Good values, sensible prices.

72. Get your 1966 catalog of *Cisin's* TV, radio, and hi-fi service books. Bonus—TV tube substitution guide and trouble-chaser chart is yours for the asking.

29. Install your own TV or FM antenna! *Jefferson-King's* exclusive free booklet reveals secrets of installation, orientation; how to get TV-FM transmission data.

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Cross-Coupled Circuits

Continued from page 48

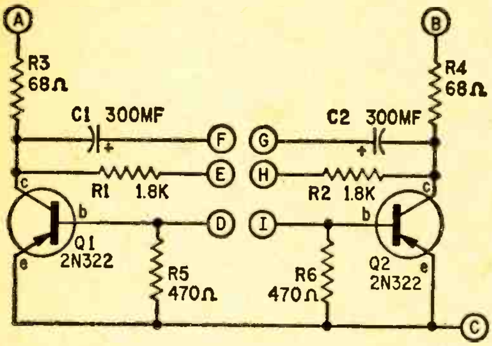


Fig. 9. Circuitry mounted on perforated phenolic board indicates points that are wired to components, mounted on panel of cabinet, that control action.

filing is necessary. However, care should be used to be sure the slot is straight.

Looking at Fig. 7 you'll notice that we've mounted the lamp assemblies on 1 inch spacers—the rounded ends of the bulbs act as pilot jewels. So it's important to coat the end of each lamp with nail polish so the light will be diffused and the entire end of the lamp will light. Thus, when lighted, the ends of the bulbs look like frosted glass.

Wiring. Wiring the demonstrator is easy. The parts are mounted on a stock size

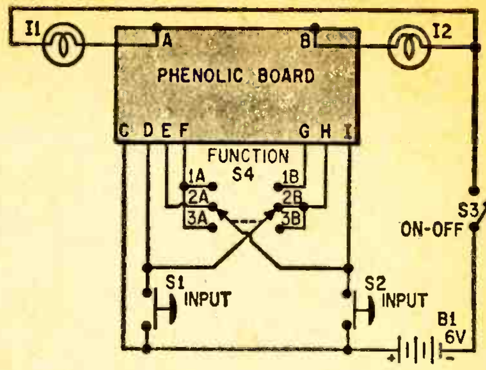


Fig. 10. Panel-mounted components showing interconnections and connections to phenolic board. The 6-volt battery is mounted on bottom of cabinet and, to keep leads short, should be last connection.

(2-7/16 X 3-3/8-inch) phenolic board with flea clips as shown in Fig. 8 and it's wired as shown in Fig. 9. Each of the lettered terminals should have an 8 to 10-inch lead attached. These leads are fastened to the *bottom* of the flea clips and run out through a 15/64-inch hole in the board as shown in the photo (Fig. 8).

When it's complete the phenolic board is attached to the back of the cabinet as shown in Fig. 7. Spacers (1/4-inch long) should be used between the cabinet and the board to prevent the wiring from touching the metal.

The final wiring is done according to Fig. 10 and the 6-volt battery is attached to the bottom of the cabinet. ■

Making Zener Diodes Work

Continued from page 80

ers and their type numbers. But you can select other Zeners to obtain other voltages. The only consideration is that all Zeners be of the same wattage rating and that their voltages add up to somewhat less than the full voltage output from the supply. In this example, 1-watt Zeners are used throughout and they add up to about 100 volts. You could use heavier Zeners, say 10-watters, for more output current, but you'd have to increase the power transformer and silicon diode ratings to handle the additional current. With the 1-watters you can draw up to about 15 ma., fine for many projects.

The supply is not critical in construction. You might, however, avoid the usual technique of using a metal chassis ground for the negative leads. Run a common, but insulated, ground lead to transformer, filter capacitors and other components, then bring it to an output terminal strip, along with the other voltages. By insulating all outputs on the terminal strip, you might avoid an accidental short circuit when tapping voltage from a Zener high up on the series string.

There is some preliminary calibration before using the supply. It's at R_s, the series resistor. It must be selected so maximum current to the Zener is about 25 ma. One method is to insert a 5K potentiometer and milliammeter in place of the resistor (R_s) and adjust for the desired 25 ma. current. Then remove the meter and pot, measure the resistance of the pot, and substitute a fixed 1-watt resistor of the same number of ohms.

There are numerous other uses for the Zener, these are listed in the application notes and the Zener manuals published by the semiconductor manufacturers. Not only do they suggest other circuit ideas, but they list important specs you'll need to know. ■

Fabulous Fuel Cells

Continued from page 86

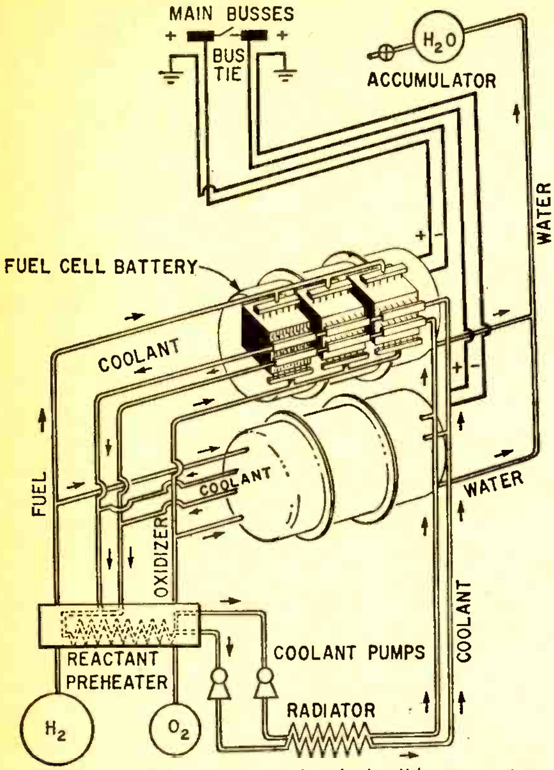


Fig. 3. Diagram of a complete fuel-cell battery system shows plumbing required to convey fuel, oxidizer, coolant and pure water by-product. Main busses can be connected in parallel for maximum current output.

tate the electric motors, which in turn generate an opposing magnetic field that slows the motor. No friction, no brake shoes, no drums. And like a child's electric train, the fuel-cell powered car would need neither warm-up, idling or even starting time; just flick a switch you're ready to burn rubber. Dreams, maybe, but Allis-Chalmers (which made the fuel-cell tractor) has toyed with the idea of producing a commercial fork-lift truck with fuel-cell power. And the U.S. Navy doesn't want to be caught napping, either. It's already awarded a contract for the development of a fuel-cell powered submarine.

Germ Power. One of the most intriguing ideas to come along the pike is the *biological fuel* cell. It's based on the ability of bacteria to produce chemical activity. (Just consider the germ-generated acid that cuts cavities in teeth.) It could lead to the day when a garbage truck runs on its own refuse . . . or when all manner of cast-off material, from sewage to sawdust, becomes fodder for the fuel tank. Some researchers have taken definite steps to harness the vast energy locked within bacteria. General Scientific Corp. has demonstrated a model boat that propels itself on power derived from bacterial action.

But For Now. The rest of this decade the spotlight will probably be on fuel-cell applications in space, where their special benefits can be realized right now.

Let's take a look at the fuel-cell power plant that's a working reality. It's the system built into the Gemini capsule that carried two men in orbit around the earth for two weeks. You may recall that fuel cells attracted much notoriety during that flight; they kicked up a fuss soon after launch. But problems were minor and did not seriously threaten the flight.

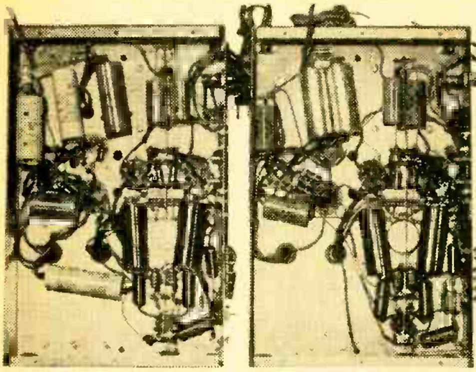
The overall system is shown in Fig. 3. Near the center are two large containers which house the fuel-cell batteries, with one cutaway to reveal the three modules of one battery. At the top is an accumulator, which receives the cell's exhaust, or water. Next to it are the main busses to carry power from the fuel cell to the spacecraft electrical system. Fuel sources—tanks of hydrogen and oxygen—are seen at lower left. One refinement of the system is the use of liquid coolant which circulates around the cells at temperatures of 75 to 120 degrees F. This protects the cells against overheating from the small, but potentially damaging amount of heat due to inefficiency (about 30%). There are cells under development, however, which will tolerate higher levels.

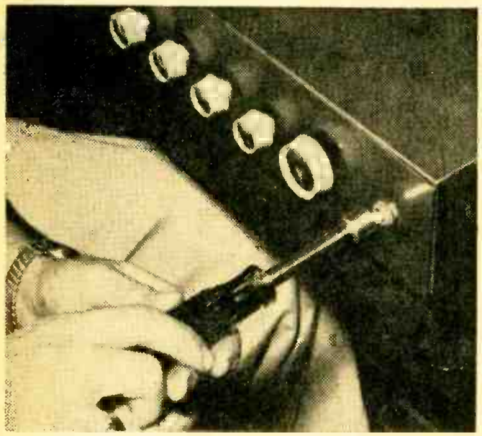
Another important area of potential application is in military ground power. Silent operation, mentioned earlier, is not the only benefit. Fuel-cell systems ranging up to 15 KW would be extremely lightweight and portable. Too, it would be possible to produce needed fuel locally. Oxygen can be drawn from the air, while hydrogen can be obtained from water. This reduces the need for shipping fuel over great distances, which could be crucial in a military operation. Virtually no moving parts is another attractive feature.

Until nuclear energy proves practical for everyday use in industry, car or home, watch for increasing applications of the fuel cell. At its present fast pace of development it may well make the lead-acid or zinc-carbon battery as obsolete as a cat's whisker (adjustable-crystal detector) radio. ■

Build 'em Good

Continued from page 56





Large-size nutdrivers have hollow shafts to accommodate control shaft. A thin washer of paper or felt will shield finished surfaces and panels. This is really important around toggle-switch and phone-jack nuts since they aren't hidden by control knobs.

pigtail leads are straight—just how much to trim off and to straighten bent lugs, etc. The instructions in construction articles are generally less specific. However, there is a right way and a wrong way.

Many kits and other projects are designed around a printed-circuit board, rather than the older hand-wired construction where wires and components are run from lug to lug. This simplifies the construction job, but should not be an excuse for sloppy workmanship.

Of course, each part must be mounted in the right place (if you have any hopes of making the device work!). Just as important, parts should be mounted tightly against the circuit board (unless the instructions direct otherwise). With most circuit board wiring, the leads of each part should be in-

An easy way to ruin a pair of pliers as well as scratch the front panel. Better to use an open-end or adjustable wrench.

The chassis at left show the differences in a factory-wired and home-workshop wired kit. Major differences are in lead dress and the positioning of components. It is not always possible to have components dressed.

serted through the correct holes in the board, and then bent outward, slightly, on the other side of the board to hold the part in place. After a group of parts has been installed, solder the leads to the foil and clip off excess lead lengths close to the board.

Wherever possible (on non-kit construction projects) arrange the major parts such as tube sockets and terminal boards at locations where the interconnections can be made with the pigtail leads of the resistors and capacitors. This eliminates the need for additional wiring. Usually, the leads on resistors and capacitors are longer than needed to make the required connections. The leads should be just long enough to reach and fasten to their connecting points. In some cases it will be impossible to arrange the major parts so that component leads will make all connections. Here you connect one lead of the resistor or capacitor to the major part, and route the other lead to a *tie point.* Unused tube-socket terminals are excellent tie points, if there is no room for a tie strip (but make sure that the tube socket terminal *is unused*). Then complete the connection with hookup wire.

Sleeving or spaghetti is used to prevent pigtail leads from touching other bare leads, terminals, or the chassis. Use sleeving where it is called for in the instructions, or where there appears to be even a remote chance of bare wire touching exposed areas.

When you remove insulation from the leads of transformers or parts with similar insulated leads do not pull on the lead. This strain could break the internal connection. When stripping such leads, hold the lead with pliers to remove the strain.

Now you know just what to tell to your sloppy-workmanship friend. But now you'll have to be on your toes to keep your next project even neater looking. ■

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Angles on DX

Continued from page 64

rival will be. But unless you're atop a very high mountain your antenna will not receive signals that arrive at angles of less than 5 degrees (nor will a station's antenna transmit signals at less than 5 degrees.)

An even more important consideration is that many antennas receive poorly between signal angles of 5 and 9 degrees. This makes the F and E layers skip distances about 1500 and 700 miles, respectively. The exact skip distance varies depending on the height of the layers and the height of the antennas. The higher the antenna is, the better it will receive at low angles of received signal.

Okay, Some Examples. From your scribe's location just outside Buffalo, N. Y., the British West Indies island of Jamaica is about 1650 miles—a 7-degree F-layer angle of arrival—and a reasonably good antenna is required to get a good signal from the Cable & Wireless transmitter on 5920 kc.

Radio Station XEQM (6150 kc.) in Merida, Yucatan is 1500 miles—an angle of arrival of about 9 degrees—and just a fair antenna will pull in a pretty good signal.

On the other hand, Puerto Cabenza, Nicaragua is 1900 miles—which hits that 5 degree barrier just about on the nose. In order to log radio beacon PZA (1662 kc.) an outstanding antenna is needed.

Double Hop. While suffering substantially more from absorption than single-hop signals, certain 2-hop signals also provide critical tests for your antenna. The station at Chiclayo, Peru, is 3300 miles from the home of the author. Since it is 2 times 1650 miles it produces a 7-degree angle of arrival like the signals from Jamaica, B. W. I. Again, for a fairly good signal a reasonably-high antenna is needed.

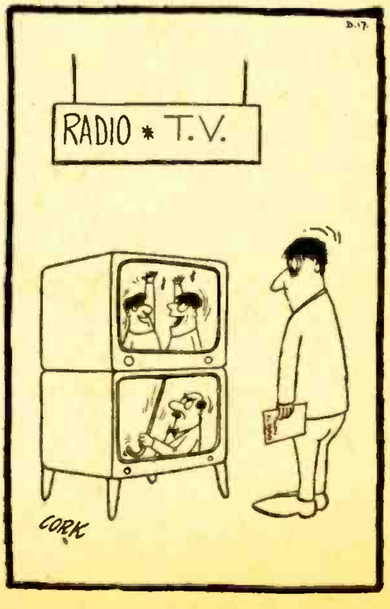
Hops vs S-units. In practice, as the number of hops goes up they produce less and less difference in signal strength at the receiver. When we are forced by poor low-angle reception to go from 1 hop to 2 hops, the absorption is doubled. However, when forced from 2 hops to 3 hops the absorption is increased only by half more.

There's More. The exact antenna height required to receive a given station depends upon the antenna's directional characteristics (if any), the transmitter's power and frequency, QRM (noise and interference) on the channel and the quality of the receiver.

Most SWL's use antennas of random length. To determine the weak spot of these antennas requires a good deal of experimentation. With the aid of WHITES RADIO LOG (a regular feature in RADIO-TV EXPERIMENTER Magazine), an accurate polar map or globe, a ruler and several evenings of DX listening, you should be able to establish some definite reception patterns. These will determine, for your setup, what is rare DX and what isn't.

For example, how many stations do you hear on the 49-meter band (in the same general direction) that are 1900 miles away, 1800, 1700 and on down? It goes without saying, keep track of your results from night to night.

When you've collected enough data on the 49-meter band move on to the 60-meter band; then 90, etc. And don't forget the Broadcast or Medium-Wave band where all of this applies in *spades.* If the results of your tests make you decide a higher antenna is called for, try to put up a second wire and leave the original (present) sky-wire intact. The results of your tests may indicate that you should do better with a lower antenna. Remember, the system works both ways—a low antenna can reduce QRM from certain areas too. Then again, a signal may be poor on both antennas. Generally, over a period of time, the reception results will show that a choice of antennas in your listening "shack" is desirable. ■



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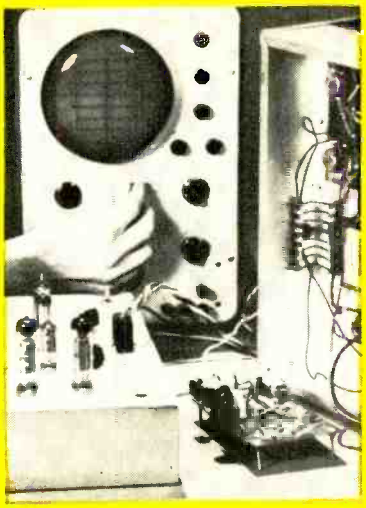

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