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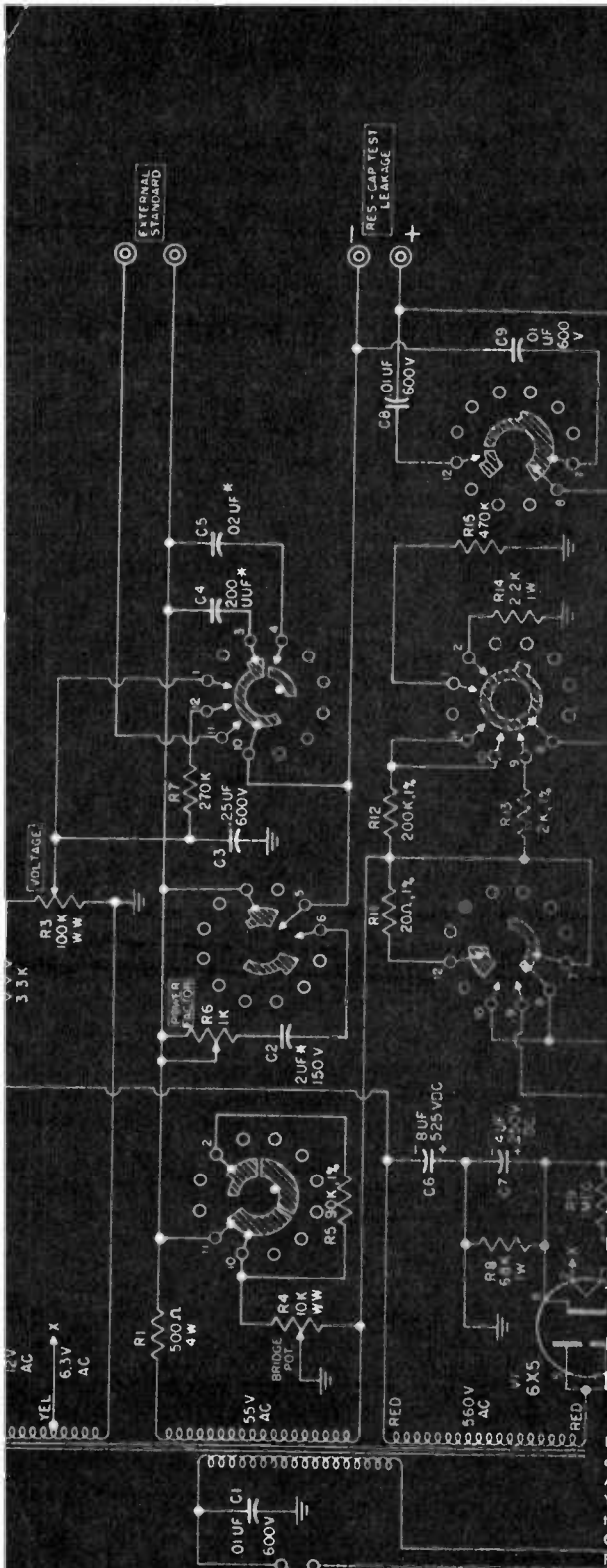

ELECTRONICS Guide

By the Editors of MECHANIX ILLUSTRATED in collaboration with ROBERT HERTZBERG

A FAWCETT BOOK • NUMBER 347

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ELECTRONICS GUIDE, Fawcett Book 347, is published by Fawcett Publications, Inc., Greenwich, Connecticut. Editorial and Advertising Offices: 67 West 44th Street, New York 36, New York. General Offices: Fawcett Building, Greenwich, Connecticut. Gordon Fawcett — Secretary-Treasurer. Roscoe Fawcett — Circulation Director. Trademark of Fawcett Publications, Inc., Printed in U. S. A.

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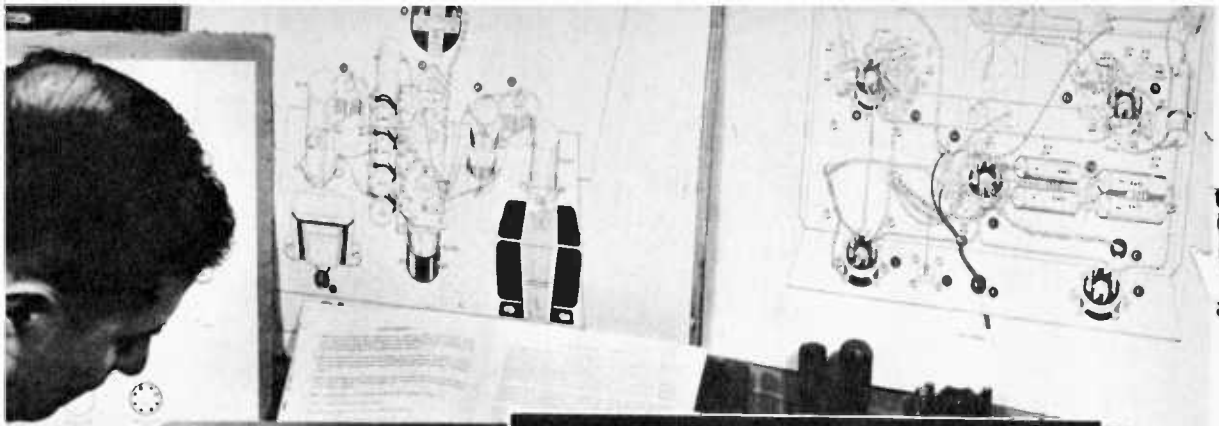

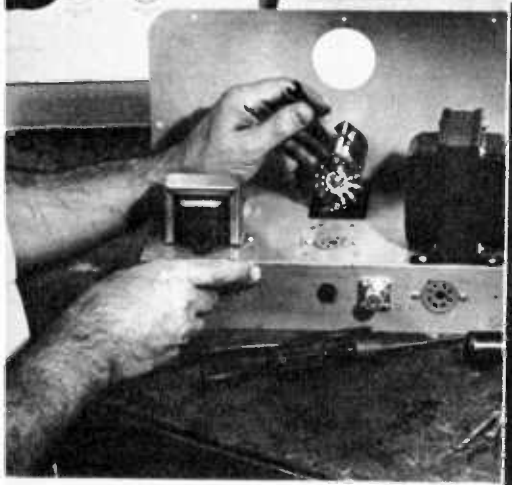

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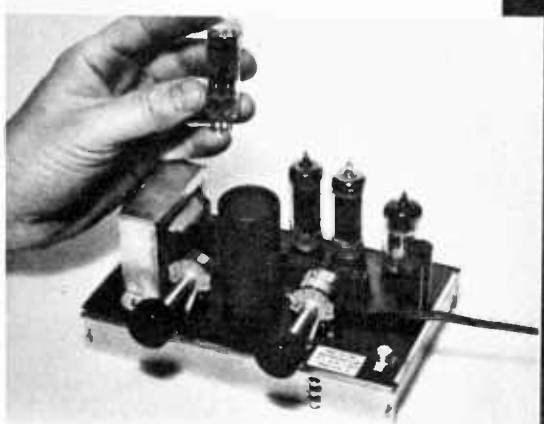

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12. **Concert by the Sea** Erroll Garner in an actual jazz performance at Carmel, Calif. *Teach Me Tonight, Where or When, I'll Remember* [illegible] more

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INTRODUCTION:

ELECTRONICS as both a hobby and a vocation continues to attract new converts in large numbers. In the amateur radio field, for example, the Federal Communications Commission is having a difficult time keeping up with license examinations and processing. The popular public conception of the radio "ham" as a boy in short pants is shattered by the cold fact that the "average" amateur is in his middle thirties, has children of his own, and spends almost as much for his short-wave equipment as he does for the family car. Also surprising is the large number of female hams, who become that way usually as a measure of self-defense against their husbands' devotion to the activity. Significantly, the 1956 Edison Award winner is a woman, as recorded on page 34.

Home building of electronic gear of all kinds is being made painless and foolproof, but still rewarding, through the marketing of numerous do-it-yourself kits. All of the projects described in this book were bench-tested in my shop before publication, and the accompanying photographic illustrations were made at the same time.

Transistors are slowly but surely sweeping the design field. That's why you see them turn up so often in the pages that follow. All the "bugs" haven't been removed from them, but they'll disappear in time. Some of the applications diagrammed in this book are considered routine today, but were thought to be impractical or impossible only a year or two ago.

Robert Hertzberg

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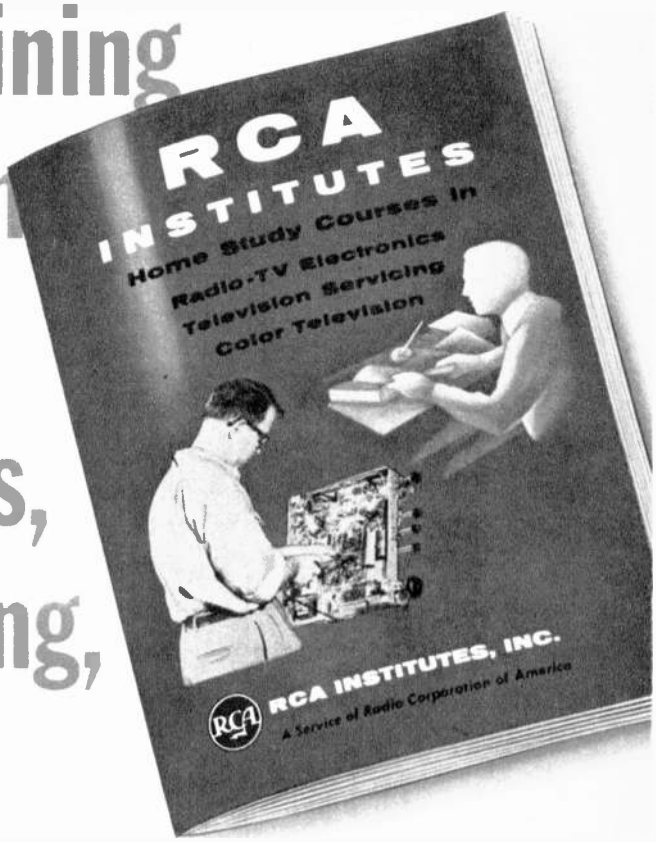

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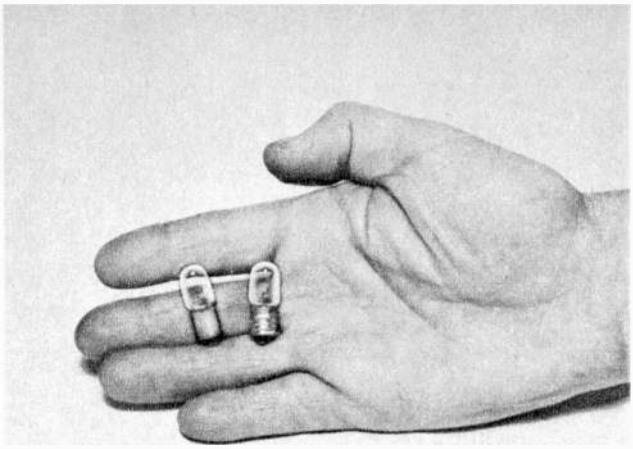


It's small but important because it lengthens the life of your tubes

IN five-tube AC-DC radio receivers, the most widely used type in the country, the 35Z5 or 35W4 rectifier tube is invariably the one that requires most frequent replacement. In many cases its relatively short life is due to some extent to the fact that a pilot light of the wrong electrical size has been installed. Just any small light won't do; it must be one designed specifically for the slightly tricky AC-DC power supply circuit, as shown in the diagram.

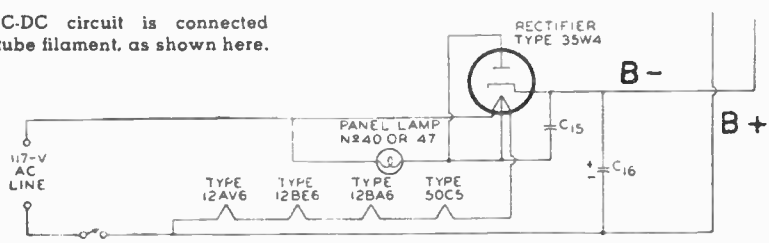
To save the cost and weight of a power transformer to reduce the line voltage to lower values for filament operation, it is standard practice to connect the filaments of the tubes in series. The total of the voltage requirements of the individual tubes adds up neatly to the line voltage. The panel lamp could be added to this series string if the resistances of the tube filaments were adjusted in manufacture to allow for it. However, the lamp would burn out quickly, because the tube filaments initially have a low resistance, and the first rush of current in the circuit, while they are warming up, would snuff out the thin filament of the lamp.

To get around this difficulty, tube designers put a tap on the filament of the 35Z5 and 35W3 rectifier tubes. The pilot light goes to this tap and the end of the filament that connects to the power line. The current distribution in this split series-parallel circuit is correct only when either a No. 40 or No. 47 lamp is used. It is also off balance if a lamp burns out through normal wear and is not replaced; in fact, the voltage across the rectifier tube filament goes up from 32 to 35, an appreciable increase. It is therefore highly advisable to replace a dead lamp as soon as possible, and not to wait until the receiver stops working altogether and forces you to look into it.

The two lamps mentioned differ only as to their bases. The No. 40 is of the miniature screw type, the No. 47 the miniature single-contact bayonet type. Both are rated at 6 to 8 volts, .15 ampere (150 milliamperes).

In receivers of the straight AC type, wherein the tube filaments are operated in parallel from a low-voltage winding of a power transformer, the pilot light (or lights—some sets have as many as four) is also connected to the same winding. The tubes and the light all heat up independently, and the failure of one does not affect the others. (In AC-DC sets, the burn-out of any one tube breaks the series connection, just as if a switch were opened, and all the tubes go cold.) In AC sets, any pilot light of the correct voltage marking can be used, regardless of its resistance value and its current drain. Lights of all sizes are common items in electronic supply houses, so you might as well buy the right replacements while you're at it. •

PANEL LAMP in AC-DC circuit is connected across part of rectifier tube filament, as shown here.



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Here is an excerpt from a letter that we received from Loren DePriest, 1496 4th St., Mansfield, Ohio: "I have spent many pleasant hours in constructing the radios from the schematics in your book, and have learned a great deal from them. Being as I am interested in Radio, I consider the money spent for your course as a wise investment. I have learned more from your course by actually doing than I did from an expensive course."

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

FROM OUR MAIL BAG

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

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

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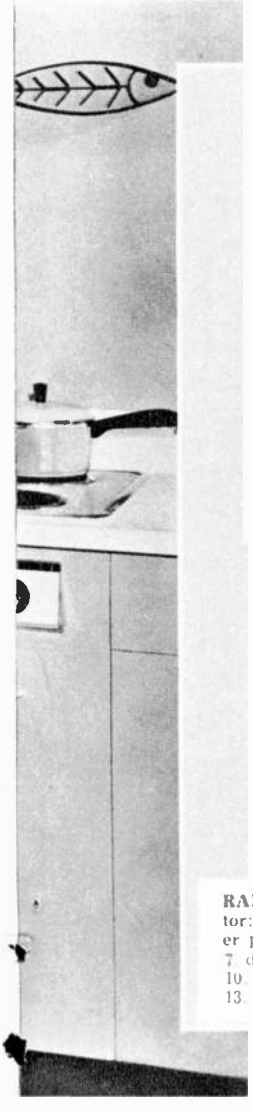
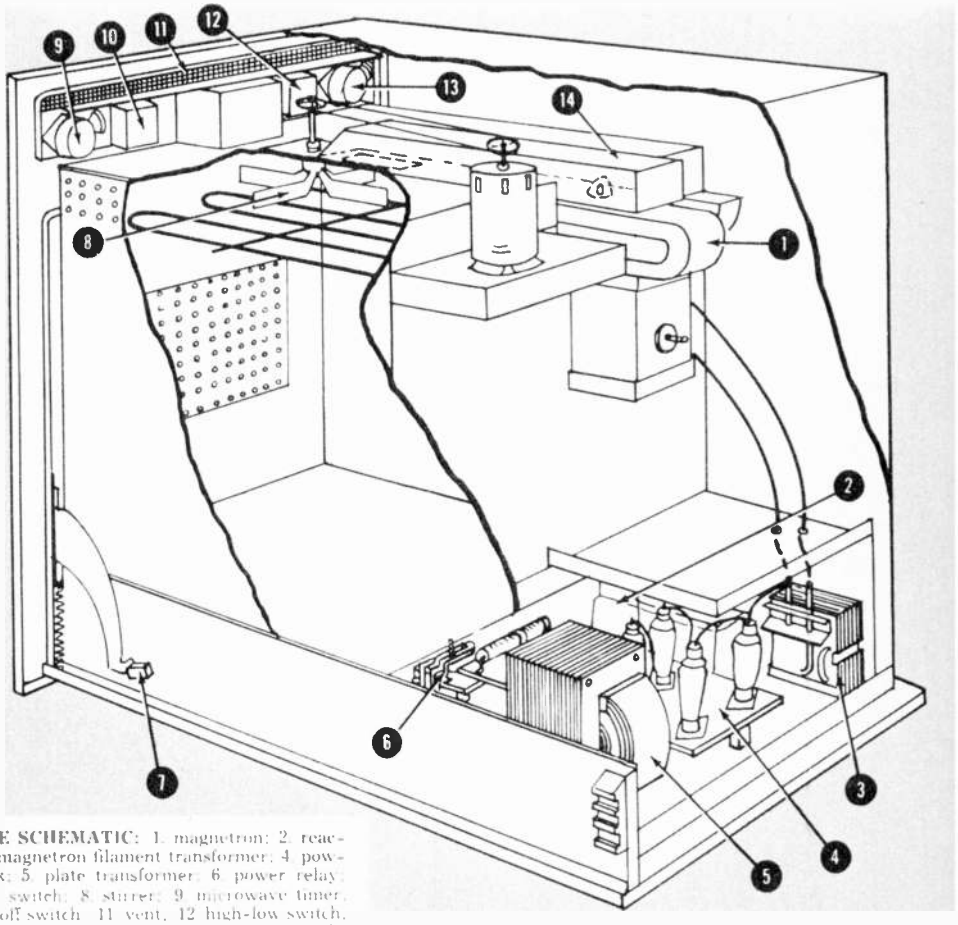
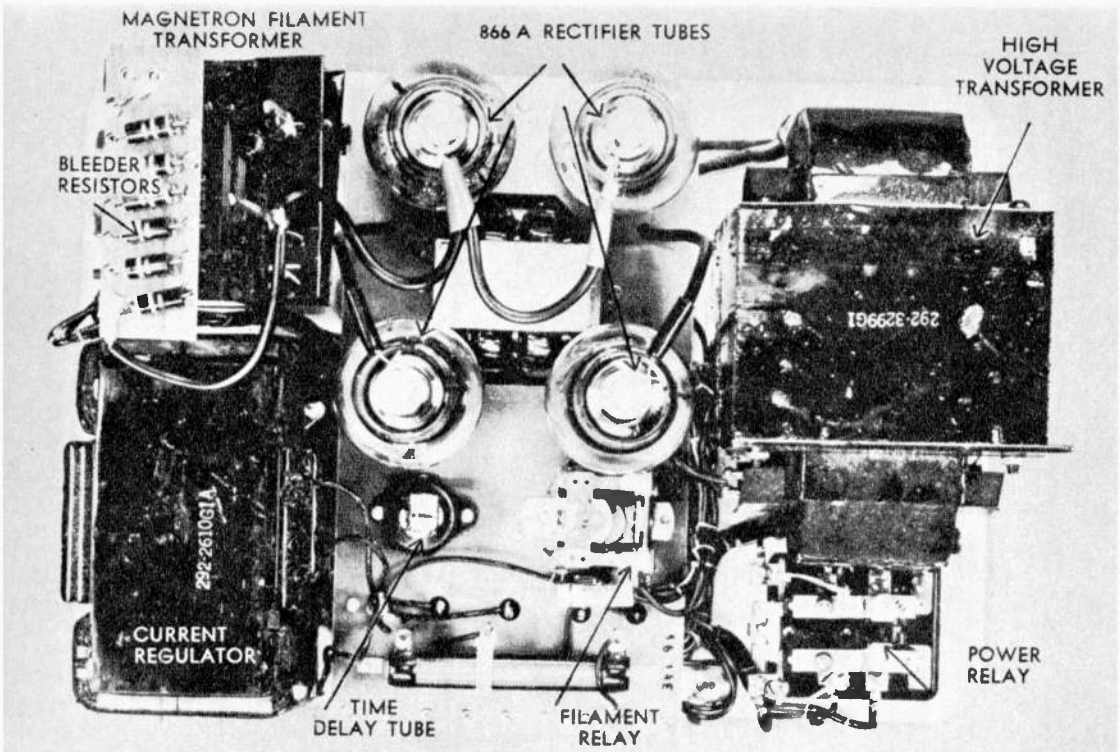
Electronic or rather "microwave" cooking is an unexpected by-product of World War II radar research. In this unique system of detecting distant airplanes, ships, submarines, etc., radio transmitters operating on extremely high frequencies (short wavelengths) are used. At high frequencies, the radiated energy is reflected by some materials, notably metals, without being absorbed. It is transmitted by air





RANGE SCHEMATIC: 1. magnetron; 2. reactor; 3. magnetron filament transformer; 4. power pack; 5. plate transformer; 6. power relay; 7. door switch; 8. stirrer; 9. microwave timer; 10. on-off switch; 11. vent; 12. high-low switch; 13. browning timer; and 14. wave guide

CUT-AWAY INTERNAL APPEARANCE of the Westinghouse Electronic Range is shown above. Microwave energy produced by the magnetron (1) is conducted by a curved wave guide or duct and is directed downward onto the food in the front part of the oven. The "stirrer" (8) is a slowly revolving metal fan that diffuses the waves evenly throughout the oven cavity. Directly under the stirrer is a regular heating coil, which functions as a browning element to give outer surface of food the familiar "well-done" appearance.



TOP VIEW of the power-supply deck of the Westinghouse Electronic Range. Suggestion: Hands off!

and certain inert materials such as glass, china, and paper, again without being absorbed. However, it *is* absorbed by foodstuffs, and in the process the radio energy is converted into heat.

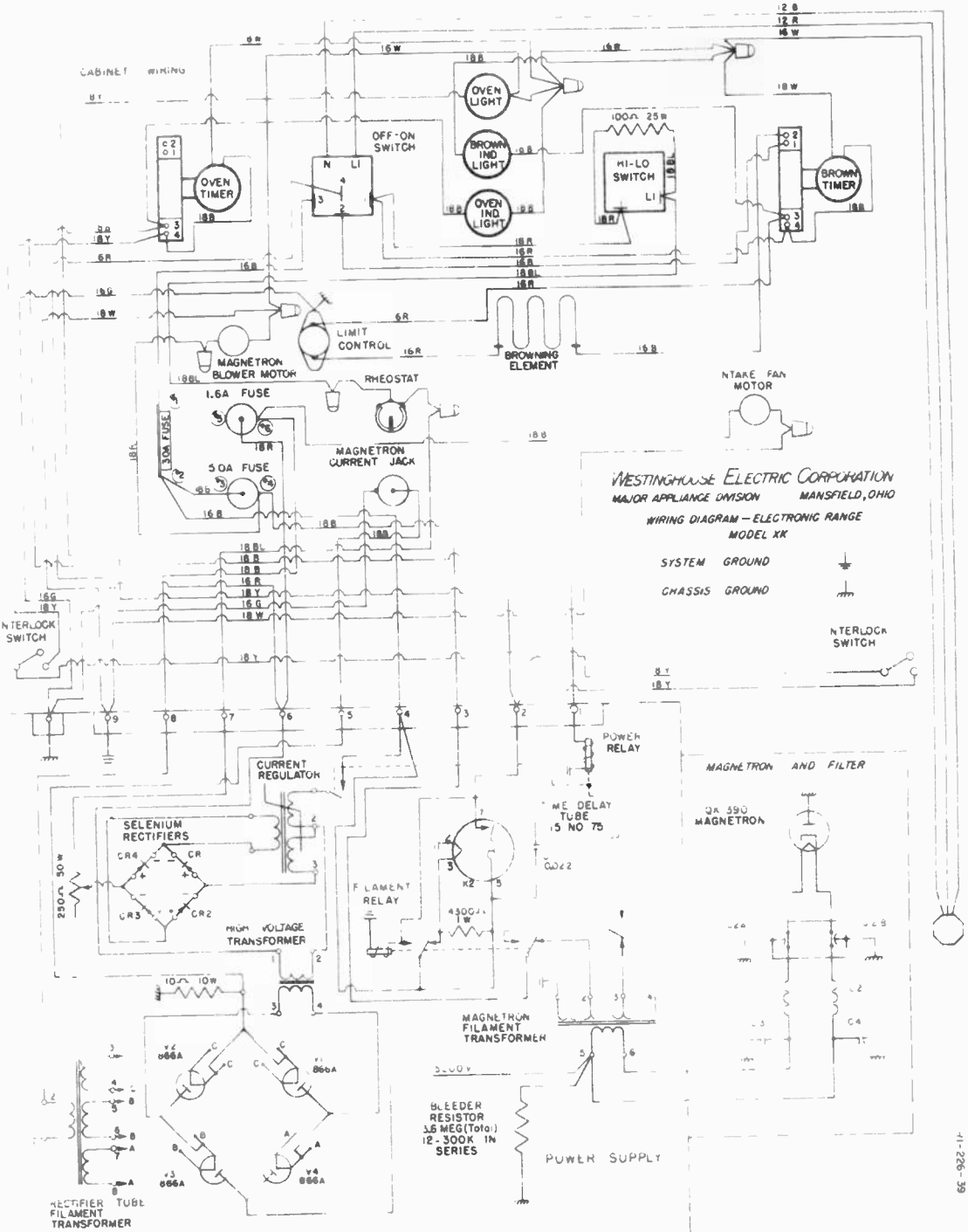
Recognizing this new application of electronics, the Federal Communications Commission has assigned a special frequency of 2450 megacycles for electronic ranges. Ordinary house current alternates at the rate of 60 cycles; that is, it flows first in one direction and then in the other, making 60 such complete shifts in one second. Radio broadcast signals alternate at the rate of perhaps 1,000 kilocycles per second; 1,000 times 1,000 cycles, or 1,000,000 cycles. A channel 11 television station works on about 200 megacycles; 200 times a million cycles, or 200,000,000 changes of current per second. The electronic range generates current that changes 2450 times a million cycles per second, the almost inconceivable rate of 2,450,000,000 cycles per second. As the molecules of the food try to rearrange themselves in conformity with these changes of current, they rub against each other, and it is probably this friction that produces the internal heat.

Because the microwaves soak into the food almost instantly and cause it to heat all through almost uniformally, it cooks in much less time than is required by the conventional, externally-applied heat method. Here are some figures obtained from actual tests conducted at the Hotpoint Home Economics Institute:

Food	*Regular Range*	*Electronic Range*
Bacon	6 minutes	90 seconds
Hamburgers	12 minutes	4 minutes
Baked potato	60 minutes	4 minutes
5-lb. roast	1¾ hours	20 minutes
Apple pie	50 minutes	12 minutes
Roast chicken	3½ hours	35 minutes

Heat is produced only in the food and not in the container or the walls of the oven (except for slight heat conducted to the container by direct contact with the food), so an electronic range is remarkably cool. It is safer to use and easier to clean than an ordinary oven.

Some foods cook too quickly to become browned on the outside. To give them the familiar finished color, electronic ranges are equipped with regular electric heating coils, which glow red hot when turned on and give the outer surface of the meat a quick browning. Users of electronic ranges can't always trust their previous cooking experience in this connection; until they



learn how to use the available speed they usually overdo their meals.

Inasmuch as metal utensils tend to reflect microwave energy, ordinary pots and pans cannot be used. This is no handicap, as use can be made instead of glass, paper, plastic or china dishes. Bacon can be done directly on a piece of paper toweling. The latter doesn't burn because it is not affected by the microwaves. Individual helpings of food can be cooked on the same plates on which they are served at the table. •

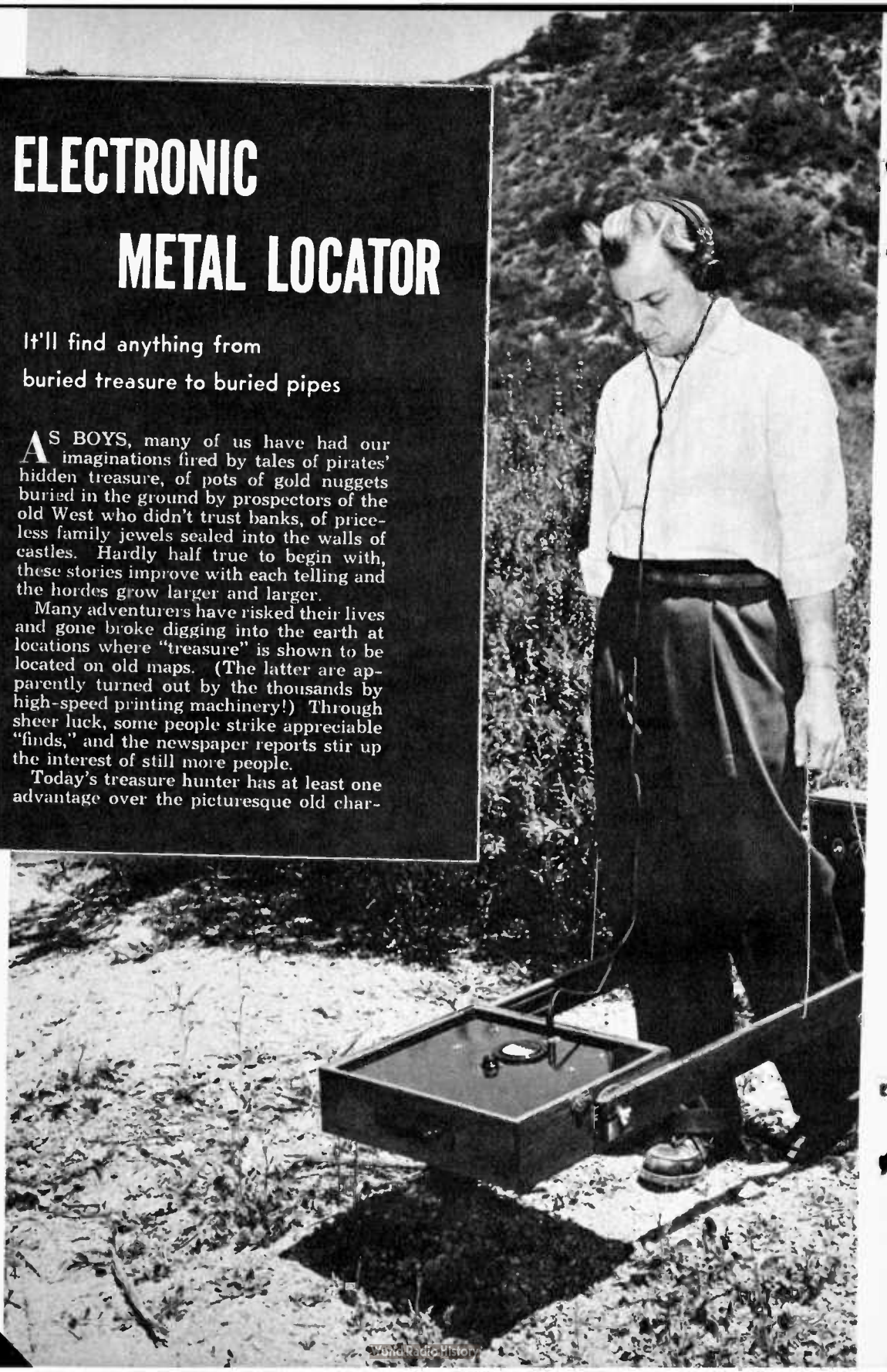
ELECTRONIC METAL LOCATOR

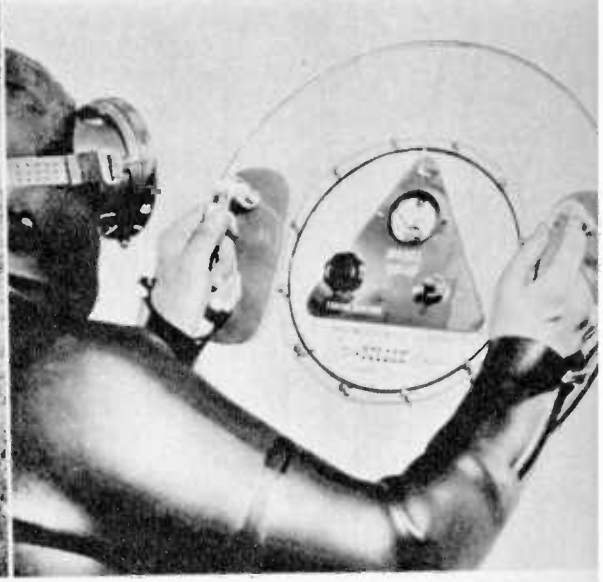
It'll find anything from buried treasure to buried pipes

AS BOYS, many of us have had our imaginations fired by tales of pirates' hidden treasure, of pots of gold nuggets buried in the ground by prospectors of the old West who didn't trust banks, of priceless family jewels sealed into the walls of castles. Hardly half true to begin with, these stories improve with each telling and the hordes grow larger and larger.

Many adventurers have risked their lives and gone broke digging into the earth at locations where "treasure" is shown to be located on old maps. (The latter are apparently turned out by the thousands by high-speed printing machinery!) Through sheer luck, some people strike appreciable "finds," and the newspaper reports stir up the interest of still more people.

Today's treasure hunter has at least one advantage over the picturesque old char-



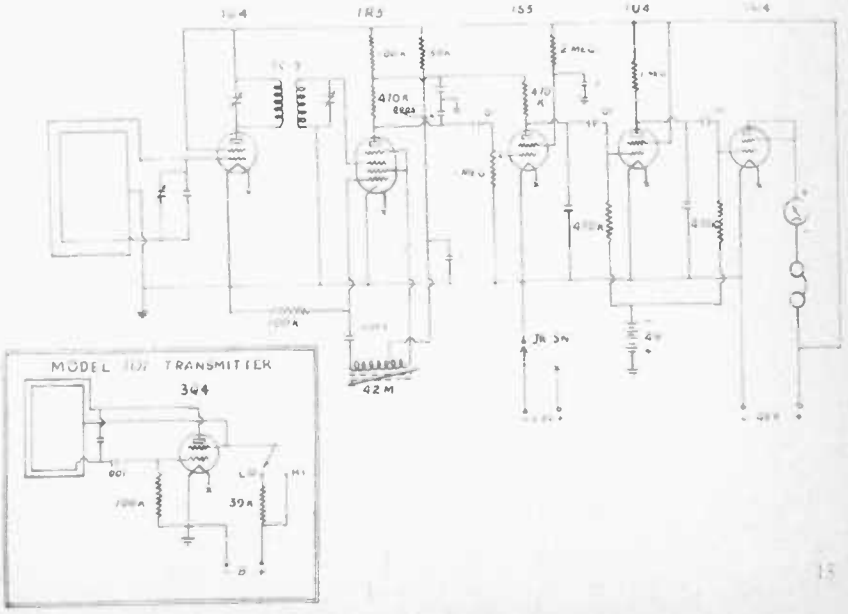


GOLDAK MODEL 599 locating instrument as carried by user in field (photo left). Transmitter is in rear box, receiver in front one. Presence of metal under ground is indicated by changing sound in earphones, by movement of meter on receiver case. Unit made by Goldak Company, 1544 West Glenoaks Blvd., Glendale 1, Cal. It makes any treasure hunt a lot of fun.

GOLDAK MODEL 520 is smaller and lighter than Model 599, is suitable for locating smaller objects at relatively shallower depths than is other model.

FROGMEN have electronic assist: The new Goldak Model UD-10 locator.

MODEL 101 DETECTOR AMPLIFIER



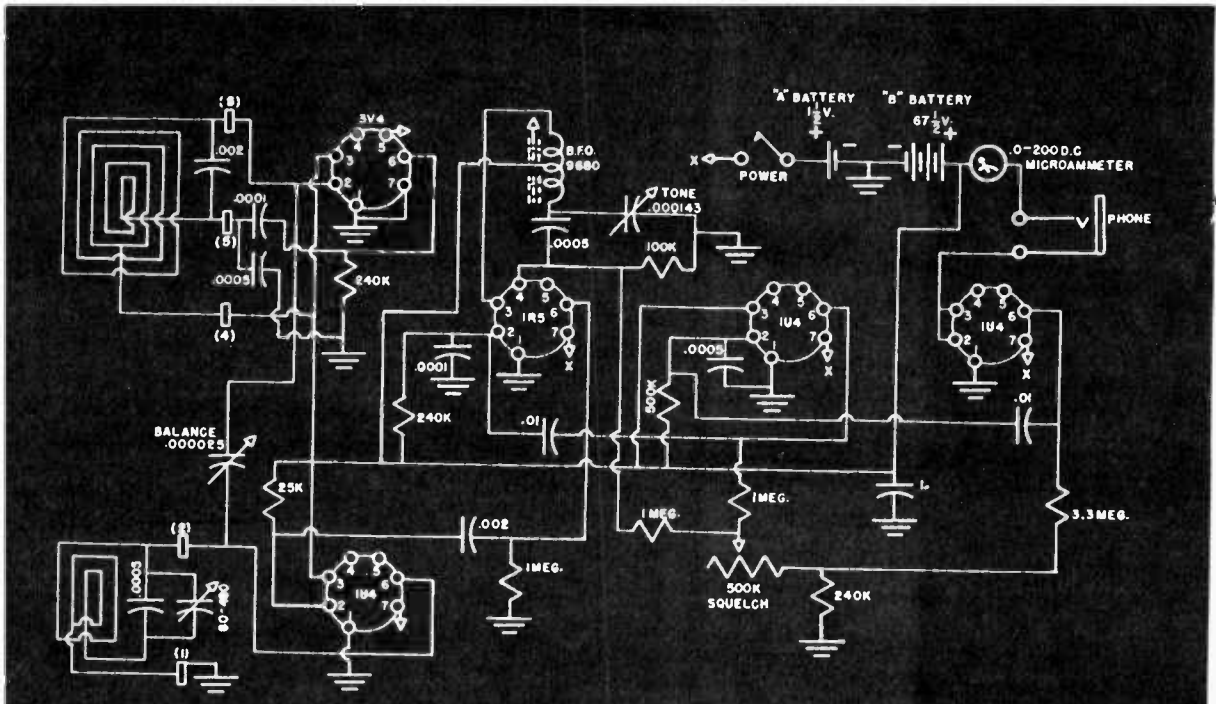
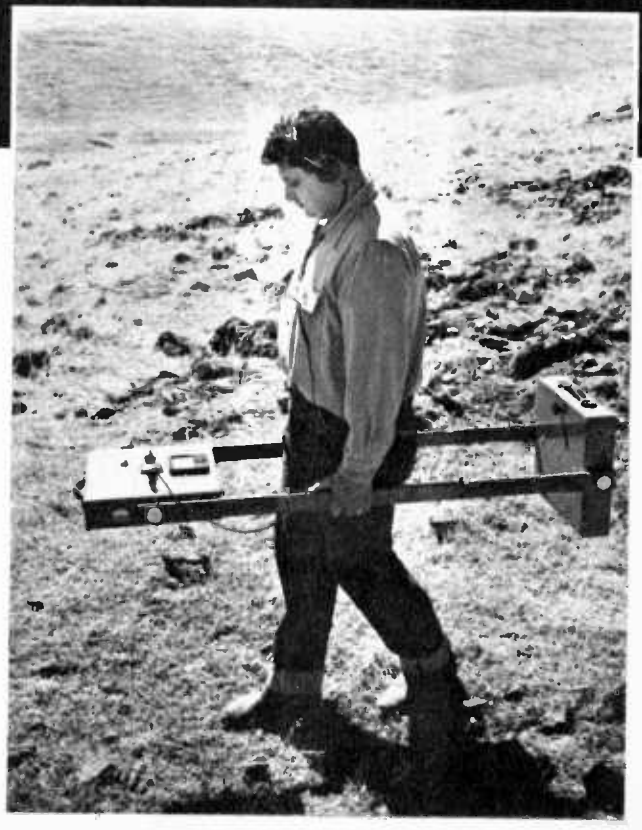


DIAGRAM of Fisher Model T-10 metal locator.



FISHER M-SCOPE Type MA is heavy-duty metal and mineral locator for rugged field use. Its maximum penetration is approximately 25 feet. By balancing the weight of the outboard transmitter and receiver units, the user can walk comfortably. Made by Fisher Research Laboratory, Inc., 1961 University Ave., Palo Alto, Cal.

acter who roamed the countryside with a mule and a pick axe. He has at his disposal electronic metal locators that do a very creditable job of revealing sub-surface metal objects. Note carefully that the devices are referred to as "*metal* locators," not "*treasure* locators." What is treasure, anyway? To some people, it is gold or silver; to others, it is old firearms, cannon balls, sabers, belt buckles and cap ornaments from battlefields of the Revolutionary, Indian and Civil Wars; to still others, it can be a vital water pipe. A locator will definitely reveal the presence of hidden metal, within certain depth limitations, but the only way to tell whether the metal is a gold dinner plate or an old wash boiler is to dig it up and brush it off.

During World War II and again during the Korean fighting, a refinement of the metal detector became the Army's highly successful SCR-625 mine detector.

Electronic detectors are of three basic types: the transmitter-receiver, the beat-frequency, and the induction bridge.

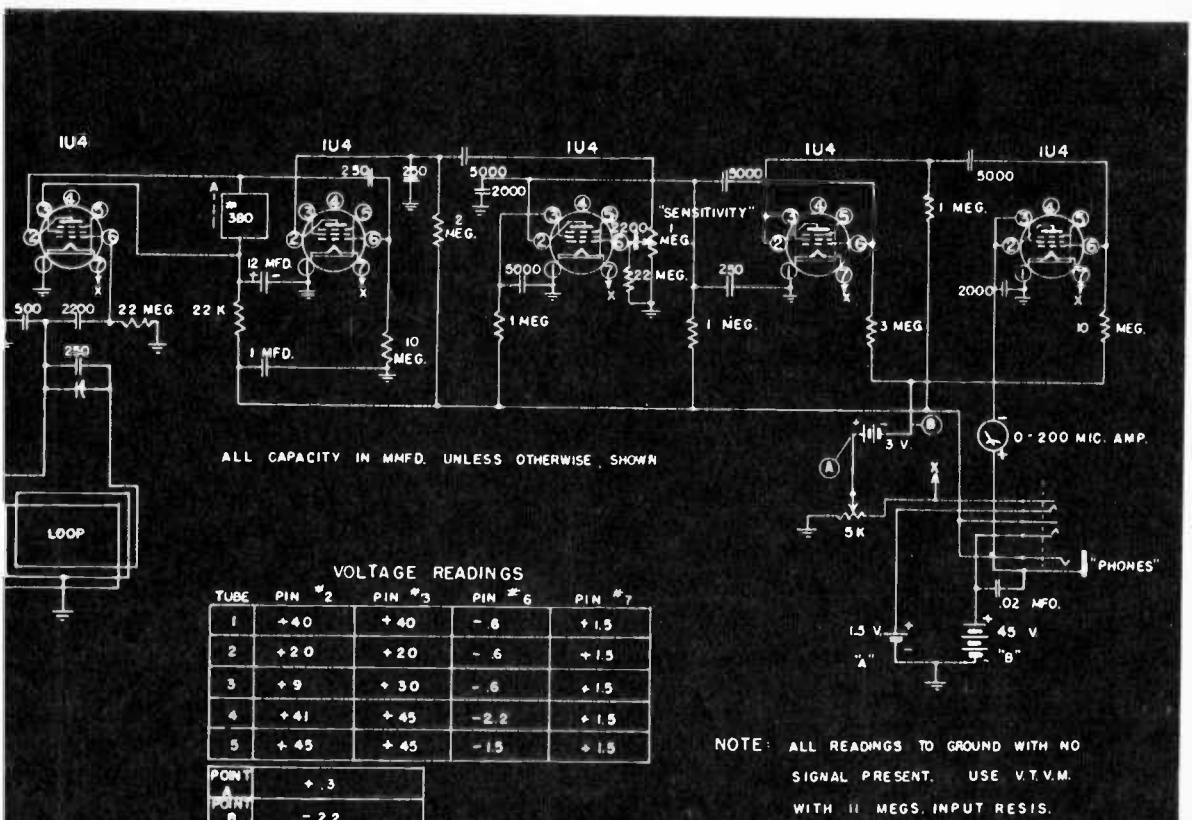
In the first type, two loop antennas are used, one for a low-power transmitter and the other for a receiver tuned to its frequency. The arrangement is such that the

THE FISHER MODEL ME locator (photo above) discloses the presence of an overgrown tower base through its large iron bolts. It's easy to handle.

A RELATIVELY light-weight instrument, the Fisher Model ME (photo below) can be carried in one hand. Here it is used to explore banks of a stream

A FISHER MODEL T-10 locator (photo above) actually found this buried cooking pot containing $1800 in gold coins. A really good find for a day's work.

HIDDEN "TREASURE" is often something like a water or gas pipe, which must be located for replacement, etc. Used here: Fisher Model T-10.



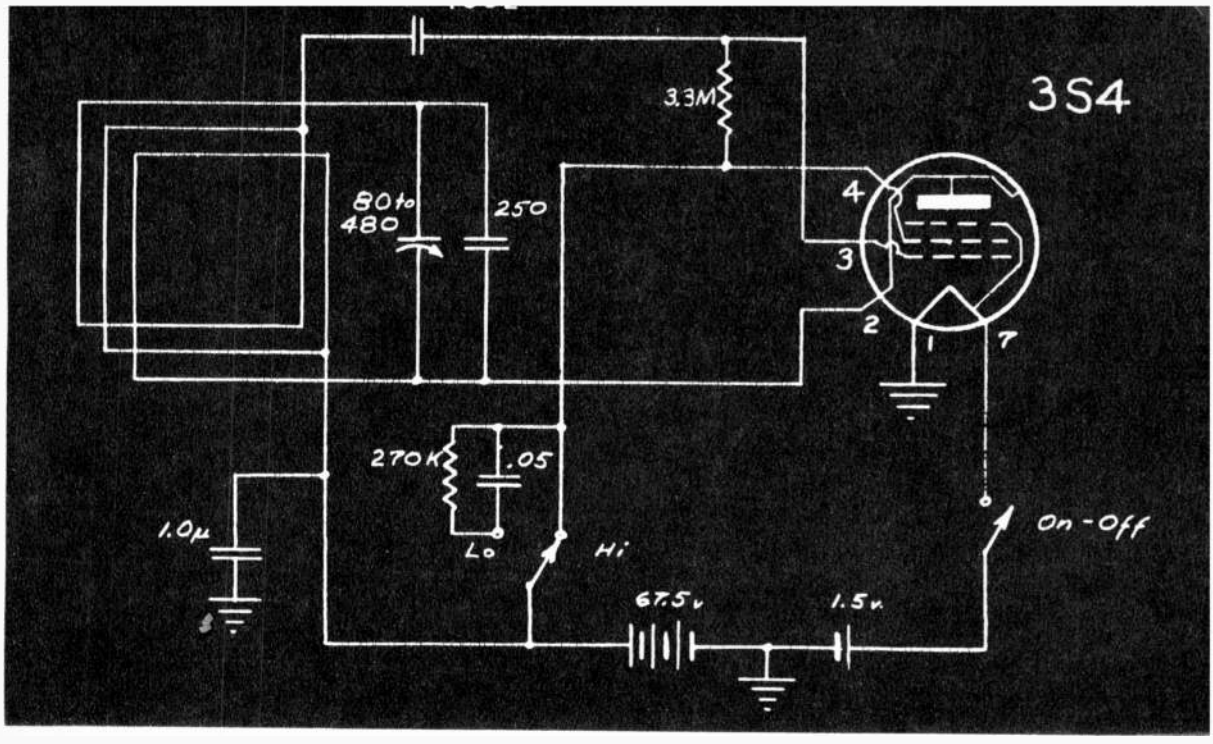
VOLTAGE READINGS

TUBE	PIN #2	PIN #3	PIN #6	PIN #7
1	+40	+40	-.6	+1.5
2	+20	+20	-.6	+1.5
3	+9	+30	-.6	+1.5
4	+41	+45	-2.2	+1.5
5	+45	+45	-1.5	+1.5

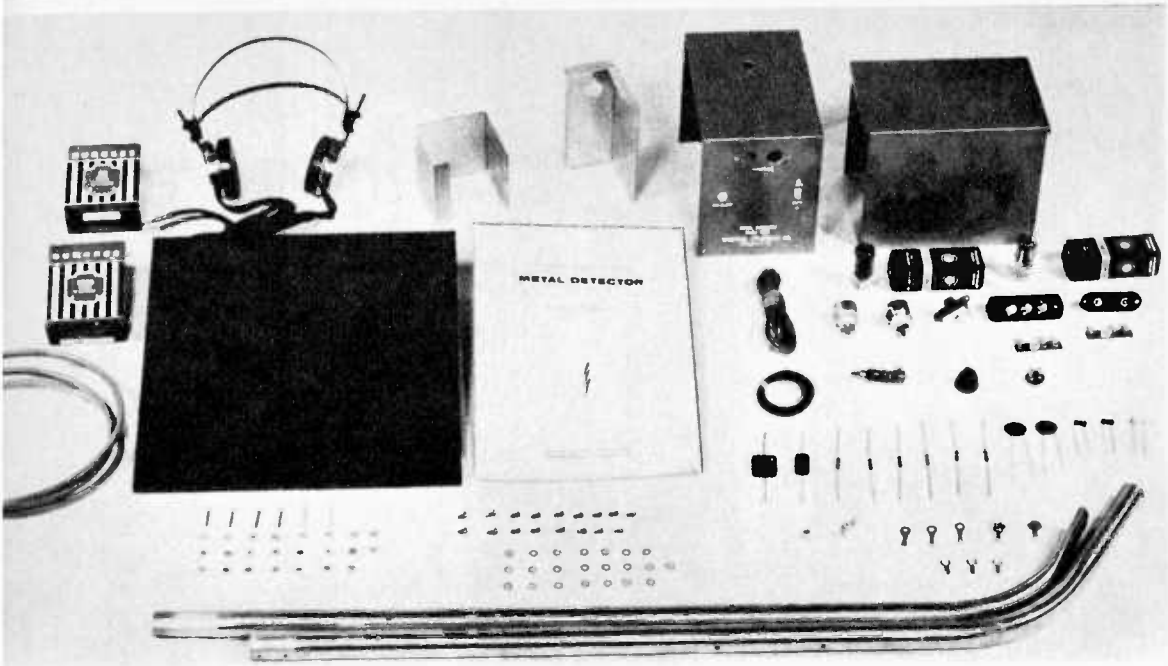
POINT A	+.3
POINT B	-2.2

NOTE: ALL READINGS TO GROUND WITH NO SIGNAL PRESENT. USE V.T.V.M. WITH 11 MEGS. INPUT RESIS.

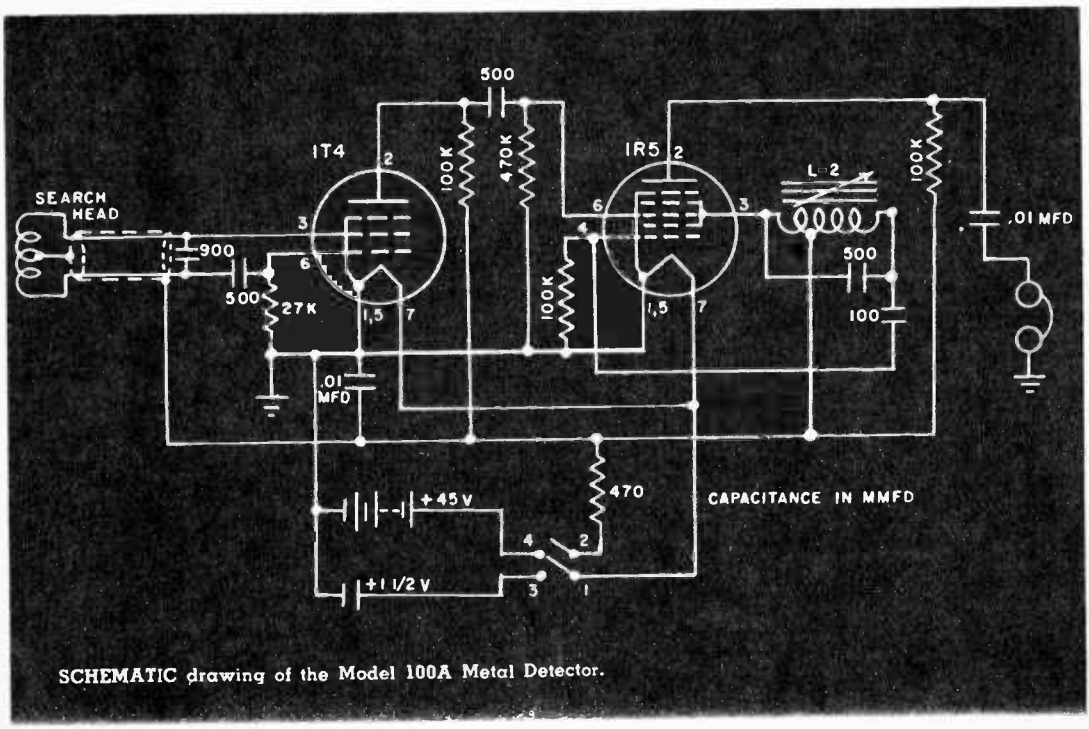
RECEIVER SECTION of Fisher Model ME locator.



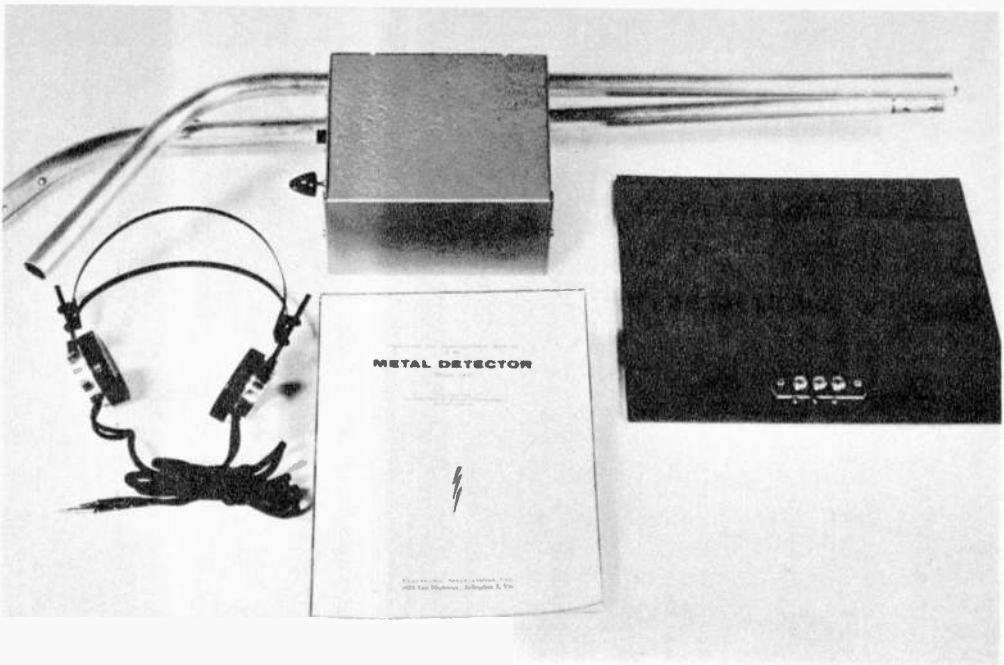
OLD ADOBE RUINS provide owners of metal locators with many interesting and often rewarding hours of fun. Coins, tools, cooking utensils and similar metal objects, long buried in the walls, are revealed quickly by the search coil. Diagram of the receiver section of Fisher Model ME unit is shown above.



AVAILABLE IN KIT FORM, as above, the Electronic Applications Model 100A Metal Detector has strong appeal to the do-it-yourself man. Assembly is a nut-and-bolt, soldering-iron job. The equipment is also available factory-assembled. Made by Electronic Applications, Inc., 5024 Lee Highway, Arlington 7, Va.



SCHEMATIC drawing of the Model 100A Metal Detector.



THE FACTORY-MADE Model 100A Metal Detector is knocked down for shipment, but ready for use. Search coil is at right; oscillator box top center.

signals from the transmitting loop are sent into the ground, where they bounce back into the receiving loop. The circuits are "zeroed" so that a uniform signal of a predetermined pitch is heard in the earphones worn by the "prospector." The "locating" action derives from the fact that the radio waves are distorted or reflected irregularly when they strike an electrically conductive material. A change in the earphone signal warns the user that something is happening.

The beat-frequency locator works just like the front end of a superheterodyne receiver. It uses a single exploring coil, which is part of one oscillator circuit. In the locator proper is a second oscillator. The two oscillators are tuned to the same frequency, so no "beat" or difference frequency is generated. In the presence of a metallic body, the inductance of the search coil changes slightly. This throws off the frequency of oscillation, and a distinctly audible beat note results in the earphones.

The inductance bridge type is more complicated than the first two and not as generally used. It employs the principle of the Wheatestone Bridge, wherein a change of the inductance of the search coil caused by nearby metal unbalances a very sensitive circuit.

Some representative metal locators currently in production are illustrated in these pages. At least one kit is available All tools, however, require practice. •

MODEL 100A is so light that it can be held easily in one hand while it is being tuned up for use.

SOUND WAVES YOU CAN'T HEAR TUNE YOUR TV SET

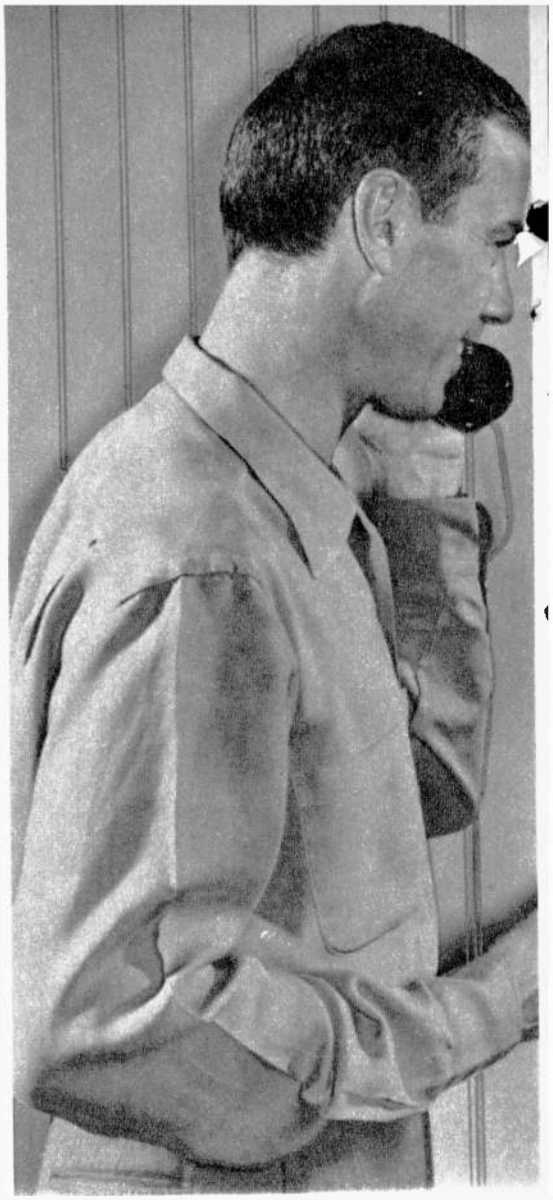
New remote control system represents first use of ultrasonics in the home

AN entirely new and exceedingly ingenious approach to the problem of remote control of television receivers is represented by the "Space-Command TV Tuning" used in the 1957 line of Zenith, one of the oldest companies in the electronics industry.

By means of ultrasonic sound waves, so called because they are too high pitched to be heard by the human ear, the set owner can activate and control reception from anywhere in the room or even from an adjoining room within sight of the set. The inaudible signals, in the range between 37,750 and 40,250 cycles, are produced *mechanically*, not electronically, by a small control unit slightly larger than a package of cigarettes. It weighs eight ounces, and contains no wires, batteries, tubes, transistors or lights. The control impulses are effective up to about 30 or 40 feet.

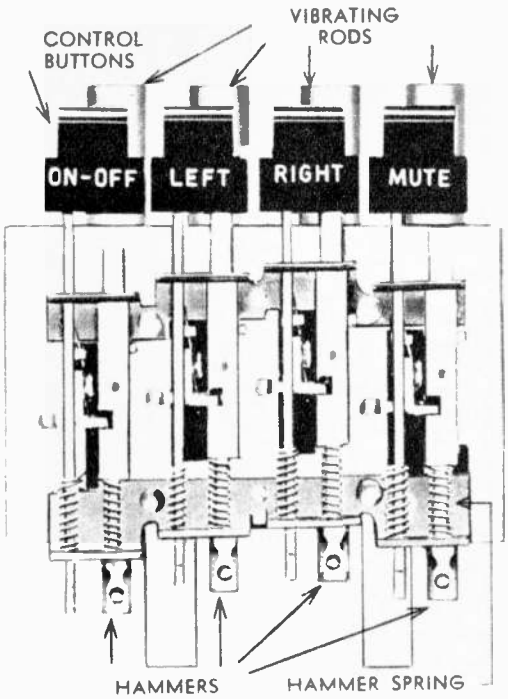
The response unit in the television receiver itself is a microphone that is sensitive to the high-frequency impulses. The electrical signals produced by the mike as the sound waves hit it are relayed to a combination of amplifier and control circuits that perform four different functions at the bidding of the user.

Although the "Space Commander" control box sounds like something out of a comic book, it is a very precisely engineered unit. It is in effect a miniature piano containing four small aluminum alloy rods, each with a spring-actuated hammer at its end. The rods are cut in length to vibrate at four different frequencies, whose control functions are as follows.

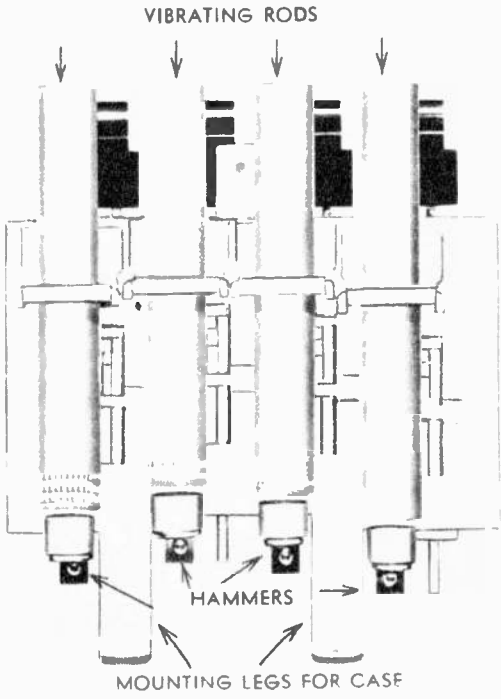


TELEPHONE ring in the middle of your favorite program? Press the "Mute" button on the Zenith "Space Commander" and the sound goes off. Unit is palm-sized and requires no connecting wires of any kind

"SPACE COMMANDER" unit is simplicity itself. Ultrasonic impulses come out of the open grille area at top of the case. Page 26 shows the operation.



FULL-SIZE view of the "Space Commander" unit as seen from the control button side. Note parts



FULL-SIZE close-up of the vibrator rods and the hammers which are important parts of the unit.

37,750 cycles — Turns set on or off. ON OFF button

38,750 cycles — Turns sound on or off. MUTE button

41,250 cycles — Turns channel selector clockwise- RIGHT button

40,250 cycles — Turns channel selector counterclockwise. LEFT button

Pressing any of the control buttons compresses a related spring mechanism. As the button is pushed all the way down, the spring is suddenly released, driving a tiny hammer against the end of the rod. The latter then vibrates at the frequency determined by its length, and the sound issues from the open grille end of the control box. Release of the button causes a damper device to stop the ultrasonic vibration, so only a single impulse of short duration is sent out. The response of the television receiver to the "commands" is virtually instantaneous.

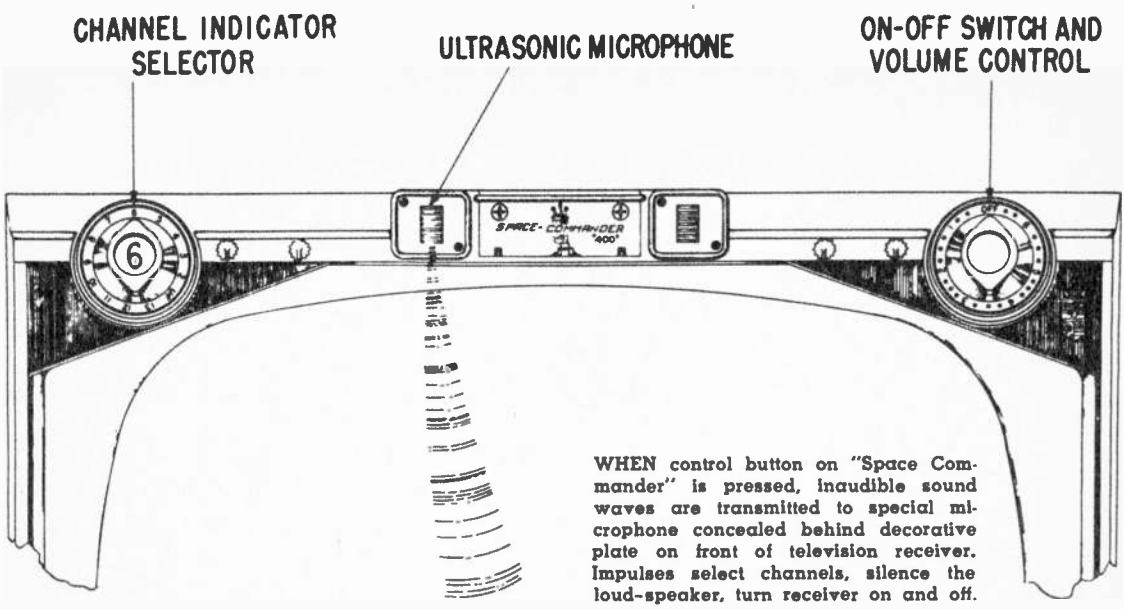
Normal manual tuning of the set is possible at any time by [illegible]

an "AUTO-MANUAL" switch to the desired position.

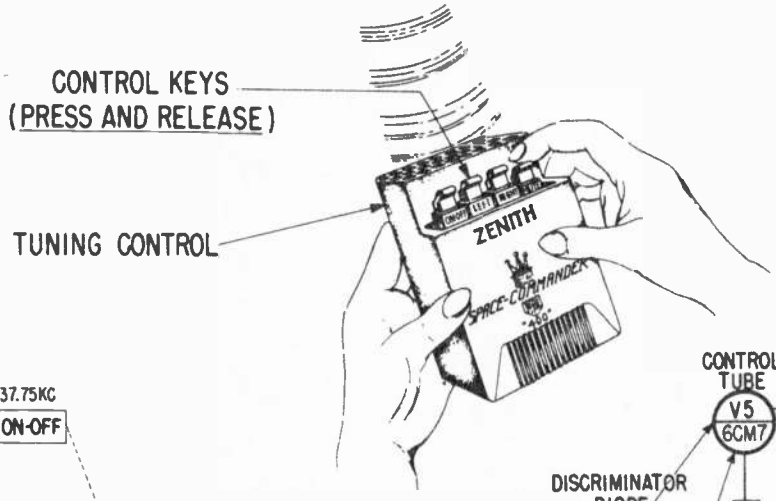
Another application of this ultrasonic principle suggests itself immediately: to garage doors openers. Present remote-control arrangements require the installation of a full-blown radio transmitter in the car. This could be done away with entirely and replaced by a one-rod tone generator that would certainly be small enough to fit into an existing horn in the front of the radiator. The response unit in the garage could easily be permanently "on" transistorized receiver, consuming less energy from the power line than a common doorbell transformer.

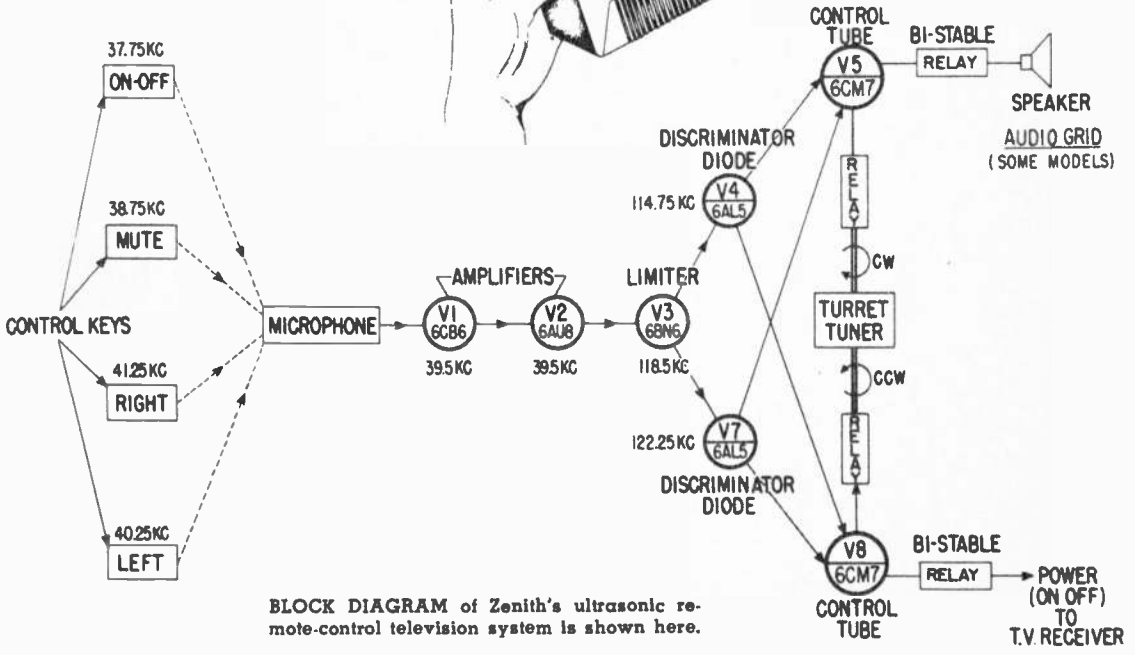
The actuating mechanism for the tone generator could be the striker part of an ordinary doorbell with the bell itself removed. For control purposes, it would only be necessary to install a push button on the dashboard and to wire it through the doorbell magnet to the hot side of the storage battery.

Of course, several tones could be used [illegible]

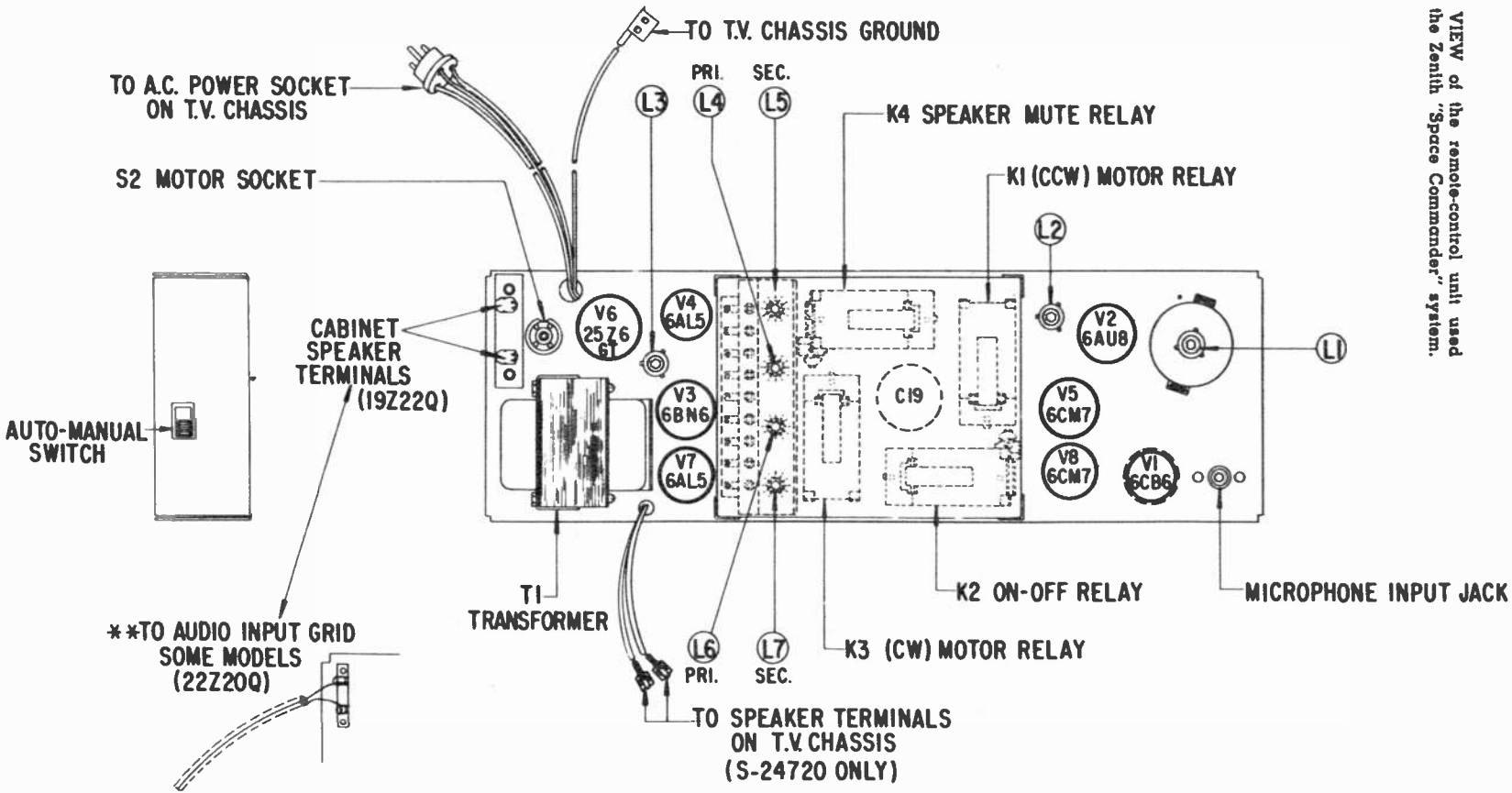


WHEN control button on "Space Commander" is pressed, inaudible sound waves are transmitted to special microphone concealed behind decorative plate on front of television receiver. Impulses select channels, silence the loud-speaker, turn receiver on and off.

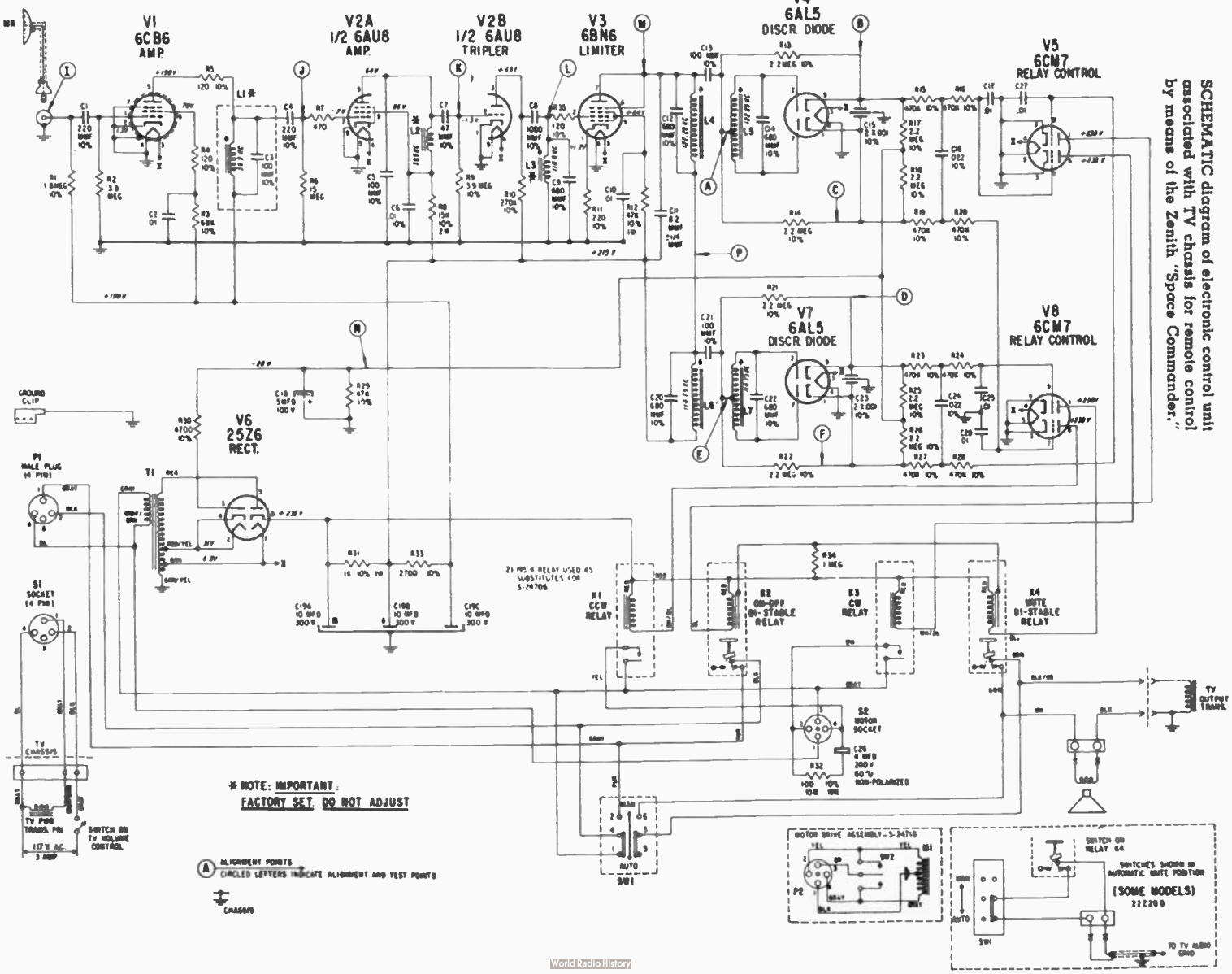




BLOCK DIAGRAM of Zenith's ultrasonic remote-control television system is shown here.



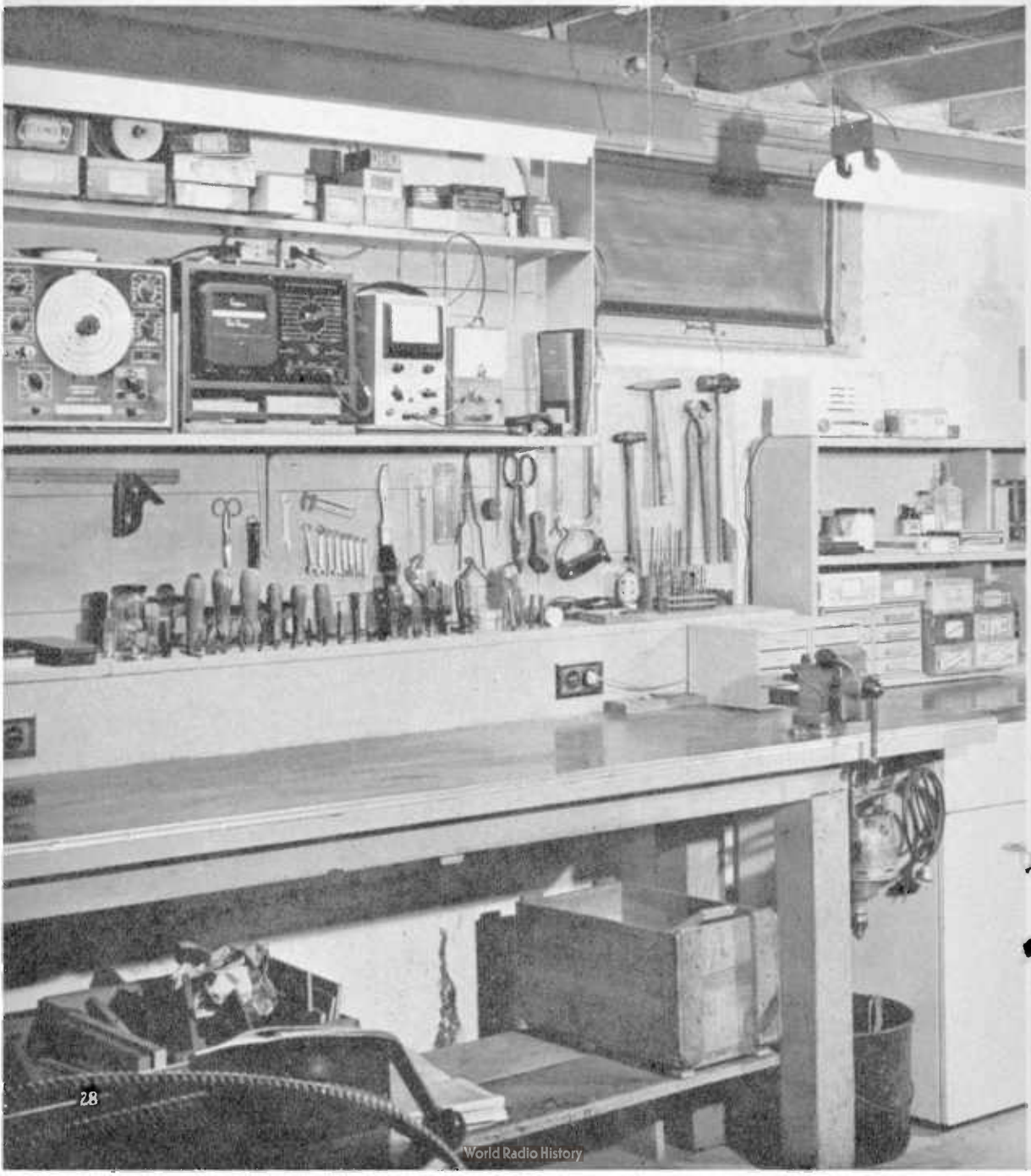
TOP VIEW of the remote-control unit used with the Zenith "Space Commander" system.



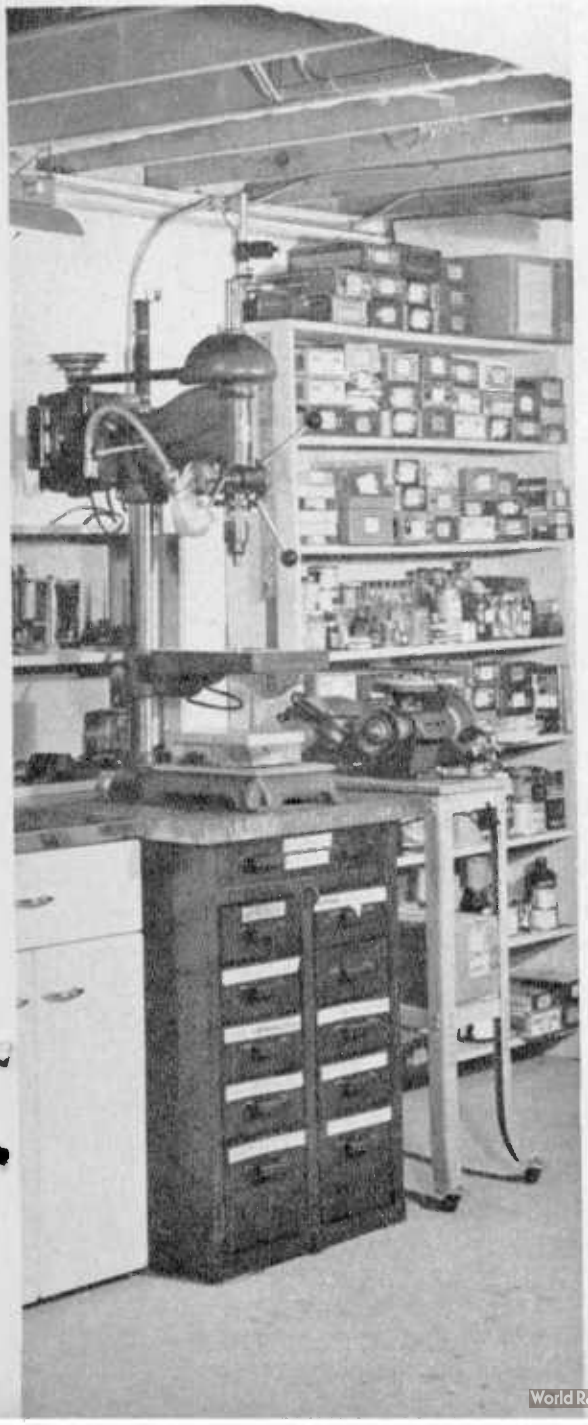
SCHEMATIC diagram of electronic control unit associated with TV chassis for remote control by means of the Zenith "Space Commander."

HOBBY INTO BUSINESS

You can make money out of
spare-time servicing of electronic equipment



HERE IS a representative cellar shop whose owner picks up a neat bit of extra income by fixing radio and small TV sets, hi-fi amplifiers, hearing aids, etc. Shelf above tools holds basic test instruments: (left to right) RF signal generator, multimeter, VTVM, capacity meter. Spare parts are in cigar boxes on both sides of drill press. Smooth, Masonite-covered bench top and bright fluorescent lights contribute to working comfort.



YOUR next door neighbor Bill, knowing that you have assembled, wired and installed your own hi-fi system, drops around one Sunday morning with a small table-model radio under his arm.

"Say, Joe," he begins, "you're a pretty handy guy with that electronic gear. Wanna do me and the wife a favor and look at the bedroom radio of ours? It quit cold last night."

You can't be unfriendly, or admit that you've never fixed an ailing set in your life. Anyway, you pull off the knobs, unscrew the chassis and slide it out of the cabinet. With the aid of your small multimeter, you check the tube filaments, and sure enough, the rectifier shows dead open. Luckily, you have a tube of the same number that you saved from an old set you junked years ago. In a minute Bill's radio is again working in fine style.

"Gosh, Joe," he says earnestly, "you're a real genius. Let me pay you for the tube, huh?"

"I don't even remember what it cost," you reply in all honesty. "Suppose you just get me a replacement tomorrow when you're downtown, and we'll call it even."

A couple of days later, your phone rings after supper.

"Hello, Mr. Jones," a male voice says. "You don't know me, but I work in the same office with your neighbor Bill. He says you can fix anything with electrons in it. Could you examine a set of mine? It has the darnedest noise in it and I've had it to two shops without any improvement. This is strictly business, you understand."

The caller brings the set to you. It's noisy, all right, with the kind of noise that comes from loose connections. As you turn the dial you think you hear a slight metallic scraping. You put your ear to the set, with the circuit off, and quickly you note that an outer movable plate of the tuning capacitor is bent and rubs against a fixed one. You straighten it out, and the set plays beautifully without a sign of disturbance. The caller presses a five-dollar bill in your hand, thanks you profusely, and departs. Whether you intended it or not, *you are now in the electronics repair business.* Unless you take firm steps to control your enthusiastic boosters, you can easily find yourself with more customers than you can handle conveniently in your spare time.

The number of radio hams and electronic hobbyists who drift naturally into spare-time servicing is very large. From the guarantee cards and questionnaires mailed back by purchasers of test equipment, manufacturers know that the practitioners

are as varied as they are widespread. Name almost any vocation or business, and it's sure to be represented among the "sundowners," as the part-time operators are called in some areas. There are mailmen, bank clerks, firemen, policemen, bus drivers and teachers, who find the work stimulating, challenging and interesting, as well as profitable. The extra income goes toward maintaining their families in this era of high prices, or is ploughed back to the purchase of still more technical equipment.

Need for Repairmen

There have been successful part-timers since the earliest days of broadcasting, especially in the many towns and villages all over the United States too small to support full-time service dealers. Today, with industry gobbling up all the professional technicians and engineers it can find, sparetime independents thrive almost everywhere. Because they don't depend entirely on their service work for their livelihood, they can afford to be completely honest. Thus they develop good reputations in their neighborhoods, and quickly attract a following of faithful clients.

What do you need to make a start in electronic servicing? Aside from a firm footing of technical know-how, surprisingly little that you don't already have in your basement or garage "lab." The real difference between a service shop and a lab lies in the replacement parts with which the former must be stocked. The basic "parts" are tubes, because more than 90% of all radio-TV repair jobs consist of nothing more than identifying defective tubes and replacing them.

Which tubes to stock is quite a problem for a beginner who doesn't want to make a heavy investment of cash. Almost 500 different receiving tubes and more than 100 different television picture tubes are listed in a representative parts supplier's catalog. The answer, initially, is not to stock any, but to order needed replacements by mail from the nearest mail-order jobber, or to pick them up yourself during your lunch hour or on Saturdays if there's a jobber in your own town. Your customer might have to wait a few days for his set, but that's normal in all service business. You'll soon learn through experience what tubes, pilot lights, filter capacitors, etc., are most likely to go bad, and then you can buy replacements in lots of six or more and get a slightly better price.

Test equipment is, of course, important. Undoubtedly you already have a multirange combination volt-ohmmeter or vacuum tube voltmeter, which is by far the most generally useful of all test instruments. Many men find it advisable to have both a multi-meter and a VTVM; the former is handier for outside work because it is self-contained, while the AC-operated latter is more sensitive for certain purposes in the shop, where AC power is available anyway.

As a ham or hobbyist you probably had no need for a tube checker, but as a service technician you will find one a great time saver. A multi-meter or VTVM can only determine if a tube's filament is OK or burned out; it gives no indication of the tube's actual operating condition if the filament is OK.

Probably nine out of ten of the radio sets you will be asked to repair will be of the AC-DC or "hot chassis" type, which can give you a nasty jolt under some circumstances. Good insurance, therefore, is an isolation transformer.

For checking through the circuits of broadcast receivers, a radio-frequency signal generator is indispensable. All instruments of this type also generate a 400-cycle audio signal, which is extremely useful for trouble-shooting in hi-fi amplifiers. Small sets rarely require actual realignment of their tuning circuits. When they do, you can perform the operation "by ear" as well as you can with a signal generator, as there are always stations on the air furnishing convenient signals.

Transistorized radio sets and hearing aids are increasing in number. Mostly, "servicing" on them involves battery replacement, but eventually you'll want a transistor checker. Provisions for transistor testing are included in the newest tube checkers.

Auto Radio Sets

The vast number of auto radio sets in use represents a particularly active and profitable service market. By far the greatest single cause of trouble is a stuck vibrator, so it is worth while to stock a few each of standard 6- and 12-volt replacements. They plug in like tubes.

For bench testing of auto sets it is necessary to have a 6-12 volt power supply. This can double as a charger for the battery of your car, and is therefore a good investment. Also very useful is a variable high-voltage DC supply. If a suspected vibrator is removed, and a set comes to life when this DC supply is clipped in, you can be pretty sure that the vibrator is shot.

For investigation of the complex signals that run around in television circuits, a cathode-ray oscilloscope has no equal. However, it is not the magical cure-all that

many people think it is. If you expect to get any benefit from it, you must use it a lot and learn how to interpret the wiggly lines and queer patterns that flicker across its screen. Fortunately, TV repair, like radio repair, is largely a matter of tube replacement.

If mere tube replacement doesn't do the trick and you must look into the chassis of a radio or TV set, you must have the service data and a complete schematic diagram of the unit. This important information is available from radio parts jobbers in the form of large service manuals, small packets, and individual diagram sheets.

As a part-time technician, you will be smart to restrict your activities to the limits of your overall facilities, to take on only small jobs, and to leave the big ones to the full-time service dealers. Some part-timers do not go out on house calls at all, but handle only the radio receivers, hi-fi amplifiers and small television sets brought in by the owners themselves. Many television sets are entirely too large and heavy for one man to carry out of a customer's house and to stuff into an ordinary passenger car. If you can't fix a TV set in the home by tube replacement, back-apron adjustments or other on-the-spot repairs, the wise thing to do is to leave it, make no charge, and refer the problem to a local dealer who has a truck and the necessary manpower. •

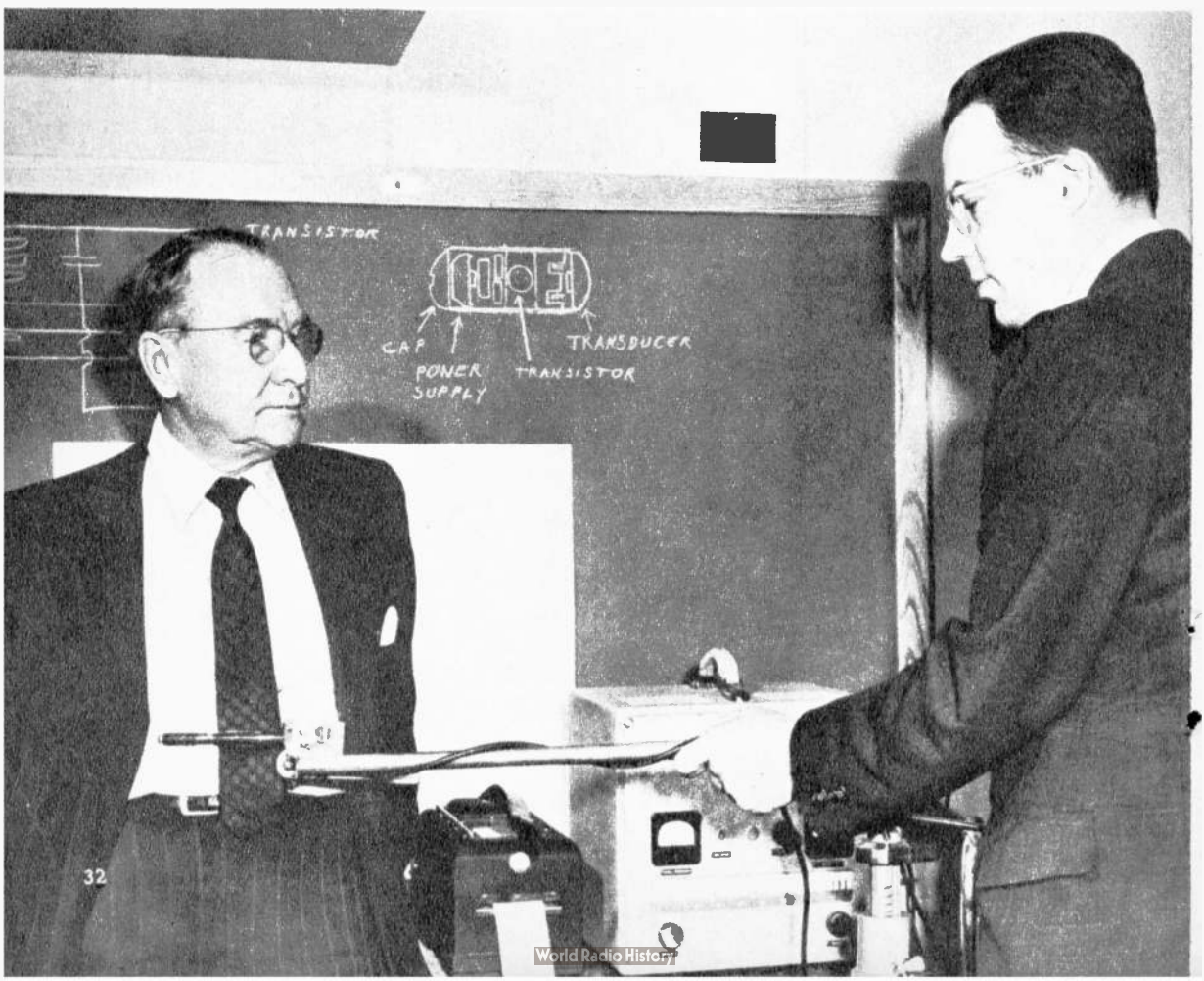
THESE racks contain miscellaneous meters and test equipment, spare parts and replacement tubes. Most equipment was assembled from kits. Shallow shelf arrangement makes all units readily accessible. Equipment shown represents accumulation of about 10 years, is more elaborate than needed for service work.

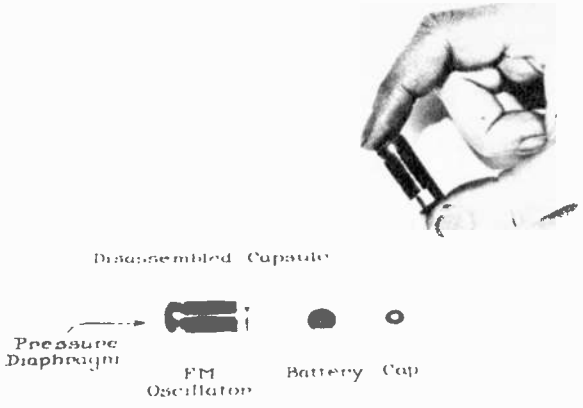
THE STOMACH IS "WIRED FOR SOUND"

A radio pill developed for medical research sends out FM signals as it passes through the body

A "RADIO PILL" that sends out FM signals to medical researchers as it passes through the human body was demonstrated recently in New York at the Rockefeller Institute. Designed for research in the intestinal tract, it is a plastic capsule one and one-eighth inches long and four-tenths of an inch in diameter. It is the world's smallest FM radio transmitter.

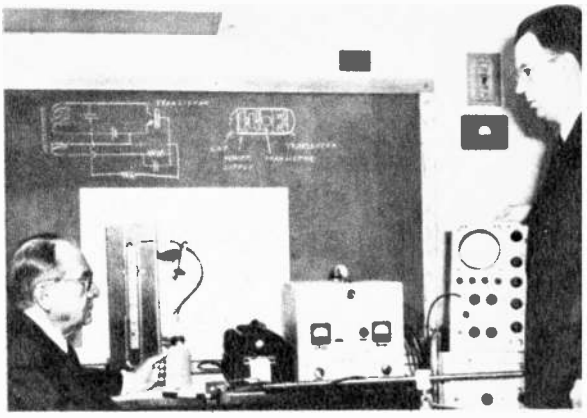
The "radio pill" has been developed and tested jointly by the Rockefeller Institute, the New York Veterans Administration Hospital, and the Radio Corporation of America. It was designed by Dr. V. K. Zworykin, Honorary Vice-President of RCA and Affiliate in Biophysics in the Medical Electronics Center of the Rockefeller Institute, and his associates, as it had been envisioned by Dr. John T. Farrar, Chief of the Gastroenterology Section of the New York Veterans Administration Hospital and Assistant Professor of Clinical Medicine at the Cornell University





CLOSE-UP of radio pill. Pressure diaphragm works against the core of oscillator coil, changing its inductance, thus varying frequency of transmission.

AN ANTENNA on end of stick or wand picks up weak signals from radio pill in patient's stomach, as demonstrated by Drs. Zworykin and Farrar.



DR. VLADIMIR K. ZWORYKIN (left) and Dr. John T. Farrar watch the recording apparatus as the radio pill sends out FM signals. The pill is in the bottle in Dr. Zworykin's left hand, where it undergoes pressure changes that simulate the action of the intestinal tract of the human body. The wiring diagram of the pill is shown on the blackboard.

College of Medicine. The "pill" was developed by engineers of RCA's Commercial Electronics Products unit in Camden, N. J.

"The 'radio pill' seems to offer many possibilities as an important new tool in medical research," said Dr. Farrar. "It can be swallowed like any other medicinal capsule without discomfort, and will permit measurements on internal organs with minimum psychological and physical disturbance to normal bodily functions. It is hoped that the pill will prove valuable in studying human digestion and absorption in normal and pathological states. The new information which may be obtained on the physiology of muscular contractions is expected to be important in understanding gastro-intestinal disorders.

"The knowledge which is gained about the muscular activity of the right side of the colon, heretofore almost inaccessible to study, may prove useful in understanding the pathological physiology of such ailments as spastic colitis, ulcerative colitis and other organic and functional disease states. Besides measuring pressure changes in the digestive organs of the body, the 'radio pill' is being modified so that it may generate and transmit impulses relating to temperature within the gastro-intestinal tract."

Dr. Zworykin, who pioneered in the development of the television picture tube and also did fundamental work in perfecting the electron microscope, said the new "radio pill" has several electronic components. It consists of a tiny transistor, an oscillator coil with a ferrite cup inductance core, two capacitors, two resistors, and a minute, replaceable battery which powers the oscillator and has a life of fifteen hours. This battery is similar to the one used in the famous proximity fuse for anti-aircraft shells during World War II.

Heart of the capsule is the oscillator, which is so sensitive that its frequency varies with changes in the pressure to which the "pill" is exposed. Information about these pressure changes is transmitted continuously in the form of FM radio signals that carry for a distance of several feet. These signals can be picked up on an outside FM radio receiver when an antenna is held close to the body. They can be recorded on one or more of three instruments: a meter, a recording galvanometer which makes a permanent record of wavy lines on paper much like an electrocardiograph, and a cathode-ray oscillograph similar in principle to the picture tube of a home television set.

When the "pill" is swallowed by the patient, its course through the gastro-intestinal tract can be traced by fluoroscopy or other means. Since it has magnetic properties, it can be manipulated by magnetic forces outside the body. The capsule can be recovered and re-used later. •

THE HAM OF THE YEAR IS A "SHE"

Mary "Mae" Burke, W3CUL, top traffic handler, is 1956 Edison Radio Amateur Award Winner

W3CUL at the keying position of her elaborate ham station. Receivers are on shelf just above table; transmitters at rear. Mae is first "XYL" (ex-young-lady) to win Edison Award. She is known far and wide for her ability to "pound brass," that is, operate a radio key speedily with the International Code.

THIS IS a month's messages handled by W3CUL, many of them to and from U. S. service personnel.

PHOTO RIGHT shows Mr. and Mrs. Burke, W3VR and W3CUL, respectively, during one of the rare moments when they are not operating the powerful ham radio station in their home. Mounted on the chimney is a rotatable beam antenna, used with their various radio transmitters and receivers.

THE first woman to win General Electric's coveted Edison Radio Amateur Award for public service is Mrs. Mary ("Mae") Burke, who operates station W3CUL at her home at 265 Waverly Rd., Morton, Pa.

Mrs. Burke won the fifth annual Edison Award for voluntarily handling an average of 3000 messages per month, principally for servicemen overseas. She is one of the nation's top "traffic" operators, using Morse Code almost exclusively.

She prefers to be called "Mae" because in Morse this nickname takes only half as much time to send as "Mary"—and to her, operating eight hours a day in six different radio message networks, time is important. Asked if she ever uses voice radio circuits, she replied: "Very seldom; it is so time-consuming." However, she makes no claim to extremely high speed Morse Code operating: "I stay at about 30 words a minute to maintain accuracy." Actually, this is more than twice the 13-words-per-minute required for a general-class amateur license.

Mae's husband, Alfred, also is a radio amateur, licensed as W3VR. He courted her by Morse Code for several years before they were married in 1942. Al is a devoted husband and extremely proud of her operating ability and the message service she provides. He cooks breakfast before going to his work as a maintenance supervisor of electrical equipment on ships operated by the Sun Oil Company out of Marcus Hook, Pa. Mae manages to prepare herself some lunch between mid-day radio schedules. At night Al returns from the docks and cooks supper while Mae continues to rap out messages relayed to her from far flung military outposts throughout the world. Al's "on-the-air" radio operating is limited nowadays; he maintains their $5000 worth of radio receivers and transmitters, which run almost continuously.

Mae also operates at her home a key station in the civil defense emergency communications network. This equipment features a gasoline generator power supply for use in the event commercial power lines fail.

Before her marriage she played the piano professionally. In what little spare time she has, she relaxes by playing her church model Hammond electric organ. A third hobby is growing violets and gardening.

Mae has handled more than 312,000 radio messages since 1949, occasionally reaching a total of 10,000 messages in a single month. Her longest stretch of operating without missing a schedule was 1825 days—five years without taking a vacation or a single day off from her voluntary service.

She was nominated for the award by C. W. B. Barger, District Heights, Md., a government radio engineer who manages one of the radio message networks by which amateurs provide auxiliary com-

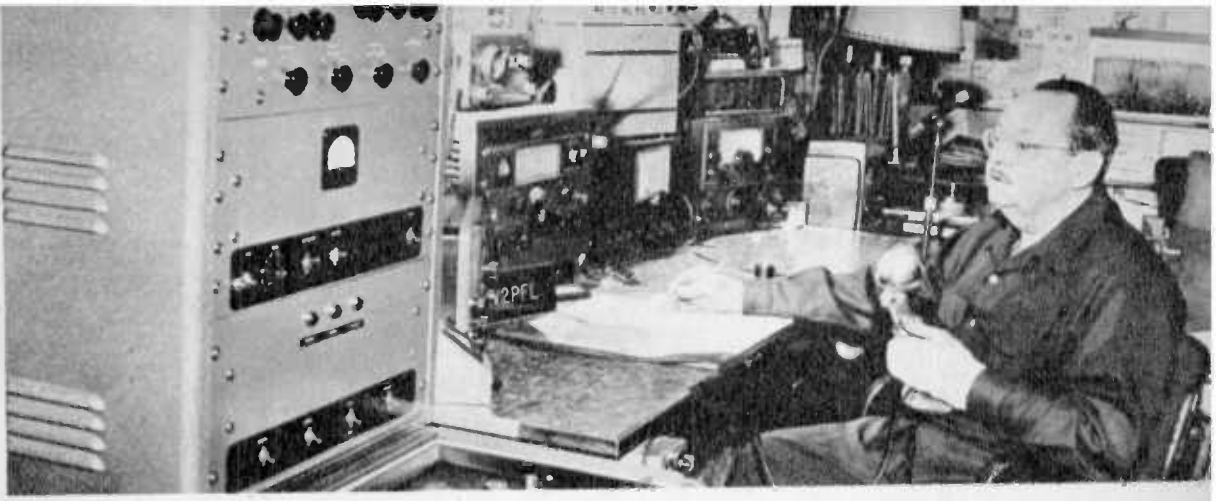
AS SUPERVISOR of radio communication for the Atlanta, Ga., Police Department, James P. Born, Jr., enjoys both his vocation and his ham avocation. Another citation winner, W4ZD has performed many outstanding public services. He conducts training classes for novice hams and helps them obtain their government licenses. He is also the communications chief of the Atlanta Civil Defense Control Center.

munications for the public. A letter endorsing the nomination from Cosmo Calkins of the Michigan State Senate cited these examples of the messages relayed by Mae: "How I wish I could be home with you this Christmas . . . Please send $100; urgent . . . Don't sell the car until I return stateside."

Mae starts her daily radio operating at 6:30 a. m. with an on-the-air meeting of the "Dog Watch" Net managed by Everett L. Battey, radio station W41A at Warrenton, Va. At 7 a. m. she joins the "Hit and Bounce" Net controlled by station W4PL operated by a 73-year-old retired lawyer, Benton White, at Chattanooga, Tenn. She said: "Mr. White has been my inspiration for many years, but I met him for the first time only two years ago."

At 11 a. m. she trades messages on Mr. Barger's Transcontinental Relay Net. From 2 to 4 p. m. in the afternoon she works California amateurs on a higher frequency, picking up messages relayed from the Far East. At 6 p. m. she joins section four of the Transcontinental Relay Net, and finally closes her station after a session in the Traffic Exchange Net, directed at 8

C. NEWTON KRAUS, W1BCR, of Warren, Rhode Island, a citation winner in the Edison Radio Amateur Award contest, has handled hundreds of written messages, press dispatches, long-distance telephone call relays, and U. S. Navy official business conferences for "Operation Deepfreeze" in the Antarctic. He does most of this work between midnight and dawn, when transmission conditions are most favorable.



SPECIAL CITATION WINNER in the Edison Radio Amateur Award contest is Harry L. Fendt, W2PFL, of Great Kills, Staten Island, N. Y. The walls and ceiling of his "ham shack" are completely covered with acknowledgement cards from amateurs all over the world with whom he has communicated. His equipment includes two transmitters, left foreground; four short-wave receivers, on table, and tape recorder.

p. m. from Houston, Texas, by Roy Armstrong, W5RIH.

The 1956 Edison Award judges who chose Mrs. Burke as the "Ham of the Year" were Herbert Hoover, Jr., the former Under Secretary of State; Commissioner Rosel H. Hyde, Federal Communications Commission; Chairman E. Roland Harriman, American National Red Cross; and President G. L. Dosland, American Radio Relay League.

In addition, the judges named the following amateurs to receive special citation plaques:

Atlanta, Ga.—James P. Born, Jr., W4ZD, 25 First Ave., N.E.—In charge of communications at an Atlanta Civil Defense control center; conducts periodic drills, in addition to many other services that include: director of Southeastern Division of American Radio Relay League; member of Military Affiliate Radio Systems; chairman of Georgia television interference committee; conducts classes for novice radio amateurs.

Clark, N. J.—Julius M. J. Madey, K2KGJ, 1037 Raritan Road—This 16-year-old boy has [*Continued on page* 144]

A 52-YEAR-OLD grandmother, although she doesn't look it, Mrs. Martha Shirley, of Black Hawk, South Dakota, won her citation in the Edison Radio Award contest for handling emergency traffic during several severe storms. In November, 1955, when home alone snowbound in a blizzard, she relayed messages for 24 consecutive hours, and later stayed on the air with her station WØWZL for four days and three nights.

PORTABLE TAPE RECORDER

Introducing a model which really deserves to be called "portable"

IS SHE getting her money's worth from her voice lessons? She can tell herself by listening to how she sounds on this small Geloso tape recorder. The recorder, its microphone and several reels of tape are easily carried in a special case.

PUTTING a handle on a piece of equipment that weighs 25 pounds or more doesn't make it portable. This is just too much weight for an ordinary person to lug around when he's on foot, yet there are tape recorders of this size sold as "portables." What the manufacturers mean is that they are transportable, which is another matter altogether.

The reaction against these overgrown monsters has been the development of recorders so compact and so light that they can be carried with ease in a coat pocket. Battery operated and therefore independent of power lines, they are proving successful for a number of special applications.

Italian Model

Out of Italy now comes a portable that is a good compromise between the arm-straining big jobs and the tiny pocket units. It is intended for straight AC operation or for automobile use with a suitable inverter. Employing regular double tracking on ¼-inch tape, it provides 90 minutes of playing time with thin tape or 60 minutes on regular tape at a tape speed of 1⅞ inches per second, or 45 or 30 minutes, respectively, at a tape speed of 3¾ inches per second. It has full push-button control for all functions, rapid advance of the tape, volume indicator and built-in loudspeaker. The entire machine measures only 10 by 6 by 5½ inches, about twice the size of a cigar box, and weighs only 8 pounds, less than half as much as most portable typewriters.

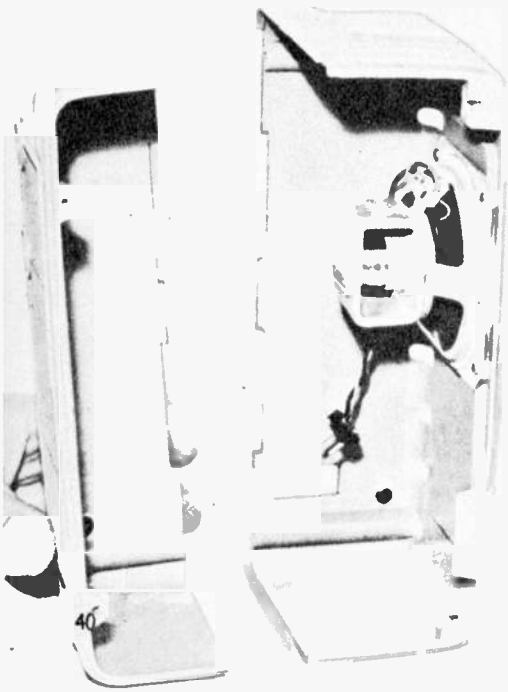
In a simulated leather case, the machine is an easily carried piece of hand luggage. Because of this feature, it has achieved immediate popularity among traveling men, who send back detailed reports of their activities to their offices; among business executives, who practice important speeches on it; among doctors and lawyers, who record interviews, conferences and agreements; among students, who seek to improve their command of foreign languages; among both amateur and professional entertainers, who perfect their singing, jokes, routines, etc., before trying them on live audiences. One parent with three children in different out-of-town schools bought four machines, and the family keeps a series of tapes in constant circulation. The voices of both parents and children give a liveness and immediacy to this electronic means of correspondence that is completely missing in ordinary written letters.

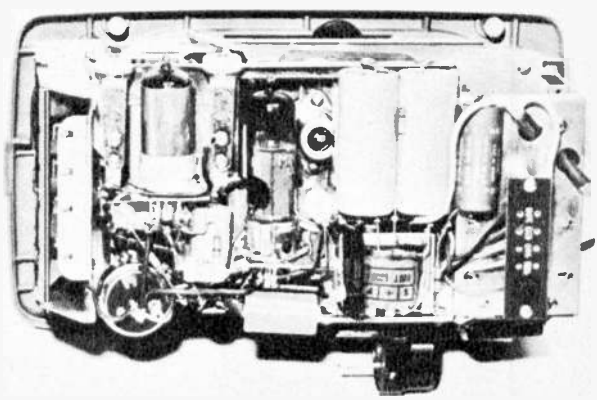
Made by Geloso

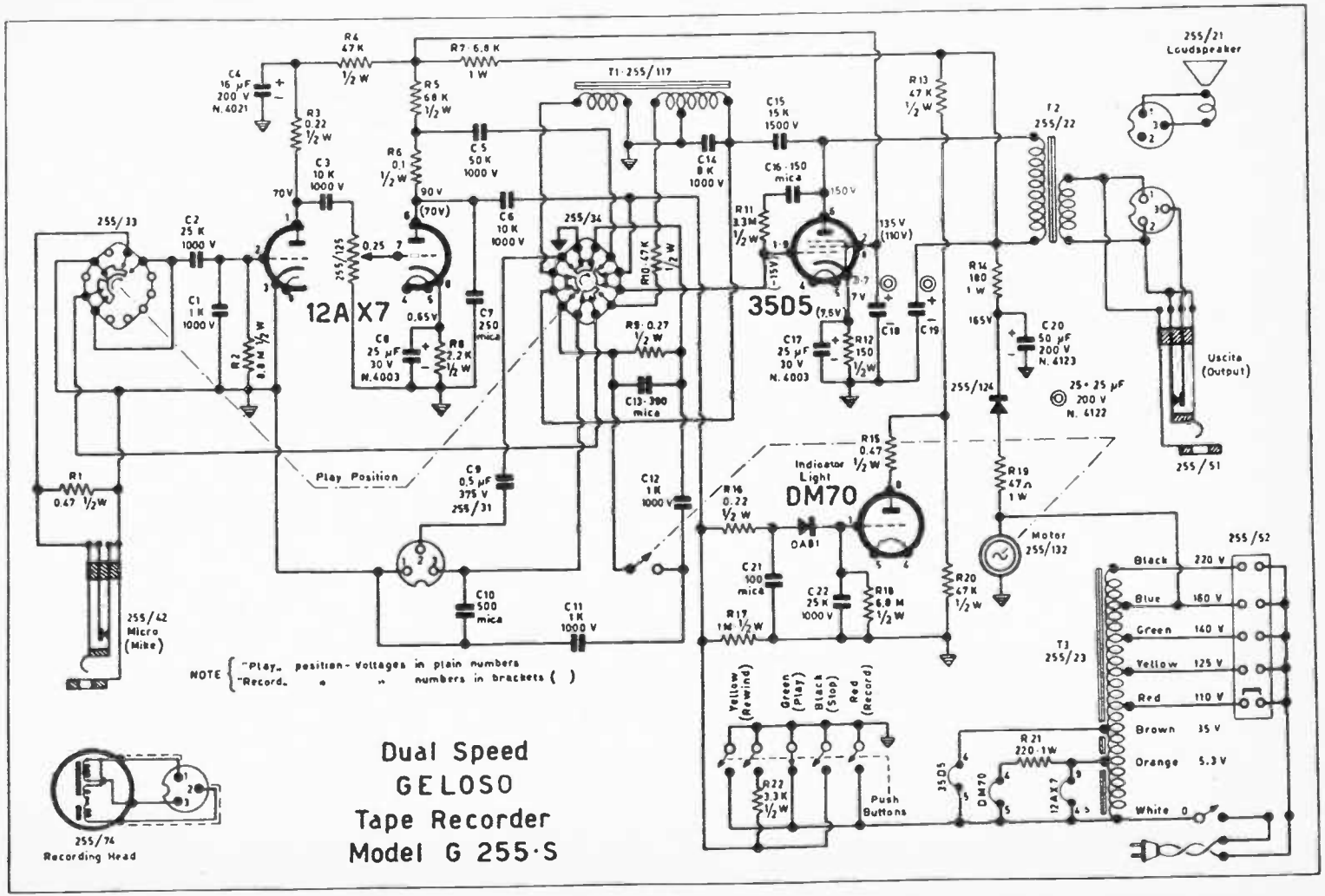
This recorder is made by John Geloso, of Milan, Italy, one of the largest radio manufacturers in Europe. And he really manufactures it, and not merely assembles it. He molds his own cases, knobs and other plastic parts; makes all his own resistors, capacitors, transformers and loudspeakers; he even draws the copper wire that he uses for all coils and connections. Geloso himself was for several years chief engineer of a once-important American radio firm, so he knows how to produce equipment to American standards. •

THE REELS of the Geloso tape recorder are protected by a hinged transparent cover that lowers over them but leaves the controls free. Push buttons, along right edge, make the machine record, stop, rewind or playback. Lever at left front edge is for rapid forward motion of tape, useful when it is desired to skip portions without having to hear it. Unit at left is microphone, which plugs into back of case. Note size comparison between hand and entire recorder. Complete unit weighs only eight pounds.

NO WASTE SPACE inside the Geloso recorder! The chassis mounts as a unit on the underside of the main deck, as shown at right. Small board in lower right corner provides adjustment for any line voltage between 110 and 220. Split case, left, has 3-inch dynamic loud-speaker mounted in front section.

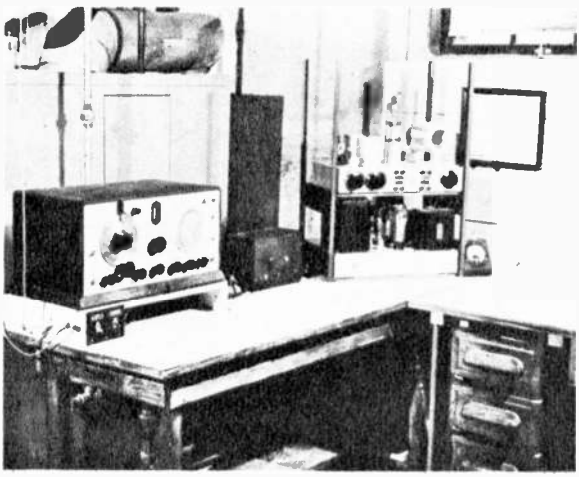




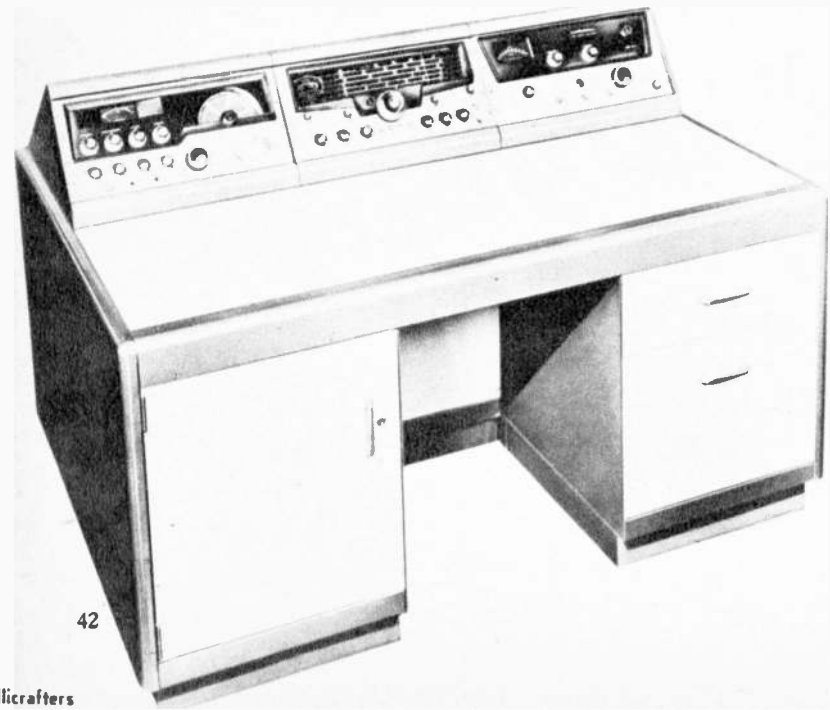


A HAM WHO MADE GOOD

Bill Halligan is a pioneer radio operator who put his hobby to work for him



BILL HALLIGAN'S compact "shack" (photo right) in his Chicago apartment contains a Hallicrafters SX101 receiver (left) and a Hallicrafters HT32 transmitter (on the shelf). His basement station (photo above), typical of the middle 1930's, featured the first Hallicrafters short-wave receiver (left end of table). Transmitter on right is open rack construction.



IN CONTRAST with 1937 Hallicrafters equipment, here is Halligan's 1957 "dream" station. At left is Hallicrafters HT32 transmitter, at right a companion amplifier using maximum power allowed by law, one kilowatt. In center is SX101 receiver. Units are angled to make dial observation easier.

MEN who are now about forty or older have good reason to remember—and forget—the 1930's. Following the stock market crash of 1929, the country was in the depths of the worst depression of its history. Established businesses by the score folded up overnight. Many former executives sold apples on the street or went on government relief.

The time hardly seemed ripe for the starting of new and uncertain enterprises. However, a bright Chicago radio ham, at thirty-four, old enough to know what he was doing, chose 1933 to put into effect an idea that had been burning in his head for years. He wanted to manufacture high-quality, precision-made communications equipment for "hams" like himself and other users of short-wave radio. What limited equipment was already on the market at the time was expensive; his object was to turn out quality at prices that depression-struck hams could afford. The optimistic operator was William J. Halligan, Boston born and bred but working in Chicago as a sales representative for eastern radio firms.

Bill was one of the pioneer gang of hams who started in radio prior to 1917 with much the same elementary spark transmitters and crystal receivers used by Marconi only a few years earlier. Sixteen and out of high school, he qualified for a commercial operator's license and for sea duty as "Sparks" on Atlantic Coast vessels. When the United States entered World War I, Bill at the age of 18 was an experienced radio man, and the Navy grabbed him fast when he volunteered for service. He came out a chief petty officer, and enrolled in the electrical engineering school of Tufts College, in Boston. However, he

was soon back in uniform, this time as a cadet at the United States Military Academy. He was well on the way to becoming a second lieutenant when he met a diversion named Kate Fletcher, from New Rochelle, N. Y. West Point has a cast-iron rule that no cadet can marry and remain a cadet, so Bill promptly ceased to be a cadet. He would have graduated with the Class of 1924, which produced numerous colonels and generals who made a fine name for themselves in World War II. By that time a big shot in the radio industry, Bill's conferences with high Signal Corps brass in Washington were often in the nature of old-home week parties.

The early sledding, however, was not easy. Older radio manufacturers said the ham market was too small to bother with and predicted that Halligan wouldn't last long. Bill fooled them. First, he devised a catchy name for his young firm, Hallicrafters. With a combination of salesmanship, nerve and technical know-how, he proceeded to sell Hallicrafters to the radio trade. For a while he had nothing to sell but the name. In 1934 his employees totalled eight and actual sales were not even worth recording. By 1935 he was rolling, with sales of receivers achieving the then-staggering figure of $157,960. In 1936 the amount jumped to almost $350,000, in 1937, to $661,189. Hallicrafters was now a going business, and Bill Halligan was easily the best known ham figure in the industry. "The radio man's radio" was the popular description for Hallicrafters equipment.

Used Own Products

Bill was one of the most enthusiastic users of his own products. After spending a long working day in the factory living and breathing radio production and sales, he would go home at night and get on the air himself, building up a wide circle of friends all over the world.

By 1938 Hallicrafters was putting out compact, powerful transmitters, as well as receivers of various kinds and related items. In 1940, the company hit its first million-dollar year.

Even before the United States was officially in World War II, Bill was working closely with various government agencies on both standard and special electronic gear. He was in on the ground floor, so to speak, and his contribution to the war effort was enormous. War-time fiscal figures have an unreal, astronomical air, but it is worth noting that Hallicrafters

"THE VOICE of the Signal Corps" is how the Hallicrafters-built Radio Set SCR-399 was often described during World War II. Truck contains radio gear; the trailer a gasoline-engine driven generator.

A SMALL section of the Hallicrafters factory in Chicago, devoted to manufacture of precision communications equipment, is shown in photo right.

sales in one year reached $36,119,986. Not bad for a ham who started with little.

Hallicrafters turned out vast quantities of military communications equipment. The outstanding item was the famous Signal Corps SCR-299—SCR-399, a complete radio station in a truck, with its own gasoline-engine generator in a trailer towed at the rear. The Army needed a powerful outfit, and wanted it in a hurry. It already had a rugged receiver designed for use in tanks, but no suitable transmitter. Some Signal Corps engineers and officers, themselves hams of long standing, reminded themselves of the Hallicrafters HT-4, a transmitter highly prized among amateur operators because of its flexibility, good design and sturdy construction. It filled the Army's requirements admirably.

Rechristened the BC-610, this transmitter went into a one-ton station-wagon type truck along with two receivers, a BC-312 and a BC-342, which are alike except for power supply, a control board and a stack of spare parts. With a 7½-kilowatt generator, which could be started remotely from inside the truck, the combination was called the SCR-299. The truck engine

THE "INSIDES" of an SCR-399. Rear left: operating table containing two receivers and control unit. Rear right, transmitter, a revamped amateur-model Hallicrafters HT-4. Center bench, for operators.

proved underpowered for the load, which included three or four men and all their impedimenta, so the same electronic gear was shifted to the Army's big workhorse, the 2½-ton "six by six" truck, to become the SCR-399. No radio set saw harder service or gave a better account of itself. As a Signal Corps officer in Europe, I'll venture the entirely biased opinion that we couldn't have won without it.

Back to Business

After VJ day, Bill lost no time putting Hallicrafters back into the public eye. Literally, the public eye, because he sold a raft of television sets, among other things. The faithful HT-4 was retired, and has been replaced by a succession of new ham units to meet changing conditions of amateur operation. The current Hallicrafters receivers and transmitters are not only superb pieces of technical equipment but also high-styled examples of the industrial designer's art. Many people who are not hams at all buy the receivers because of their intriguing appearance. Not surprisingly, this greatly pleases the ham who made good. •

ULTRA-high-frequency receiver is one of special units made by Hallicrafters for military purposes.

I TALK TO THE WORLD...FROM MY CAR

Author Robert Hertzberg uses this mobile radio station to contact friends and fellow hams all over the globe

HUNG DIRECTLY from center section of dashboard, Gonset G-66B short-wave receiver (left) and Gonset G-77 transmitter are within easy reach of driver. Heavy wire from end of transmitter goes to antenna on back of car, light wire to battery under hood of a 1957 Chevrolet.

THIS IS WHAT the driver sees. Two units look identical, but left one is receiver, right one transmitter. Meter on receiver indicates signal strength; on transmitter, correctness of tuning. Lid of glove compartment has been removed to make space for equipment. Microphone is resting between receiver and transmitter; above it is regular car radio. Ammeter on right is a valuable addition to the car.

THE morning air was chilly, so I let the engine idle after I pulled the car out of the garage. To keep myself occupied, I turned on a short-wave receiver and its companion transmitter, both suspended from the instrument panel, put a microphone under my nose, and called out the "ham" operator's universally recognized invitation.

"Hello CQ, CQ, CQ. Calling any ten-meter phone for a short contact. This is W2DJJ mobile, William Two David John John mobile, in Long Island, calling CQ. What say someone please?"

I released the mike button and fished around with the receiver tuning knob. I nearly jumped out of my windbreaker when an accented voice issued from the loud-speaker mounted over the rear vision mirror.

"Hello William Two David John John mobile. This is DL9MZ, Dog Love Nine Mike Zebra. You certainly are putting a fine signal into Berlin, Germany. The name here is Gerd. What are you using and where are you located? W2DJJ mobile, DL9MZ. Take it away."

Berlin! I was in a hurry to make a train, but this was too good to pass up. We chatted back and forth for fifteen minutes until his signals faded out. I realized I would miss the next train, too, if I didn't get going. My hand was reaching for the control switches when another voice on DL9MZ's dial setting boomed in.

"Calling W2DJJ mobile, William Two David John John mobile. This is King Zebra Five Peter Peter, KZ5PP, in the Canal Zone. Heard you working that DL9 in Germany, Bob, and just wanted to horn in. . . . ."

First Germany, now Panama! I looked with wonder at the equipment in the car and then at the eight-foot stainless steel whip antenna on the rear fender.

"It doesn't seem possible, but here I am parked in my own driveway, talking from behind the wheel to other amateur radio operators thousands of miles away. Would anyone believe this if I told about it?"

Understandably, several Fawcett editors did express polite incredulity when I described this experience and many others, including direct conversations with England, Florida, Alaska and all through the Far West of the United States.

"Show us!" they challenged.

So one rainy afternoon I took Editor Larry Eisinger out for a ride in Central Park, in New York City. We pulled into a side road, and I called a short CQ. These letters have no meaning in themselves. The combination is an arbitrary one, and means, in effect, "I am on the air and will talk to anyone who can hear me."

A clear American voice, so loud that it drowned out the local interference, caught our attention.

"William Two David John John mobile, W2DJJ mobile. This is 5A5TE, Five Able Five Thomas Edward. How are all the pretty girls in Central Park? W2DJJ mobile, 5A5TE. Go ahead."

The call letters sounded odd, even phony. The signal was too strong to be true. Then I remembered a dentist friend, a ham, who has a station in his office on Madison Avenue a scant quarter of a mile away. He amuses himself between patients by going on the air and working lots of DX, or distance.

"I'll go along with the gag," I remarked to Larry, and I answered in a jocular vein, making a not-too-subtle crack about the call letters.

"W2DJJ mobile from 5A5TE. I can see that you're a bit dubious about this. I'm a tech rep with the U. S. Air Force, and I'm located in Tripoli, Libya, North Africa. . . ."

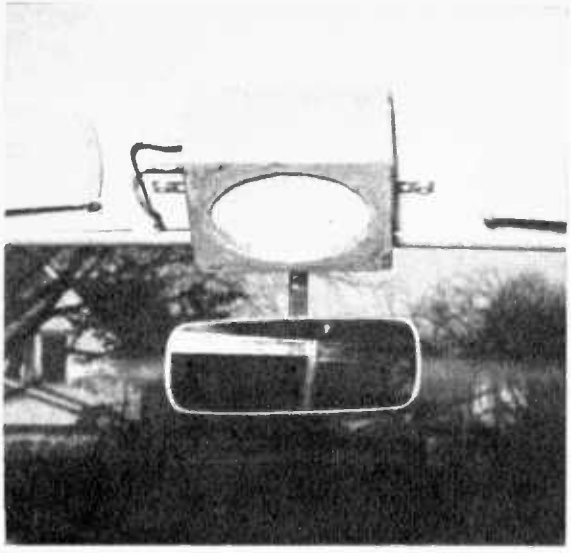
I stared at Larry and Larry stared at me. It was no gag. We actually *were* talking from Central Park to Tripoli. We had a very interesting chat for ten minutes, and then the signals dropped out. While all this was going on, a procession of police prowl cars slowed down around us, and the cops in them looked us over in obvious puzzlement.

"They probably think we're FBI men or dicks on special assignment," I said to Larry. They didn't bother us, and indeed they can't, as the more than 150,000 licensed hams in the United States operate under the authority of the Federal Communications Commission and not of any municipal or state agency.

Ham License Requirements

The FCC requirements for an amateur "ticket" are very modest. You must be able to send and receive in the dots and dashes of the International Morse Code at the rate of five words per minute to qualify for a "Novice" class license or thirteen words per minute for the "General" class, and also you must make a satisfactory showing in a technical examination consisting of questions of the multiple-choice type. How difficult are these tests? The most indicative answer is that boys and girls *under* the age of ten sail through them successfully.

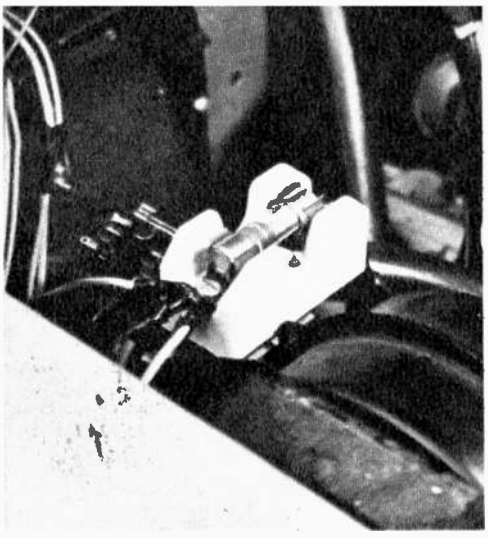
Any citizen of the United States can apply for a license. It costs nothing. Ex-



SIGNALS FROM receiver are heard through "squawk box" mounted over rear vision mirror. This contains a 4-inch dynamic speaker. Plywood box is painted to match car interior, and is fastened by small L brackets and self-tapping screws. Connecting wires are concealed under windshield molding.

THE PROOF of the pudding: A few of the acknowledgement cards received by W2DJJ verifying communication with other hams when car was in New York.

PART OF TRANSMITTER (the power supply and modulator section) is mounted in trunk compartment. It is operated automatically when the push-to-talk button on hand microphone is pressed.



SHORT-WAVE EQUIPMENT is connected directly to battery (through ammeter) and through these protective fuses, mounted on blower frame under hood. These extra fuses protect the ignition system.

aminations are held daily in FCC offices in large cities; at frequent intervals in smaller places. The Novice license is good only for a year and is not renewable; the holder must qualify for the General license or quit. The latter license runs for five years and can be renewed indefinitely.

When I dropped Larry at the Fawcett Building at 44th Street and Sixth Avenue, a very busy and noisy spot, he said, "Let's try once more."

We did, and in a minute raised station W5GVC in Houston, Texas!

With this "mobile station" in the car, I don't mind waiting for my wife when she loses herself in a big shopping center. I find an open slot in the middle of the parking field, as far as possible from power lines, neon signs and truck traffic, and scan the amateur bands for hot stations. An unexpected catch one day was EA7GS, a physician in Alosno, Spain. His English was poor and my Spanish non-existent, but we did manage to exchange greetings and technical signal reports. I have an acknowledgment card from him, too.

Another time, when my XYL (ham lingo for ex-young lady, or wife) was delayed at a Parent-Teachers Association meeting, my CQ was answered by a voice with a strong Scotch burr. The caller turned out to be VE8MI, way up on the shore of Hudson Bay in the wild North West Territory of Canada, on the fringe of the Arctic Circle. He is one of forty white people at a remote fur trading post, reached by mail perhaps once every two weeks when they're lucky. Can you imagine what these personal radio contacts with the outside world mean to them? It means a great deal.

I remarked that the temperature in New York was 37 degrees and that the air had a touch of snow to it. VE8MI answered with the remark that the temperature in his location was also 37 degrees, *below* zero, and that they have snow eleven months out of the year.

Husky Generator Needed

Until recently, relatively few amateurs were able to take advantage of the opportunities that mobile operation offered. Equipment wasn't the problem. The restricting element was the car's electrical system, which wasn't big enough to power a receiver and a transmitter in addition to ignition, lights and accessories. In most 1957 cars the regular generators are husky enough to take care of radio equipment, and for an extra margin of safety oversize generators are available on request. For example, it cost me only $7.75 extra for a 30-ampere unit to replace the 25-amp unit that comes normally on a Chevrolet. I figured I needed those five additional amperes to give full strength to the Gonset G-66B receiver and Gonset G-77 transmitter I planned to install, and I was right. When I press the mike button to transmit, the ammeter on the dashboard swings full to 30 amps, and it is very comforting to know that the generator can handle the load without groaning or overheating.

Car radio operation is so much fun and full of so many surprises that many hams are giving up their home stations altogether and are concentrating on mobile. It is a great thing particularly for men who

use their cars every day for one purpose or another. It is utterly terrific on a long business or vacation trip.

For mobile reception, the practice heretofore has been to connect a small short-wave converter unit to the car's regular broadcast receiver. The newer and better technique is to use an entirely separate and self-contained short-wave receiver.

Conscious of the rapidly expanding mobile market, manufacturers are now offering some very handsome receivers and transmitters, usually of matching appearance, that make a stunning addition to any car. In practically all cases the equipment is mounted under the dash, within reach of the driver. Elements of the transmitter that do not require manual adjustment can be mounted either in the engine compartment or the rear trunk. The under-hood space in late cars is pretty well filled with multiple carburetors, air cleaners, and gadgets for power brakes and steering, so the trunk is usually a more convenient location. Mounting the various units is a simple nut-and-bolt job.

What It Costs

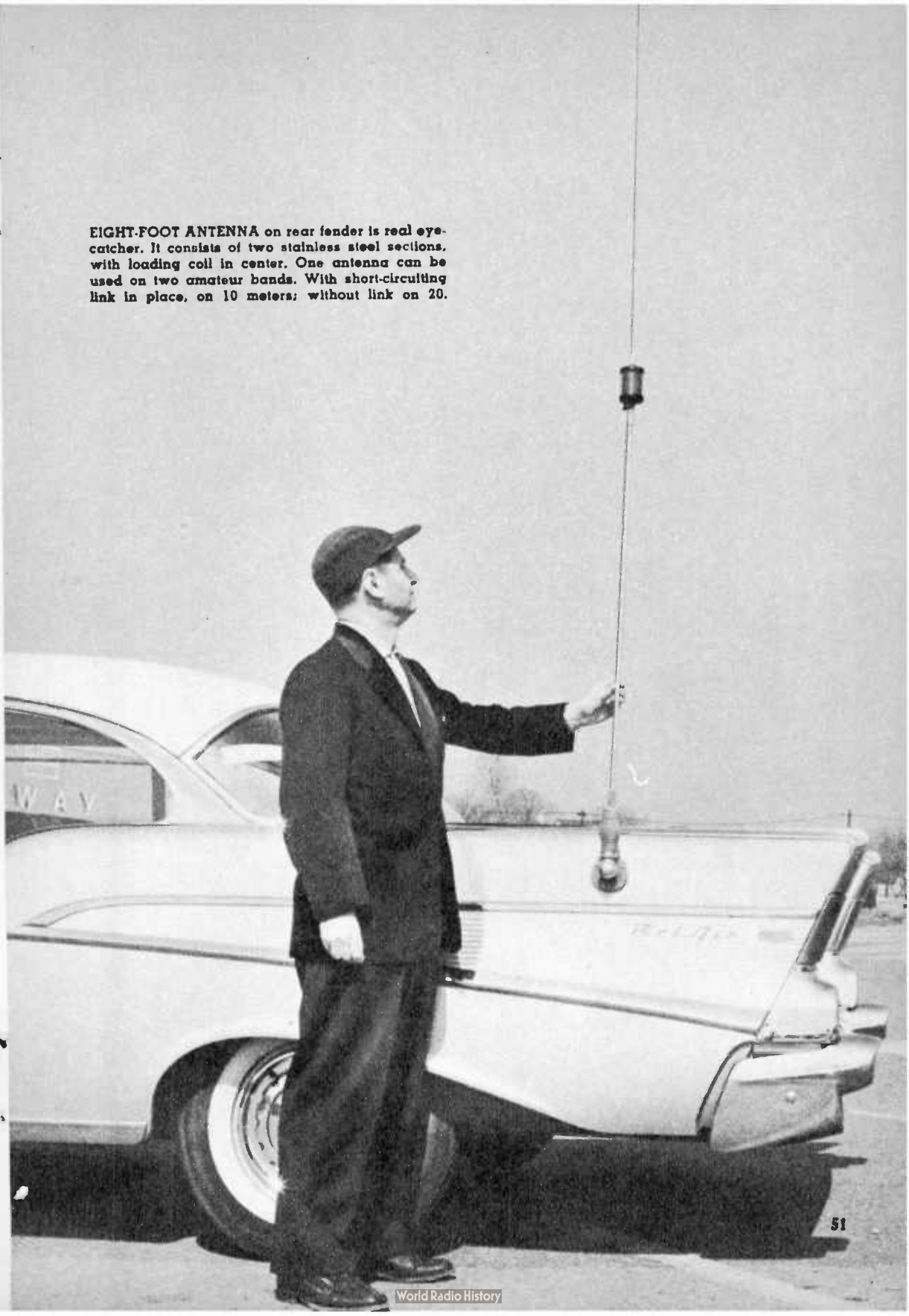
Prices of mobile equipment are in line with those of home stations. Converters cost $53, $70 and $80. Separate receivers, which take in the regular broadcast band as well as the ham channels, run $190, $200 and $235. Transmitters sell for $217, $269 and $269. Microphone, loud speaker and antenna add perhaps $5 or $50. The investment is not small, but the returns in pleasure are large.

The one serious problem with a mobile installation is the antenna. People who don't like to cut holes in the outer body of a car mount the aerial on the rear bumper, and bring the lead-in wire up through a hole in the underside of the trunk and thence under the floor rugs to the firewall. A much better location is the top of a rear fender, as this brings the antenna out in the clear. After some hesitation, I bored a gaping two-inch hole in the fender of my shiny, brand-new Chevrolet, and here I bolted a heavy spring-loaded base for the antenna. I'm glad I did. I'm sure the free antenna is responsible in part for the extraordinary results.

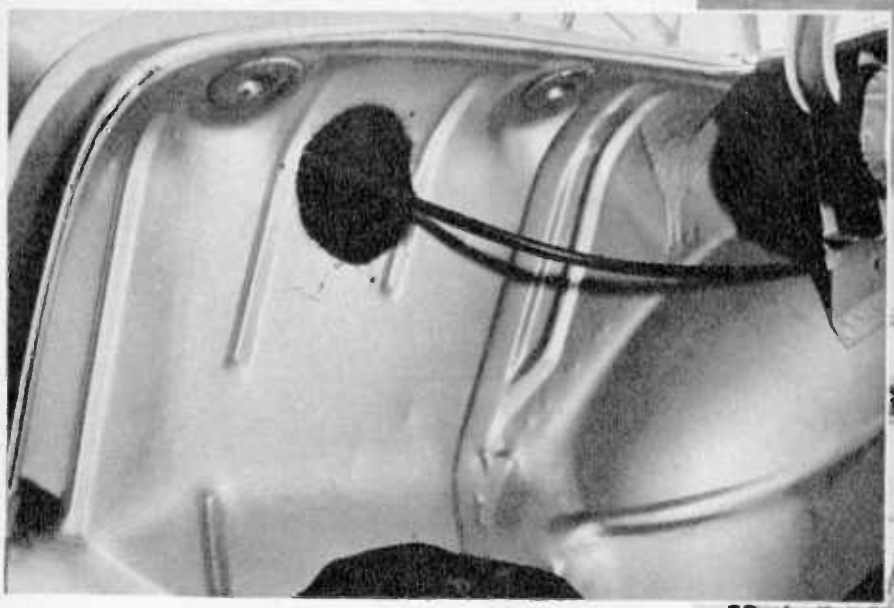
Long Antenna Used

The standard whip for amateur purposes is eight feet long, and is usually made in two pieces so that extra "loading" coils of heavy wire can be inserted in the center if desired. Eight feet is the optimum length for the very popular and effective ham 10-meter channel. For the 15-, 20-, 40- and 75-meter bands the antenna should be longer in direct proportion, but anything beyond eight feet gets snarled in trees, overhead wires, toll booths, etc. The loading coils make the eight-foot aerial "think" it is longer; satisfactory results are obtained with this expedient. Invariably, the whip must be tied down to the rain molding of the body to permit the car to get into any ordinary garage.

The sight of a tall antenna flapping in the breeze and of the occupant of the car talking into a microphone is sure to draw curious and skeptical onlookers on any busy street. One warm afternoon, while

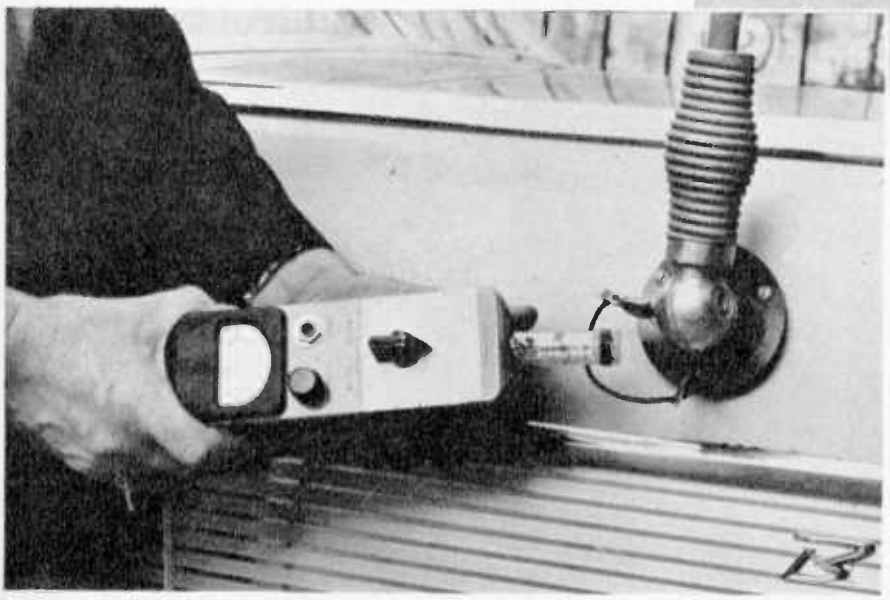


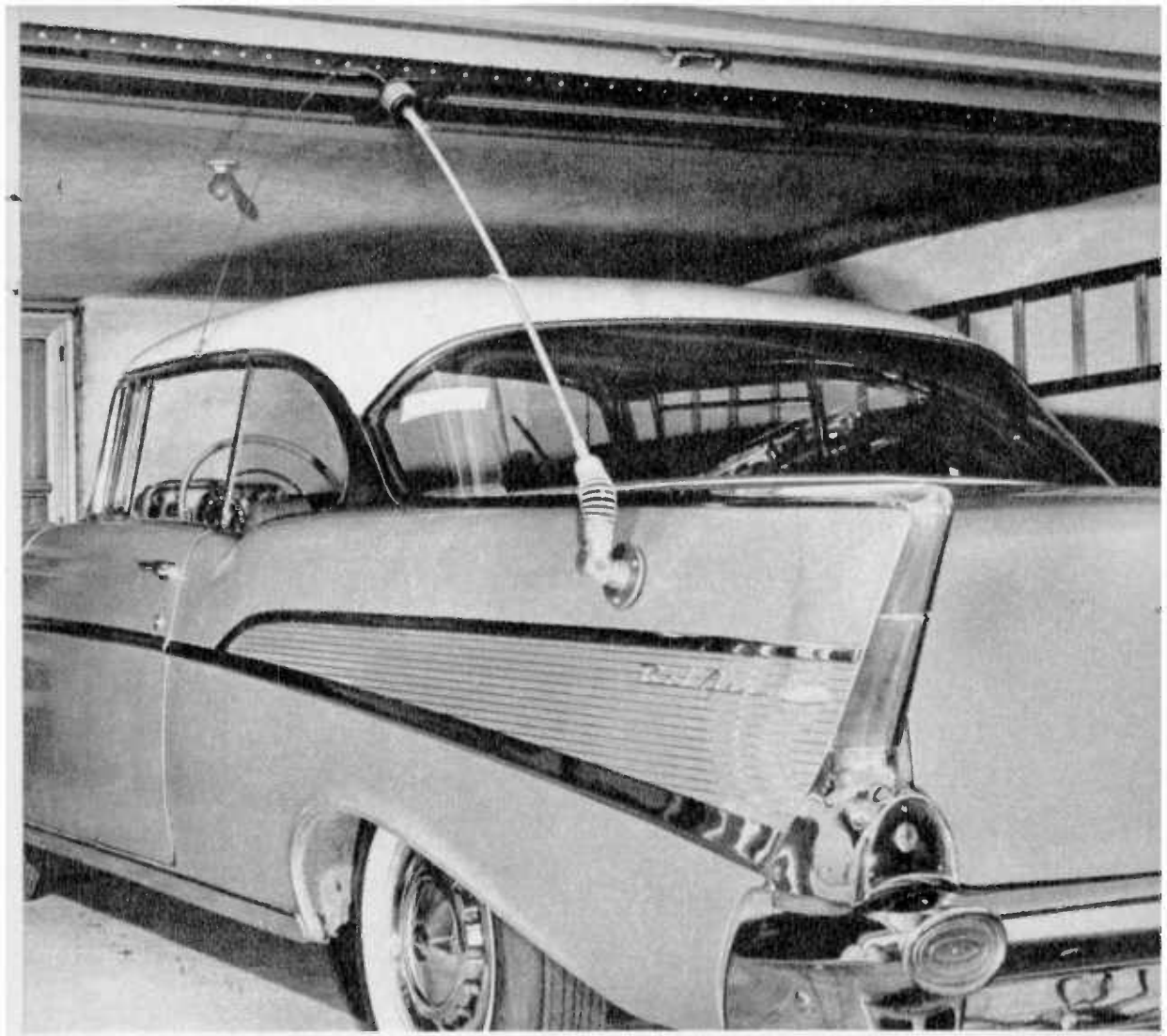
EIGHT-FOOT ANTENNA on rear fender is real eye-catcher. It consists of two stainless steel sections, with loading coil in center. One antenna can be used on two amateur bands. With short-circuiting link in place, on 10 meters; without link on 20.



LEAD-IN WIRE from fender-mounted antenna passes through hole on inside of trunk. It had to be made this large to accommodate a heavy flange matching the outside plate of the antenna base.

IMPORTANT PRELIMINARY STEP is determining "natural" frequency of antenna, with aid of Heathkit grid-dip meter. Lead-in wire to transmitter has been disconnected, and a short coupling link has been clipped between the mast base and the body of the car, which acts as a "ground" to complete the circuit.





GETTING IN AND OUT of the garage is no problem with tip of antenna clamped to rain molding of car.

waiting to pick up my wife at the Long Island school in which she teaches, I had the windows wide open. The bleating of the loud-speaker could be heard twenty feet away. Some parents, including one father, were also waiting at the school. First I raised W5IXU, who was demonstrating ham radio at a high-school science fair in Belton, Texas. On about the third exchange, W6FLL, in Felton, California, asked if he could join the party. W5IXU said he could hear both of us, so we had a merry time for ten minutes discussing the weather in New York, Texas and California. When we had signed off, the waiting father sauntered over and said, "That wasn't really on the level, now was it?"

Just then a rather odd voice drifted out of the loud-speaker. Then *I* became the unbeliever. It was ZL1OF, unmistakably giving his location at Auckland, *New Zealand*. This was completely freakish reception for four in the afternoon New York time. When he signed off, I called him at length, trying to control my excitement. I wish I could report that he answered, but he didn't. My signals probably disappeared in the bottomless ionosphere, that mysterious electronic mirror around the earth that sometimes bounces signals back and sometimes absorbs them. Give me a little time and I'll add the Antipodes to my log book. •

PUZZLED BY HAM LINGO?

It becomes more understandable if you know the phonetic alphabets and how they're used on the air

WHEN A HAM gets his hands on a mike, he talks mike talk! This is Sam E. Baker, W3FIQ, of West Springfield, Pa., one of the special citation winners in the 1956 Edison Radio Amateur Award. His receiver sits on top of the transmitter, and the whole combination fits snugly into a corner of the room.

THE first time you tune into one of the amateur phone bands on a short-wave receiver, you'll quickly get the impression that you are hearing a group of Martians who haven't quite learned to talk English.

"Hello william number seven george love love slant five this is william two david john john mobile. Thanks for the fast answer to my c q. Handle here is bob, baker oboe baker and the q t h is Long Island, New York. Running fifty watts into a gonset g seventy seven and receiving you about s nine on a gonset g sixty six b. Some q s b and the usual q r m but read you fine. Where you located? W7GLL slant 5 this is W2DJJ mobile. Over."

This is a transcription of an actual transmission, one of my own from the automobile station described elsewhere in this book. It probably doesn't make much sense, but it can be translated.

First of all, it is important to know that in all voice radio operation some form of phonetic alphabet is needed to eliminate confusion over letters that tend to sound alike. For example, B, C and V are hardly distinguishable when they are masked by noise or other interference. The Federal Communications Commission does not prescribe any official alphabet, so hams are free to use any equivalents they choose. The phonetics in most general use are an inheritance from World War II, when the military services, after much wrangling, agreed on the following list:

A—Able	N—Nan
B—Baker	O—Oboe
C—Charlie	P—Peter
D—Dog	Q—Queen
E—Easy	R—Roger
F—Fox	S—Sugar
G—George	T—Tare
H—How	U—Uncle
I—Item	V—Victor
J—Jig	W—William
K—King	X—Xray
L—Love	Y—Yoke
M—Mike	Z—Zebra

The numbers require no phonetics, as they are unmistakable. However, the cipher 0 must be given as "zero," not as "Oh," and in written form it is Ø to distinguish it from O or Oboe. The initials WØ or KØ are part of all call letters assigned to ham stations in the states of Minnesota, Colorado, Iowa, North and South Dakota, Kansas, Missouri and Nebraska. These are spoken as "W Zero" or "K Zero," never under any conditions as "W O" or "K O."

Because common names have excellent recognition value, the following alphabet

is recommended by the American Radio Relay League, the ham's national organization:

A—Adam	N—Nancy
B—Baker	O—Otto
C—Charlie	P—Peter
D—David	Q—Queen
E—Edward	R—Robert
F—Frank	S—Susan
G—George	T—Thomas
H—Henry	U—Union
I—Ida	V—Victor
J—John	W—William
K—King	X—Xray
L—Lewis	Y—Young
M—Mary	Z—Zebra.

There are ten duplications between this alphabet and the military list, so if you know one you know much of the other.

Some hams have gotten into the deplorable habit of using place names as phonetics. This is often confusing, as a listener catches only one letter and immediately concludes that the station is in that country. Example: for W2DJJ, isn't it misleading to say, "This is Washington Two Denmark Japan Japan"?

Colorful phonetics devised to fit particular call letters are often heard. W5PPS is "Pistol Packin' Sam." W5RHW is "Red Headed Woman." W3YAA is "Young And Able."

Probably the most often heard combination of letters is "CQ," given straight, not in phonetic form. CQ is a purely arbitrary pair, the letters having absolutely no meaning by themselves. It is a general call, an invitation by the transmitting operator to any ham who might hear him.

"Calling CQ, hello CQ, CQ, CQ. Calling any 10-meter phone. CQ, CQ, calling CQ. This is W6PXH, William Six Peter Xray Henry. What say someone, please?" You can hear this or something like it on some band almost anytime.

Three-letter groups beginning with Q are quite a different matter. Known as the international "Q" signals, they are intended for CW transmission, not for voice at all, but have crept into voice-radio lingo. They have the same meanings in all languages, and enable operators of entirely different nationalities to exchange a large amount of important information. Followed by a question mark, a Q signal has an interrogative meaning; without a question mark, it is the answer, or it can be used alone. The complete list is too long to be published here, but a few of the common ones heard on the air can be explained easily.

Go back to the bit of dialogue quoted in the beginning of this article. The combination QTH was mentioned. QTH? actually means, "What is your position in latitude and longitude (or according to any other indication)?" QTH alone means, "My position is . . . latitude . . . longitude (or according to any other indication)." Obviously, these meanings are intended for maritime use. In ham practice, QTH has acquired the general meaning of "location." Instead of doing it the easy way and saying, "My location is Omaha, Nebraska," most hams will automatically say, "The QTH is Omaha, Nebraska."

The combination QSB? means, "Are my signals fading?", and QSB means, "Your signals are fading." In voice operation, then, QSB is understood to mean "fading."

QRM is widely used, because it is a short term for "interference," of which there is always plenty. QRM? means, in full, "Are you being interfered with?", and QRM means, "I am being interfered with."

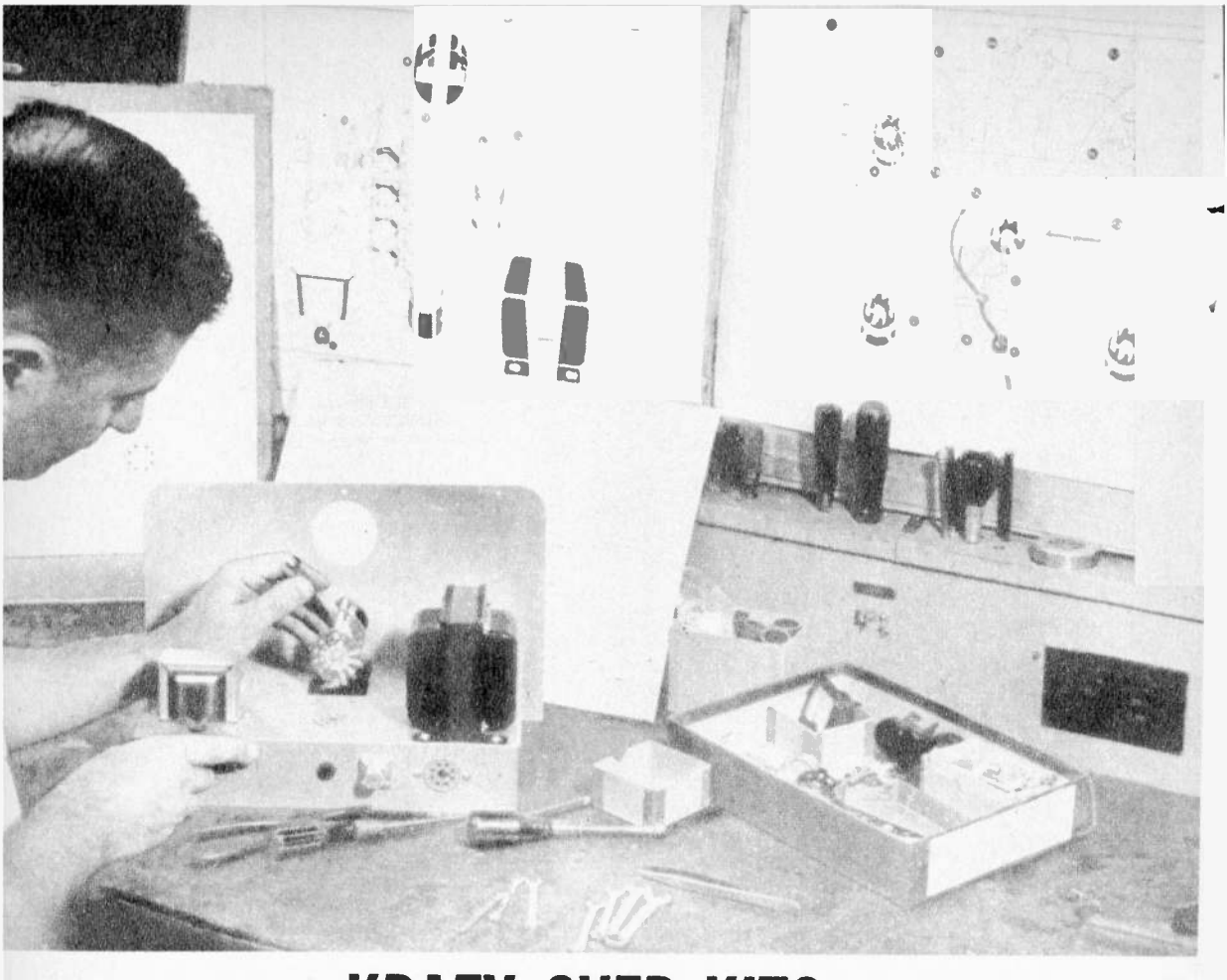
When a ham has called CQ and hears an answer from a station he can't quite identify, he often returns to the air with the plaint, "QRZed the station calling K2DUX. Please try again, old man, Over."

The Q signal is QRZ, and the Z is invariably stretched out to "Zed," which is what the British call the last letter of the alphabet. QRZ? means, "Who is calling me?" and QRZ means, "You are being called by. . ."

"Over" is an ending signal, and is an invitation to the other fellow to answer. "Go ahead" is also used, and its intention is obvious.

The word "Roger" is often heard in the sense of a signal of receipt or understanding. This has a rather odd background. "Roger" of course is phonetic for the letter R. In radiotelegraph practice, R is an international signal and means simply "received." When the Allied forces adopted the Able-Baker-Charlie phonetic alphabet, they decided for some never-explained reason not to use the universally-recognized expression "Okay" as a voice signal of acknowledgment; instead, they specified "Roger" as the phonetic equivalent of the telegraphic R. Why they didn't adopt the simple word "received" instead of a relation twice-removed is a mystery to this day. More and more, hams are going back to the old reliable "Okay."

"Handle" is mike-talk for "name." "Old man" is any male ham, and carries no connotation of age in terms of years. A thirteen-year-old junior high school student who has just gotten his ham "ticket" is just as much an "OM" as a 83-year-old retired major general who has been a ham for more than four decades. •



KRAZY OVER KITS

Electronic hobbyists will have a good time with these assembly jobs

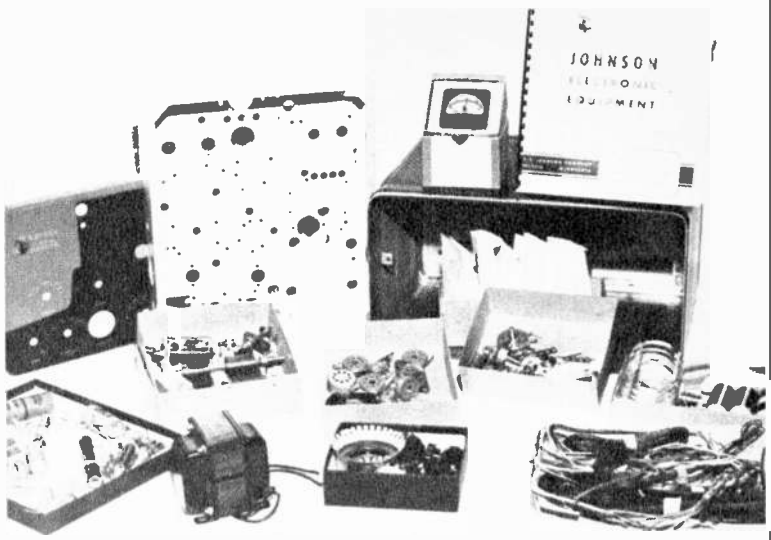
UNTIL fairly recently, an experimenter or hobbyist who wanted to make a piece of electronic equipment bought all the required parts individually, sometimes from several sources of supply; formed his own chassis out of sheet aluminum or bought blank panels and bases and drilled and cut all the necessary mounting holes himself; and then wired the unit in accordance with a schematic diagram. Now there's nothing wrong with this practice. It's interesting and educational. The only trouble is that it involves a lot of mechanical work not directly related to electronics and often beyond the facilities of beginners or more advanced people living in small apartments.

Today, a person interested in practically any phase of electronics can satisfy the do-it-yourself urge by buying packaged kits. These eliminate the laborious drilling, cutting and forming associated with chassis construction, but leave the builder the enjoyment of the assembly and wiring operations. With all holes and other openings already made in the pre-formed chassis members, assembly is a simple nut-and-bolt job. Step-by-step instructions and large picture diagrams make the wiring almost foolproof. Furthermore, the finished instrument has a clean professional appearance, very difficult to achieve with "home brewed" gear.

The first kits that appeared after World War II were for vitally-needed test equipment. The biggest seller, overnight, was

THE SECRET of kit success lies in the large, clear drawings showing all details of assembly and wiring. In this typical workbench scene (photo left) the drawings are shown mounted on cardboard for ease of handling. Only a few small hand tools are needed for the assembly.

SOME KITS contain hundreds of parts. This Johnson "Viking Ranger" (photo right), a powerful amateur radio transmitter, is representative of the more advanced units now on the market. Look at all the holes in the main chassis (rear row, second part from left) and consider how much work this pre-forming saves.



the vacuum tube voltmeter. Formerly, this was almost exclusively a laboratory instrument, costing well above a hundred dollars. When a complete kit was offered for less than twenty-five, the makers were swamped with orders.

The VTVM was only a beginning. It was followed in quick order by the cathode-ray oscilloscope, previously a luxury that experimenters only dreamed about; signal generators, tube checkers and audio oscillators; amateur radio transmitters of low and high power; complicated television receivers containing thirty tubes; Geiger counters; and recently, the biggest kit of them all, an electronic computer.

Hi-Fi Craze

When the high-fidelity craze hit the market, just as the television boom was flattening out in 1952 and 1953, the kit manufacturers were ready for it. It was a happy coincidence that the hi-fi and the do-it-yourself manias developed almost simultaneously. Doctors, lawyers and Indian chiefs, who didn't know a transformer from a tepee, plunged into the assembly and wiring of tuners, amplifiers and loudspeakers. They followed the instructions, and somewhat to their own surprise were rewarded with success.

The very nature of the hobby turns most hi-fi fans into boasters. You've heard them. "My amplifier is louder than your amplifier, so there." The hi-fi man who made his own system can become hard to take socially. At every opportunity he lets visitors know that he personally is responsible for the fancy equipment that pours out the beautiful music that fills the room.

One of the curious aspects of this kit business is that builders with absolutely no previous knowledge of electronics often have less trouble with the projects than some experienced radio men. The former follow the manufacturer's detailed step-by-step assembly and wiring instructions faithfully and carefully; the latter tend to skip over the instructions and to make what they think are short cuts.

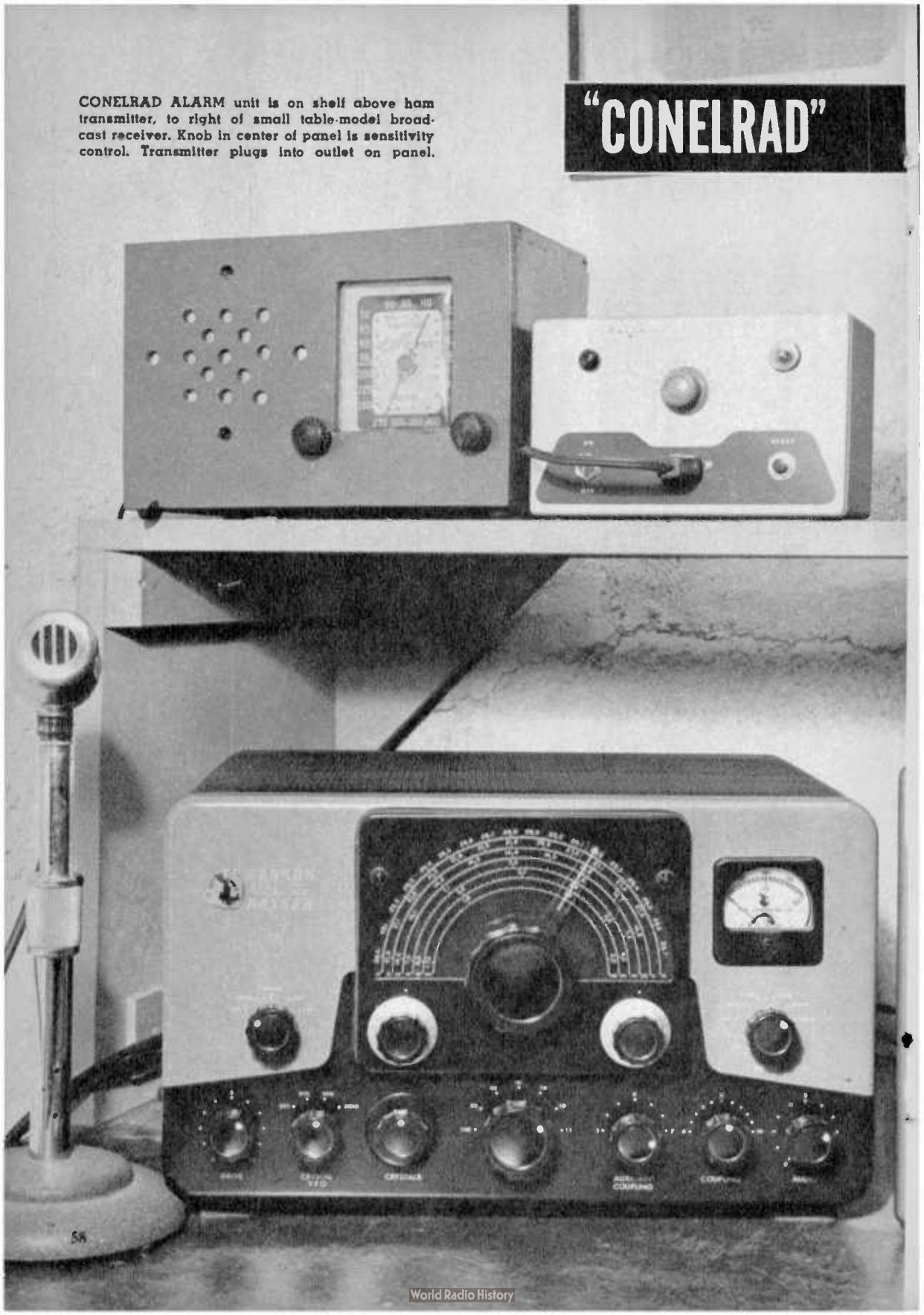
At one stage of the game, regular manufacturers thought that the kit people were crazy to put out packages containing hundreds of parts for really complicated things such as transmitters, tuners, etc.

"They'll go broke just handling complaints and repairs," they predicted.

They were wrong because they underestimated the desire, the willingness, the interest and the native manual skill of the current generation of American hobbyists. Of the many thousands of kits of several dozen types sold by the Heath Company alone since 1946, less than 2% had to be returned to the factory for check-up. In most cases the trouble was due to poor soldering.

Kit work has lead many young men into electronics as a career, and slightly older men into electronics as a fascinating hobby. They might not have the faintest notion as to what they are doing when they assemble their first kits, but they read into the subject and soon become well informed on it. Practical, first-hand experience with actual equipment, coupled with a moderate amount of study, turns many a beginner into an expert in a matter of months. •

"CONELRAD"



CONELRAD ALARM unit is on shelf above ham transmitter, to right of small table-model broadcast receiver. Knob in center of panel is sensitivity control. Transmitter plugs into outlet on panel.

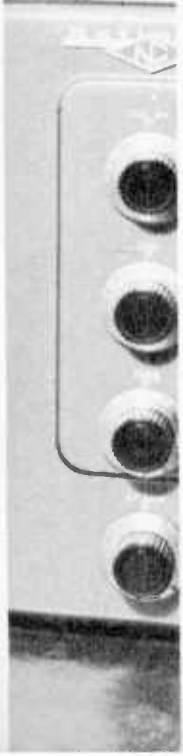
ALARM TURNS OFF TRANSMITTER

This important device is available in both kit and assembled forms

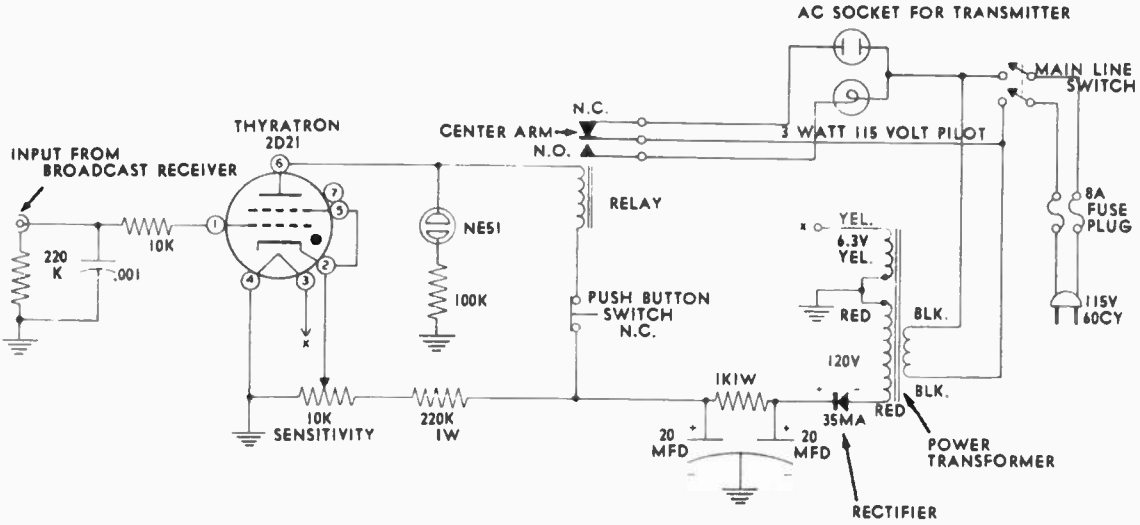
AS part of our overall Civil Defense plan, the government requires that operators of radio transmitters must have some means of determining when a "Conelrad" alert is in effect, and that they cease operation immediately upon hearing the alert. "Conelrad" is a coined word meaning "control of electronic radiation." The requirement applies to amateur stations as well as to others.

At the start of an alert, broadcasting stations will make suitable announcements, and then either close down themselves or change to the special Civilian Defense frequencies of 640 or 1240 kilocycles. Most broadcast receivers of recent production have these frequencies identified on their dials by the letters "CD."

The simplest way of observing the Conelrad rules is to keep a small table model radio set going at low volume next to or near the short-wave receiver of the ham "shack." This is satisfactory for a while, but eventually the background of music and commercials becomes annoying. A much better idea is



CONELRAD alarm chassis with parts mounted but not yet wired. Finger points to relay that turns off transmitter when alert is on.



SCHEMATIC
HEATHKIT CONELRAD ALARM
MODEL CA-1

to install an automatic Conelrad alarm. A number of these devices are available in both kit and assembled form. Since they are rather simple circuitwise, they are particularly popular as kits.

The new Heathkit Model CA-1 is typical. From boxed kit to finished instrument, my working time was under an hour. This is no particular record, as the unit uses only a single tube and a handful of other components. The tube is a type 2D21 thyratron, which is in effect an electronic switch capable of instantaneous response.

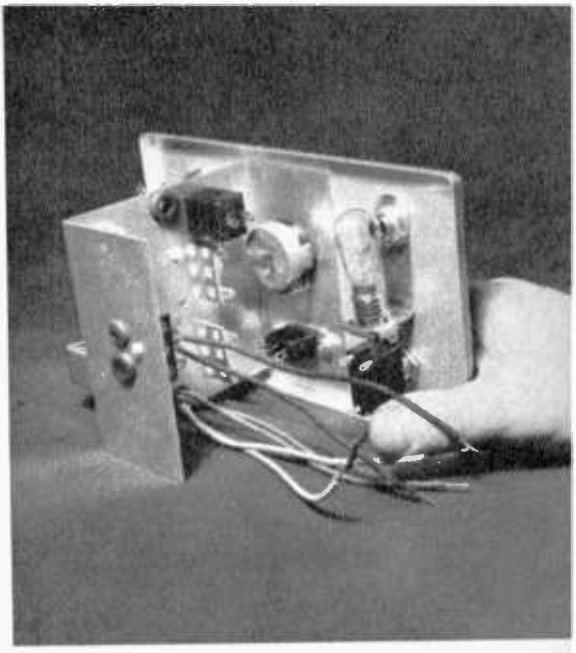
Follow the diagram for the details of the functioning. The grid of the thyratron is connected through a flexible shielded cable to the automatic volume control ("AVC") circuit of the broadcast receiver, which is left tuned to any local station. As long as the station is transmitting and its signals are being received, part of the negative voltage developed in the AVC circuit remains on the grid of the thyratron. This negative bias keeps the plate current of the tube, flowing through the winding of the relay, at such a low level that the relay is not energized. In this dormant state, the center arm of the relay makes contact with the upper arm. This is marked "N.C.", meaning normally closed. The transmitter, which is plugged into the top AC socket, thus receives power in the usual way from the AC line through the main line switch, a double fused plug, and the nearest AC wall outlet. The push-button switch in the relay circuit is also "N.C.", or normally closed.

When the broadcast station interrupts its transmission during a Conelrad alert, the loss of its signals in the broadcast receiver causes the thyratron in turn to lose its negative bias. The plate voltage, which is applied through the push-button switch and the relay winding, causes the tube to "fire"; that is, to flash instantly to a much higher plate current than existed before with the grid biased. This current makes the relay pull down its center arm to hit the lower contact marked "N.O.", or normally open. The N.C. contact to the transmitter socket opens, killing the transmitter. The AC is now applied through the N.O. contact to a 3-watt red pilot light, which is a warning to the operator that something important has happened.

Conelrad Connected

With a Conelrad alarm connected to it, the broadcast receiver is normally left silent; that is, the volume control is turned all the way counterclockwise. This mutes the loud speaker, but does not affect the AVC circuit. When the red light comes on, the operator will naturally turn up the

CONELRAD chassis, top view, completely wired. Thyratron tube is in the right front corner. Bottom wires are for AC power and AVC voltage from set.



BOTTOM VIEW of alarm chassis. In center are selenium rectifier, sensitivity control and transmitter socket; on right is the switch and pilot.

broadcast receiver, tune to one of the CD frequencies, and find out what's going on.

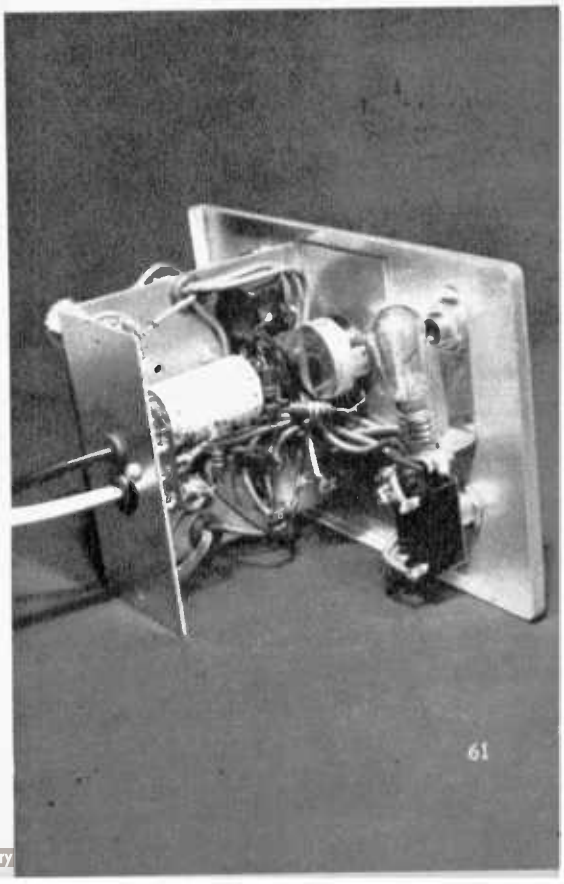
When the situation clears up, the operator retunes the receiver to the local broadcasting station and presses the push-button switch on the Conelrad alarm panel. This opens the plate circuit temporarily, deactivates the relay, and enables the negatively-biased grid to regain its reducing effect on the plate current. When the switch is released back to its N.C. position, the relay stays deactivated and the center arm returns to N.C., thus applying power back to the transmitter socket and to the transmitter.

If the transmitter is not on when the alert sounds, all that happens, of course, is that the red pilot flashes on.

Also connected in the plate circuit of the thyratron is a small NE-51 neon bulb. This merely indicates that the plate circuit is alive.

The tripping action of the thyratron is adjusted by a 10,000-ohm potentiometer functioning as a sensitivity control on the cathode and screen-grid elements of the tube. This control must be tried at different settings to match the signal strength of the broadcast station and the level of the AVC voltage developed in the receiver. A few minutes of experimenting puts the combination into operating order. •

COMPLETE ALARM CHASSIS with all parts and wiring in position. Unit in its cabinet measures only 7⅜ by 4 11/16 by 4⅛ inches; stacks easily.



THE KEY THAT UNLOCKS THE DX

A phone is fun, but you reach farther with a code transmitter

WITH THIS key radio plugged into CW transmitter, you literally open the air waves to the world. Operation is little slower than with voice, but more reliable.

MANY electronic experimenters who are interested in getting into the "ham" radio game do not appreciate certain important advantages of dot-and-dash ("code") transmission over voice operation. The fact that code transmitters are much simpler and cheaper than phone outfits is only incidental. The significant point is that communication by dots and dashes is much more reliable, can be accomplished with much lower power, and is much less susceptible to interference than the microphone method. Hams refer to code transmission as "CW," meaning "continuous waves," so let's do the same here. See "The Code Is a Must," *Electronic Handbook* No. 319.

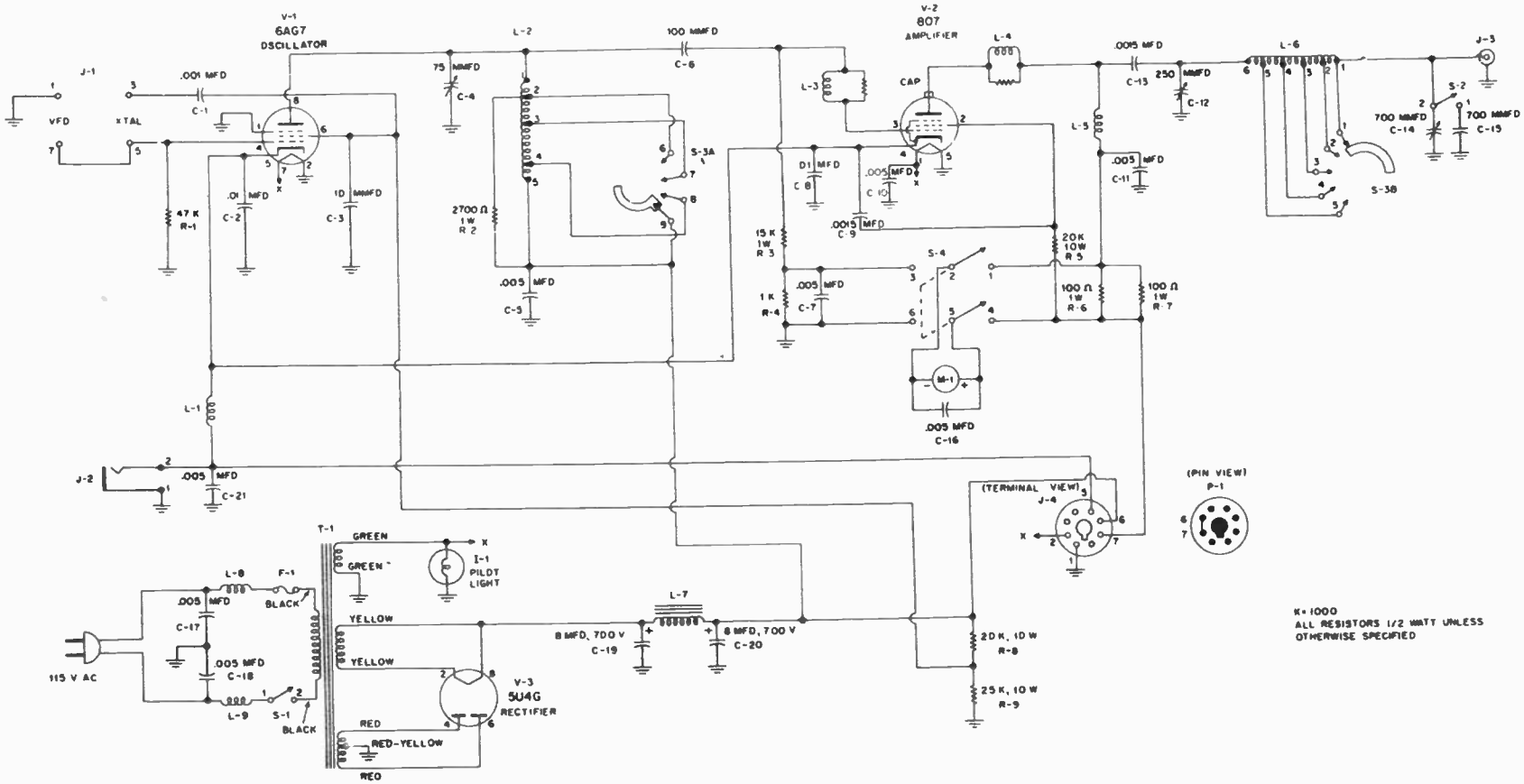
Voice signals occupy a rather broad slice of space on a tuning dial. Two or three signals that are very close to each other in terms of kilocycles have a tendency to interact and give rise to secondary signals. The net result is usually a high-pitched mixture of squeals and whistles, and *all* the original signals are likely to lose their intelligibility. CW signals, on the other hand, require only very narrow spaces on the air.

The usefulness of a CW signal depends only on its presence. The dots and dashes can be distorted or mixed with random noise and interference. As long as some signals are short sounds, representing dots, and others are slightly longer sounds, representing dashes, they can be recognized as characters of the alphabet. The sounds can be pleasant whistles or raucous grunts; if they can be heard as short and long whistles or grunts, they make sense. Some skilled operators can even "read" two different messages coming in together on one dial setting.

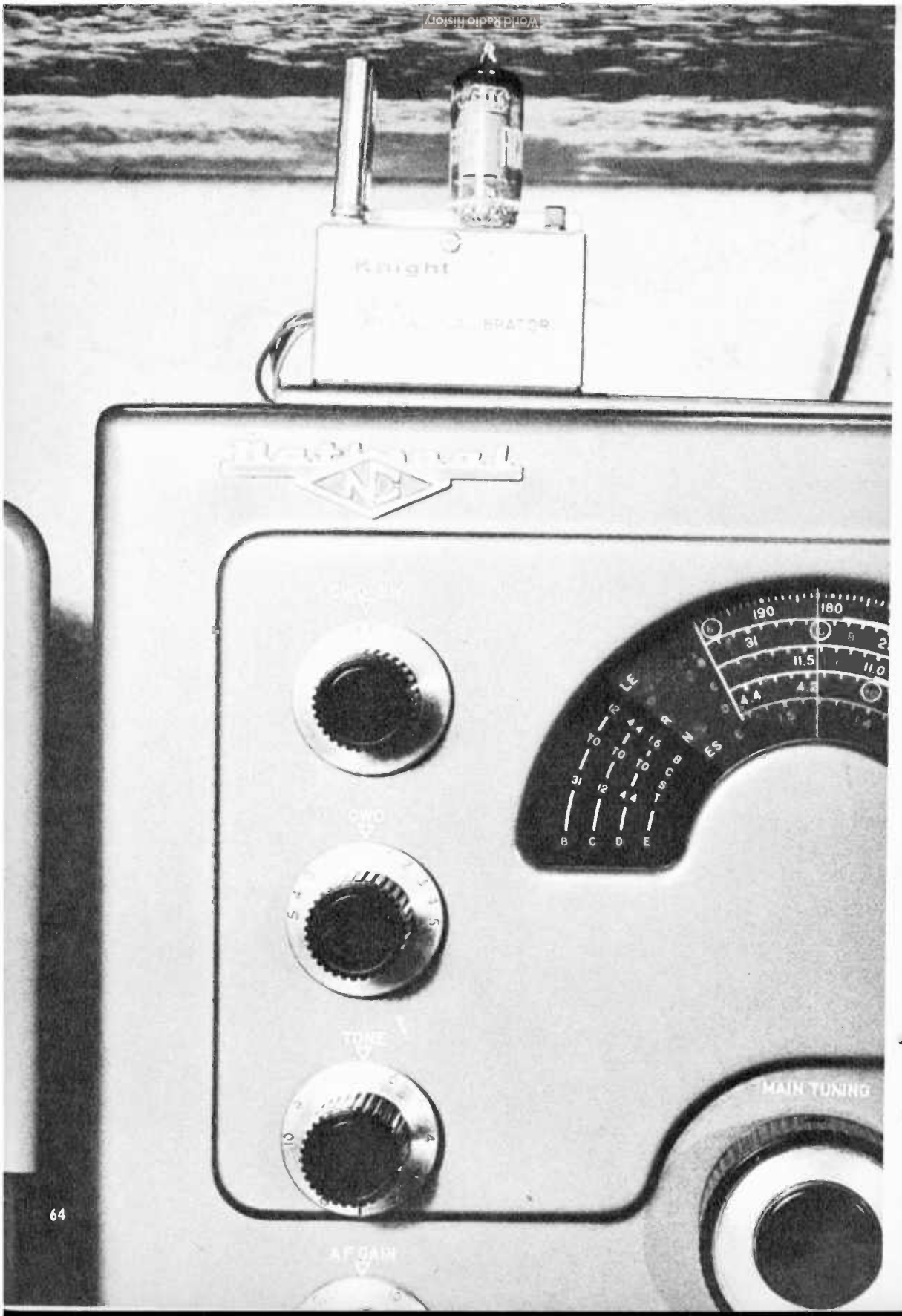
It takes a fairly strong signal to make itself heard these days on the busy ham phone channels. It would be more accurate to say ". . . to make itself heard and understood." Many signals can be heard, but they are drowned out in the interference of stronger signals. However, hams with CW transmitters of extremely low power often "work" other hams thousands of miles away. By "low power" is meant as little as 1/20 of a watt, which isn't enough to make a flashlight bulb even glow.

The beginning ham who takes out a novice grade license initially, instead of the General class, is more or less forced into CW operation if he wants to work distance ("DX"), as the only phone bands available to him are suitable mainly for local or short-distance communication. If he's smart, he'll buy the best receiver he can afford, and a straightforward CW transmitter of low power. After he gains operating experience and the General license, he can readily add a modulator for voice operation.

Assembling and wiring a CW transmitter from a kit is a very good way to obtain practical knowledge of basic ham equipment. Several excellent medium-power units are available. •



THIS SCHEMATIC DIAGRAM of the Knight 50-watt CW transmitter illustrates the simplicity of equipment of this class. Only two tubes plus a rectifier are used. The transmitter is available in kit form and makes an interesting assembly project for the beginning ham.



USING A CRYSTAL CALIBRATOR

It's highly recommended to insure accurate frequency adjustment

FOR many purposes, it is important to be able to tune a short-wave receiver precisely to a specific frequency. Ham operators must know the exact limits of the amateur bands, because it is a serious Federal offense to transmit above or below the defined edges. People who are interested in picking up foreign broadcasting stations must know where to "spot" them on the dial without wasting a lot of time tuning back and forth.

The dial calibrations of the popular, medium-price short-wave receivers are only an approximation. Fortunately, it is a simple and inexpensive job to add a crystal-controlled calibrating unit to any set. This consists basically of a very accurately ground 100-kilocycle crystal and a single small tube. Filament and plate voltage are picked off from the receiver itself. The power requirements are so slight that the latter is not strained at all: only 150 milliamperes at 6.3 volts AC for the filament and 3 milliamperes at 150 volts DC for the plate.

Fundamental Frequency

The fundamental frequency of oscillation of the calibrator is, of course, that of the crystal, 100 kilocycles. This rather low value is used because a very accurate low-frequency crystal is made much more easily and cheaply than a high-frequency crystal. The circuit produces harmonics (corresponding to *overtones* in musical parlance) every 100 kc up the scale, all the way to about 30,000 kilocycles, or 30 megacycles. That is, after the fundamental, the next signal detectable in a receiver is 200 kc, the next 300, the next 400, etc. After 1000 kc, the next is 1100, then 1200, 1300, and so on.

Even the very slightest deviation from the indicated fundamental crystal frequency is multiplied to such an extent in the upper harmonics that the latter becomes useless for calibration purposes. Crystals intended for calibrators are ground to hit 100 kc right on the nose, and are marked 100.000 kc to show that their harmonics can be trusted arithmetically.

Calibrator Parts

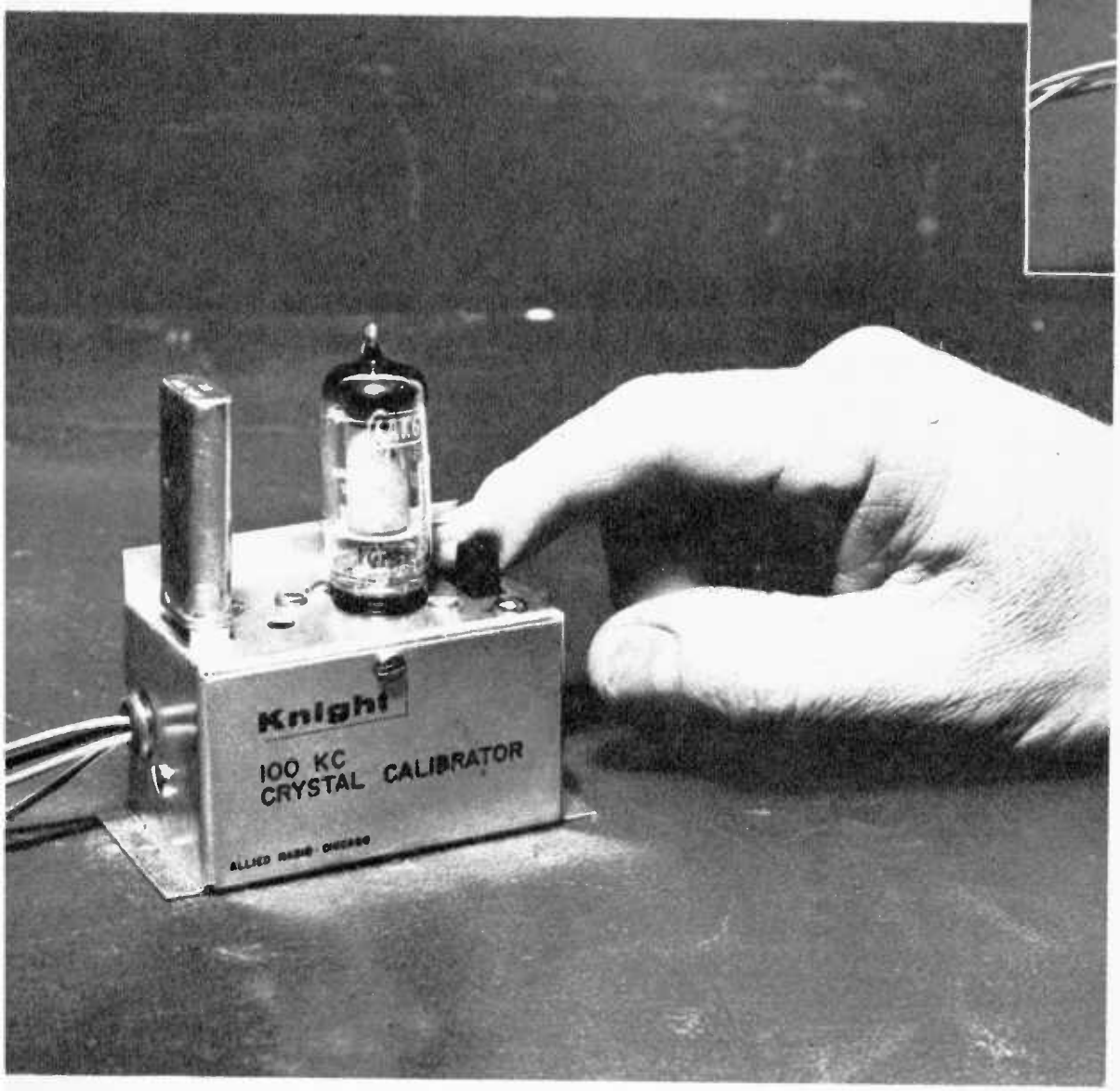
Besides the crystal and the tube, a calibrator contains a few small resistors and capacitors and a small choke coil. An excellent little unit in convenient kit form is the Knight job, pictured herewith. Since the chassis was already formed and punched, assembly of the parts took me only about ten minutes, and wiring fifteen more. The completed calibrator measures only 3 inches long, 1½ inches wide and 3¼ inches high to the tip of the tube. It can be mounted inconspicuously on top or next to the short-wave receiver, or even inside if the latter has a hinged lid. Access to the calibrator is needed, to turn the plate voltage on and off when calibrating signals are desired. The tube filament stays on with the tubes of the receiver.

The signals of the calibrator are conducted into the receiver by the wire marked "Output." This is connected to the aerial binding post of the set.

There is no quick way of identifying each harmonic in terms of its own frequency; the successive harmonics are merely 100 kc

SO SMALL it is almost lost on top of the short-wave receiver (photo across page), the crystal calibrator is accessible but inconspicuous. The four wires from the unit enter the set under the set's hinged cover.

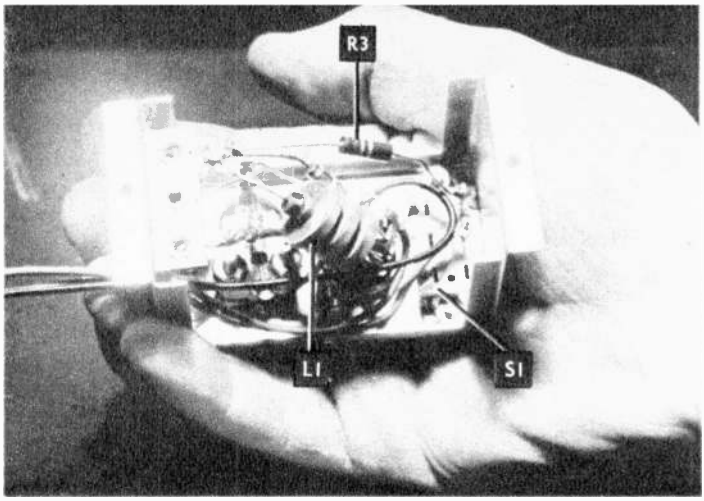
CRYSTAL is metal-cased, plug-in unit at left. Finger is against plate-voltage switch. Lips on back and bottom of aluminum box permit mounting the calibrator to inside or outside of receiver.



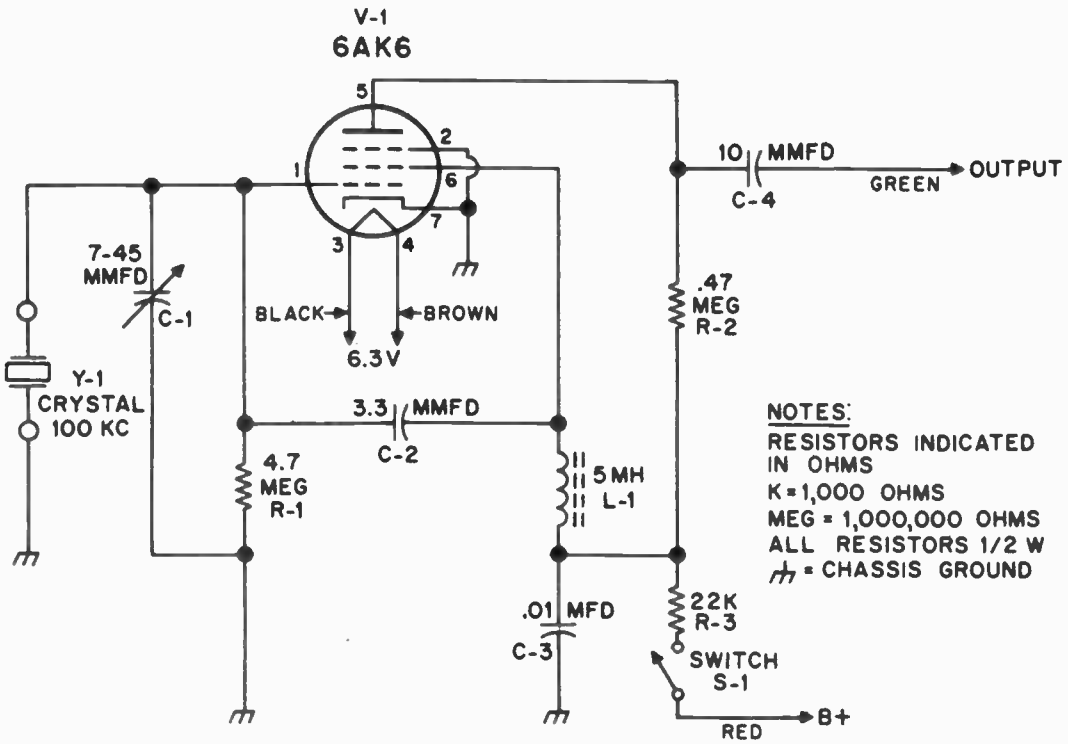
apart. Therefore, it is necessary to follow the receiver's dials and to note where the calibrator's signals fall. Most short-wave receivers have a main tuning dial and a bandspread dial. With the latter set to an even frequency corresponding to an expected harmonic, the main dial is then adjusted to bring the harmonic in.

With the bandspread dial fixed, it is possible to obtain a number of settings of the main dial, 100 kc apart, that produce calibration signals. However, the dial markings of even the lowest priced receivers are sufficiently close to show the correct frequency.

If the dial markings are suspected for any



THE ENTIRE calibrator (photo left) is a mere handful. Cover of case has been removed to show parts inside. Markings are same as in diagram.



CIRCUIT DIAGRAM of crystal calibrator is very simple. C-1 is a small trimmer capacitor for zeroing unit to standard frequency station such as WWV. L-1 is small choke coil. Switch S-1 controls only the plate voltage to the 6AK6 oscillator tube. The filament of the tube, terminals 3 and 4, is wired permanently to any 6.3-volt filament in the receiver. The calibrator thus comes on automatically with the latter.

reason (possibly the scale slipped at one time and was retightened improperly), they can be double checked against the standard frequency transmissions of stations WWV and WWVH. See the article entitled "Is Your Short-Wave Receiver Accurate?" in "Practical Electronics," No. 1, page 66.

The frequency accuracy of most broadcasting stations is exceedingly high. This is true of regular amplitude-modulated and frequency-modulated transmitters as well as of short-wave stations. These stations announce their frequencies at regular intervals, and represent convenient reference points for checking of dial settings. •

GOT THE RIGHT TIME?

The best way to keep track of Greenwich Civil Time schedules is with a clock which has a 24-hour face

EVERY new owner of a short-wave receiver soon learns that clocks in his house set for local time are of little help to him in keeping track of foreign programs, ham schedules, etc.

Because of the way the earth revolves on its axis in relation to the sun, the areas of daylight, darkness, dusk and dawn shift constantly. When people in New York are getting back from lunch at 1:00 p. m., their cousins in Los Angeles are having their 10:00 a. m. coffee break, while friends in London are piling into the 6:00 p. m. trains headed for home. Time changes one hour for approximately every 15 degrees of longitude. The dividing lines are usually natural or political boundaries.

Basis for Time System

In the temperate latitudes, 12 o'clock noon is represented by the highest overhead position of the sun, although this is often modified by the local adoption of one or two hours of "daylight saving" time. For international purposes, the starting place for the figuring of time has long been the imaginary line of 0 degrees longtitude running from the North Pole to the South Pole through an astronomical observatory in the Greenwich area of London, England. Hence the expression "Greenwich Time," abbreviated correctly as "GCT," meaning Greenwich Civil Time. In the GCT system, which is the basis for all international radio schedules, the 24-hour day starts at midnight and all times are expressed in four figures without "a. m." or "p. m." The first two figures give the hour, the second two the minutes past the hour. The moment of midnight is 2400 hours, which is stated verbally as "twenty-four hours" or "twenty-four hundred." The first minute of the new day is then 0001; half after the fourth hour is 0430, and a quarter after the tenth hour is 1015. Noon is 1200 hours, but the next hour, note carefully, is 1300. The sixth hour after noon is 1800, and three-quarters after the next hour is 1945. The elimination of the "a. m." and the "p. m." designations makes it impossible to confuse morning and evening times, a frequent and common experience when the usual 12-hour system is used.

Clock Useful and Impressive

The only way to keep track of GCT schedules is with a clock having a 24-hour face. This makes an attractive and useful addition to any radio shack or den, and in addition is an interesting conversation piece for visitors. It is such an important accessory that dealers in amateur equipment stock it regularly. An impressive one ten inches in diameter costs about $15. •

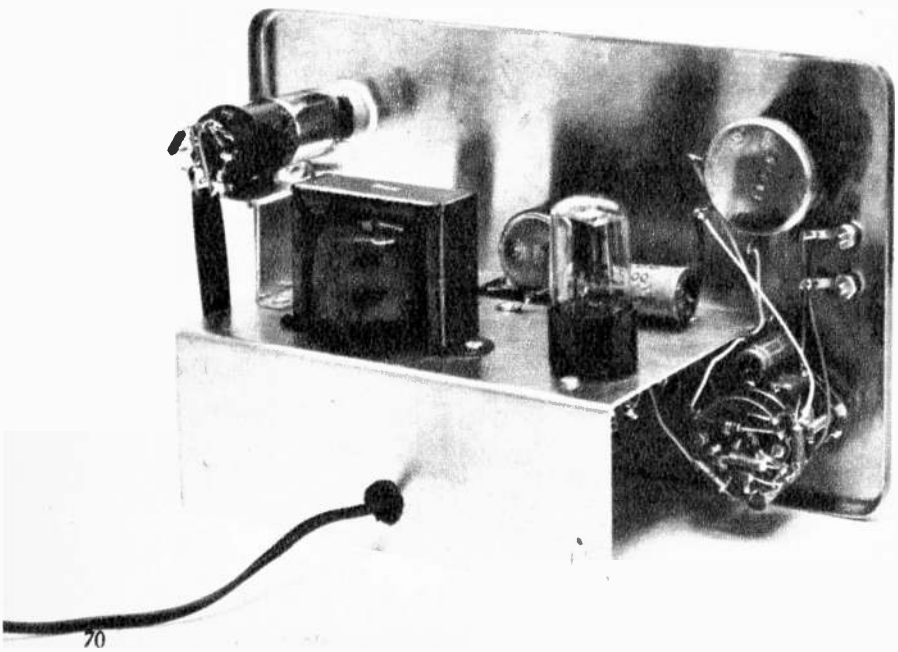
A BIG CLOCK with a 24-hour face is prominent on the wall of the well-equipped ham shack of Al Pichitino, WEDX, of Waseca, Minn.

CHECK CAPACITORS WITH A BRIDGE

A "bridge" test determines a capacitor's value and internal condition

IT IS very easy to determine both the value and the condition of resistors of all sizes by means of an ordinary combination voltohmmeter. With the latter set for resistance measurement, you apply the test leads to a resistor. If the meter reads, you know that the resistor is good, and you also learn its value in ohms. If the needle doesn't move, the resistor is worthless for any purpose. This quick test is possible because resistors pass direct current in direct proportion to their resistance. The flashlight batteries in multimeters are a very convenient source of that current.

Except to determine if they are completely short circuited, a multimeter is of little utility in checking capacitors, because they do not pass direct current at all. They do pass alternating current, but



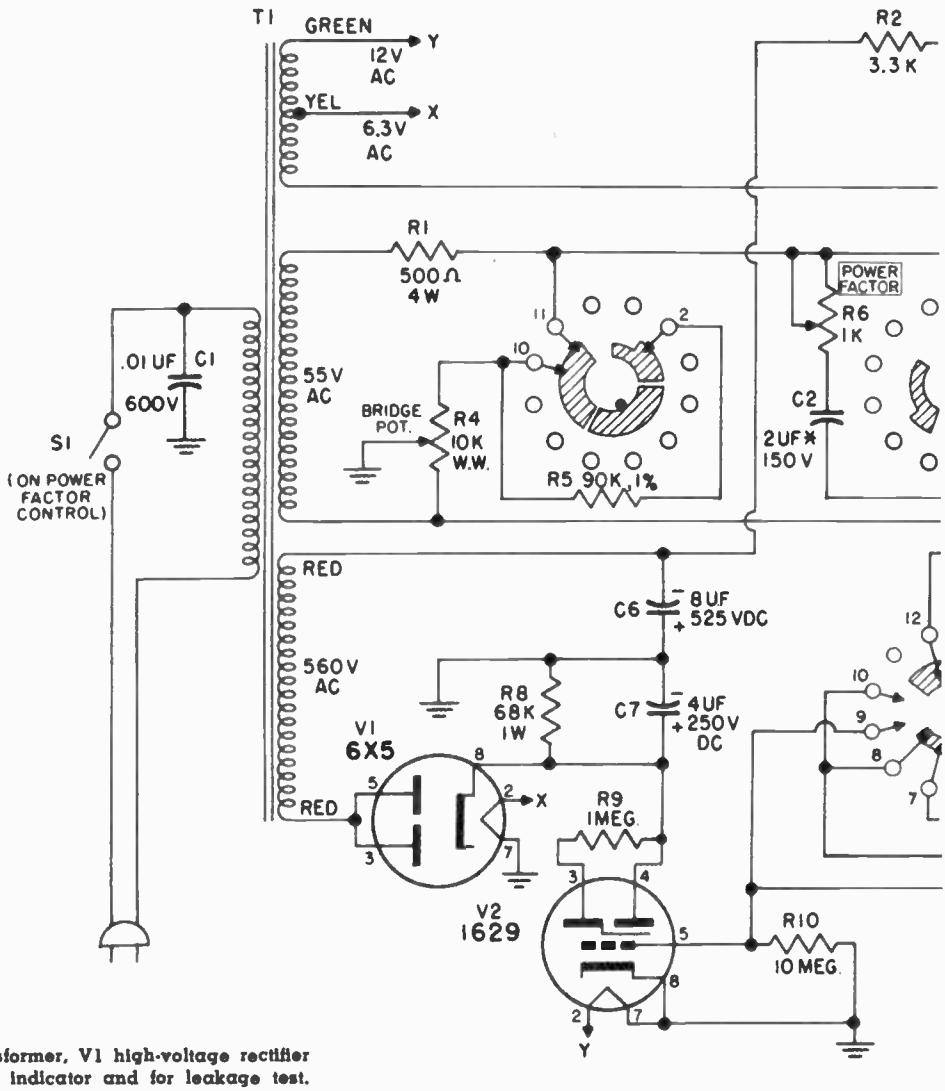
ARE THESE capacitors any good? A "bridge" test reveals not only their capacitance but their internal condition. A typical set up, using the new Paco Model C-20 Bridge, a kit job, is shown in photo above. Inside view of Paco Model C-20 Resistance-Capacitance-Ratio Bridge, made from a kit, is shown in photo left. Magic-eye indicator tube is at upper left; power transformer and rectifier tube along back of chassis, with bridge potentiometer between them, on front panel. Voltage control for leakage test is upper left.

their reactance (the AC equivalent of resistance) depends on the frequency of that current. For really significant testing of capacitors, the preferred instrument is a "bridge," so called because the schematic diagram of the basic elements resembles the arrangement of cables and towers of a typical bridge. The electrical bridge principle was developed more than a century ago, has long been used in laboratory equipment, and is now earning new appreciation on the part of the current generation of electronic experimenters, hams and service technicians.

Some excellent bridges at low prices, in both kits and assembled form, are now on the market. They are simple construction projects, as they consist mostly of small capacitors and resistors and a multiposition switch for bringing them into the circuit. These are important because they are accurately measured units, and are the standards against which the capacitors under test are compared. Practically all the popular bridges provide resistance as well as capacitance measurement because this extra facility can be included at virtually no extra cost.

An extremely valuable feature of a bridge is the leakage test, under which a capacitor is subjected to its rated operating voltage and its behavior then observed. The indicator in the bridge is a "magic eye" electron-ray tube, which is very sensitive.

A capacitor intended to keep voltages out of certain portions of a television, radio or amplifier circuit should not show any internal leakage. If it lets even a minute current flow through, the operation of the equipment can become very erratic and very difficult to diagnose. This is especially true of TV sets, in which a dozen or more voltages of widely different frequencies and values must be kept under

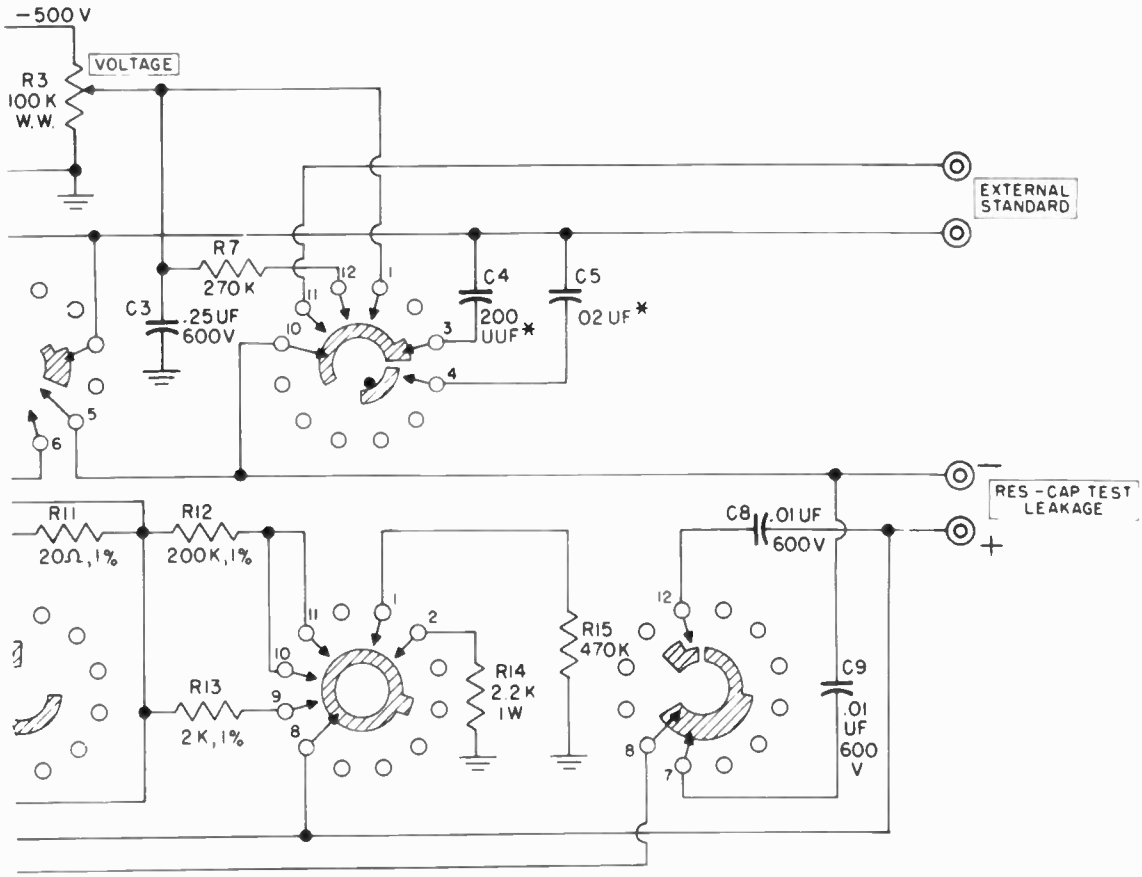


T1 is power transformer, V1 high-voltage rectifier for V2 magic-eye indicator and for leakage test. R4, marked "bridge pot.," is the main control in the center of the front panel of the instrument.

absolute control or the picture goes to pot. "Intermittents," by far the worst kind of trouble in electronic apparatus of any type, are in most cases due to creeping leakage in capacitors.

It is very interesting to take a handful of common paper dielectric capacitors and to run them through a leakage test. Very clearly, the voltage rating figures marked on some of them are on the optimistic side. In trying out the Paco Model C-20 illustrated on these pages, I tested several dozen capacitors that had accumulated in a cigar box labeled "Odd Caps." Some unbranded paper units marked "400 volts DC working" seemed OK at 150 and 200 volts, made the magic eye flicker a little at 250 volts, and leaked like sieves at 300 volts. They went into the trash can in a hurry! By way of contrast, some new ones rated at 400 volts showed no sign of leakage even at 500.

The Paco Model C-20 Resistance-Capacity-Ratio Bridge is a brand-new entry in the kit field. It makes up into a very professional looking instrument 11½ inches wide, 7 inches high and 5 inches deep. The two-tone scales, of white and yellow against a gray background, are wide open and especially easy to read. The range of measurements is very great: from 10 micromicrofarads through 2000 micro-



PACO MODEL C-20 SCHEMATIC

NOTES

1. ALL RESISTORS ARE 1/2 W ±20% UNLESS OTHERWISE NOTED
2. RANGE SWITCH (S1) SHOWN IN EXTREME COUNTER-CLOCKWISE POSITION (10-5000 UUF) ALL SECTIONS VIEWED FROM FRONT
3. ▭ INDICATES MARKING ON FRONT PANEL
4. * INDICATES PRECISION CAPACITOR

farads for capacitors, and from ½ ohm through 200 megohms for resistors.

While the resistance-measuring feature of the bridge is incidental to the primary capacitance checking function, it proves useful and time-saving when the only multimeter in a shop is tied up for voltage measurements or other purposes. For resistors of very low value, i.e., below a couple of ohms, the bridge is more accurate than most multimeters.

When the bridge is set for the measurement of very small capacitors, the capacitance of the test leads alone should be taken first, and this value subtracted from the reading given by the instrument. Leave the leads open, stretched out flat, and separated about an inch. At values above 50 mmf., this precaution is not necessary.

Since acquiring a sample bridge, I check all capacitors for value and leakage before using them in new equipment or as replacements in old, and I discard about two out of ten because they don't come within reasonable distance of their marked ratings.

Although the name "Paco" is new, the manufacturers of the line are not. Actually, Paco is a division of Precision Apparatus Co., Inc., of Glendale, Long Island, for more than twenty-five years a producer of high-grade test equipment. •

HOW TO MOUNT AN OSCILLOSCOPE

It's easy if you'll follow these instructions

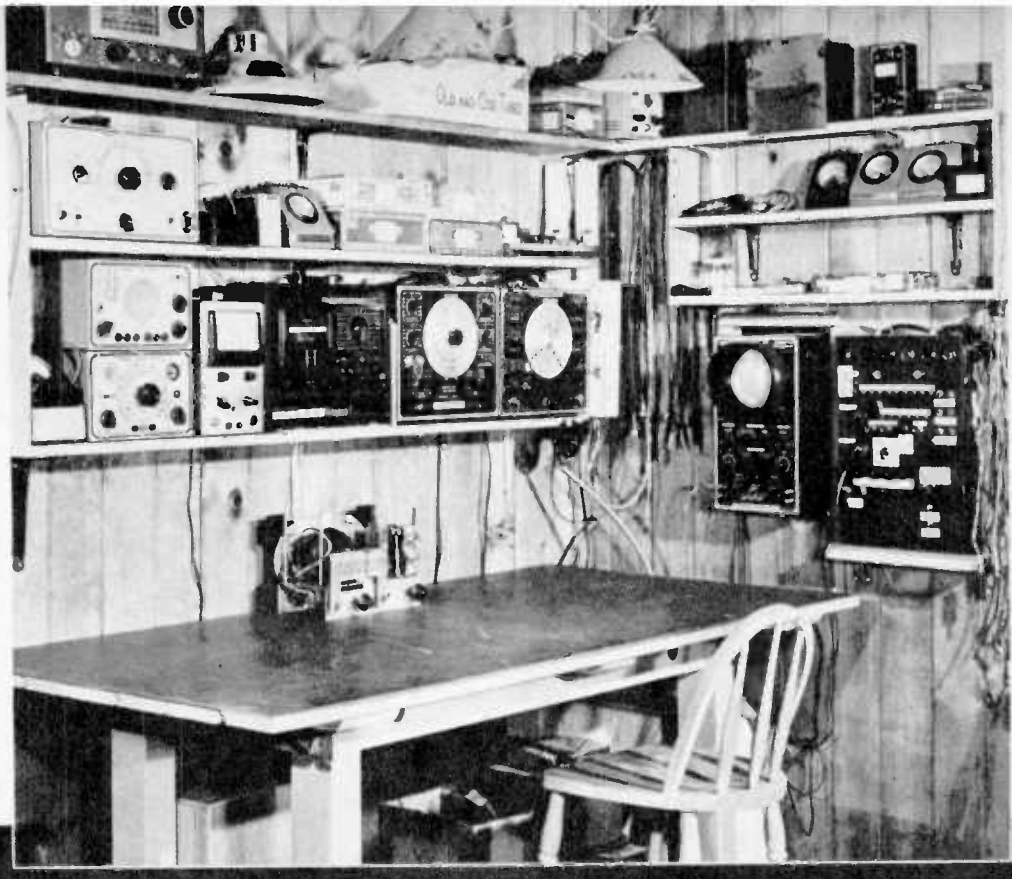
THE cathode-ray oscilloscope is one of the most useful and interesting of all the tools used by electronic experimenters, engineers, service technicians, and hams. It is also the largest and the most awkward. It has a relatively small frontal area but considerable depth, whereas practically all other test instruments are flat and shallow. Just finding a comfortable spot for a scope on a crowded bench top can be something of a problem.

In most shops and labs, the best place for a scope is on a separate little table fitted with casters, so that it can be moved around. This arrangement is widely used in service shops because it leaves the bench top free for large television and hi-fi chassis. The construction of a suitable table is a very simple job of woodworking.

For legs, scrap lengths of 2x3's or 2x4's are used. The top can be a piece of ½ or ¾-inch plywood, or two pieces of ¾-inch shelving, side by side. Before cutting the legs to length, measure the height of the casters, add the thickness of the top, and figure the legs so that the top of the completed table will be level with the top of your workbench. The table shown in the photo above has legs 31 inches long.

The cross braces, about six inches off the floor, are three-inch wide pieces of shelving, notched into the legs and fastened with flat head wood screws. The top is secured to the legs by means of 5x7-inch shelf brackets, on the narrow inside surfaces of the legs. A plywood shelf, nailed to the bottom cross braces, is a very convenient spot for other test equipment. The photo shows a loud-speaker in a plywood box, cut to fit neatly between the legs.

For a five-inch oscilloscope, the largest used in most shops and labs, a suitable top measures 12x22 inches. The legs are spaced 11 inches in front, 20 inches on the side.

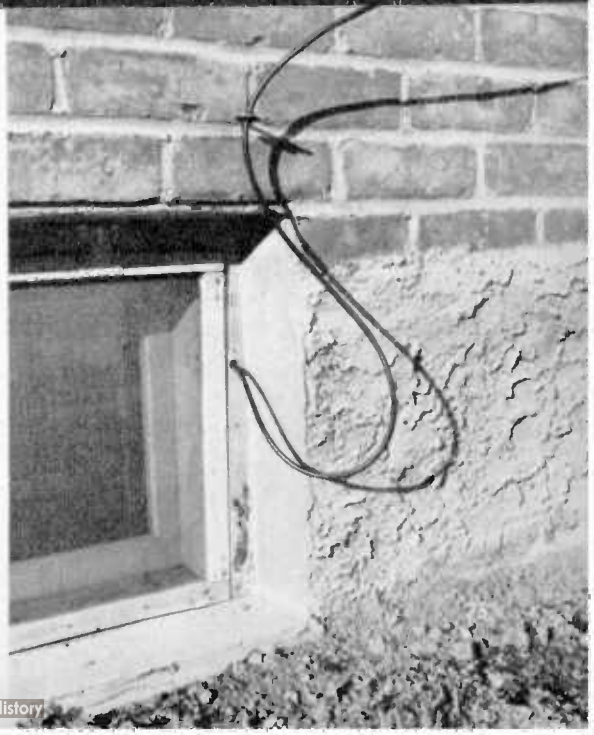


ON CASTERED TABLE (photo left) this 5-inch scope is easily, quickly moved to convenient position next to workbench. Bottom shelf holds speaker. Although 19 inches deep, cathode-ray oscilloscope (second from right, above chair in photo above) occupies little wall space. Body of scope is behind wall. Opening in wall is one inch larger all around body, so scope can be removed easily for inspection, cleaning. Lead-in wire of radio or TV aerial (photo below) can conduct rain as well as entertainment into house if run straight through window. Always form loop in it, to allow water to drop off harmlessly.

Before assembling the wood members, smooth them thoroughly by planing and sanding. A coat of paint gives a finished appearance.

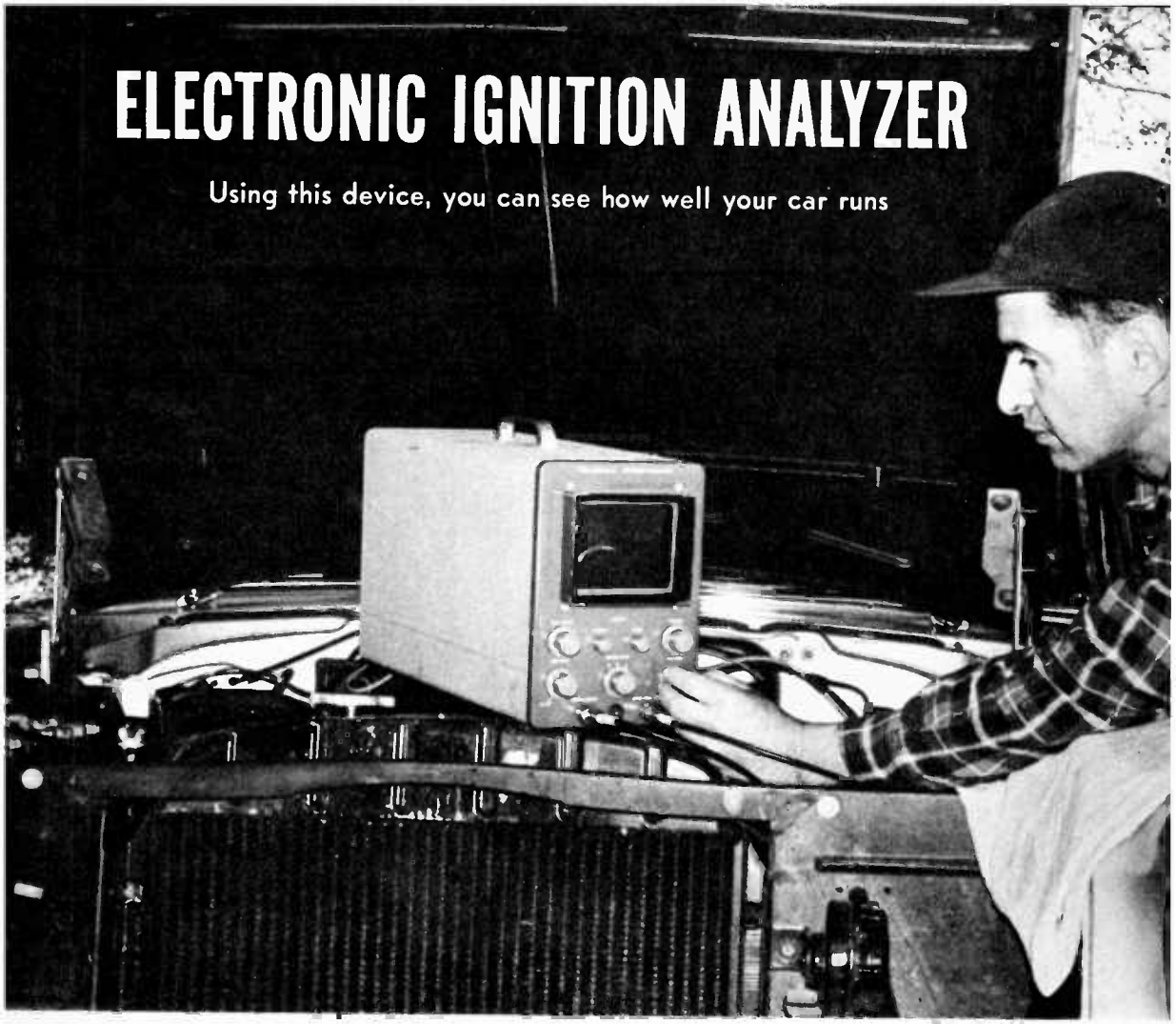
Use common socket-type casters for the legs. These require 3/8-inch holes.

If the room construction permits it, a very good place to mount a scope is right in the wall above the workbench, as shown in the photograph above. Cut an opening slightly larger than the front of the scope, and install a small shelf on the rear of the wall to support the weight of the instrument. The front need protrude only enough to leave the controls and the binding posts easily accessible. In the shop pictured, the right wall faced the oil storage tank in the basement of a house, and there was plenty of space for the deep body of the scope. The front wall could also have been used, as part of it faced a flight of stairs. •



ELECTRONIC IGNITION ANALYZER

Using this device, you can see how well your car runs

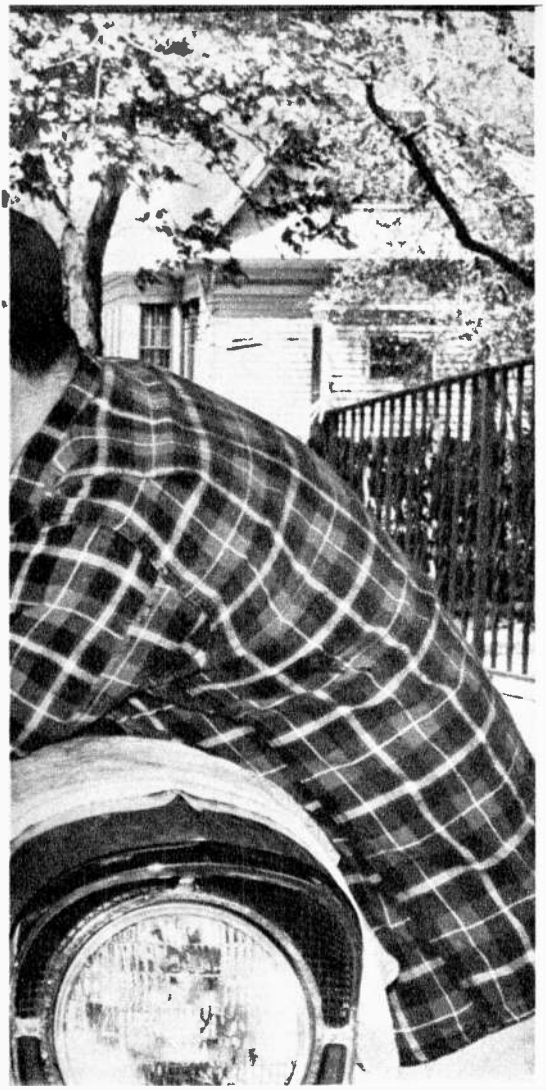


IT LOOKS LIKE a small television receiver, but its "pictures" are wavy green lines which show ignition system of car in action. The Heathkit "Ignition Analyzer" is a fascinating, new, automotive instrument.

THE functioning of a spark plug in an internal combustion engine is rather simple. Just after an upward movement of a piston has compressed a mixture of air and gasoline vapor in the top of a cylinder, the ignition coil shoots a strong jab of high voltage across the separated points of the plug. A small electrical flame jumps the gap. This flame ignites the air-gas mixture, causing it to explode and to push the piston downward. This is the power stroke of the common four-stroke automobile engine.

It has long been known by electronic engineers that the spark plug is much more than a match. The ignition system of a car acts almost exactly like the spark-type transmitters used universally for "wireless" communication prior to World War I. In fact, an ignition coil out of the original Model T Ford was the mainstay of many early "ham" stations. To this day, an untreated ignition system is a troublesome source of interference over a wide band of frequencies. Noise-free reception with a car radio is possible only if "suppressors" in the form of resistors and capacitors are connected to the high-voltage coil and the generator.

The post-World War II sports car hobby attracted many electronic engineers and experimenters. It occurred to some of them



that they might treat the ignition system as a radio transmitter, hook it to a cathode-ray oscilloscope, observe the form of the ignition current as the engine ran, and thus obtain valuable information as to ignition performance. They ran into some problems, mainly involving the dangerously high voltages that run around in the spark plug wires, and they achieved some success. They didn't pursue the matter as thoroughly as they might have liked, because they were too busy at the time with television. One commercial scope-type checker did reach the automobile market, but its price of around five hundred bucks was unrealistic and discouraged many of the prospective customers.

The engineer-car enthusiasts who work for the Heath Company, the well-known kit firm, were very happy recently to take on the "electronic ignition analyzer" as a development project. They have come up with a practical, easy-to-use instrument which costs only sixty dollars as a complete kit and is therefore sure to be a success. It is not merely a regular oscilloscope with an ignition adapter, but a completely new piece of equipment.

I happened to be visiting the Heath plant in Michigan just when the first test samples of this analyzer were going through the laboratory. I "borrowed" one for trial, and now have endless fun idling my car or friends' cars in my driveway while we watch the face of the screen. My neighbors are quite certain that I am trying out a new automobile television set. With its rectangular screen mask and elongated case, the analyzer certainly looks like one.

As a construction project, the analyzer is no more difficult than a regular 'scope, a test meter or a hi-fi amplifier, all of which have been assembled and wired by the thousand by people with little or no previous experience in either electronics or soldering. In finished form it is quite a handful. The front panel is 6½ by 11 inches, the case is 20 inches deep, and the weight is 16 pounds. The "picture tube" is five inches in diameter, and is fitted with a shadow mask to give an effective screen size of 3x4 inches.

Two long leads are provided for connection to the engine. The input lead has two wires with clips. One goes to the low-voltage breaker terminal on the ignition coil, the other to any clean "ground" on the engine. The second long lead has only one wire, terminating in a wide clip that not only looks like an ordinary paper clip but *is* an ordinary paper clip. This is attached to *but not metallically connected* to the center high-voltage wire of the ignition coil, to the No. 1 spark plug wire, or to any of the others in turn. The jaws of the clip merely touch against the rubber insulation. Since the latter is very heavy, and prevents current leakage even where the wires touch against the engine, the clip can be moved from wire to wire without danger of shock. I know because I have done it scores of times.

If the paper clip doesn't actually connect to the wire, what *does* it do? The surfaces of the clip are parallel to a facing length of wire inside the insulation; the combination forms a very small capacitance on the order of a few micromicrofarads. This is

THE HEAVY TEST leads of the analyzer are 10 feet long, permitting the instrument to be set up on a bench adjacent to the car. The low-voltage breaker point lead, with its two connector clips, is on the left. On the right, the hand is holding the paper clip that goes around but does not connect to a spark plug wire. Front panel controls of ignition analyzer are similar to those found on standard oscilloscope.

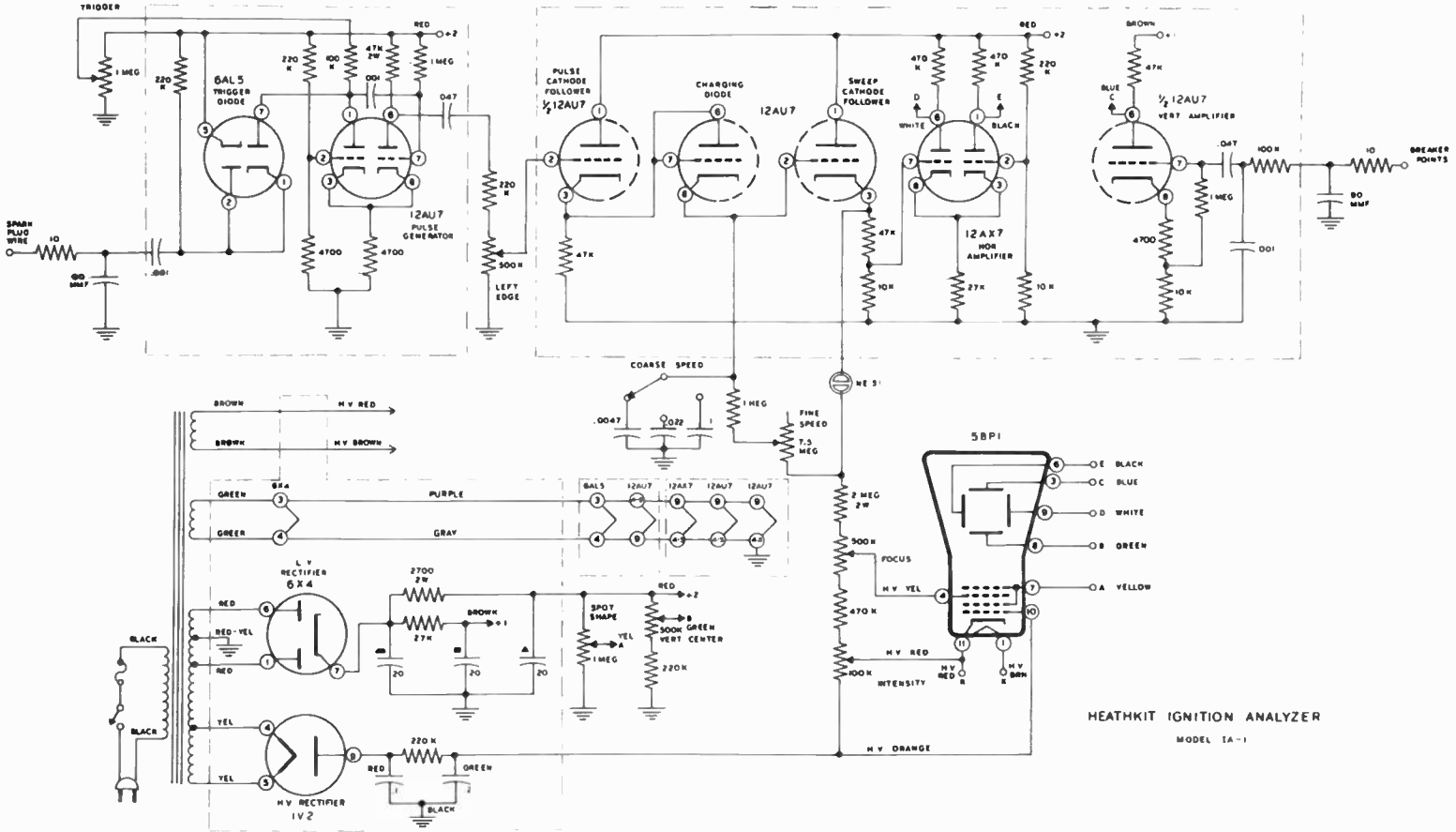
enough to pass a minute part of the sparking voltage, in the form of pulses, to the oscilloscope. Here they trigger the internal horizontal sweep oscillator correctly in relation to the pulses of current passed to the scope by the connection at the breaker points. Since the ratio of breaker point openings and closings to spark plug firing in any engine is fixed, varying the engine speed does not change the "display" of wavy green lines on the screen. Neither of the two scope connections has the slightest effect on normal engine operation, a very important consideration.

All the "information" displayed on the scope as lines is obtained from the connection to the breaker points. The low voltage, six or twelve, comes directly from the breaker connection to the primary of the ignition coil; the shape of the high voltage in the secondary is reflected back to the primary by ordinary transformer action. We don't ordinarily think of an automobile ignition "coil" as a transformer, but that's precisely what it is. It contains a primary winding of a few turns and a closely overwound secondary of many turns; the voltage developed in one coil under the influence of a voltage in the other coil is in exact proportion to the turns ratio, just as it is in a power transformer in a radio or TV set, a bell-ringing transformer, a toy train transformer, etc.

The diagrams shown on page 81 are line drawing reproductions of actual photos of ignition displays made off the face of the cathode-ray tube with a Polaroid camera. They represent normal, good ignition performance. Diagram 1 shows the firing of four cylinders. The controls of the analyzer can be adjusted to show all six or eight cylinders of a car, or for closer study, just one at a time, as in diagram 2. In the latter, the flat line D-A represents the period of distributor rotation when the breaker contacts are closed; in auto parlance this is called the "dwell time." Smooth direct current from the car's battery is flowing through the primary of the ignition coil. A strong magnetic field created by this current in the primary also permeates the secondary. This field is stationary, and has no effect on the secondary winding; the latter is dead electrically and there is no ignition anywhere in the spark plug system.

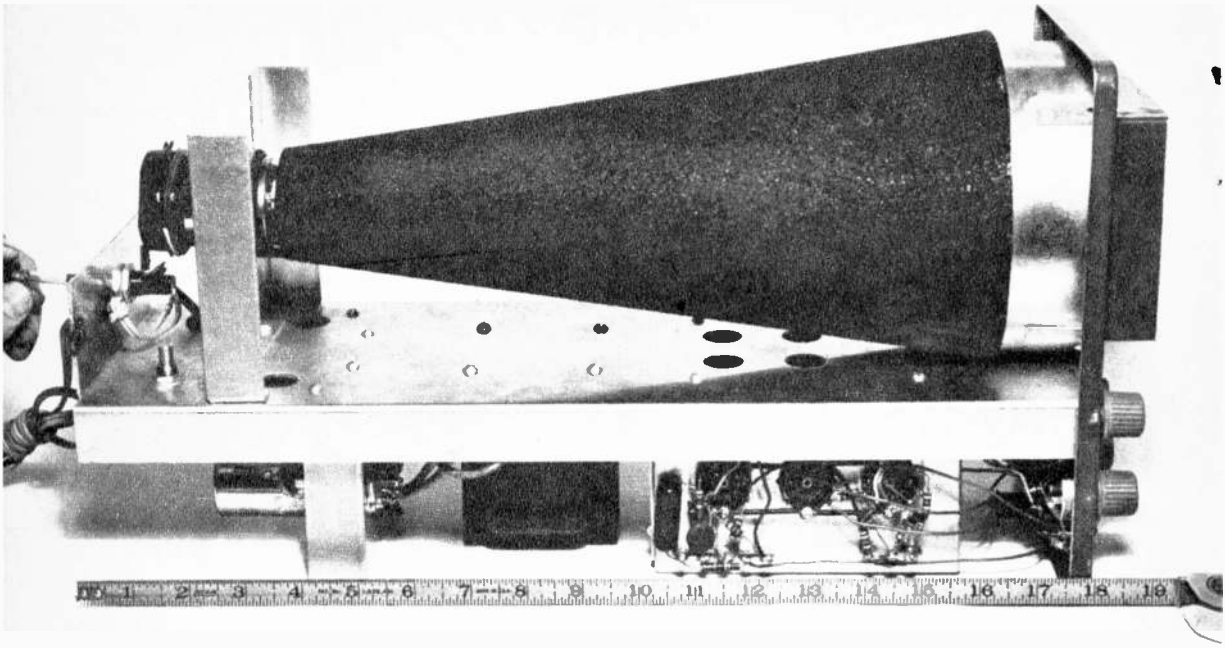
The point A marks the instant when the breaker contacts are broken open by the cam inside the distributor. The current from the battery is cut off. The previously static magnetic field now collapses, and in doing so across the wire of the secondary induces a voltage in it. This is very high and jumps the gap in the connected spark plug.

It is characteristic of high-voltage spark discharges to be "oscillatory"; that is, the energy does not dissipate itself as heat and light in a single spurt, but instead trembles back and forth, decaying smoothly until it is spent. The action was known and recognized before the turn of this



HEATHKIT IGNITION ANALYZER

MODEL IA-1

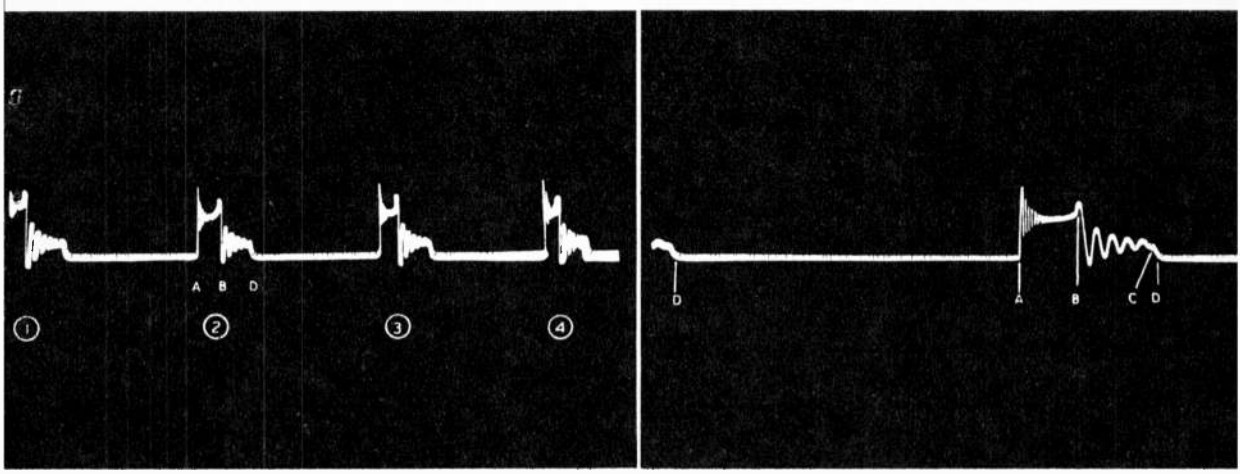


TOP INSIDE VIEW of analyzer, with case removed. Long black funnel is iron shield around cathode-ray tube to protect it against random magnetic disturbances in the air, which are troublesome in some areas.

century, when the possibilities of wireless communication were first being investigated. The wavy line A-B is a perfect representation of this high-frequency oscillation. The plug is sparking between A and B. At B, the oscillatory voltage has dropped to the point where it can no longer jump the gap, so sparking stops. What little energy remains in the coil now quickly dies out as the magnetic field collapses altogether; this is the wavy tail B-C. By this time the distributor cam has allowed the breaker points to close, so another dwell cycle starts again at D.

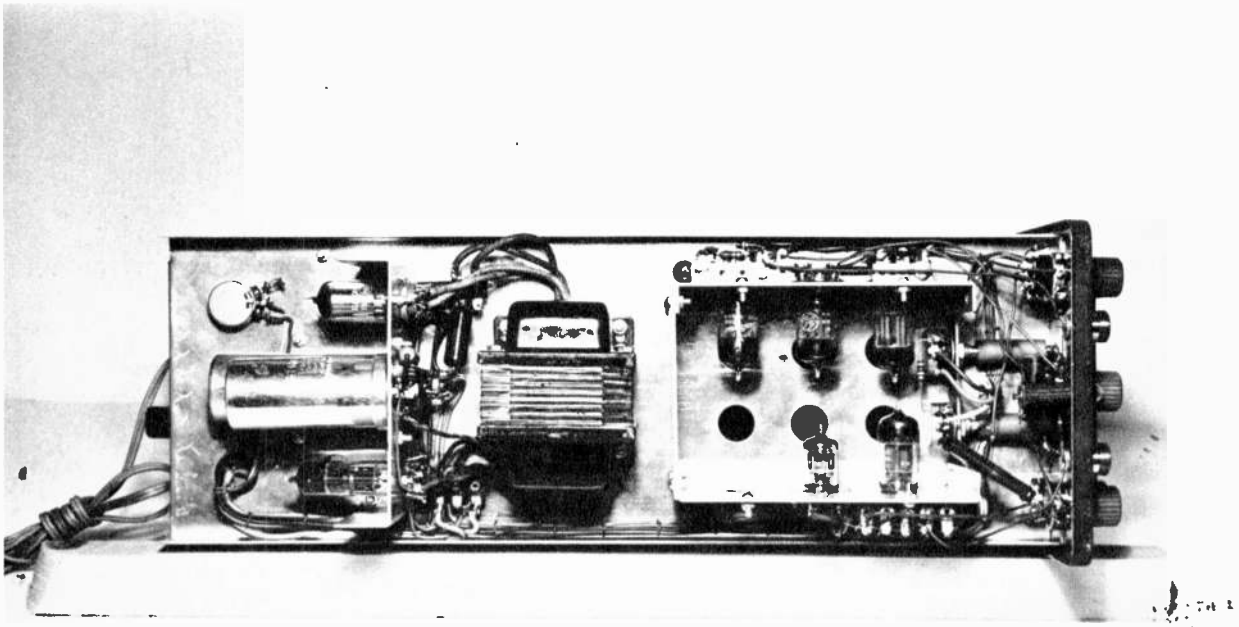
Strictly speaking, this instrument is not an "analyzer"; only the user is. You must use it quite a bit and familiarize yourself with the patterns produced under various conditions of engine operation. Ideally, you should start with a car in good shape, having new, accurately gauged plugs, and clean, carefully set breaker points. You'll obtain patterns closely duplicating those shown. Then you should simulate troubles of various kinds. Short a plug completely, or replace it by a badly fouled one, or one with too small or too large a gap, and see—literally see—what happens to the scope patterns. Also experiment with the breaker settings, with open or leaky breaker point condensers, with various types of radio suppressors, etc. Only by knowing in advance which patents are right and which are wrong can you associate them at some later date with proper or improper ignition conditions. In this respect the analyzer is very much like a doctor's stethoscope.

One thing is sure: the analyzer is a fascinating tool, and the more you use it the more you'll want to use it. Its application is, of course, not limited to automobiles. Try it on single-cylinder lawn mower engines, on four-cylinder boat engines. •



FULL-SIZE REPRODUCTION of typical patterns produced by four cylinders of an engine. Analyzer controls can be set to produce all cylinders at once, or one individually. The wavy portion A-B-D represents the entire high-voltage discharge of the ignition coil for one plug. This is expanded in the second illustration which shows complete ignition action for one plug. D-A is "dwell time," with breaker points closed and only direct current flowing in the ignition coil primary. At A, breaker points open, causing high-voltage oscillatory discharge across gap of spark plug. At point B, spark goes out, and energy remaining in coil dies out quickly from B to C. At D, breaker points close, another dwell time starts, and the entire cycle repeats itself.

BOTTOM VIEW of analyzer, showing all wiring. As a construction project, the instrument is a simple screwdriver-socket wrench-soldering job, takes a few evenings.



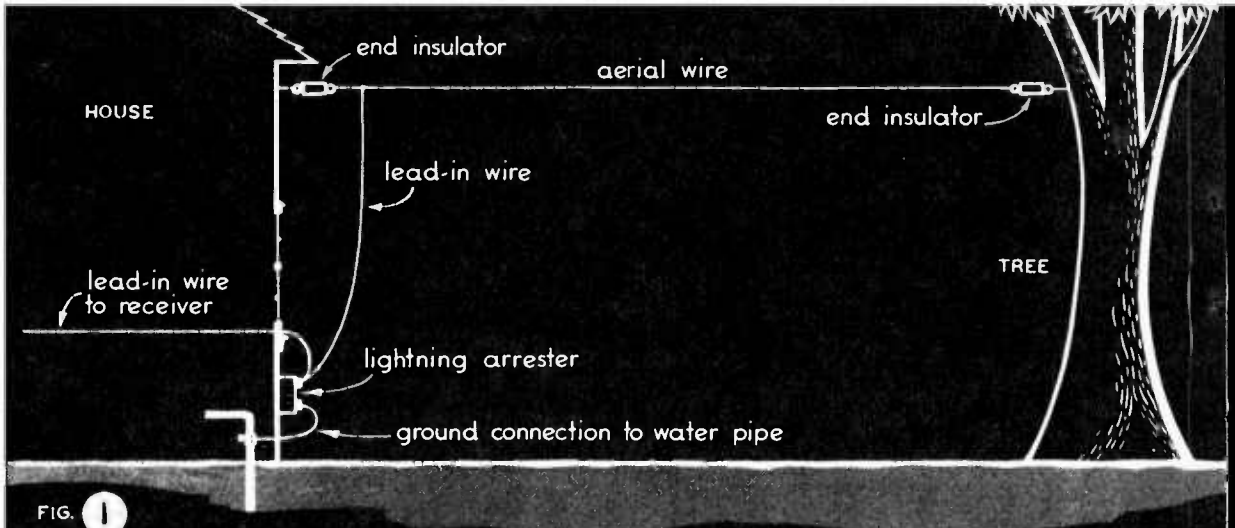


FIG. 1

AN OUTSIDE AERIAL

It's a "must" for really good reception

"I LIVE in Blanktown. The nearest radio station is in Milltown, about 150 miles away. Will I be able to receive it with a Blooperdyne Mark I set?"

This question, in a variety of forms, is constantly being asked by residents of relatively remote areas in the United States and Canada. Unfortunately, there is no simple answer. "DX" (distance) reception depends on several factors, some of them beyond the direct control of the interested person.

In the case of regular "sound" broadcasting, the first consideration is the power of the transmitting station itself. A station rated at 50 or 25 kilowatts will be heard further than one rated at 15 or 5 kilowatts, under similar conditions. The second element is the sensitivity of the receiver installation. Note that I say "receiver installation," and not just "receiver." A prospective listener can't do anything about the distant transmitter, but he can do a great deal about his own set-up.

Receiver "sensitivity" is a measure of its ability to reproduce weak signals; the word "gain" is also used in the same sense. In a general way, the more tubes or transistors in a set, the better its gain. Radio tubes have undergone half a century of development, and have probably reached their maximum capabilities. Transistors have been in commercial use for hardly five years, and as yet do not offer the same performance as tubes. For maximum receiving results under difficult conditions, a tube-type receiver is therefore preferable if AC power is available. If it isn't, a transistor set at least has the advantage of practical, economical operation from small dry batteries.

Broadcast receiver design is so standardized that there is little to choose among sets of the same number of tubes or transistors but of different makes. Practically all sets nowadays use small, self-contained loop aerials. These are entirely satisfactory when powerful stations are fairly close by, but they can be quite inadequate out in the country where the signals are much weaker. *Reception can be improved enormously if a loop is supplemented by an outside aerial.* The longer and higher it is, the better. In most places length is easier to achieve than height. The wire should run in a fairly straight line, but a few bends here and there don't do any harm. Advantage can be taken of available supports such as chimneys, trees, barn roofs, etc.

Any copper wire, bare or insulated, will work as a radio aerial. Solid wire tends to kink and stretch. By far the best material is known as "7x22," which consists of seven strands of No. 22 wire. This is flexible, strong and easy to hang.

The longer the better, it says above. How long is long? Start with a standard 100-foot roll and drape it over the landscape, and wherever it touches anything or must be supported, use small glass or ceramic insulators. At the end

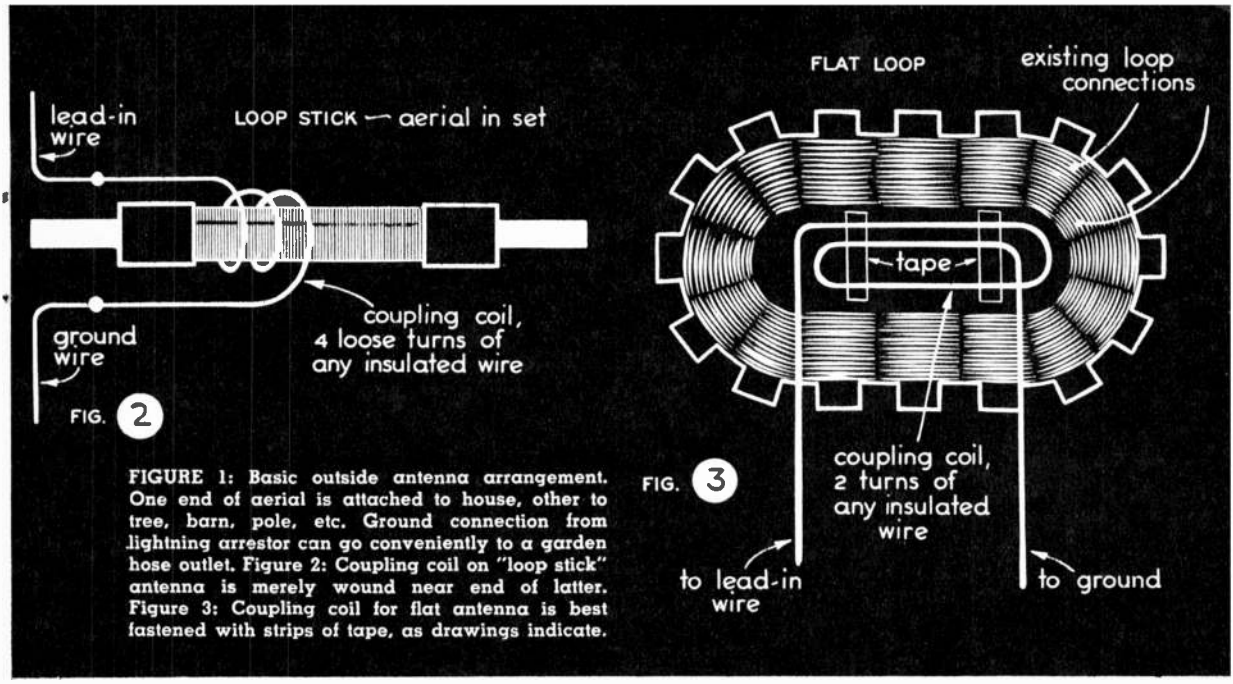


FIGURE 1: Basic outside antenna arrangement. One end of aerial is attached to house, other to tree, barn, pole, etc. Ground connection from lightning arrestor can go conveniently to a garden hose outlet. Figure 2: Coupling coil on "loop stick" antenna is merely wound near end of latter. Figure 3: Coupling coil for flat antenna is best fastened with strips of tape, as drawings indicate.

nearest the house, use an insulated lead-in wire and bring this in under a window or through a hole in the window frame. As there is little strain on this wire, it can be ordinary single-conductor flexible lamp cord, bell wire, or any other insulated wire size No. 18.

An exposed wire in the open country is susceptible to lightning, so do not fail to install and connect a lightning arrestor, as shown in the sketches.

A whole antenna kit can be bought from the radio parts houses for a little more than two dollars.

Aerial Connection

Many loop-equipped radio receivers have provision for the connection of outside aerials. This is either a small clip-type binding post on the back of the chassis, or more commonly one or two short, bare ends of wire. If there is one connection, hook the outside aerial to it; if there are two, put the aerial to one and a ground wire to the other. If the set is of the AC-DC type, do not ground the chassis; under some circumstances this puts a dead short-circuit on the power line.

If there are no extra connections in sight on or near the loop, it is a simple matter to make a "coupling coil" as indicated. If the loop is of the flat type, fasten the coil with sticky tape; if it is of the rod type, wind the wire over it directly.

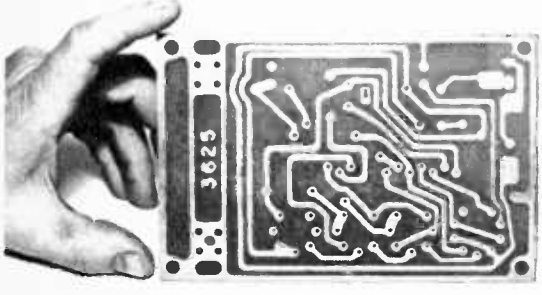
If a 100-foot aerial makes a noticeable improvement in reception, will adding to it further the improvement? The only way to find out is to try it. Generally speaking, increased length *does* help reception on the regular broadcast band.

Theoretically, a long horizontal wire receives best from the direction in which the lead-in end points. However, this effect is very sensitive to the presence of structures in the immediate vicinity, so it isn't very important.

Broadcast reception is usually much better after sunset than during the daytime, and also in the winter rather than in the summer. These effects are tied in somehow with the action of the sun in "ionizing" or changing the electrical conductivity of the atmosphere around the earth.

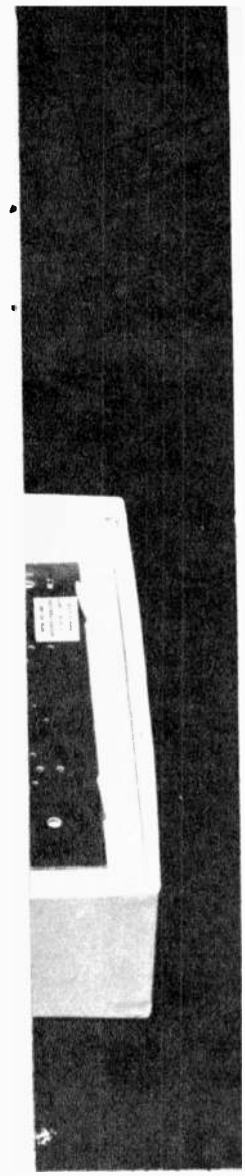
People who are in really bad locations should give some consideration to the idea of buying an amateur "communications" receiver. While intended primarily for short-wave reception, many sets of this type take in the regular broadcast band as well. Their gain is much greater than that of common sets, for the simple reason that they use more tubes in more amplifier circuits.

Another and not so incidental advantage of a communications receiver is that it often gives fine reception of short-wave stations thousands of miles away, even though bad local conditions prohibit the reception of broadcast stations only a few hundred miles away. •



THE LINES on the underside of the amplifier board (photo left) are actually embossed copper, and represent the circuit connections. Entire unit comes packaged as in photo above.

AFTER THE various components are mounted on the top side of the amplifier board, their protruding lugs on the bottom are merely soldered to the copper lines, as shown in photo right. As latter are close, a small pointed iron must be used, with minimum amount of solder to avoid spillover.



PRINTED CIRCUIT AMPLIFIER

It takes twenty-five minutes to unpack and assemble this easy-to-build, four-tube audio unit

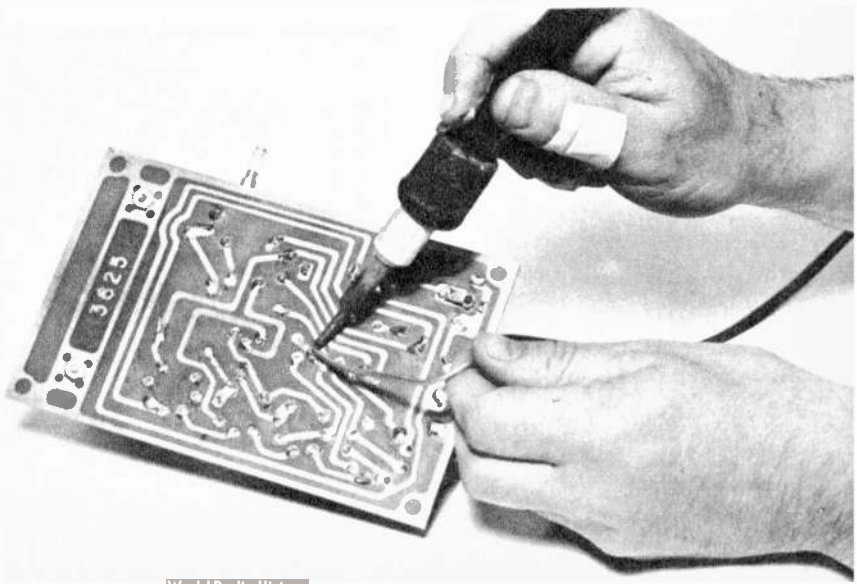
TWENTY-FIVE minutes from unpacking to playing . . . that's exactly my time for assembling, wiring and testing an extremely neat and compact four-tube audio amplifier that deserves a modest hi-fi rating. The entire secret of this speed lies in the printed-circuit board on which all the components are mounted.

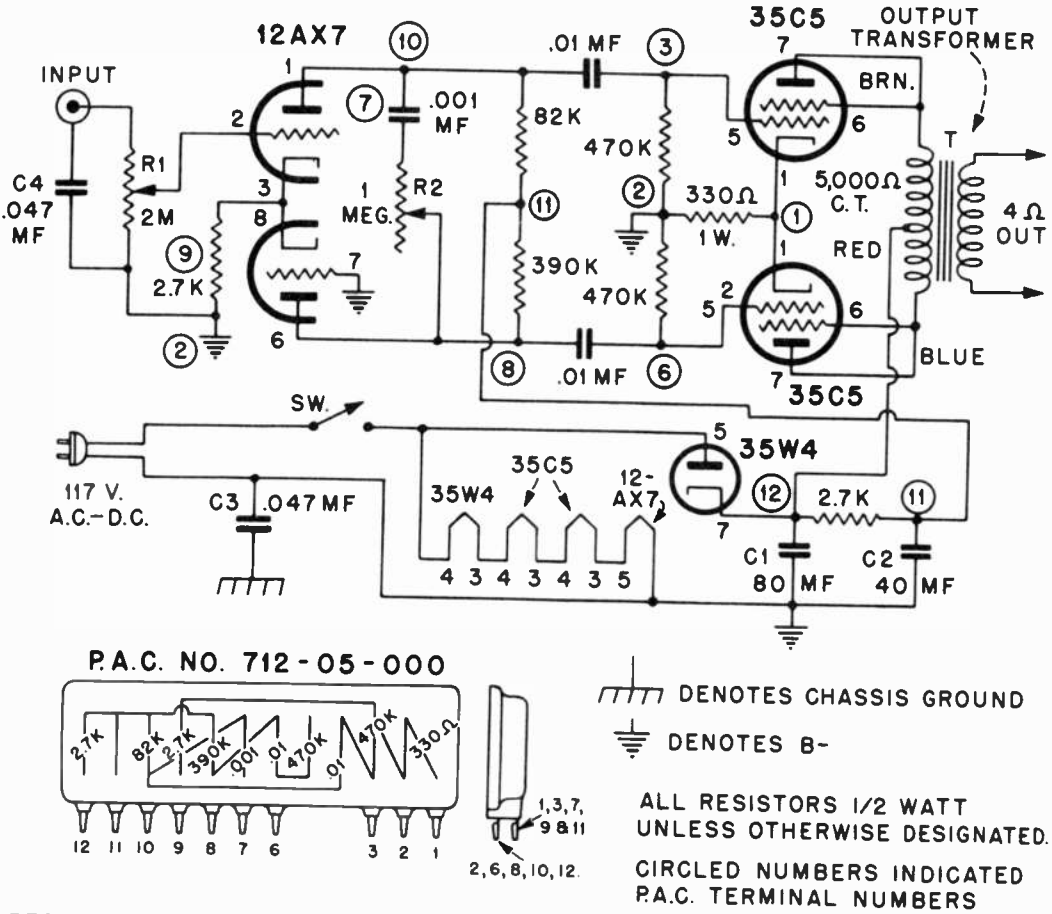
Measuring only 4¼ by 6½ inches, this board presents an odd appearance. The top surface is punctured with small holes in random pattern, almost as if it had been hit by a shotgun blast. The bottom side is a crazy-quilt of embossed copper lines. The holes and the lines, far from being random or crazy, have been very carefully laid out so that when the little legs of the various parts are pushed into the holes from the top and soldered at the bottom, they become mounted and connected at the same time.

The entire unit is marketed as the Model PAC-AMP-1 kit by the Erie Resistor Corporation, of Erie, Pa., and is available from regular radio jobbers.

The only part fastened with nuts and bolts (two of them!) is the heavy output transformer, which occupies the left edge of the base-board.

In most amplifiers, a great deal of the assembly and wiring work involves numerous little resistors and capacitors, which must be handled individually. In the Model PAC-AMP-1, a dozen assorted units are pre-assembled on board ¾ by 2¼ inches. This has ten





SCHEMATIC DIAGRAM of printed circuit amplifier is shown above. Numbers in the circles correspond with the pin markings on the plug-in resistor-capacity unit PAC-712-05-000, in the upper right corner.

feet or lugs, which snap quickly into position along the center line of the main baseboard, in front of the line of tubes.

To facilitate mounting of the completed amplifier, the baseboard is fitted with four clip-on metal strips an inch high, which form a sort of shallow pan.

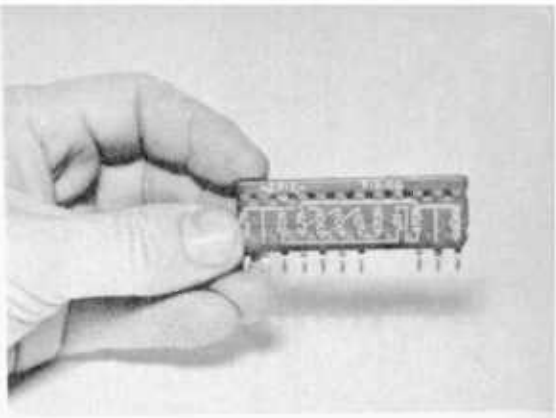
Ventilation is no problem, as all circuit components are topside.

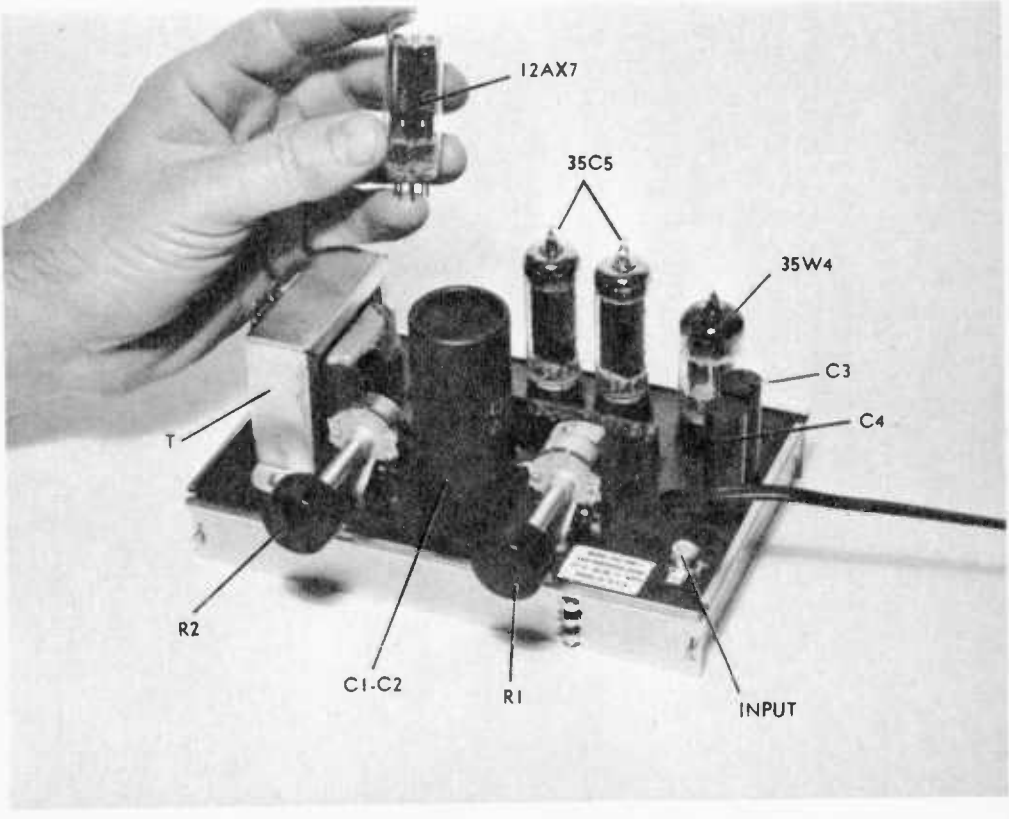
The amplifier uses a straightforward, reliable circuit. A single 12AX7 tube acts as first-stage amplifier and phase inverter, to feed a push-pull output stage using two 35C5's. A 35W5 is a half-wave rectifier for plate voltage supply. The filaments of the tubes are in series, directly across the 117-volt AC power line. As usual, the line switch and the volume control are combined, and there is a separate tone control.

Because of its compactness, this amplifier is especially well suited for combination with a small turntable and a loudspeaker to form an excellent record player. If a regular ceramic or crystal type phonograph pick-up is used, the volume is enough to provide dance music for a gym full of jitterbugs.

The unit also works nicely with AM, FM or combination AM-FM tuners. In some cases it is necessary to use a small isolating transformer between the power line and amplifier, to eliminate hum and shock. •

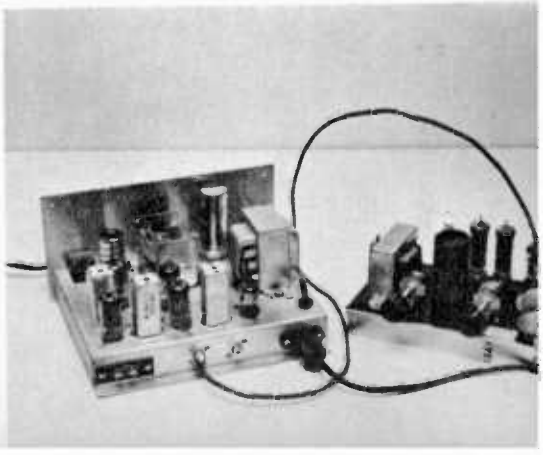
THIS LITTLE strip of resistors and capacitors plugs into the mounting board as one unit, and is soldered into position in less than a minute.





COMPLETED amplifier is not very large, as photo above clearly shows. Handle it with care, however.

TYPICAL application of amplifier (right) with FM tuner (left). Connection between the units is made with shielded cable having phono jacks on ends.



HI-FI CONVERSION

Consider these factors before you convert to high fidelity

A QUICK general answer to a commonly asked question, "Should I convert to Hi-Fi?" is "No, hardly ever." There are some good reasons.

The matter is usually brought up by people who invested quite a bit of money, before the advent of television and high-fidelity sound, in a large and elaborate piece of living room furniture containing a regular AM broadcast receiver and a record player. The receiver might even be a combination AM-FM unit, but the FM end was designed for a low-frequency band that is no longer in use. The equipment probably still sounds pretty good, but the owners feel that it is outmoded and that it "dates" them in the eyes of friends and neighbors who own record players with diamond needles, powerful amplifiers, and enough loud-speakers to fill a football stadium with voice or music.

Complicating the situation is the fact that the turn-in value of the old equipment is absolutely nil. Most dealers won't consider it on any basis. If they do at all, because a customer is considering the purchase of a hi-fi system running into a considerable sum, they'll make an allowance for it that is really a small discount off the hi-fi price tag, and then they'll tell him to junk it. The first move of old faithful will probably be from the living room to the basement; then to the garage and probably the ashcan. If it hurts you to throw out something that cost possibly three or four hundred dollars, drop a note to the local high school or college and suggest that the members of the radio club might want to tear the set down for its parts.

Salvage Parts

Can any individual element of the original equipment be salvaged? For instance, couldn't a record player be fitted with a new tone arm and cartridge? Many people are particularly reluctant to part with the record player for the simple reason that they have a small fortune tied up in records. Remember that the change from the short-playing 78 rpm discs to the long-playing 33⅓ rpm platters was one of the major technical improvements responsible for the big interest in hi-fi music. Unless the new or "converted" installation includes a solid, smooth-running long-play turntable and a diamond stylus, the whole project isn't even worth considering. You have to make up your mind firmly on the hi-fi question; go in for hi-fi that is quality in every respect, or put your money into a new car or a trip to Europe. Half-way measures in hi-fi are pure waste.

Fortunately, favorite old 78 rpm records can be played on a modern hi-fi system, because most high-quality players are adjustable to 78 or 33⅓ at the flick of a lever. Also, most new phonograph pick-ups have flip-flop heads containing the proper needles for both records. Records look alike to the naked eye, but actually the grooves in the long play ("LP") discs are much narrower than those in the 78's, and therefore require a very fine needle point. Come to think of it, the very word "needle" is outmoded now. It was appropriate when the tone arm of a phonograph was fitted with a bit of sharpened steel that actually looked like a needle. Today, the word is "stylus"; plural, "styli." For 78's, the diameter of the standard stylus tip is .003 inch, but for LP's it is only .001 inch. The quickest and easiest way to ruin expensive LP records, other than smacking them with a hammer, is to run them with the blunt stylus intended for 78's.

Steel needles are a thing of the past. Present day styli are either sapphires or diamonds. To paraphrase the title of a popular song, "Diamonds Are a Record's Best Friends." They retain their shape much longer than any other kind, and make records last longer because they minimize groove distortion. The difference in price between sapphires and diamonds sometimes startles people who are thinking of going into hi-fi. A typical sapphire for a popular player cartridge costs $2.06; a diamond for the same purpose costs $16.17. In terms of both stylus and record life, the diamond is definitely cheaper in the long run.

In many cases of contemplated conversion it is both technically and economically feasible to salvage the cabinet of the old phono-radio combination, and, with a little simple carpentry, to install the brand-new components of a hi-fi system into it. This can be a tangible saving, because the cabinet may have represented a large part of the original cost, might still be in perfectly good condition, and might still be an important part of the decorative scheme.

Measure up the cabinet carefully, and compare the available space with the in-

DISPLAY of hi-fi tuners, amplifiers and loud-speakers at representative "sound studio" of radio supply firm. It is easy to select units to fit inside cabinet that formerly housed a phono-radio combination.

stallation requirements of a new record player, an FM or a combination FM-AM tuner, a pre-amplifier or a combination pre-amplifier and power amplifier, and a loud-speaker system. Pre-World War II radio receivers were generally massive and heavy and took a lot of space. Modern equipment, using miniature tubes, is much more compact. Therefore, it may be surprisingly easy to find room for the new tuner and amplifier.

Record Players

In probably seven old cabinets out of ten, a new three- or four-speed record player can be fitted into the compartment occupied by the old 78-rpm unit. Players have undergone great improvement, but their physical size hasn't changed appreciably because record diameters haven't changed. Popular discs are 10 and 12 inches.

The loud-speaker or speakers of the new system present a bit more of a problem, because the enclosure, the box in which the speaker is mounted, must be designed and built to somewhat critical requirements if the full tonal capabilities of the system are to be realized. A quick, easy and painless way out is to buy a speaker system already mounted in a proper enclosure and to fit the whole thing into the front of the existing cabinet. A new front panel will be needed anyway for the new tuner and amplifier. A new piece of grille cloth and some decorative molding to hold it in place will conceal the false mounting of the speaker without affecting its acoustical performance.

The powerful amplifiers used for hi-fi purposes get very hot in normal operation, and therefore require good ventilation. This is usually no problem in large cabinets. If there are children in the house, the back should be covered with something protective but full of holes: perforated Masonite wallboard is fine, because it is rigid, readily obtainable and easy to cut. Otherwise, the back can be left open for maximum circulation.

In practically all early phono-radio combinations the cabinet included storage space for records. This, of course, is just as useful for LP's as for older 78's, and should be saved if possible. Hi-fi fans say that records should be stored flat so that they'll stay flat; there's sense to this policy. If existing racks are vertical, remove them intact, reinstall horizontally. •

SIMPLE RECEIVERS PRODUCE FINE RESULTS

They're sensitive, reliable, and easy to make from regenerative circuits and a few tubes

FRONT PANEL LAYOUT of completed "Space Spanner" receiver is clean and functional. The controls are clearly marked, as shown in photo above. The loud-speaker is behind square grille at the right.

SOME would-be hams are discouraged when they see the price tags on short-wave receivers. A relatively inexpensive set costs about $150, and the more popular ones run to $300. $400 and even $600. What to do if you don't have that kind of money to spend?

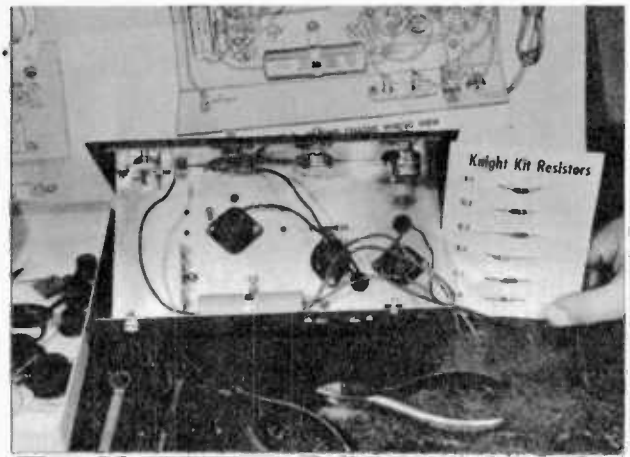
Despair not. For as little as $15 or $20 you can assemble three-tube receivers of the regenerative type that will pull in more stations than you can count in a lifetime of listening. They aren't as flashy looking as the big jobs, but they really work very well.

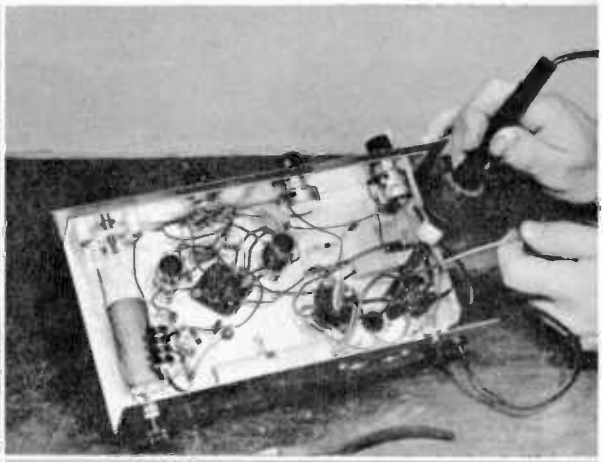
The regenerative circuit, revealed by the famed Edwin H. Armstrong in 1914, changed the vacuum tube from a laboratory novelty into the keystone of the entire art of electronic communication. Its great feature was—and still is—its utter simplicity.

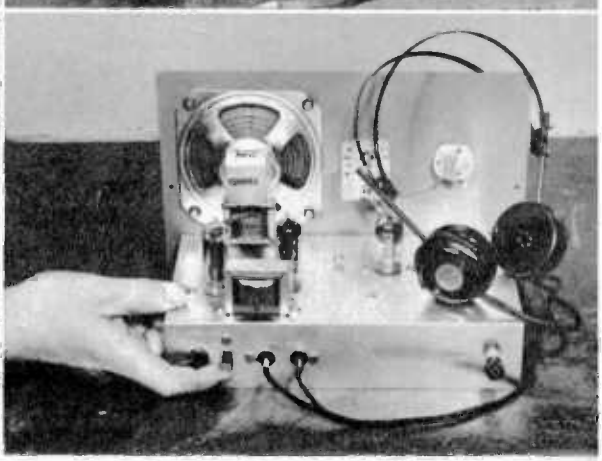
A radio tube is useful because it acts as an amplifier. Weak signals picked up by a receiving aerial are impressed on the grid

UNDERSIDE of "Space Spanner" chassis, with some parts mounted. Resistors are provided on card. Few tools are needed for assembly job.

THE LAST touches are put on the wiring of the "Space Spanner." Using only three tubes, the chassis is uncrowded, and very easy to work in.





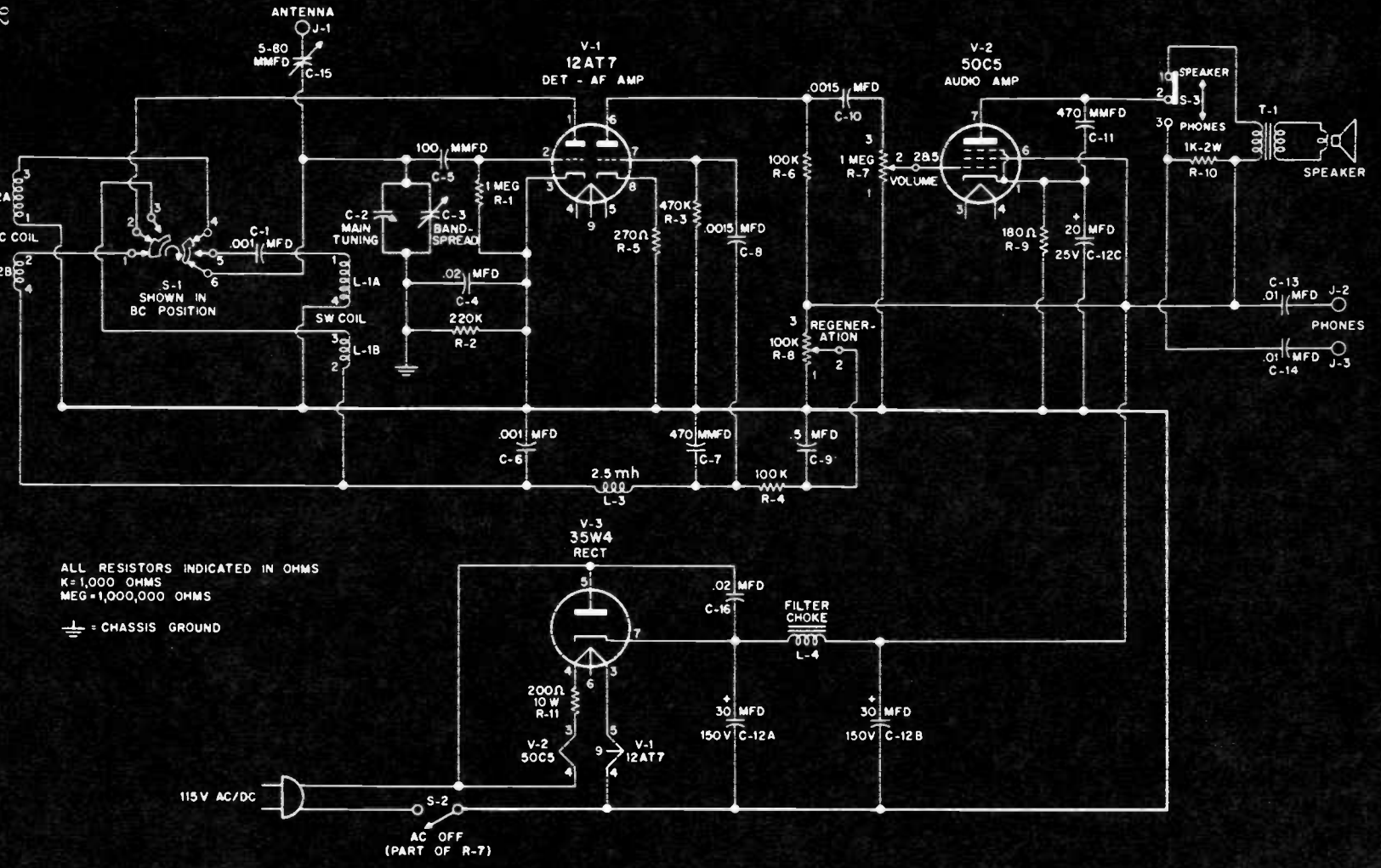


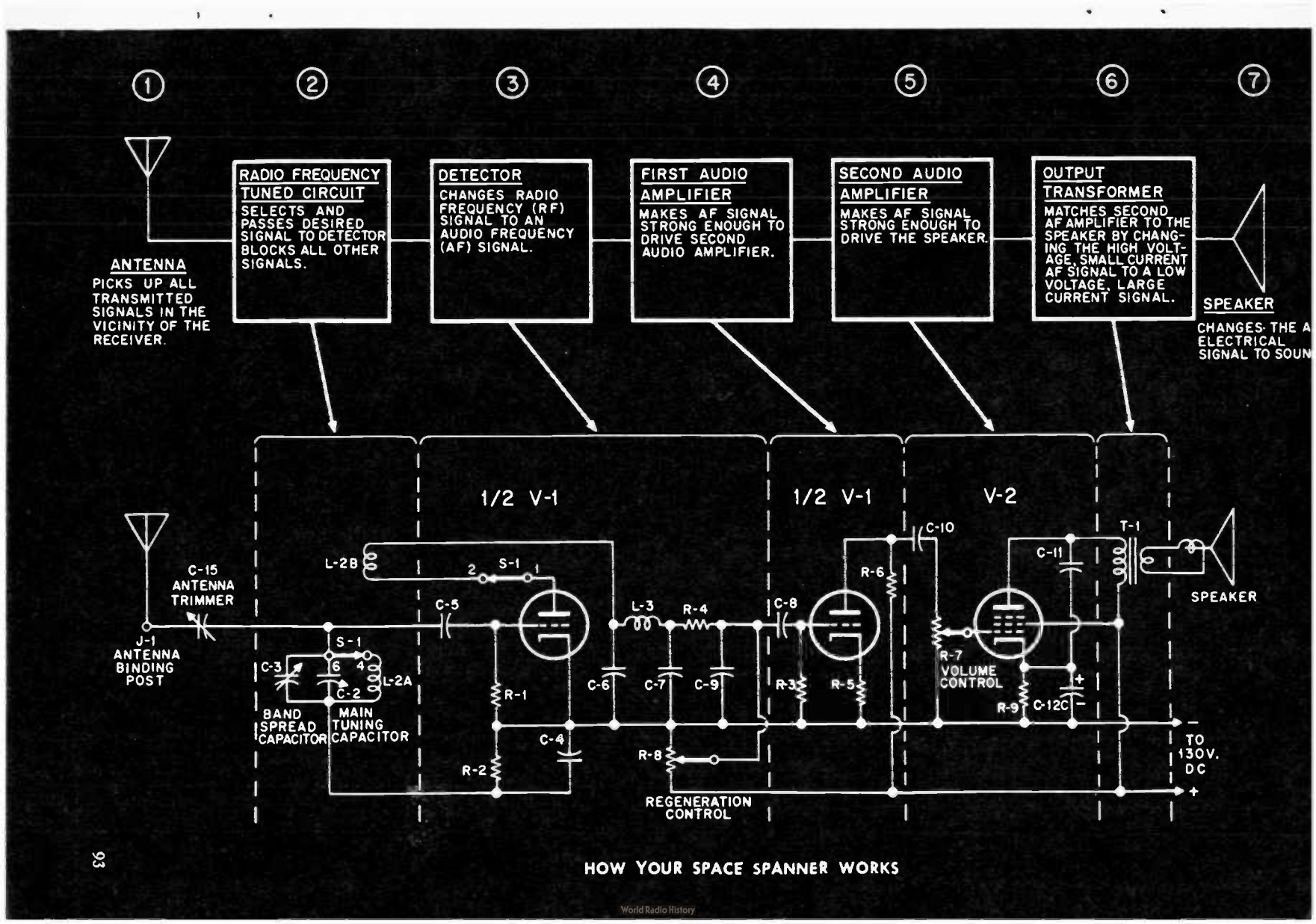
TOP SIDE of chassis, showing loud-speaker and filter choke. Large, detailed drawings are furnished with kit, facilitate working operations.

BACK VIEW of completed unit with earphones connected. Finger rests on switch that changes circuit over from the ear phones to loud-speaker.

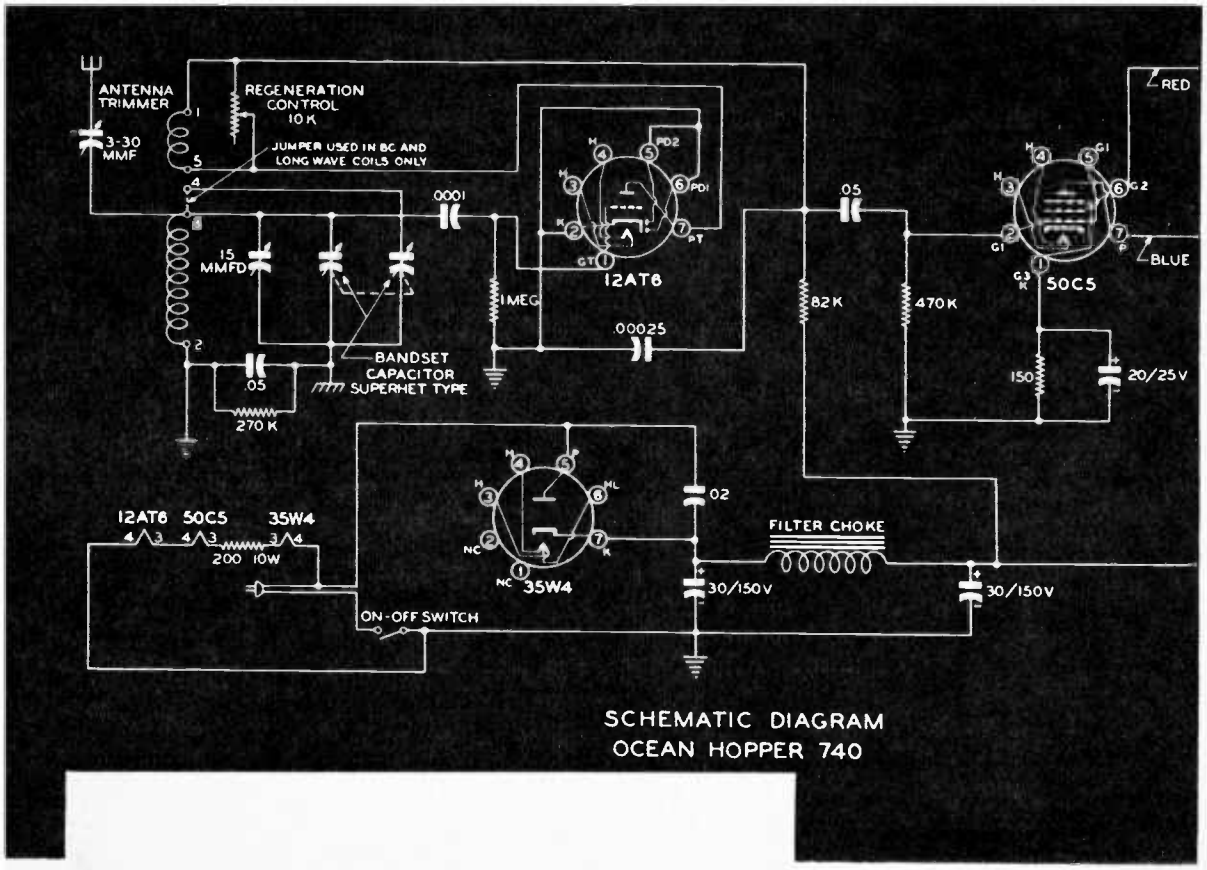
circuit; they reappear in the plate circuit in the same form, but strengthened. If the signals are very weak, the tube's basic amplifying action often is not enough to make them audible. Armstrong had the supreme inspiration to couple the plate circuit back to the grid circuit by a simple magnetic loop, so that part of the plate signals reinforced the grid signals. The latter in turn produced stronger plate signals. By careful adjustment of the feed-back or "regeneration" control, it was—and still is—possible to build up otherwise inaudible signals into very loud ones. We do not get something for nothing here. The energy for the amplified signals comes from the battery in the plate circuit, and the grid element of the tube triggers it into usefulness.

Scarcely three years later, just after the United States entered World War I, Armstrong invented the superheterodyne circuit, which offered the advantages of almost unlimited sensitivity or amplification combined with a high order of tuning

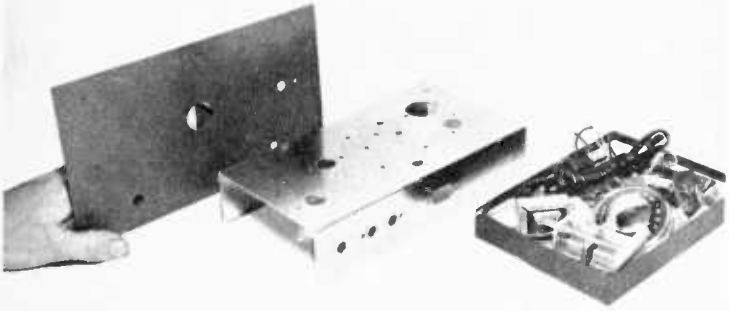




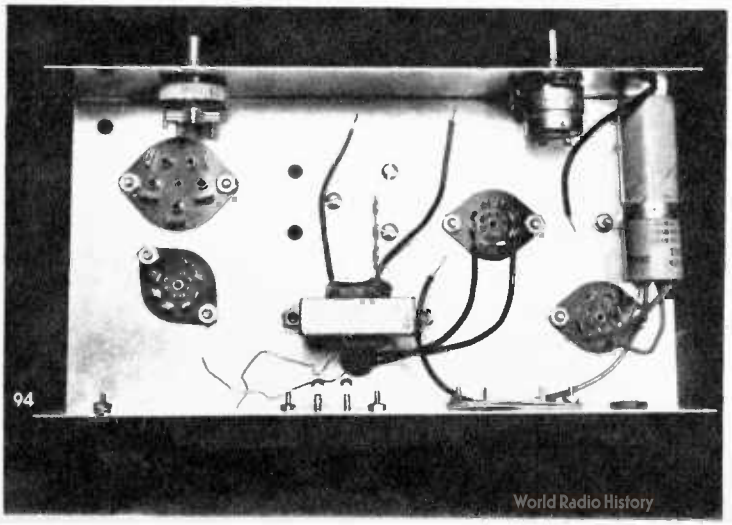
HOW YOUR SPACE SPANNER WORKS



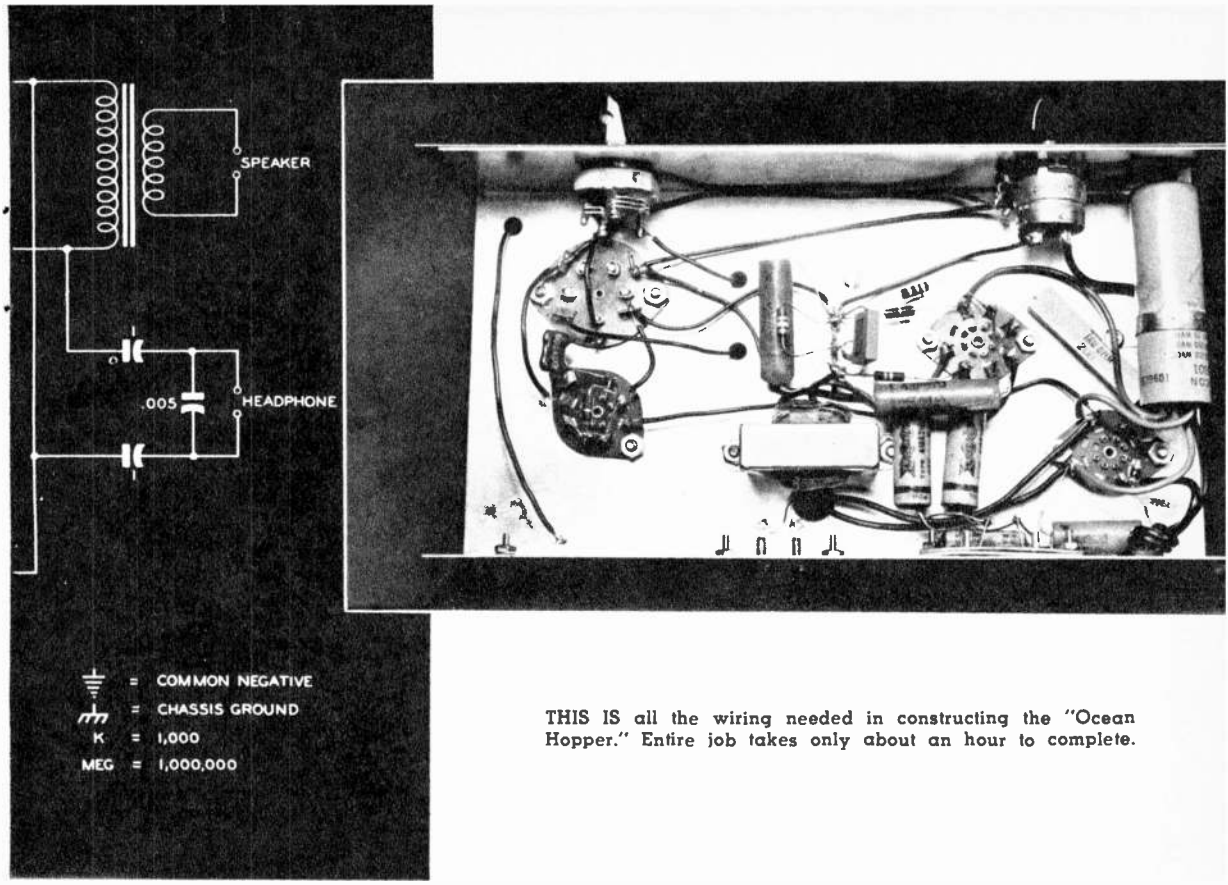
SCHEMATIC DIAGRAM
OCEAN HOPPER 740



CHASSIS and front panel of "Ocean Hopper" are formed and punched, and easy to assemble. Parts furnished with kit are in box at the right.



UNDERSIDE of "Ocean Hopper" chassis, with tube and coil sockets, filter choke, filter capacitor, regeneration control and band spread capacitor.



THIS IS all the wiring needed in constructing the "Ocean Hopper." Entire job takes only about an hour to complete.

sharpness or selectivity. He also is credited with the invention of frequency modulation broadcasting, so you can see that he was a real "brain." He died in 1955.

While the superheterodyne quickly overshadowed the straight regenerative circuit, the latter continued to be a favorite for beginners because it worked well with a few tubes, was cheap, required no alignment of any kind, and was sure-fire in operation. The extent to which these features are appreciated by cost-conscious experimenters is reflected in the long-term popularity of two kits marketed by Allied Radio of Chicago. These are the Knight "Space Spanner" and the "Ocean Hopper." They use virtually identical circuits, but have different frequency coverage and chassis arrangement.

Assembly of the sets from kits is an easy nut-and-bolt job. Each receiver took me about three hours. The results startled me. It was at least twenty-five years since I'd used a "squealer," as regenerative sets were often called, and I'd forgotten the magical action of the regeneration control. With an aerial consisting only of twenty feet of hook-up wire thrown along the cellar floor, eight feet below ground level, both receivers brought in short-wave broadcasting stations from Russia and England, ham stations from all over the United States and Canada, military and commercial radiotelegraph stations by the dozen.

Getting the "feel" of the regeneration action takes a little practice. There is a rather critical point for the reception of voice or music signals; this is reached just before the set falls into self-oscillation, a condition that reveals itself by causing the signals to be mixed with squealing.

The "Space Spanner" is a two-band set, covering the regular AM broadcast band and also the short-wave section between 6 and 18 megacycles. The tuning coils for the respective bands are fixed under the chassis, and are cut in or out by means of a two-position switch on the front panel. With a good outside aerial, most signals are strong enough to be heard quite well from the self-contained four-inch loud speaker. The circuit employs a 12AT7 tube acting as a combined regenerative detector and audio amplifier, a 50C5 power amplifier

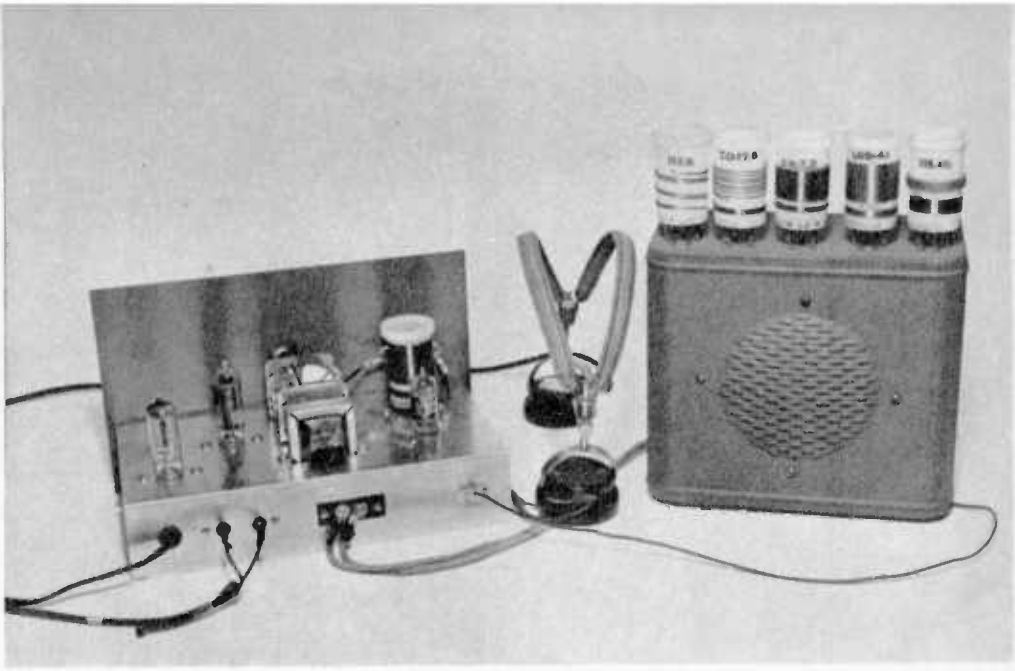
PLUG-IN COIL, held in hand at right (photo above), fits into five-prong socket on chassis. Loud-speaker connects to two screw terminals on back edge, earphones to tip jacks to left, and aerial to spring binding post on right. The combined detector-first amplifier tube, a 12AT6 (photo below), goes into socket directly behind plug-in coil. Unit to right of coil is antenna trimmer capacitor, which is adjusted from front.

tube, and a 35W4 rectifier, in a transformerless "AC-DC" arrangement.

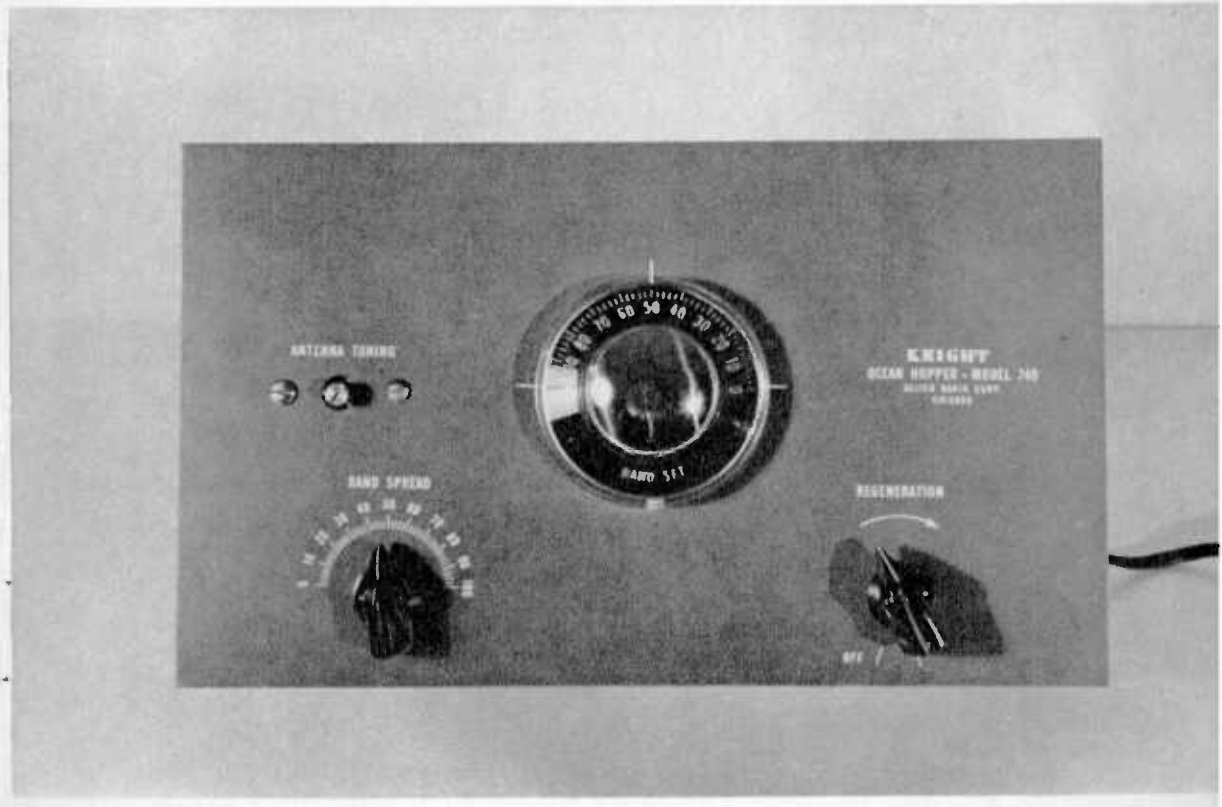
The "Ocean Hopper" is a slightly simpler receiver. It uses six plug-in coils, which give the unusually wide frequency coverage from 155 kilocycles up through 35 megacycles. This takes in the broadcast band, the ship radiotelegraph channels, all the short-wave broadcasting bands, and the most important and active amateur and other communication bands.

Earphones can be used with both sets, and in fact are recommended as a means of realizing the sensitivity of the circuits to weak signals. Stations that cannot be understood through the loud-speaker are often intelligible through the phones.

Although the receivers work very well in the form in which they are sold, I feel that tuning can be made much easier if the plain knobs and dials on the tuning capacitors are replaced by "vernier" dials. This is a small job, and can be done after the sets are in operating order. The tuning can be quite fussy, and reduction-drive dials often help in cutting interference. •



Here is the "Ocean Hopper" (above) with accessories. Any small dynamic loud speaker can be used. Broadcast band coil is in set; the other five available coils are lined up on loud speaker. Wire crossing front of latter is aerial connection. Center dial of "Ocean Hopper" (photo below) is for band setting; lower left knob is band-spread tuning. On-off switch is combined with regeneration control, to the right.



"SEMI-KIT" TEST METER IS PALM-SIZE

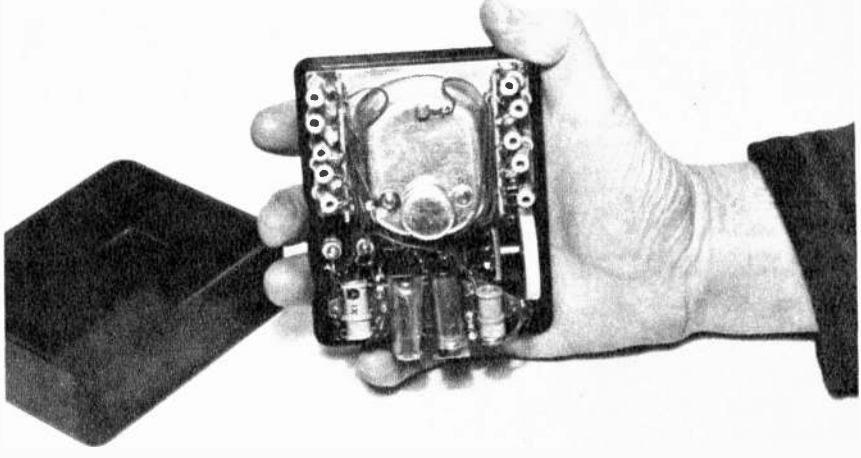
It may be a miniature, but it does a full-scale job on electronic equipment

TWO features of a new multi-meter are of interest: 1) It is supplied in "semi-kit" form, with some of the components already mounted; 2) It is small enough to fit actually in the palm of a hand or the pocket of a coat or shirt.

The "semi-kit" design saves the builder the relatively uninteresting work of assembling parts, while leaving him the more interesting and instructive task of putting in the wiring. It took me only about an hour and a half to put the instrument into working order, and I worked slowly according to the instruction folder that came with the kit.

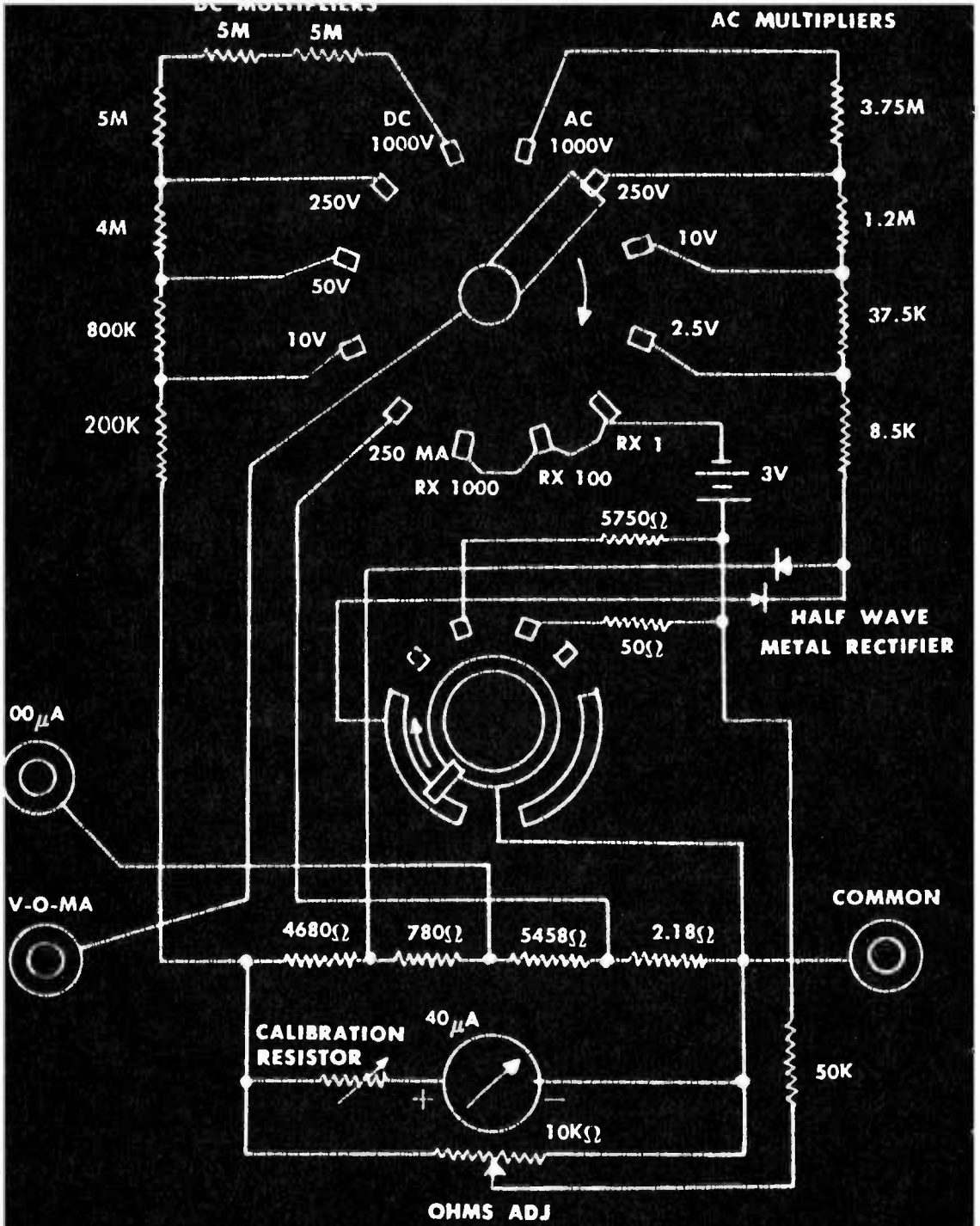
Marketed by Lafayette Radio and called the TK-20 Multi-Tester, the meter is suitable for all normal voltage, resistance and continuity checking in radio and television receivers, hi-fi equipment, electrical appliances, etc. Everybody who has seen it in my shop remarks, "Gosh, that's a cute little job."

In its black molded case, the Multi-Tester measures only 3⅜ inches wide, 4⅛ inches high and 1½ inches thick. A single rotary switch cuts in these functions: DC voltage measurements, 0-10, 0-50, 0-250 and 0-1000 volts, with the high sensitivity of 20,000 ohms per volt, which means that the meter does not change the operating conditions of the circuits into which it is connected;



IT LOOKS like a miniature, but this palm-size Multi-Tester does a full-scale job on electronic equipment. Illustration across page is full size.

INSIDE VIEW of meter. Small resistors are lined up on both sides of meter (upper center). Two batteries are in clip holders just below meter.

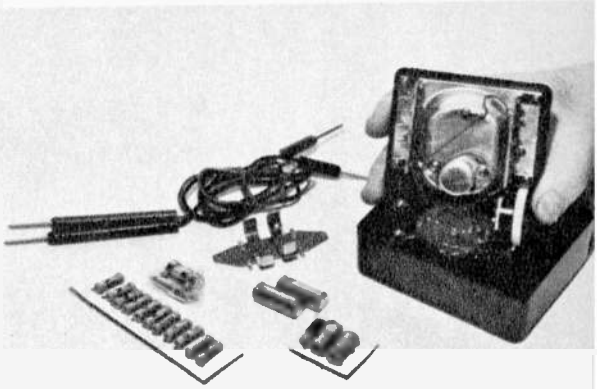


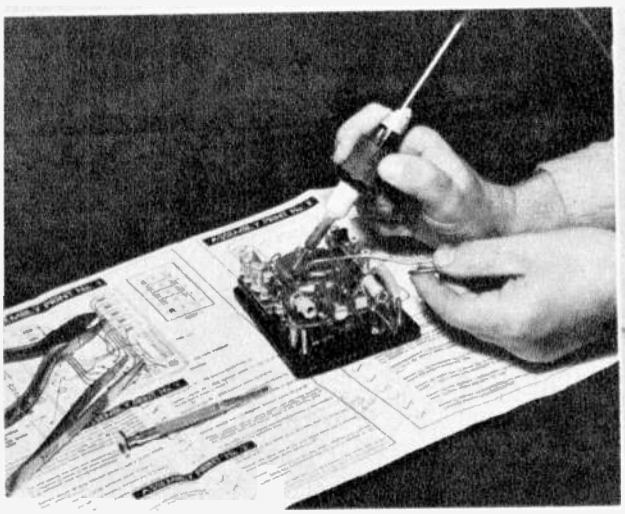
MULTI-TESTER circuit consists essentially of many small resistors connected to meter by rotary switch, as shown.

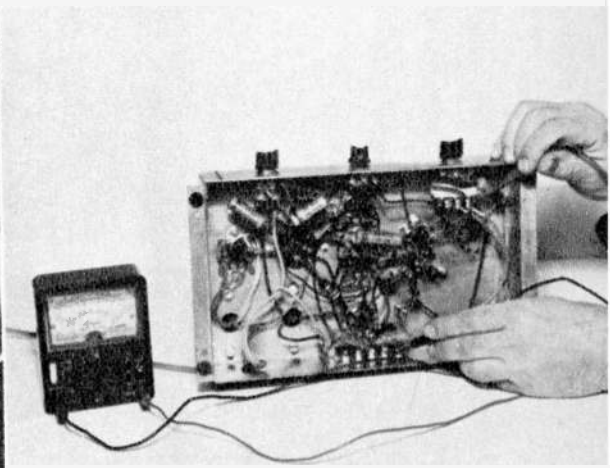
THIS IS how "semi-kit" is furnished. Only parts to be installed and connected are various small resistors (on cards), battery holder and two small batteries.

WIRING is a somewhat delicate operation, but not difficult if pencil-type iron with very small tip is used, as shown.

DWARFED by the radio chassis which it tests, meter nevertheless is an effective electronic tool for the experimenter.





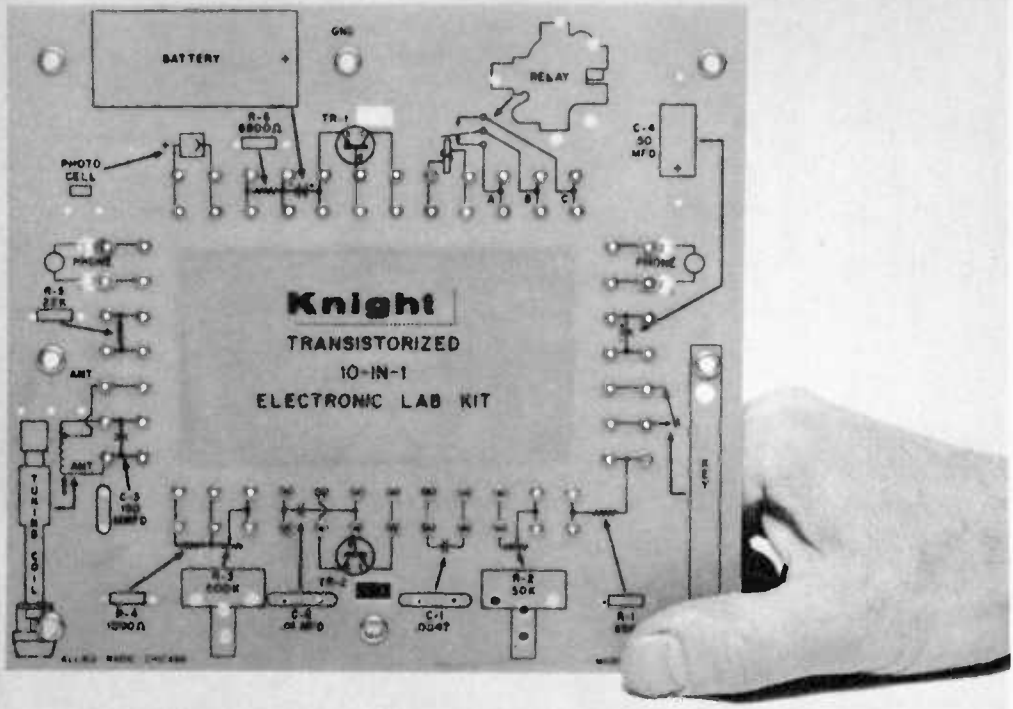


AC voltage measurements, 0-2.5, 0-10, 0-250 and 0-1000 volts; decibel measurements to +10 and +22 db; DC current measurements, 0-250 milliamperes and 0-100 microamperes, very useful for detecting very small leakage currents; and resistance measurements in three ranges up to 5,000,000 ohms.

A pair of the usual flexible test leads is included in the kit.

The parts found mounted on the front panel are the meter itself, two terminal boards for resistors, the function switch, the ohms adjusting resistor and the pin jacks for the test leads. The builder must install and connect fourteen resistors and a battery holder. While the circuit itself is very simple, the wiring requires care, good light, and a small soldering iron with a slender tip not more than ⅛-inch in diameter. There is very little clearance in some places. It is advisable to check for possible touching of parts by sliding a strip of paper between them.

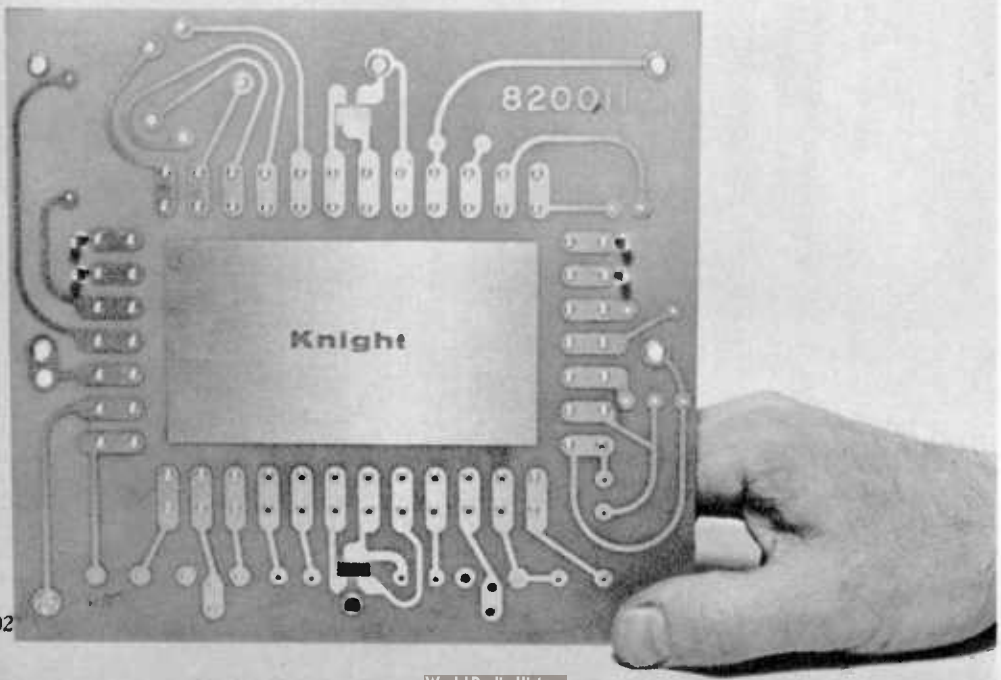
I carry this Multi-Tester in the glove compartment of my car, and find that it is very useful. While visiting some friends, I was asked to look at a hi-fi system that had gone completely silent; the meter quickly revealed a burned-out pre-amplifier tube. On other occasions I have checked house fuses that looked perfectly good but showed up unmistakably open on the tester, discovered broken leads to television receivers, revealed run-down batteries in hearing aids, etc. •



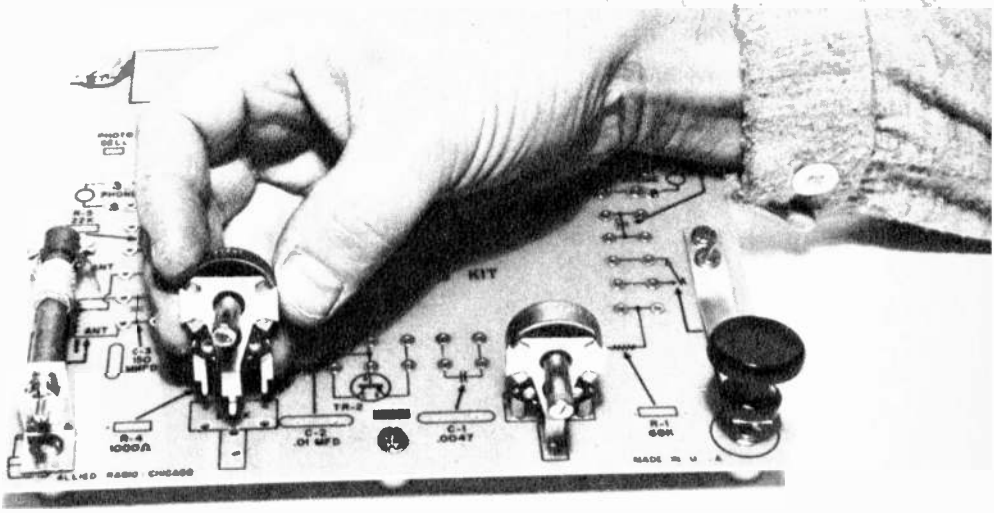
BASEBOARD TOP before parts have been mounted. Black outlines and circuit symbols indicate positions of components which plug into holes in board.

BASEBOARD BOTTOM shows printed silver lines which form connections between parts. Latter have not yet been mounted. Center area is not used.

LEARN ABOUT



VARIABLE RESISTORS have special three-pronged frame, to fit into holes in baseboard. Tuning coil, extreme left, mounts on small bracket. Radio key, extreme right, fastens with machine screws and nuts on underside.



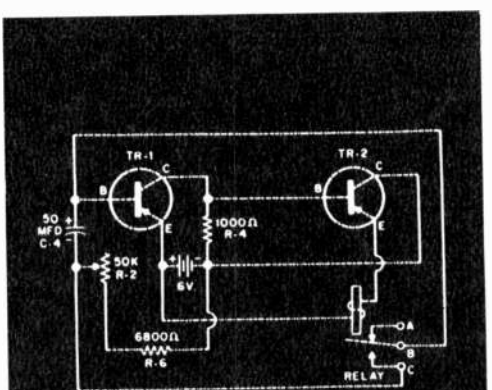
TRANSISTORS...THE PRACTICAL WAY

New printed-board kits enable experimenters to set up these working circuits

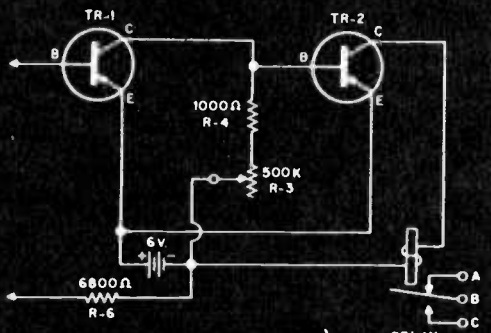
WITH their prices falling and their reliability rising, transistors are now rapidly fulfilling their early promise to revolutionize the design and construction of electronic equipment in which vacuum tubes formerly were the most important elements. It therefore behooves every electronic experimenter, service technician, ham operator, student engineer and old-time engineer to familiarize himself thoroughly with the practical applications of these pea-sized marvels.

Recognizing the importance of transistor education, Allied Radio of Chicago has brought out a "transistor lab kit." This merits attention because of its ingenious design. While its primary purpose is to show the versatility of transistors, it also features printed-circuit construction, itself a relatively new technique.

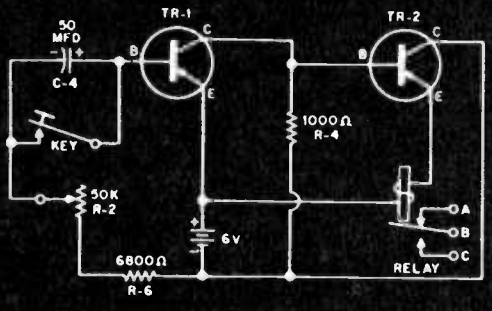
The foundation of the kit is flat baseboard of $\frac{1}{16}$-inch insulating material, 7x7⅝ inches. Around the four sides, on the top surface, is a series of 38 pairs of small hol-



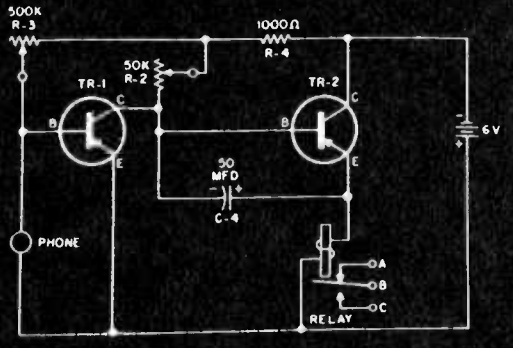
THE FLASHER SCHEMATIC



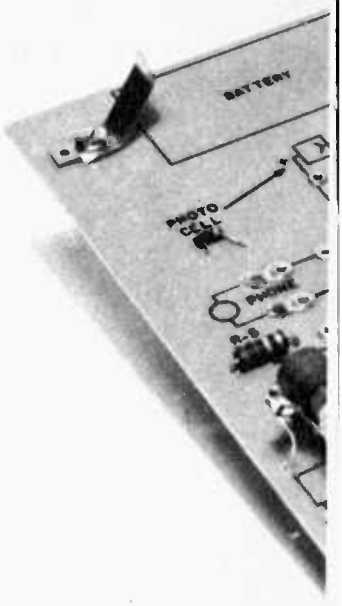
THE ELECTRONIC SWITCH SCHEMATIC



THE TIMER SCHEMATIC

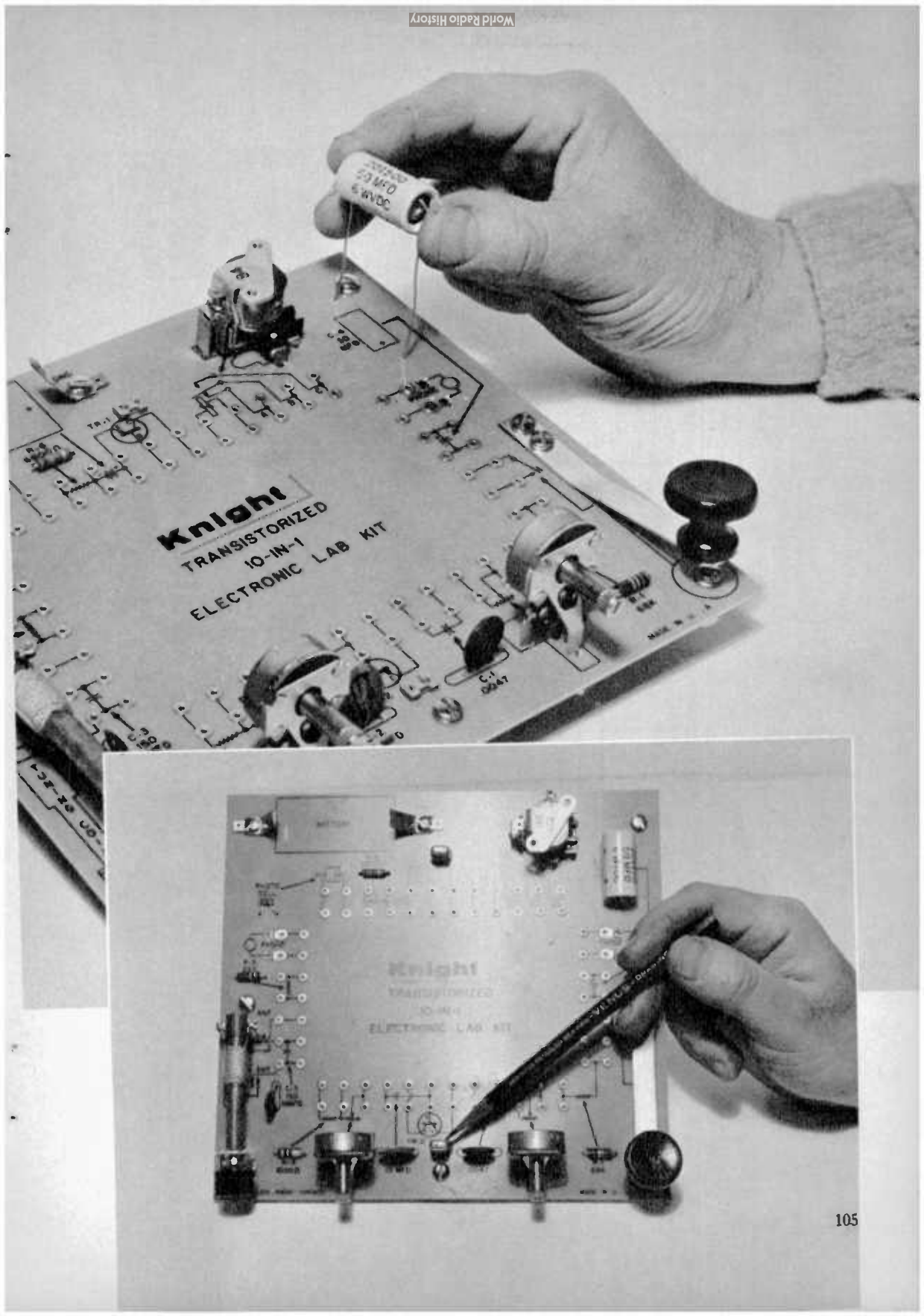


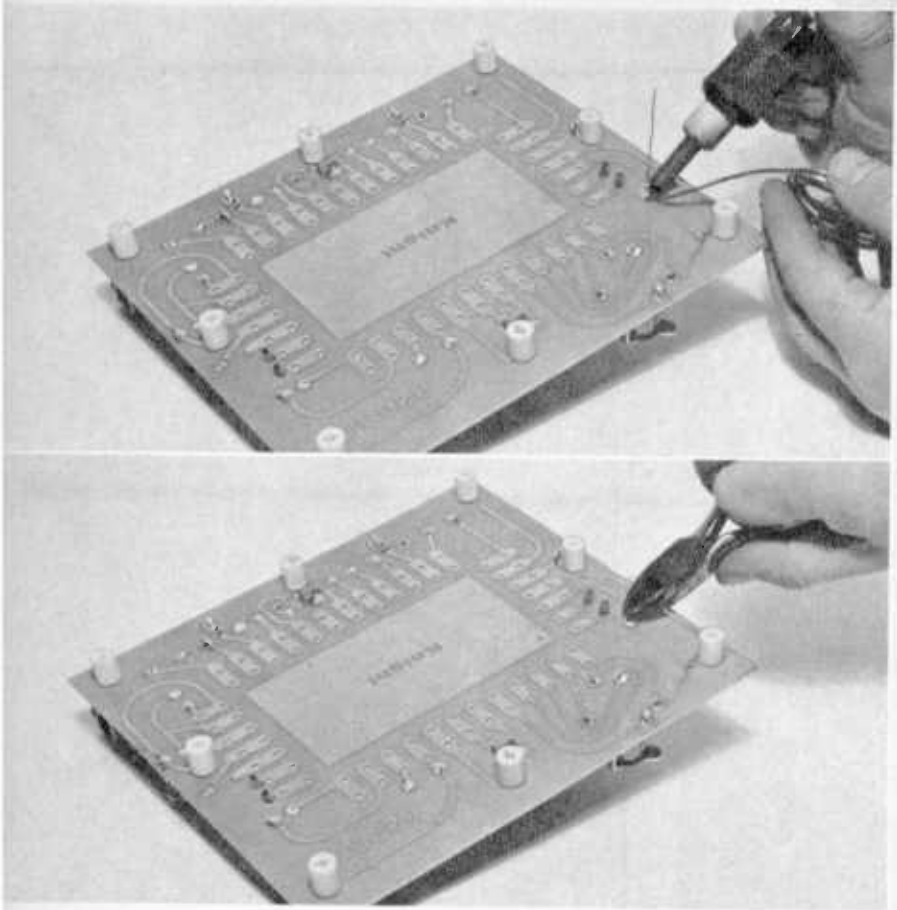
THE VOICE OPERATED RELAY SCHEMATIC

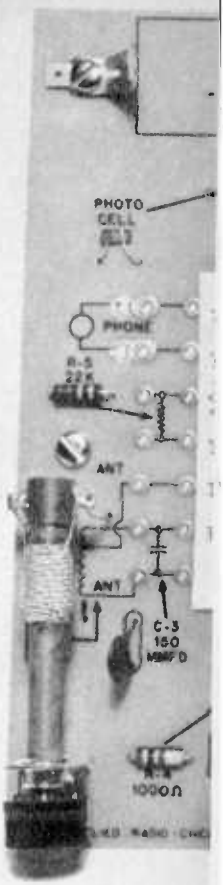


WIRE LEADS of fixed paper capacitor are being pushed through holes in baseboard of transistor lab kit. Parts already in position: battery clips and sensitive relay, along back edge; tuning coil; variable resistors, radio key and small resistors, capacitors, and transistor sockets along the front edge.

PENCIL POINTS to tiny transistor, in socket at front of baseboard. Second transistor is directly above, between the right-hand battery clip and the relay.







WIRE LEADS of components are soldered on under side of baseboard to printed silver lines. Small iron is best for this job. Note the small stand-off feet.

AFTER PARTS are soldered into place, protruding ends of wires are snipped off close, as shown.

low rivets. There are also numerous holes into which the wire leads of resistors, capacitors, a relay, a photo cell and other components are inserted. On the under side of the baseboard, the holes and the rivets are connected by printed silver lines. After the leads are pulled through, they must be soldered to the printed lines; thereafter, all connections between components are made on the top side by means of short plug-in wires.

Ten different working transistor circuits can be set up quickly. They are:

1) A two-stage earphone receiver for the regular broadcast band. With a small outside aerial, this brings in local stations loud and clear, with unusually good separation.

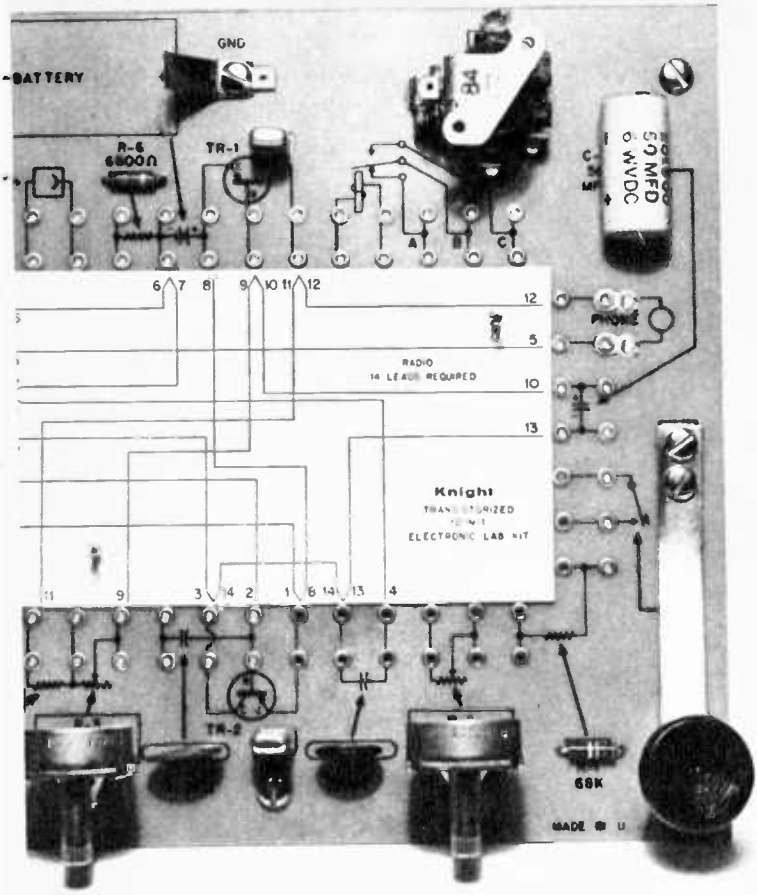
2) A photo-electric relay. Can be used as a burglar alarm and for "magic" tricks with the aid of a flashlight.

3) A wireless broadcaster. With an earphone employed as a dynamic microphone, voice can be transmitted to a broadcast receiver in an adjoining room.

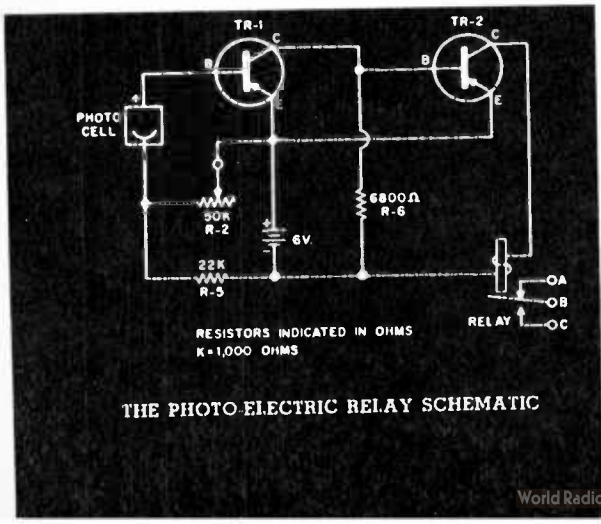
4) A code practice oscillator. Very useful for would-be "hams."

5) Electronic switch. Operates other devices with just the fingers for contact.

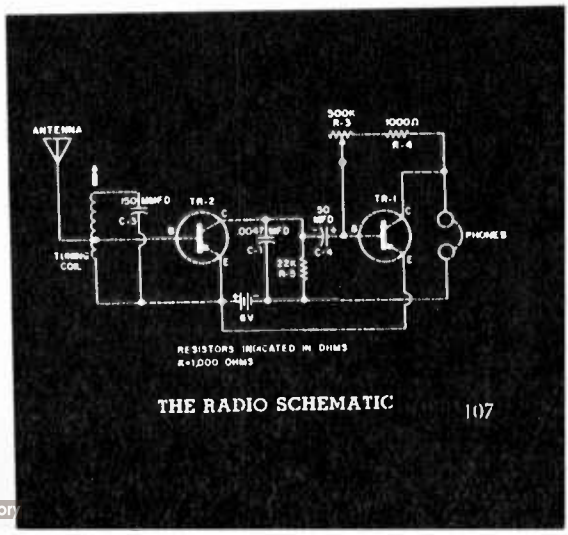
6) Two-stage audio amplifier. Used



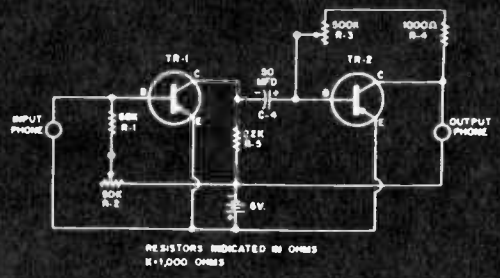
A GUIDE CARD is in position in the center area of transistor lab kit. Note how lines on it coincide with the hollow rivets to which the individual parts are connected. Flexible leads with tapered pin ends, held in hand at right, are furnished with kit.



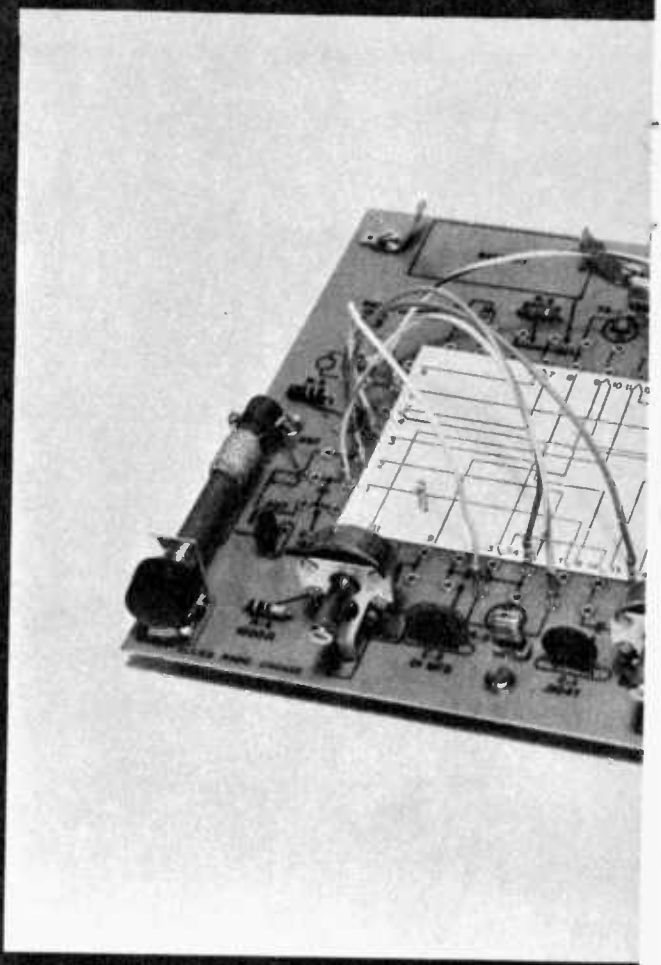
THE PHOTO-ELECTRIC RELAY SCHEMATIC

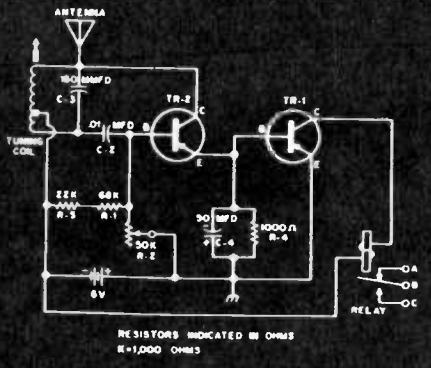


THE RADIO SCHEMATIC

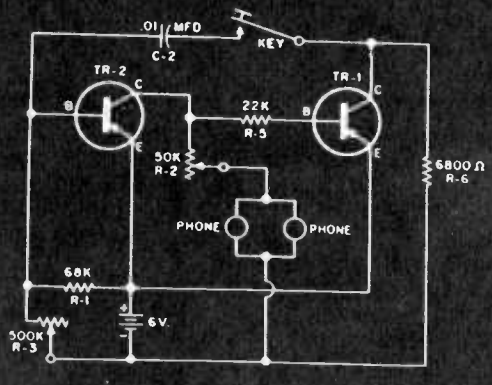


THE AUDIO AMPLIFIER SCHEMATIC

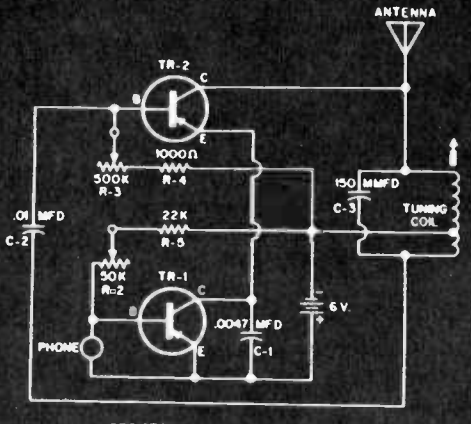




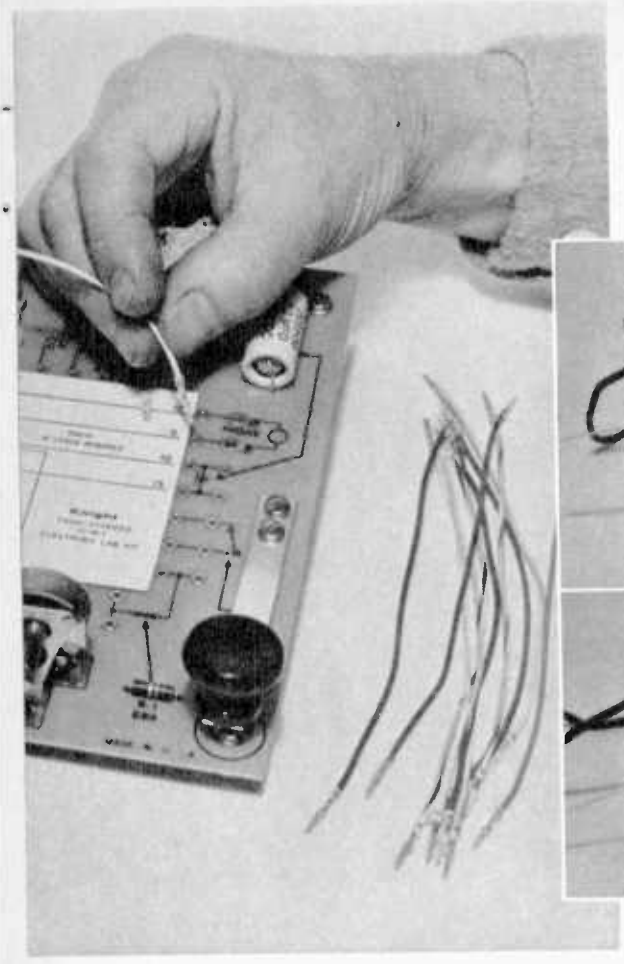
THE CAPACITY OPERATED RELAY SCHEMATIC

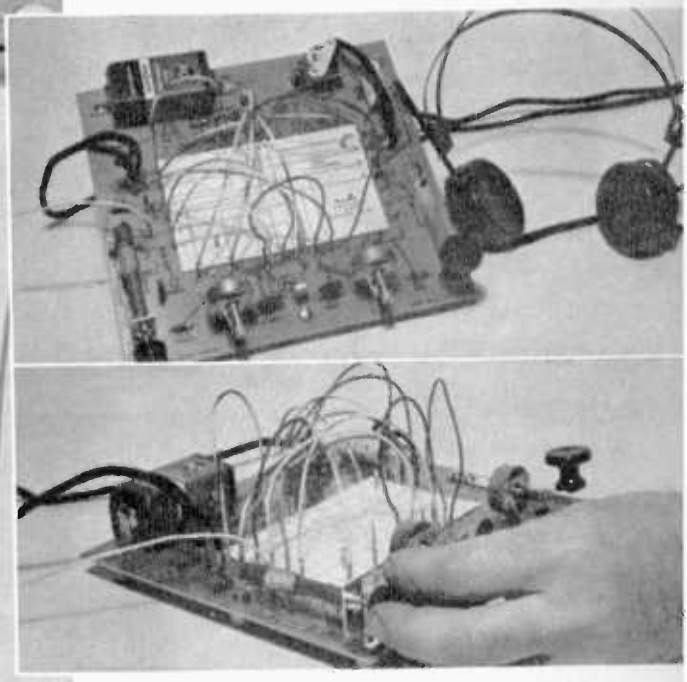


THE CODE PRACTICE OSCILLATOR SCHEMATIC



THE WIRELESS BROADCASTER SCHEMATIC





THESE PHOTOS show how connections between parts are made: Ends of flexible connectors are merely pushed into the rivet holes. In one minute, transistor lab kit becomes broadcast band receiver, working through pair of earphones. Note battery in clips, in upper left corner. Single wire running off to left is for aerial connection. Side view of completed transistor receiver shows method of tuning by means of movable slug inside horizontal coil. Wires criss-cross, but do not interfere with each other. Board rests on small feet on underside.

with earphones for private listening to phonograph records.

7) Capacity-operated relay. For "no hand" control of electrical appliances.

8) Electronic timer. Turns devices on and off.

9) Voice-operated relay. Talk into the phone-mike, and lamps will light or bells ring! A wonderful party stunt.

10) Electronic flasher. Good for lights and illuminated decorations.

The schematic diagrams of all these combinations are reproduced herewith.

The making of the actual connections between the mounted parts is virtually foolproof. For each circuit there is a white card measuring 2¾ by 4¾ inches, which is pinned into the center area of the baseboard. Numbered lines on the card coincide with the hollow rivets. A bunch of flexible leads, seven inches long and fitted at both ends with tapered pins to push into the rivets, is provided with the kit. To start, you look for the line marked 1-1, and insert the ends of one lead into the rivets next to these numbers. Then you trace out rivets 2-2, and bridge them with another lead, and continue until all the lines on the circuit card are represented by wires. In some places, there are connections to both of the rivets identified by a single number.

On the top of the board, the circuit symbol for each part is printed in black next to it, so the user learns to recognize it in schematic diagrams.

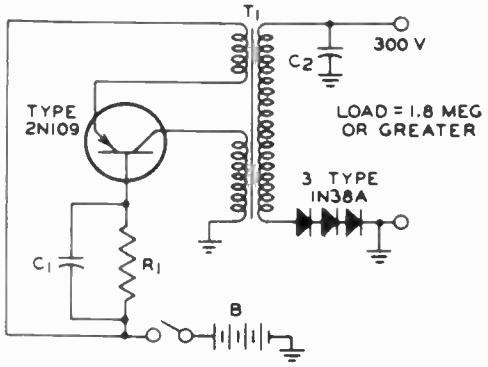
The only source of energy required for all ten hook-ups in a single little six-volt dry cell, which fits between clips in the upper left corner of the board. Because the transistors draw only a very small current, this battery will last months. •

PRACTICAL TRANSISTOR CIRCUITS

They're easy to make and will enhance your electronic knowledge

PORTABLE LOW-DRAIN, HIGH-VOLTAGE POWER SUPPLY (RCA)

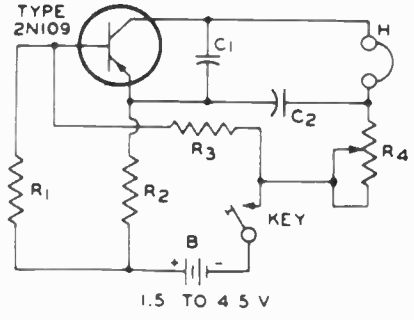
B = 12-volt battery
C_1 = 0.01 mfd
C_2 = 0.1 mfd
R_1 = 22000 ohms
T_1 = Transformer with 15-turn primary, 5-turn tickler, and 530-turn secondary, No. 26 or 28 enamel or cotton-covered wire, all close wound on one-inch wood or paper form.



THIS IS a very interesting and unusual power supply because it uses the type 2N109 transistor as a high-frequency oscillator, the output of which is changed into direct current by three type 1N38A germanium diode rectifiers. Filtering of the rectified output is provided by capacitor C2, which should have a voltage rating of 400 or 600 volts. The grounded (lower left) winding of transformer T1 is the primary and the smaller winding (upper left) is the "tickler" or feedback coil. Because of the power limitations of the transistor, the DC output is restricted to about 20 or 25 milliamperes. This is more than enough for many low-drain, portable electronic devices. An immediate use that suggests itself is in Geiger counters and similar detectors of "hot" radiations of various kinds. To prevent possible interference with nearby communications equipment, the frequency of the transistor oscillator should be checked with a grid-dip meter or a receiver having a beat-frequency oscillator. To change the oscillator frequency, simply add or remove turns of wire from the primary winding.

CODE PRACTICE OSCILLATOR (RCA)

B = RCA-VS036 1½-volt batteries (one to three depending on volume level desired)
C_1, C_2 = 0.01 mfd
R_1 = 2200 ohms
R_2 = 27000 ohms
R_3 = 3000 ohms
R_4 = potentiometer, 50000 ohms
H = 2000 ohms



MANY code-practice devices use a high-pitched buzzer powered by a couple of flashlight cells. They can be very annoying to occupants of a room other than the would-be operator. Here is a simple, inexpensive little transistorized oscillator that provides complete privacy, inasmuch as it uses a pair of headphones H. There is absolutely no shock danger, as the maximum battery voltage is only 4.5. Two batteries, totalling 3 volts, are usually sufficient for good earphone volume. For silent two-person practice, two keys can be connected in parallel, and two pairs of headphones in either series or parallel; try both connections. Values of resistors and capacitors are not critical.

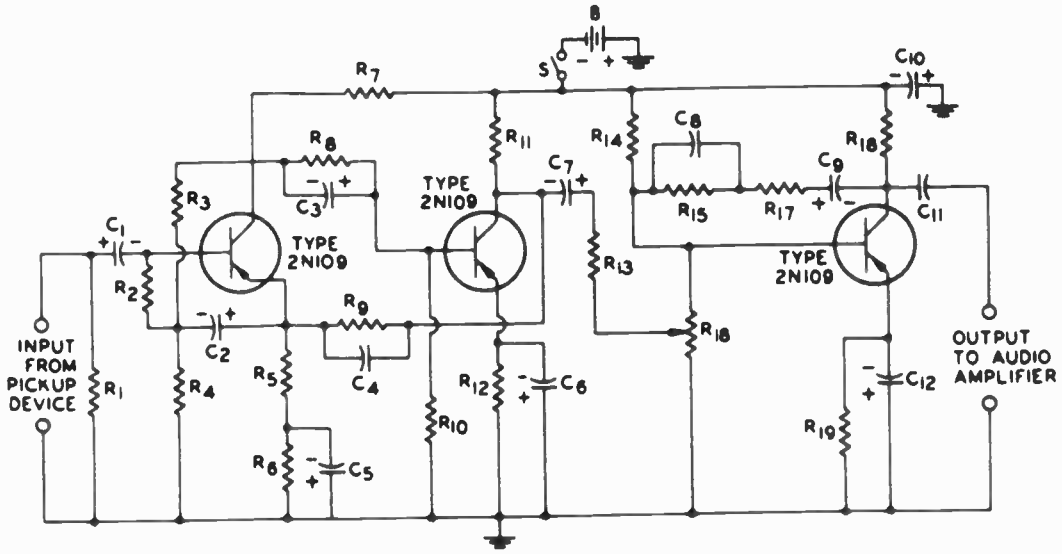
AS they become cheaper, more reliable in operation and more widely obtainable, transistors are rapidly replacing vacuum tubes in many electronic applications. Here is a collection of practical circuits of interest to experimenters, students, hobbyists and radio hams. The first group comes from the laboratories of the Radio Corporation of America, the second from CBS-Hytron.

The required parts are all standard, and those not already in the "junk box" in the radio shack are available from any radio jobber. The "power" requirements in all cases are very modest, and can be satisfied with small, low-voltage dry batteries. •

PHONOGRAPH PRE-AMPLIFIER (RCA)

B = 12-volt battery
C_1 = 15 mfd
C_2 = 5 mfd
C_3 = 1 mfd
C_4 = 0.0045 mfd
C_5 = 10 mfd
C_6 = 100 mfd
C_7 = 5 mfd
C_8 = 0.02 mfd
C_9 = 1 mfd
C_{10} = 100 mfd
C_{11} = 0.02 mfd
C_{12} = 100 mfd
R_1 = 47000 ohms
R_2 = 10000 ohms
R_3 = 39000 ohms
R_4 = 10000 ohms
R_5 = 500 ohms
R_6 = 3300 ohms
R_7 = 22000 ohms
R_8 = 100000 ohms
R_9 = 30000 ohms
R_{10} = 10000 ohms
R_{11} = 15000 ohms
R_{12} = 1000 ohms
R_{13} = 3900 ohms
R_{14} = 120000 ohms
R_{15} = 300000 ohms
R_{16} = Potentiometer, 5000 ohms
R_{17} = 15000 ohms
R_{18} = 10000 ohms
R_{19} = 510 ohms

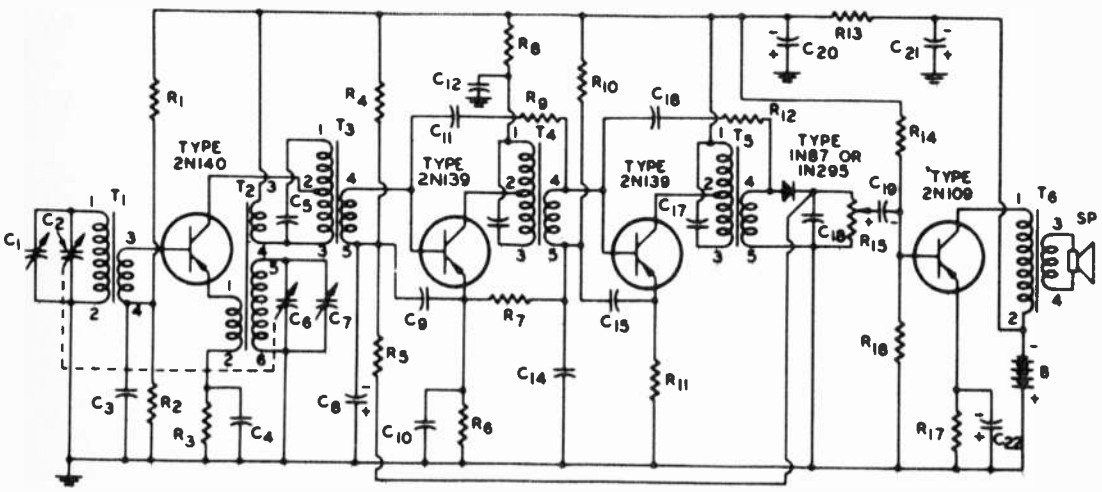
HERE IS a three-stage amplifier designed to work with a phonograph pickup of the crystal type. Capacitors marked with plus and minus signs to show polarity of connections are of the electrolytic type. Since the highest voltage anywhere in the circuit is 12, the capacitors can be of either 12 or 25 volt rating. Resistors can be the very small ones made especially for miniaturized transistor equipment. Note carefully that the positive side of the battery B is grounded, not the negative, and that all the capacitor positives are similarly grounded. Study diagram shown here for a complete understanding of unit's operation.



FOUR-TRANSISTOR RADIO RECEIVER (RCA)

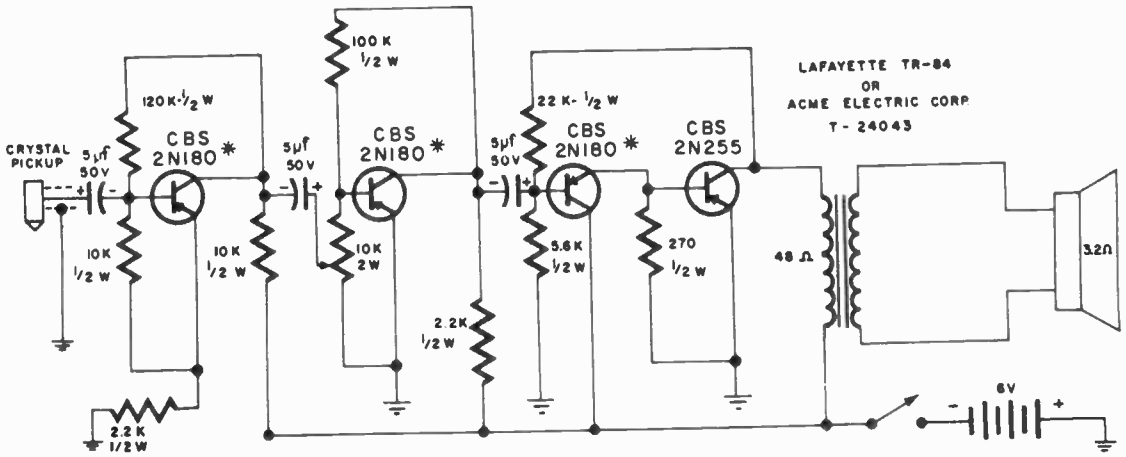
B = 9 volts, RCA VS300 or VS301
C_1 = 0-20 mmfd
C_2 = 12-230 mmfd
C_3 = 0.05 mfd
C_4 = 0.04 mfd
C_5 = 220 mmfd
C_6 = 10-105 mmfd
C_7 = 0-20 mmfd
C_8 = 10 mfd
C_9 = 0.05 mfd
C_{10} = 0.05 mfd
C_{11} = 75 mmfd
C_{12} = 0.05 mfd
C_{13} = 220 mmfd
C_{14} = 0.05 mfd
C_{15} = 0.05 mfd
C_{16} = 33 mmfd
C_{17} = 220 mmfd
C_{18} = 0.05 mfd
C_{19} = 2 mfd
C_{20} = 50 mfd
C_{21} = 50 mfd
C_{22} = 100 mfd
R_1 = 33000 ohms
R_2 = 24000 ohms
R_3 = 820 ohms
R_4 = 120000 ohms
R_5 = 18000 ohms
R_6 = 1200 ohms
R_7 = 75000 ohms
R_8 = 560 ohms
R_9 = 560 ohms
R_{10} = 150000 ohms
R_{11} = 1200 ohms
R_{12} = 2000 ohms
R_{13} = 100 ohms
R_{14} = 10000 ohms
R_{15} = 2500 ohms
R_{16} = 5600 ohms
R_{17} = 220 ohms
SP = Speaker
T_1 = Ferrite Loop Antenna with 353-mh primary.
T_2 = Oscillator Coil with 207-mh primary.
T_3 = 455-Kc IF Transformer with 206,000-ohm primary and 1000-ohm secondary.
T_4 = 455-Kc IF Transformer with 29,000-ohm primary and 500-ohm secondary.
T_5 = 455-Kc IF Transformer with 10,900-ohm primary and 1000-ohm secondary.
T_6 = Audio Output Transformer with 500-ohm primary.

THIS IS a more or less standardized design for a portable or pocket set to cover the regular broadcast band. Components made especially for compact construction are available from radio jobbers and mail order firms. For experimental use, components of conventional physical size can be used without affecting the operation of the circuit. Resistors of three different types are employed. The second detector, connected between the I.F. transformer T5 and the audio output transistor 2N109, is a germanium diode, either 1N87 or 1N295. The tuning control is the dual capacitor C2-C6, shown joined by a dotted line. The volume control is the potentiometer R15, between the second detector and the output transistor. The single 2N109 provides a highly satisfactory loud-speaker volume on both the local and nearby stations.



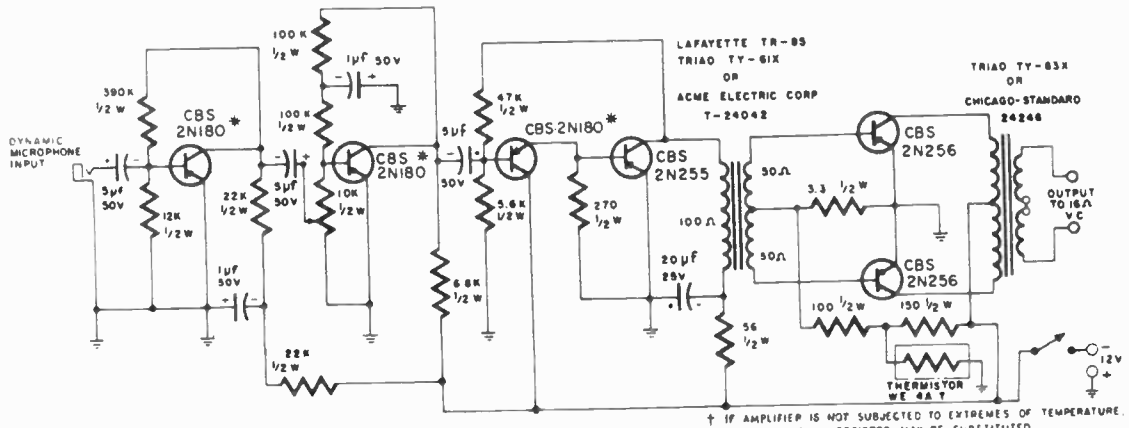
PORTABLE PHONOGRAPH AMPLIFIER (CBS-HYTRON)

A LIGHTWEIGHT portable record player having one-half watt output and a long battery life may be constructed using this transistor amplifier. The turntable used may be either the new battery-powered electric type or the manual type. The pick-up should be of the crystal type, to assure full volume. In the diagram, the letter K next to resistors means 1000, the letter W the power rating in watts. Thus, "10K ½W" indicates a 10,000 ohm resistor of ½ watt size. The volume control is a 10,000 ohm potentiometer connected between the first two transistors. The circuit has been designed so that transistors, having lower Betas, such as types 2N107, GT222, and CK722, may be substituted for the 2N180 units. Study diagram carefully.



MOBILE PUBLIC ADDRESS SYSTEM (CBS-HYTRON)

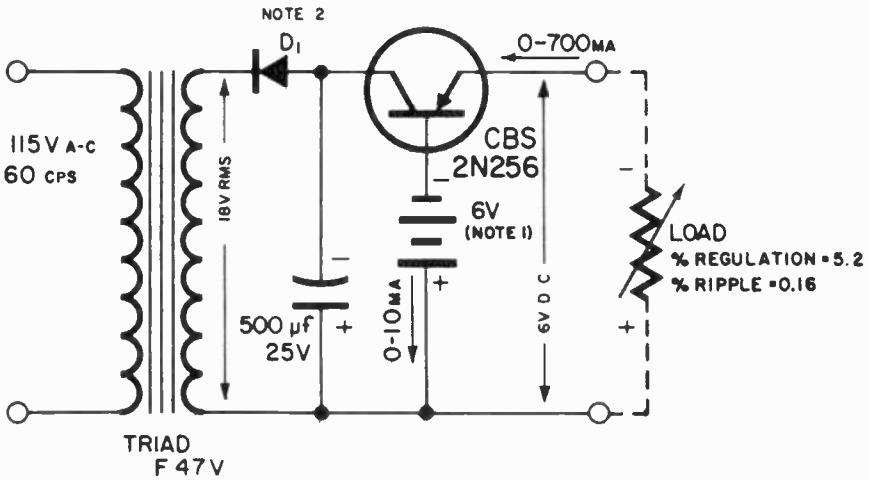
THIS HIGH-POWER amplifier, designed for compactness and dependability, will operate directly from a 12-volt storage battery without the need of a transformer and vibrator supply. The push-pull, Class B-operated 2N256's will furnish 10 watts of audio power, which is adequate for outdoor coverage of crowds of several hundred people. The two push-pull transformers connected to the 2N256 transistors are specially made for transistor service. Transformers designed for conventional vacuum tubes are not satisfactory for the purpose. The circuit has been designed so that transistors, having lower Betas, such as types 2N107, GT222, and CK722, may be substituted for the 2N180 units. Study the circuit diagram very carefully.



† IF AMPLIFIER IS NOT SUBJECTED TO EXTREMES OF TEMPERATURE, A 100 OHM ½W RESISTOR MAY BE SUBSTITUTED

REGULATED POWER SUPPLY (CBS-HYTRON)

A REGULATED supply of the series type in which the output voltage remains constant for wide variations of input (value of secondary voltage should never exceed 25 volts). The output voltage is less than one half volt higher than that of the reference battery. Different reference voltages may be used for other output voltages. This fine equipment is especially suitable for experimental use in the home laboratory.

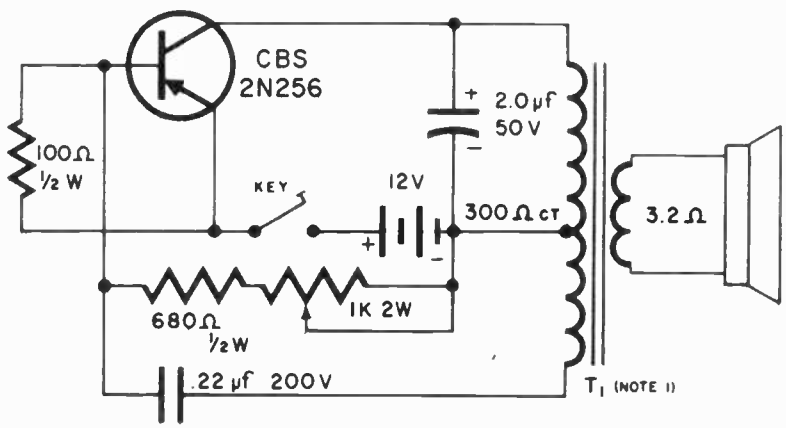


NOTE 1 6V REFERENCE BATTERY MAY BE REPLACED BY ZENER DIODE. (NATIONAL TYPE A5B OR EQUIVALENT)

NOTE 2 D_1 – TWO 500MA SELENIUM RECTIFIERS PARALLELED

CODE PRACTICE OSCILLATOR (CBS-HYTRON)

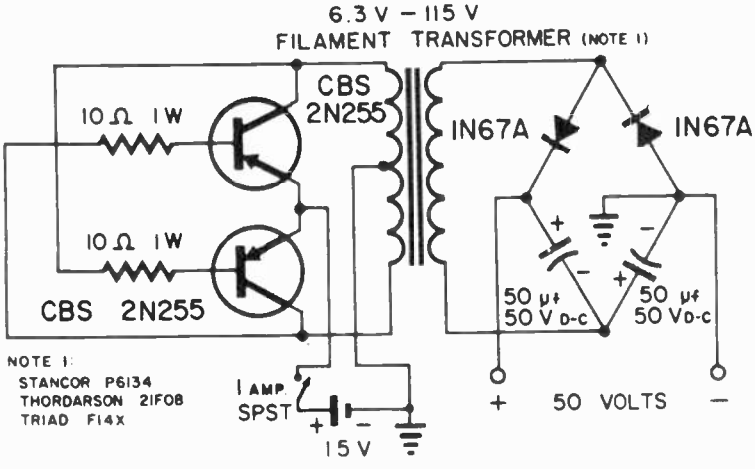
A SINGLE transistor audio oscillator for code practice that has sufficient output, 300 milliwatts, to drive a small loud-speaker. The circuit incorporates a tone control. A volume control may be added in the form of an L-pad in the speaker voice-coil lead. Its smooth variable tone output makes code practice a pleasure.



NOTE 1
T_1 – ARGONNE AR-121 OR NEW ENGLAND TYPE 399

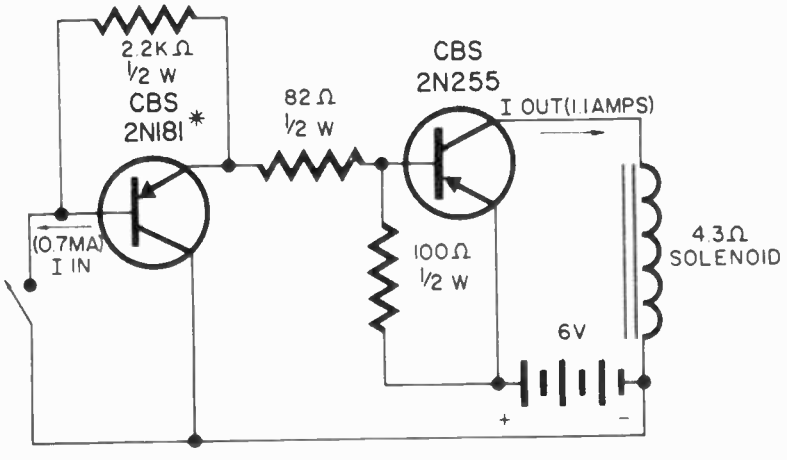
DC VOLTAGE MULTIPLIER (CBS-HYTRON)

THIS DC voltage multiplier will provide high voltage from a low-voltage source, thus eliminating the troublesome vibrator or bulky B battery. When the CBS transistors oscillate, they provide an AC voltage across the transformer. The output voltage and current are determined by the battery voltage and transformer turns ratio; therefore, they may be varied to suit the application as long as the transistor and diode ratings are not exceeded. This power supply offers interesting possibilities for the development of medium-power, high-frequency transmitters for either mobile or portable applications. Heretofore, the power packs of such transmitters have been larger and heavier than the signal-generating equipment itself. Note connections of 1N67A diode rectifiers and polarity markings of the filter capacitors.



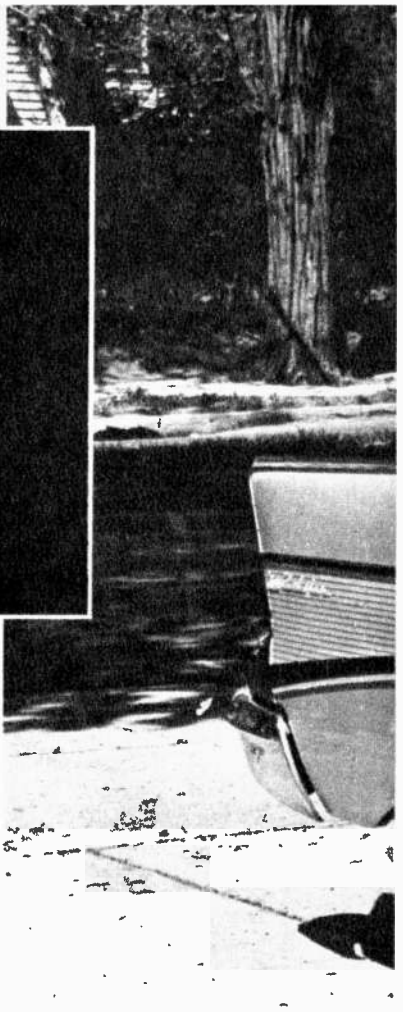
RELAY CIRCUIT (CBS-HYTRON)

A SENSITIVE relay circuit having high-temperature stability in which an input current of less than 1.0 milliampere will control a 1.0 ampere solenoid. It is useful in model boats, airplanes, and other remote control devices. An interesting and useful application might be to radio-controlled garage door openers. If amplifier is not subjected to extremes of temperature a 2N107 transistor may be substituted.



TRANSISTOR PORTABLE

This attractive new model has a fine, full-bodied tone quality



GOING SOMEPLACE? The Front view of the portable is volume control and switch on

WHEN transistors dropped sharply in price recently and became available in quantity, set manufacturers began making radio receivers smaller and smaller and smaller until they came down to the size of a pack of cigarettes.

These sets have considerable novelty appeal, but once this wears off two shortcomings become noticeable: 1) The tone quality afforded by the necessarily tiny loud-speakers is very bad; 2) The necessarily tiny batteries don't last nearly as long as we've been led to expect, and they are expensive to replace.

People who like to build electronic equipment from kits found transistor jobs interesting, but often very difficult because of the mere smallness of the components. Obviously, miniaturization can be carried too far.

A slightly different approach to the transistor portable, and in my opinion a very practical one, has been taken by the Heath people in their design of an entirely new kit receiver they call the XR-1. They acknowledged in advance that transistors are ideal for portables, but they also put forth these requirements: 1) The sound quality must be respectable; 2) The batteries must be cheap, readily obtainable, and have long operating life; 3) Assembly and wiring must be possible with ordinary tools, without the need for a magnifying glass.

The object was not to produce a pocket set, but one that could be carried easily in one hand and would work when put down on a night table, a workbench, a desk, a picnic ground, etc. The receiver as finally produced weighs only 4½ pounds, measures 8½ inches wide, 8 inches high and 4 inches deep at the bottom, and works like a charm.

Six transistors give the straightforward superheterodyne circuit plenty of sensitivity and volume. Tone quality comparable to that of any regular table-model radio is obtained from a 3- by 5-inch oval loud-speaker. The flat chassis is easy to work in. The source of energy is a bank of six ordinary "D" size flashlight batteries, available all over the world at low prices. The batteries fit in a compartment at the bottom of the chassis, giving the receiver a low center of gravity and making it virtually spillproof.

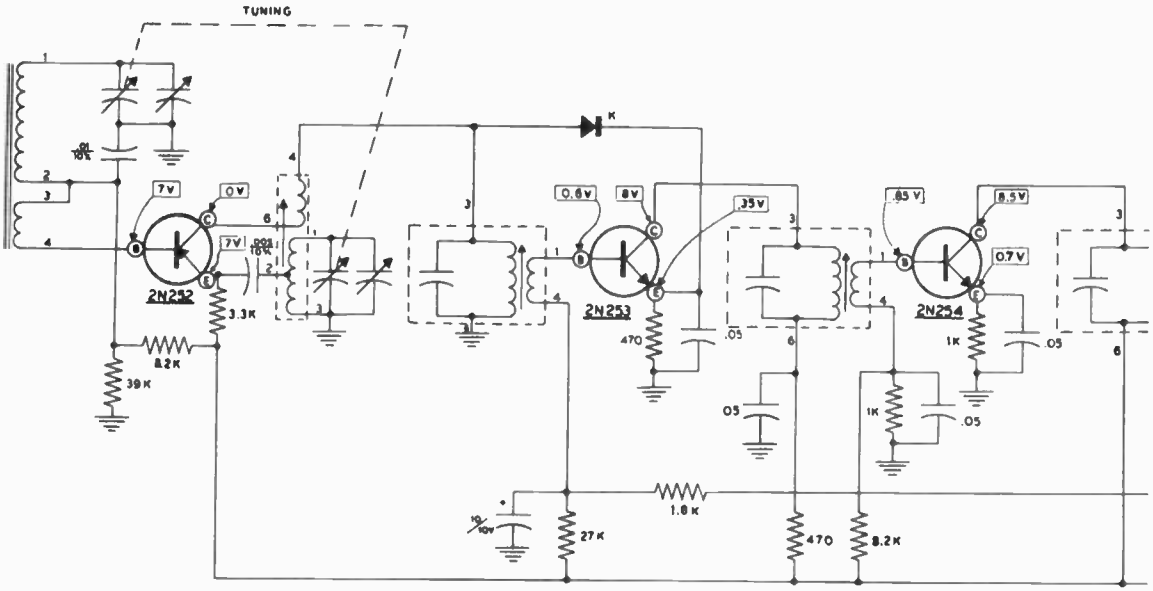
In a colored one-piece plastic case, the XR-1 looks more like a table set than a

Heathkit transistor portable is easy to take along. shown in photo right. Tuning knob is on the right. left. Top slot is finger grip, for carrying the set.

portable; the handle characteristic of portables is conspicuous by its absence. However, a finger grip is molded along the full width of the case, just above the loudspeaker grille, and this makes carrying simple.

My wife and I practically fight for this portable when we are home at the same time. We use it in every room to keep posted on the news, the weather, driving conditions, etc. It is very convenient because it has no trailing line cord and because it snaps to full volume the instant it is turned on.

Since the maximum battery output is only 9 volts and there is no connection to the power line, the set is absolutely safe for children, even when they're in a wet bathroom. •



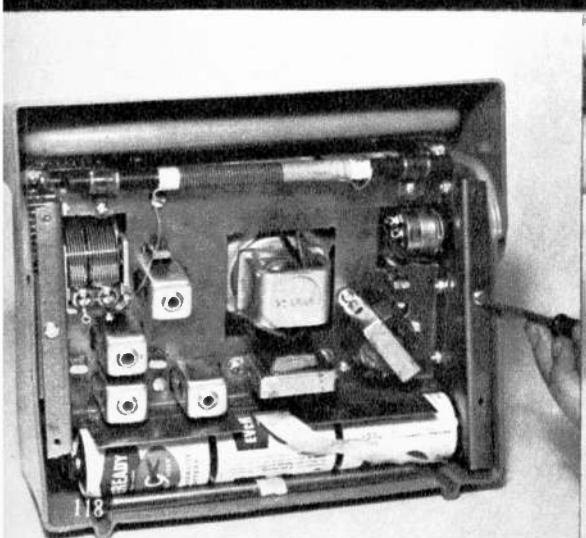
BOTTOM VIEW OF ALL COILS

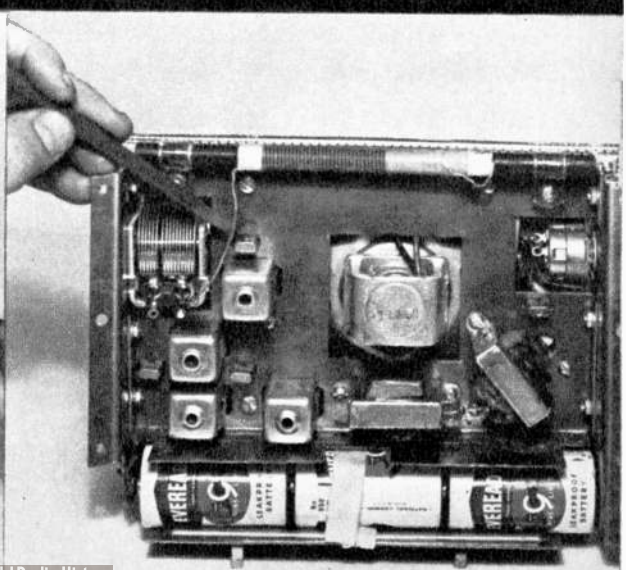
COLORED DOT

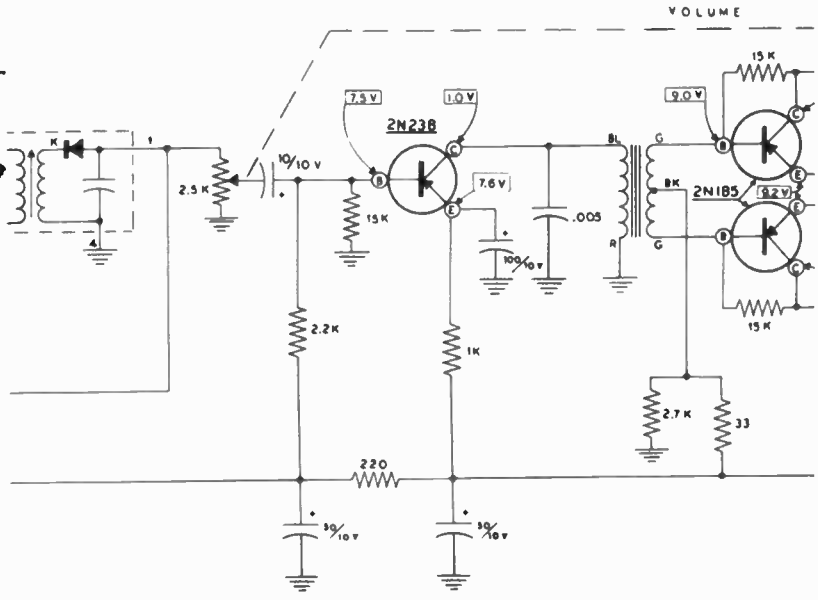
BOTTOM VIEW TRANSISTOR SOCKET

BACK VIEW of set, with cover removed to show vertical chassis. Loud-speaker sticks through square hole in center. Screws secure the chassis.

THE CHASSIS out of the case is shown in photo below. Pencil points to one of six transistors. Loopstick antenna is along top edge of unit.



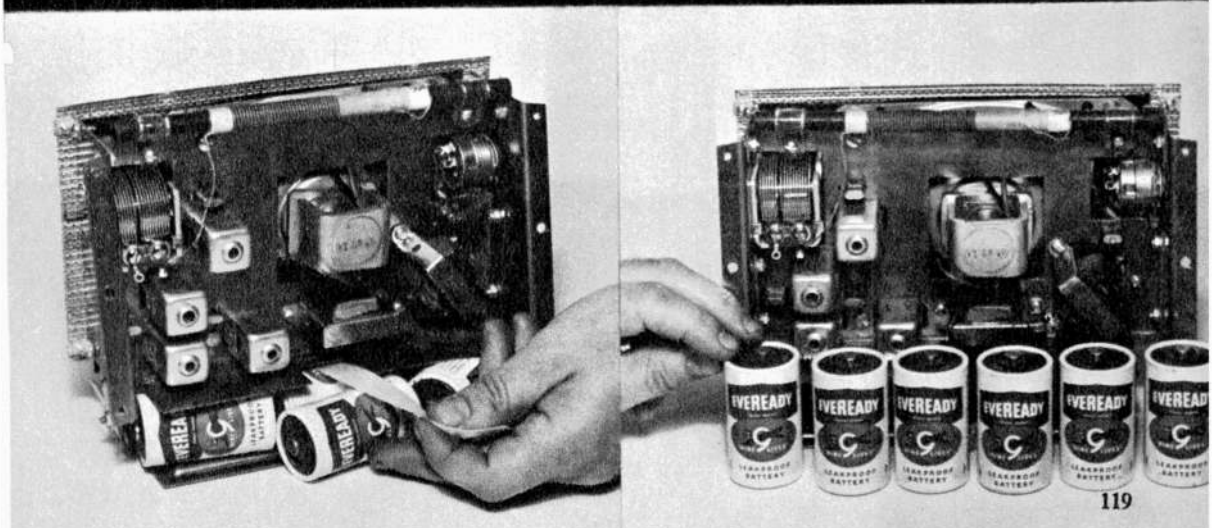




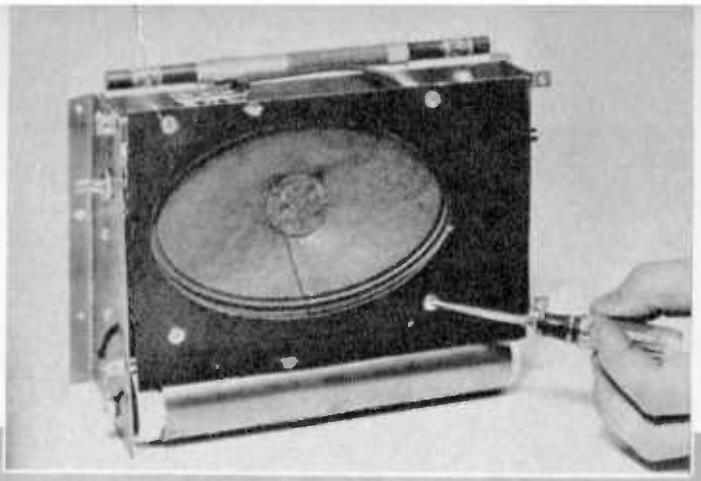
SCHEMATIC
HEATHKIT TRANSISTOR
PORTABLE RADIO
MODEL XR-1

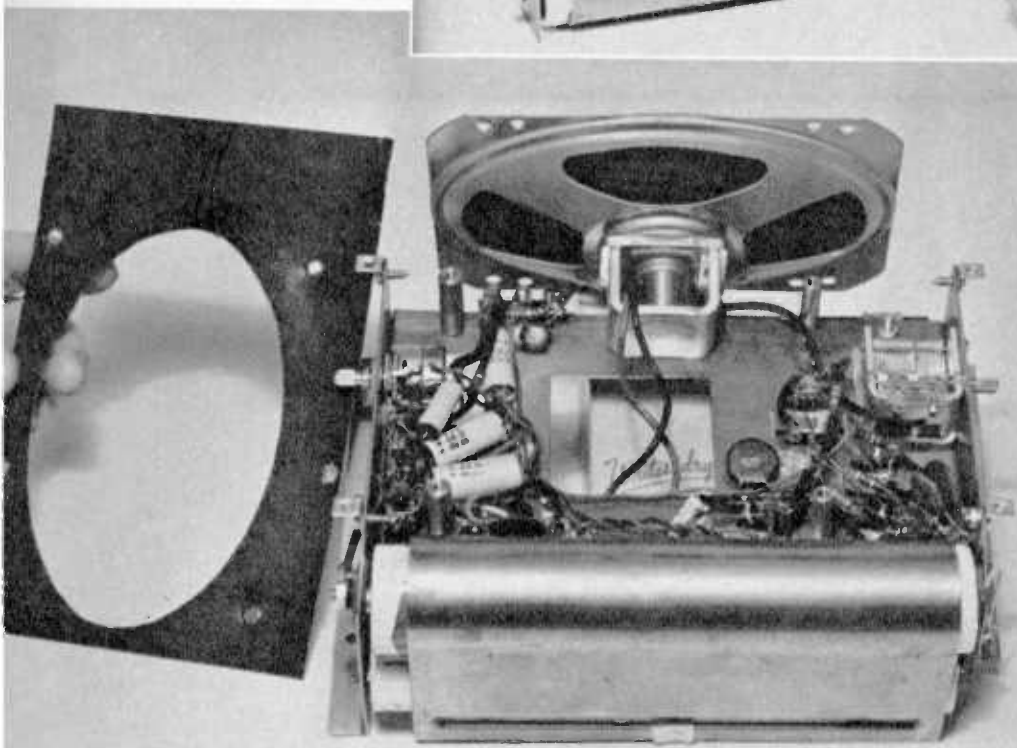
BATTERIES fit in two rows of three each at bottom of chassis. Tape around center two batteries permits them to be pulled out for replacement.

THESE SIX "D" batteries fill bottom section of compartment, and provide all operating energy for receiver. Standard flashlight cells serve the purpose.



FRONT of chassis, with loud-speaker and its fiber cover plate removed to show parts spread over chassis surface.





THE LOUD-SPEAKER (photo above) is mounted to the front of the chassis after all wiring has been completed. Note loopstick antenna along top. Loud speaker grille (photo left) is decorative piece of hardware cloth. Complete unit now slides into case.

It Won't Come Off!

ALL RECORDING TAPE is coated with magnetic oxide. On ordinary tapes this coating rubs off in use and forms a harmful deposit of abrasive dust on the recording head. Unless the head is constantly cleaned, the collection of abrasive dust eventually wears it out. A further disadvantage of oxide-shedding, common to ordinary tapes, is that after a few playings, the tape loses enough coating to alter its original frequency response characteristic.

WITH TAPE MADE BY THE EXCLUSIVE

irish BRAND

FERRO-SHEEN PROCESS

The Oxide Will Not Rub Off!

The irish *FERRO-SHEEN* process of tape manufacture anchors the oxide coating to the base permanently, inseparably and much more smoothly. The obvious advantage of the homogeneous bond is that *the entire vicious cycle of shedding and abrasion of recording head and tape is eliminated, resulting in longer life for the tape, longer life for the head and flat frequency response over a wider range.*

There's an **irish** BRAND

FERRO-SHEEN TAPE

for every recording requirement . . .

SHAMROCK on 1.5-mil preselected acetate base
GREEN BAND on 1.5-mil acetate base
LONG PLAY on 1-mil Mylar base
DOUBLE PLAY on 0.5-mil Mylar base
SOUND PLATE on 1.5-mil Mylar base

Write for name of local dealer:

ORRADIO INDUSTRIES, INC.

World's Largest Exclusive Magnetic Tape Manufacturer

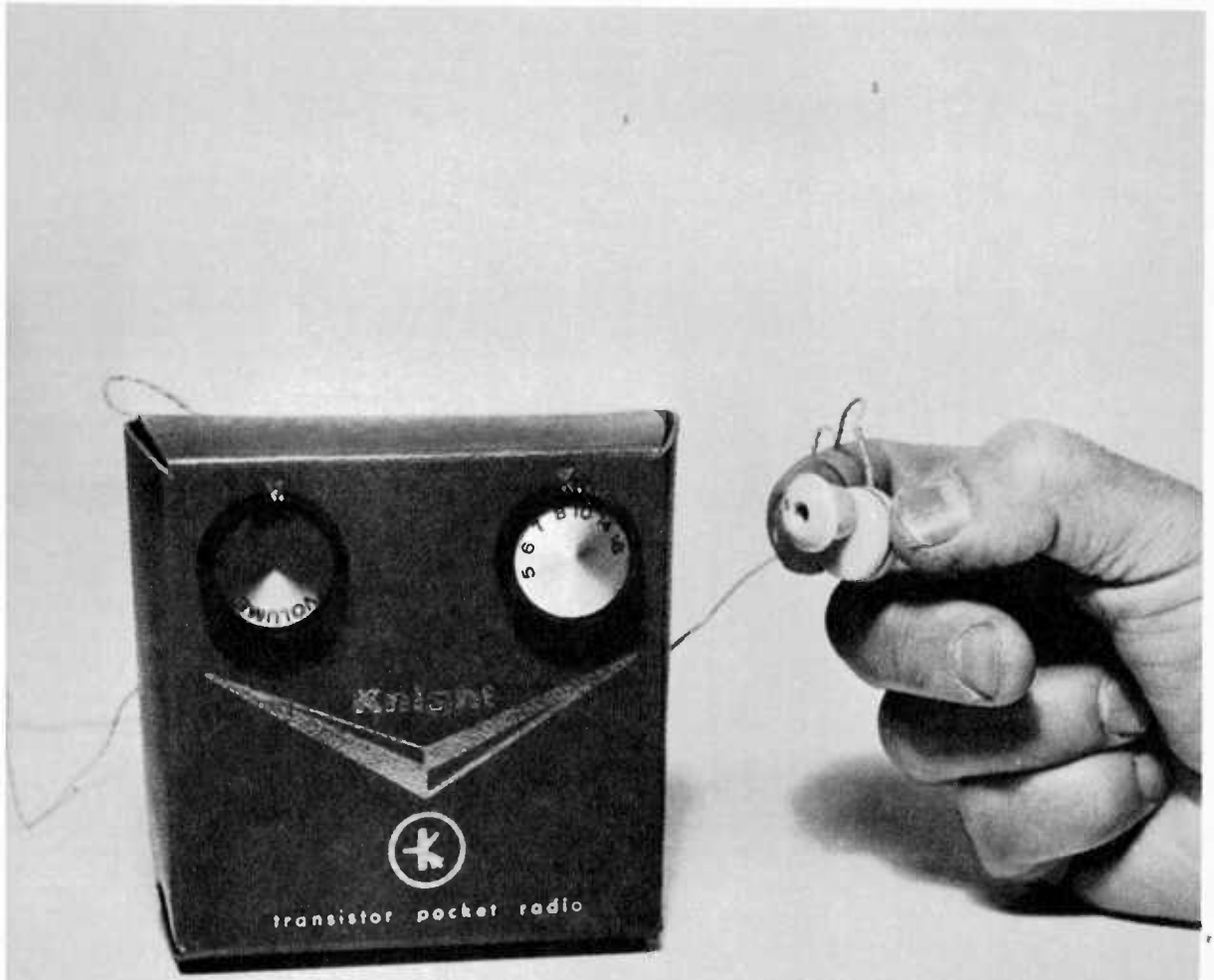
Opelika, 2 Alabama

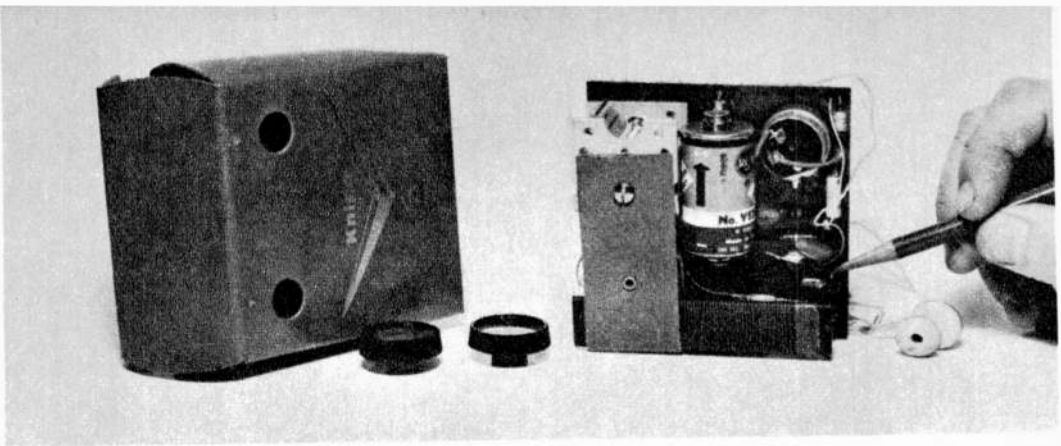
EXPORT DIVISION:
Morhan Exporting Corp., N.Y.C.
IN CANADA:
Atlas Radio Corp., Ltd., Toronto

INTRODUCING... THE 2-TRANSISTOR POCKET RADIO

It's small, uses a single earphone, gives good results

TRANSISTORIZED pocket radio uses single earphone, gives good results on local stations.





THE PRINTED circuit "chassis" out of the carrying case is shown in photo above. Pencil points to tiny transistor. Loopstick antenna, along bottom, and battery, in center, are largest components of the unit.

HOW small and simple can a radio receiver be made? One answer is represented by a new Knight kit called the "2-Transistor Pocket Radio." In a simulated leather case, it measures 3½ inches square by 1¾ inches thick. Using two transistors and a germanium diode, a loopstick antenna and a self-contained nine-volt battery, it provides good earphone volume on local broadcasting stations.

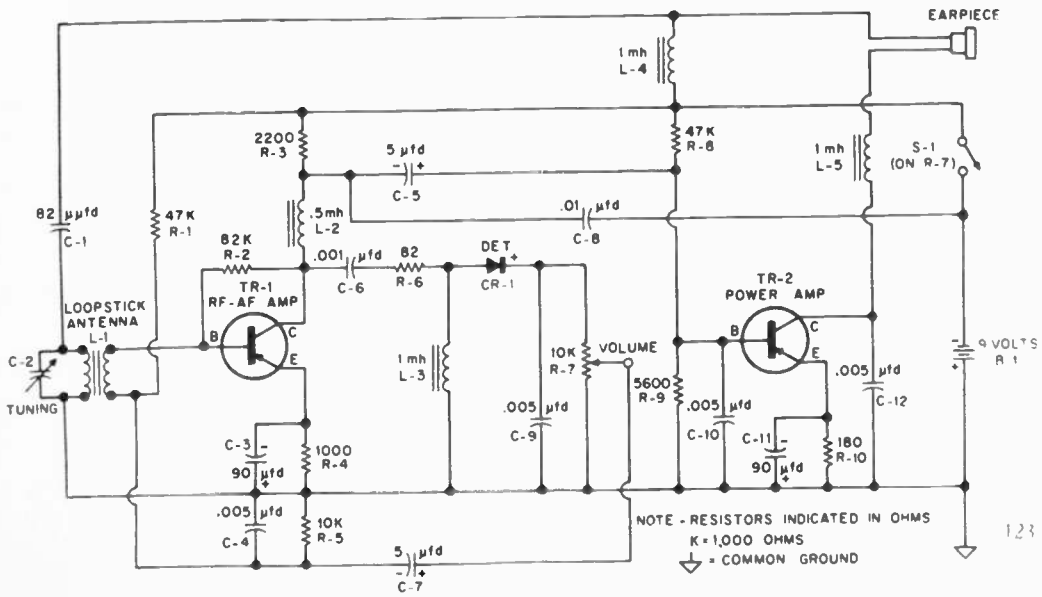
The circuit is interesting in that the first transistor, TR1, amplifies the weak radio-frequency signal picked up by the antenna L1, and also the detected audio signal after it comes out of the germanium detector CR1. This principle, known as "reflexing," was popular in the middle 1920's, before the more sensitive superheterodyne circuit was adopted for commercial production.

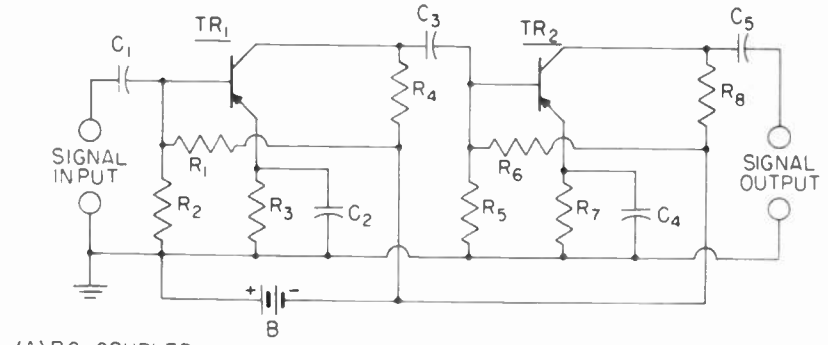
The audio signal coming out of TR1 is further amplified by the second transistor TR2, to which the earphone is connected.

The controls consist of the bare minimum: a combined volume control and switch, R7 and S1, and a tuning capacitor C2. Tuning is a bit on the broad side, a characteristic of small sets of this type.

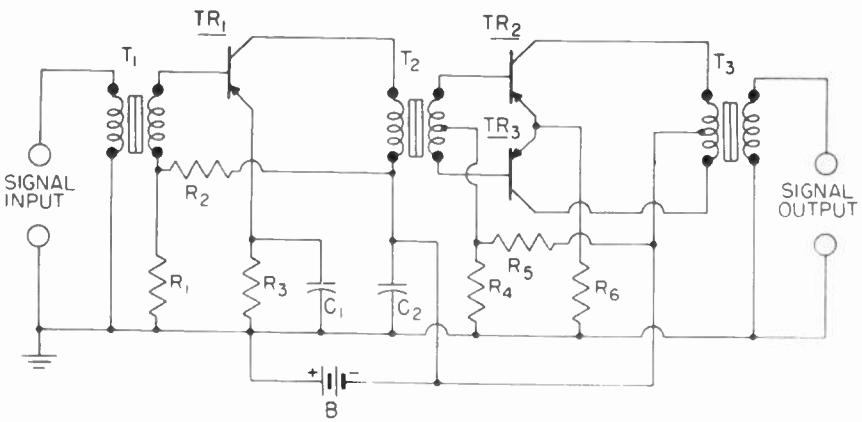
The use of a tiny printed circuit board makes assembly and wiring of the parts virtually foolproof. Because of the close spacing of the printed lines, to which the parts' terminals are soldered directly, solder must be applied very sparingly. •

COMPLETE CIRCUIT of the Knight pocket radio is shown in diagram below. Reflex principle is used to make transistor TR1 function in duo roles: as both radio-frequency and audio-frequency amplifier.

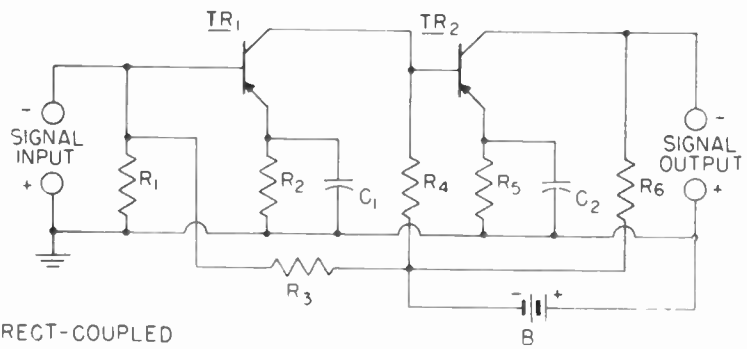




(A) RC-COUPLED



(B) TRANSFORMER-COUPLED



(C) DIRECT-COUPLED

TRANSISTOR AMPLIFIERS

FIGURE 1

TUBELESS AMPLIFIERS

They use less power, are more reliable, come in three types: transistor, magnetic and dielectric

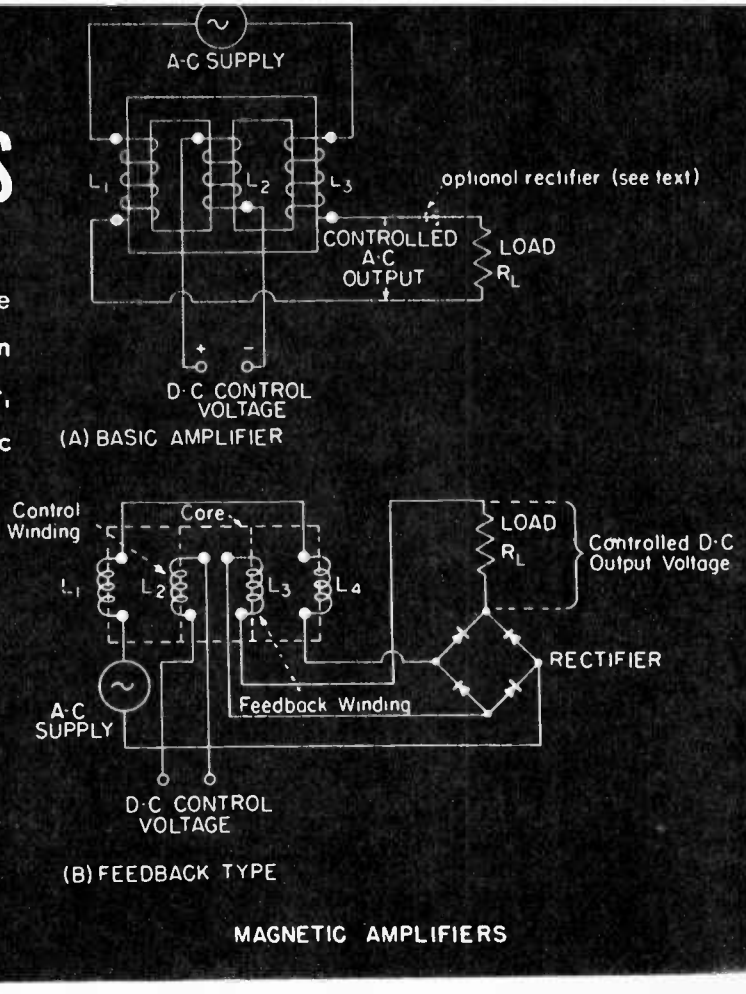


FIGURE 2 MAGNETIC AMPLIFIERS

THE mention of the term *tubeless amplifiers* brings the immediate question "Why is there interest in amplifiers which do not employ tubes?" When vacuum tubes were both costly and fragile 35 years ago, there was a constant but fruitless search for other amplifying devices. But the quest was abandoned when tube prices became more reasonable and the product more dependable. Interest in this direction has been revived in recent years because the tube often has proven to be the important unreliable link in complex electronic systems, according to the engineering department of the Aerovox Corporation, New Bedford, Mass.

The non-tube amplifiers give promise of greatly increased reliability, especially since some of these devices have unlimited life. Neither type uses a filament or heater, and thus makes more efficient use of the local power and has simpler power supply demands.

A number of tubeless amplifiers have come forward during the past ten years. Principal among these are the transistor, magnetic, and dielectric amplifiers. When contrasting these devices, it is impossible to find a more suitable basis of comparison than the type of power supply employed. The transistor, for example, like the tube, employs a DC power supply. The magnetic amplifier and dielectric amplifier, on the other hand, employ AC (often high-frequency) power supplies. Comparisons which use the tube circuit as a standard often tend to discredit from the start all devices requiring AC power supplies, even before other characteristics are considered.

The transistor depends for its operation upon the control of electron flow in a solid material (semiconductor) instead of in a

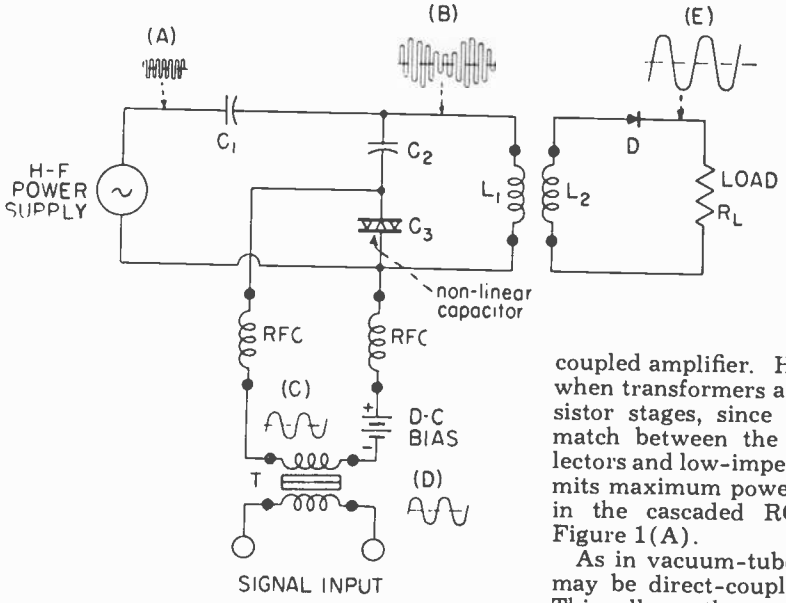


FIGURE 3

DIELECTRIC AMPLIFIER

vacuum. Transistors in widest present use are triodes, although some tetrodes have been developed and a few are available commercially.

In a triode transistor, the *emitter* electrode functionally resembles the cathode of a tube, the *base* the grid, and the *collector* the plate. A DC supply places the proper bias on the electrodes. The transistor is a current-operated device.

Depending upon the manner in which the transistor is connected into the circuit, the signal output current may be higher or lower than the signal-input current. However, since the output resistance normally is higher than the input resistance, both voltage and power gain are provided even when the current gain is 1 or less.

Figure 1 shows representative transistor amplifier circuits of the *common-emitter* type (also called "ground emitter"). Figure 1 (A) is the conventional resistance-capacitance-coupled type. The collector load resistors (R_1 and R_5) correspond to the plate load resistors in a tube amplifier. Emitter resistors R_3 and R_7 are similar to the cathode resistors in a tube circuit and are by-passed (C_2 and C_4) for the same reason—to prevent degeneration. The single DC supply, B, provides negative voltage for the collectors and negative voltage, through divider networks R_1-R_2 and R_5-R_6, for the bases of transistors TR_1 and TR_2.

Figure 1(B) shows a transformer-coupled amplifier. Higher gain is obtained when transformers are used between transistor stages, since they provide a close match between the high-impedance collectors and low-impedance bases. This permits maximum power transfer, impossible in the cascaded RC-coupled circuit of Figure 1(A).

As in vacuum-tube practice, transistors may be direct-coupled. (See Figure 1C). This allows the amplification of direct-current signals, as well as extending the frequency range of AC signal amplification down to a cycle or less per second. The direct-coupled amplifier provides somewhat less over-all gain than the RC-coupled—and transformer-coupled circuits.

Representative Characteristics

At this writing, the following characteristics are representative of transistor amplifiers:

Frequency Range. Zero to 600 Mc. (including special high-frequency types).

Efficiency. 30 to 40 percent Class-A, 50 to 70 percent Class-B.

Power Output. Up to 40 watts. (60 watts and higher have been reported in experimental, laboratory models).

Power Gain. 40 db per single-ended stage.

Size. Subminiature in conventional types. Small in high-power types.

The magnetic amplifier offers the advantages of simplicity, ruggedness, compactness, foolproof circuitry, unlimited life, and components not easily burned out in normal use. The magnetic amplifier requires an AC power supply.

Figure 2(A) shows a basic magnetic circuit. In this arrangement, coils L_1, L_2, and L_3 are wound on a three-legged core made of a special alloy having a rectangular hysteresis loop. Coils L_1 and L_3 are connected in series with each other and with the AC power supply and load. The impedance of this combined winding therefore is in series with the power supply and load and determines the load current and voltage drop.

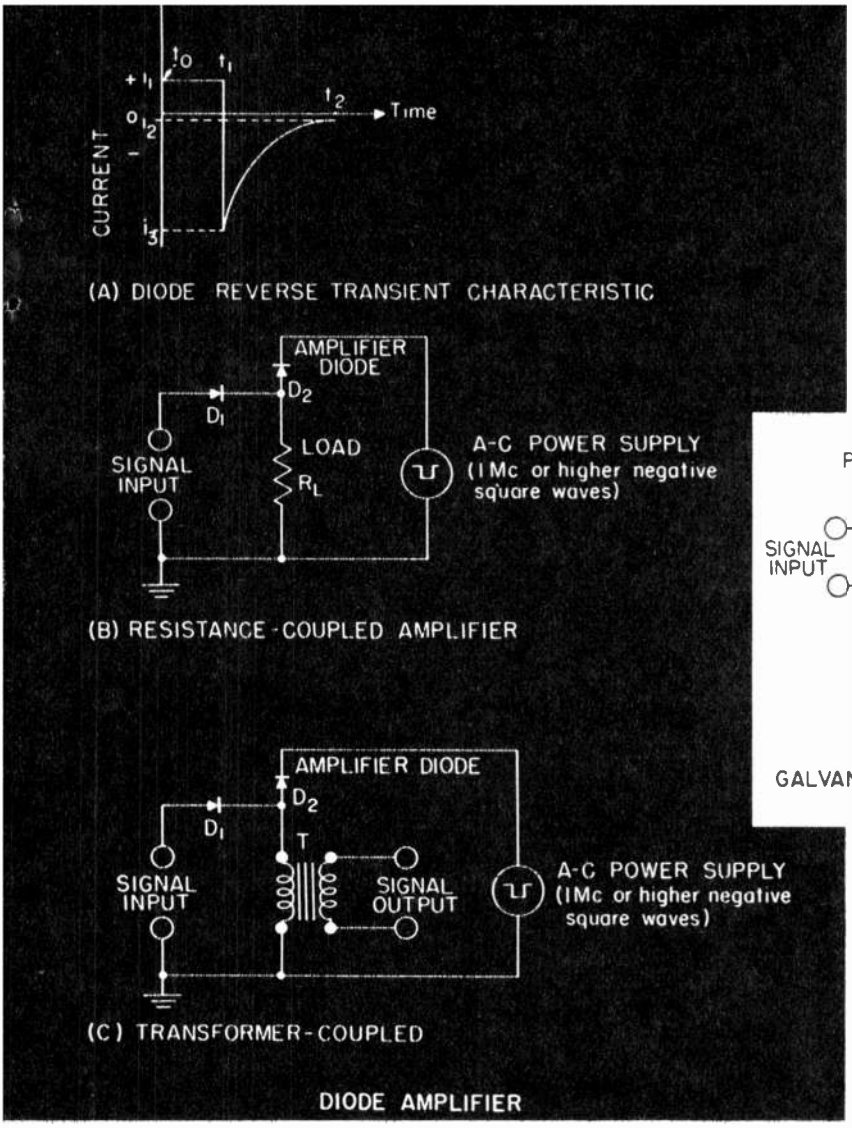
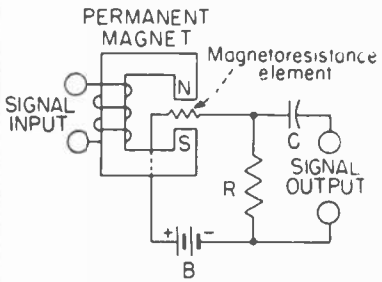


FIGURE 4

FIGURE 5



GALVANOMAGNETIC AMPLIFIER

Direct current flowing through the control winding, L_2, produces varying degrees of saturation in the core, depending upon the direct current level. This saturation lowers the impedance of the L_1-L_2 combination and allows more AC to flow through the load. The voltage drop across R_L thus is proportional to the applied DC voltage. When DC output is desired, a semiconductor rectifier may be connected in series with R_L, as shown by the dotted-line symbol. Because a small DC input produces a large change in output, amplification takes place.

Frequently, in place of DC, an AC input signal is employed. However, the power supply frequency must be several times higher than that of any AC signal which is to be amplified (usually not less than 10 times the signal frequency). This requirement has limited most large, practical magnetic amplifiers to the handling of DC and low frequencies. However, audio-frequency magnetic amplifiers have been constructed to operate from 100-kc power supplies, and special experimental amplifiers with small, thin cores of high-efficiency alloys have been operated at power supply frequencies up to 10 megacycles.

Figure 2(B) shows how a fourth core leg and winding may be added for feedback. Both positive and negative feedback have been employed in magnetic amplifiers. The feedback polarity depends upon the sense of winding L_3. The regeneration provided by positive feedback increases the

sensitivity, while the degeneration provided by negative feedback improves the signal wave-form. The circuit of Figure 2(B) is shown arranged for DC input and output. However, it may be adapted for AC signal amplification by omitting the output rectifier and feeding back a portion of the AC output to L_3 in the proper phase for regeneration or degeneration, as desired.

Like transistors, magnetic amplifiers have low input impedance. They have excellent power-handling ability, having been employed at levels up to many hundred kilowatts. They have replaced tubes in some voltage-regulated DC power supplies. Their response speed is somewhat slow when compared with that of amplifiers of other types, chiefly because of the magnetization characteristics of the core material and the limitations imposed by the low power-supply frequencies.

The dielectric amplifier may be thought of as the capacitive counterpart of the magnetic amplifier. Employing an AC power supply and operating in a similar fashion, the dielectric amplifier utilizes a change in capacitive reactance, in contrast to the magnetic amplifier which uses a change in inductive reactance to obtain control of output current and voltage.

Role of Capacitor

The heart of the dielectric amplifier is a capacitor containing a voltage-sensitive dielectric. The latter is a material, such as barium titanate, the dielectric "constant" of which decreases with applied voltage. When such a capacitor is connected in series with an AC power supply and load, it may be used to control the current flow through the load as its reactance is changed by a biasing control-signal voltage.

Figure 3 shows one type of dielectric amplifier circuit. Here, the AC power supply is a high-frequency type. (In practical circuits, the frequency is a 1 megacycle or higher.) The non-linear capacitor, C_3 (i.e., the capacitor with voltage-sensitive dielectric) is connected in series with a conventional capacitor, C_2, across inductor L_1. This series-capacitance combination forms a tuned circuit with L_1 resonant at the power supply frequency. The DC source biases the voltage-sensitive dielectric to the steep portion of its capacitance-vs-voltage curve. The input signal is applied in series with this DC voltage. C_1 is a DC blocking capacitor.

The input signal (waveforms C and D) varies the capacitance of C_3, detuning the L_1-C_2-C_3 circuit in sympathy with the input frequency. If C_2 is adjusted to place the response of the tuned circuit along its steep slope, the resulting voltage changes will be large and the amplitude-modulated signal waveform will have high peaks. (See waveform B.) This accounts for the amplification afforded by the circuit. The waveform shown at B, however, contains a high-frequency carrier component (A), as well as the modulation envelope which is an amplified replica of the input signal. The latter is recovered by passing the modulated signal through diode D, the result being the amplified wave, E.

Dielectric amplifiers have been employed at signal frequencies up to 2 to 3 megacycles. They provide high voltage gain and high power gain per stage. Power gains up to 10,000 per stage have been reported. Small units have been used to obtain audio-frequency power outputs of 300 milliwatts.

The diode amplifier utilizes the reverse transient ("recovery time") effect found in germanium and silicon *junction* diodes. Figure 4(A) illustrates this transient characteristic which is explained in the following manner: If the diode is conducting forward current resulting from the application of a positive voltage from time t_0 to t_1, and is switched suddenly to a high negative anode voltage by the application of a negative square wave, the reverse current quickly reaches a high peak value (i_3) and then recovers somewhat slowly to the value (i_2) which is normal for the particular value of applied negative voltage.

The reason for this sudden high conduction is that the carriers (holes or electrons) injected into the semiconductor by the positive-current flow are still present during the switching and they enhance the current flow. High current accordingly flows until the negative voltage has had time to sweep these carriers away. Unless the switching interval is of short duration (1 microsecond or less), the carriers will recombine (holes with electrons, and vice versa, within the semiconductor) and the high-current pulse will not be obtained. If there has been no recent flow of positive current through the diode, no transient current pulse will occur, normal, low current flowing upon application of the negative switching voltage. In a diode operating in this manner, the anode acts first as an emitter and then as a collector, simulating the action of a transistor.

The transient current is proportional to the positive current and is many times larger. The transient diode exhibits amplification, since a small positive input signal

applied to the diode in series with a negative, square-wave, switching voltage (power supply) will give a higher output signal.

Figure 4(B) shows the circuit of a simple diode amplifier. The power supply delivers 1-Mc negative square waves to the amplifier diode (D_2) with anode negative. The positive half-cycles of the signal-input voltage are supplied by D_1 which is a high-back-resistance diode having virtually no reverse transient (such as a point-contact diode). As long as there is no input signal, no voltage appears across load resistor R_L, except perhaps a small spike due to the flow of power-supply current through the capacitance of D_2, because no carriers are injected into the amplifier diode. Application of the signal, however, injects carriers into D_2, and each succeeding power supply pulse forces a large current momentarily through R_L and produces a high voltage drop across this resistor.

Output Transformer

In Figure 4(C), an output transformer has been substituted for the load resistor. By providing a stepdown turns ratio in this transformer, a current gain is realized from operation of the amplifier.

Like the magnetic and dielectric amplifiers, the diode amplifier requires an AC power supply. Power gains up to 10 per stage are reported for diode amplifiers.

The galvanomagnetic amplifier exploits the phenomenon of *magnetoresistance*, the ability of certain metallic combinations to change their resistance in response to a varying magnetic field.

Figure 5 shows the circuit of a simple amplifier employing this principle. A magnetoresistive element, made of a material such as indium antimonide, is supported between the pole pieces of a permanent magnet around which is wound a field coil, L, carrying an alternating input-signal current. The signal causes fluctuations in the magnetic flux which, in turn, cause corresponding fluctuations in the resistance of the magnetoresistive element. A fluctuating current accordingly flows from battery B and through resistor R. The resulting fluctuating voltage drop is coupled to the output terminals through capacitor C.

Since only a small input signal is required to vary a high current through R, considerable amplification is afforded by this circuit.

A gain of 30 to 40 db has been reported at room temperature and 60 db at the temperature of liquid nitrogen. •

CHECKING CAPACITORS IN CIRCUITS

Here are some good suggestions for doing this difficult job

CAPACITORS that short-circuit, open completely or develop "intermittents" are the cause of a lot of annoying trouble in electronic equipment of all kinds. Any trouble is annoying, but capacitor trouble is particularly bad because of the difficulty of checking capacitors while they are still connected in the circuit. A conventional continuity test with the ohmmeter section of a multimeter doesn't mean much because resistors and inductors of various kinds, connected across or around the capacitors, register *their* resistance rather than that of the suspected capacitors.

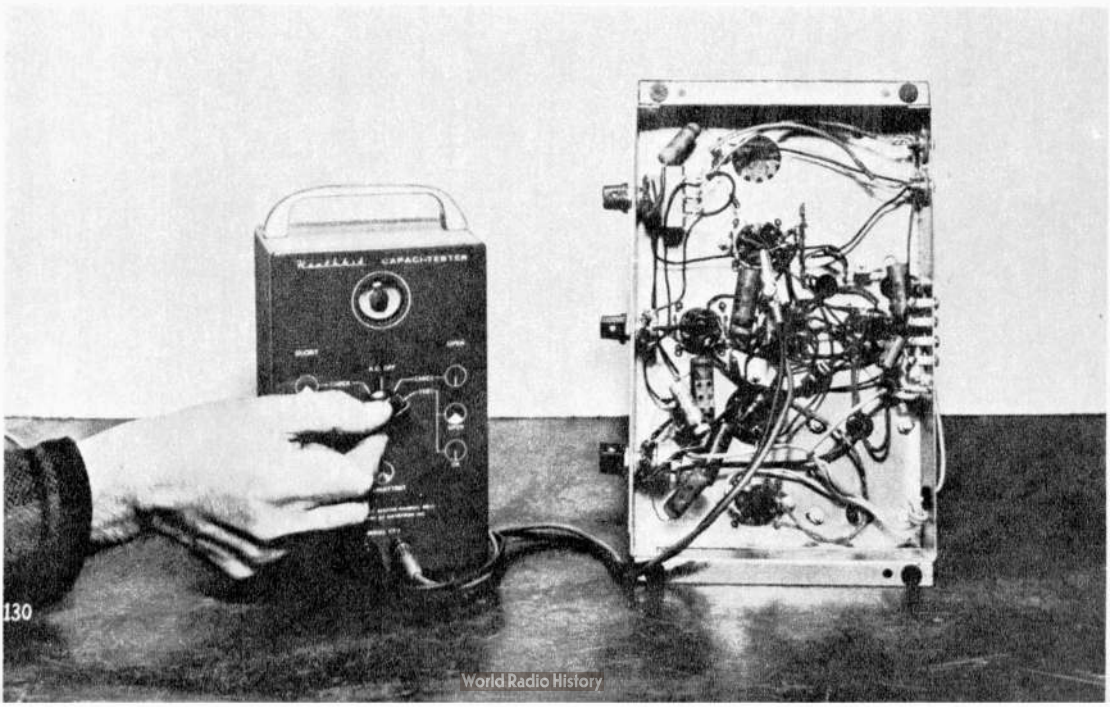
This problem of in-circuit checking has received considerable attention from the designers of test equipment, and the result has been the appearance of a number of units of interesting and novel design. A representative one is the Heathkit "Capaci-Tester," which I have been using with good results. As a kit project, assembly and wiring took me just less than two hours to complete.

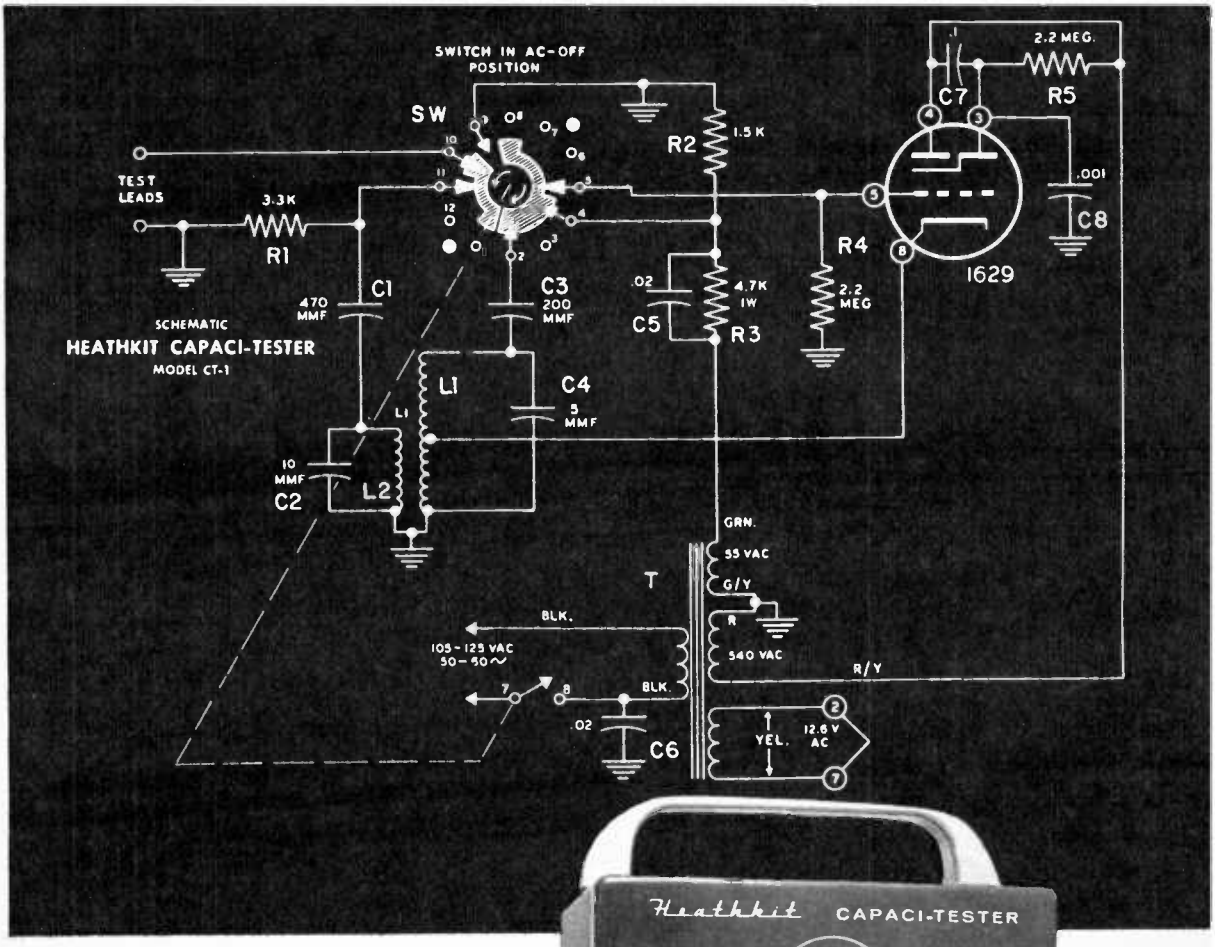
The schematic diagram deserves a little study. The heart of the instrument is a type 1629 "Magic Eye" electron ray tube, commonly used as a tuning indicator in FM receivers. The function switch SW has five positions, as shown in the front-panel view. Center is AC OFF. To the right, the capacitor is checked for OPEN. In the CHECK position of the switch, the eye is closed. With the switch advanced one notch further to the right to the TEST position, the eye remains closed if the capacitor is either in normal condition or short-circuited, and blinks open if it is open-circuited.

Since this test does not distinguish between a good capacitor and a shorted one, it is now necessary to turn the switch to the left SHORT position. At the first or CHECK setting, the eye is open. When the switch is pressed further to the TEST position, the eye remains open if the capacitor is shorted, and closes if it is OK. A complete check on a capacitor is made in about five seconds.

If the indicator eye flickers when the capacitor under test is tapped sharply, the capacitor is shorting intermittently inside, and, of course, should be pulled out and replaced.

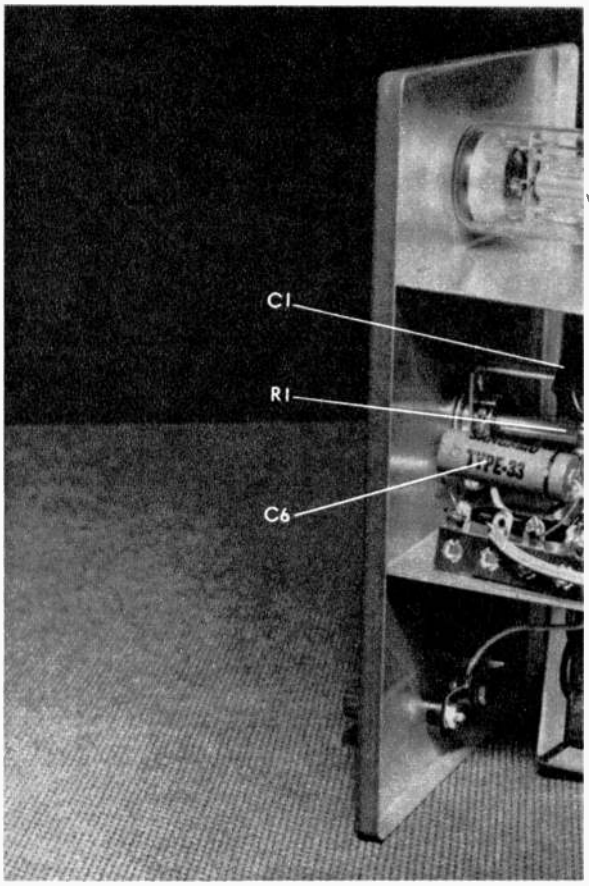
The receiver or other equipment containing the capacitors under test must be





IS THAT melted-down capacitor in the hi-fi amplifier still working? The Capaci-Tester (photo left) will tell. Two flexible leads from latter are clipped to suspected capacitor, while it remains in the circuit.

INDICATOR EYE is at top center of front panel of Capaci-Tester (photo right). Indications at various test positions are shown as openings and closings of "eye."

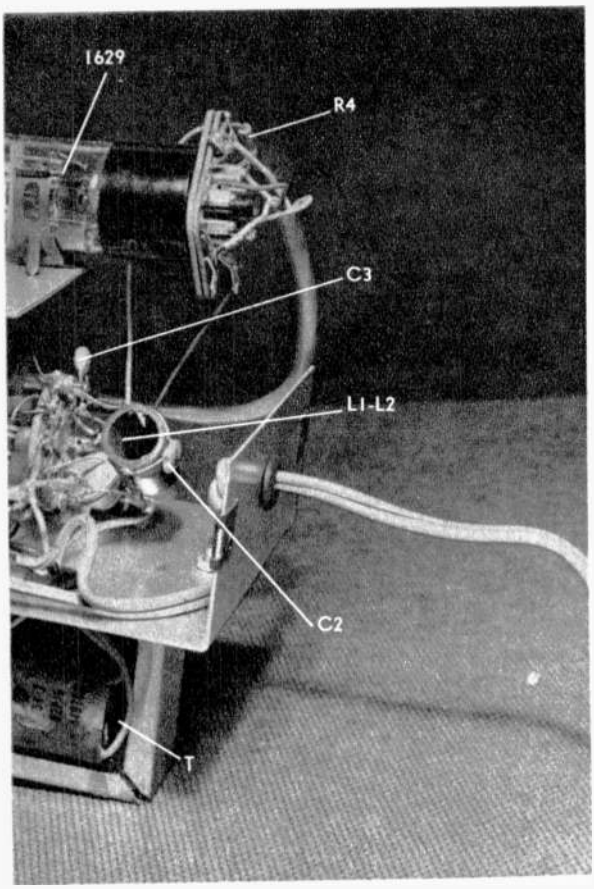


REAR LEFT side view of Capaci-Tester chassis.

turned off, as any circuit voltages in it would throw the operation of the checker completely cockeyed.

In the OPEN test, the triode section of the indicator tube works as a conventional oscillator in conjunction with the coil L1 and the small tuning capacitor C4, at a frequency of about 14 megacycles. Closely wound next to L1 on the same form is a coil L2. With parallel capacitor C2, this also is tuned to 14 megacycles. The coupling between L1 and L2 is so tight that with the test leads idle (i.e., nothing connected to them), the L2-C2 circuit tends to suck out or absorb the energy of oscillation from L1-C4 and in fact make the latter stop oscillating altogether. In this circumstance, no bias voltage is developed across the grid leak R4, resulting in maximum current flow in the tube and a wide angle of eye opening.

If an open capacitor is connected into the

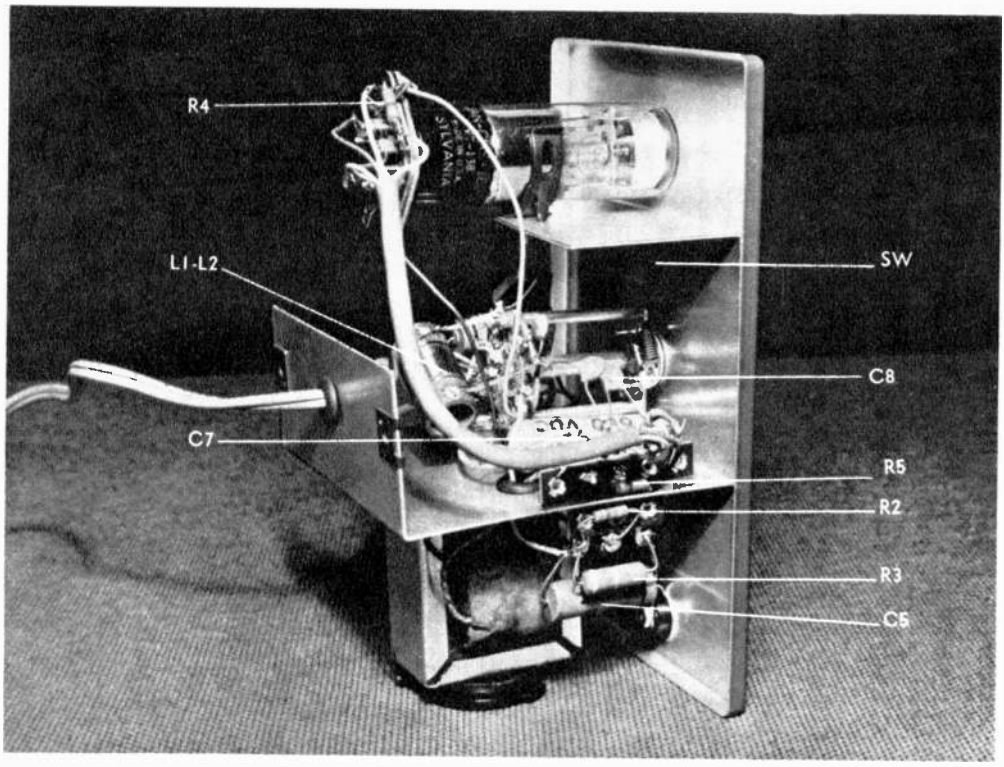


Parts bear markings of diagram on page 131.

L2-C2 part of the checker circuit through the switch SW, the condition described is not changed, so the eye stays open. However, if a good capacitor *or* a shorted one is connected, the L2-C2 circuit is thrown out of resonance with L1-C4, thus permitting the latter to resume oscillation. Bias then develops across R4, reducing the plate current of the tube and causing the eye to close.

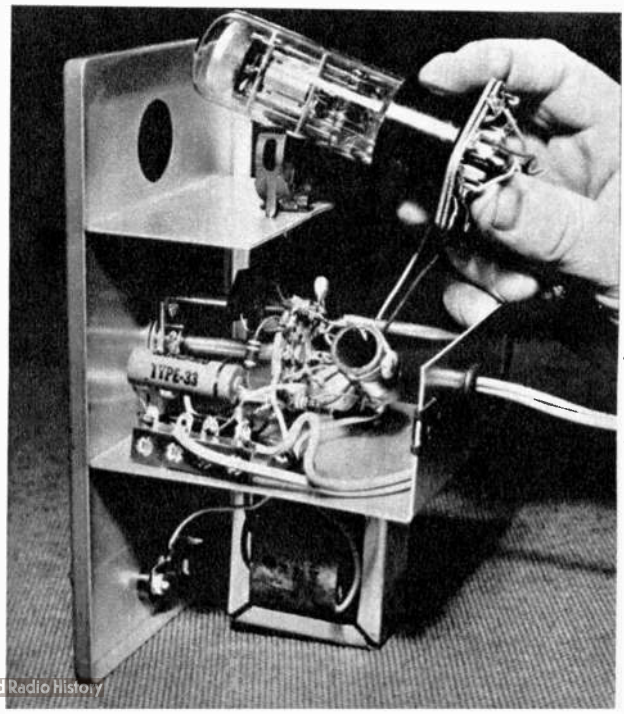
In the SHORT test, the oscillator is not used at all. Instead, a biasing voltage of about 55 volts, obtained from a secondary of the power transformer T, is fed through R3-C5 to the grid of the tube. The test leads go to grid and ground. If the capacitor under test is short-circuited, it shorts out the fixed bias, causing the eye to open. If it is not short-circuited, it does not affect the bias, and the eye closes.

As will all test instruments, the Capaci-Tester has certain limitations. If the sus-



REAR RIGHT view of Capacl-Tester chassis is shown in the photo above. Oscillator coil L1-L2 mounts directly on the end of function switch SW.

MAGIC-EYE TUBE fits on spring clip on top shelf of chassis. Socket is connected by flexible wires.



pected capacitor is smaller than about 100 micromicrofarads or if a capacitor of any size is shunted by a resistance of less than about 30 ohms, one lead should be disconnected to isolate it. Otherwise, the eye does not close completely and the indication is not positive enough. Also, the presence of inductance in the form of choke coils, transformer windings, etc., throws the tester off if the reactance of the coils is less than about 30 ohms at the test frequency, which is 14 megacycles for the OPEN position and 60 cycles for the SHORT position. All this means that you must have a schematic diagram of the equipment you are checking, with the values of all parts, and you must trace the wiring to determine where the suspected capacitors actually are connected. If no diagram is available or on hand, you are forced to unhook one lead of each capacitor to isolate it. This takes only a few seconds and enables you to make a positive test. •

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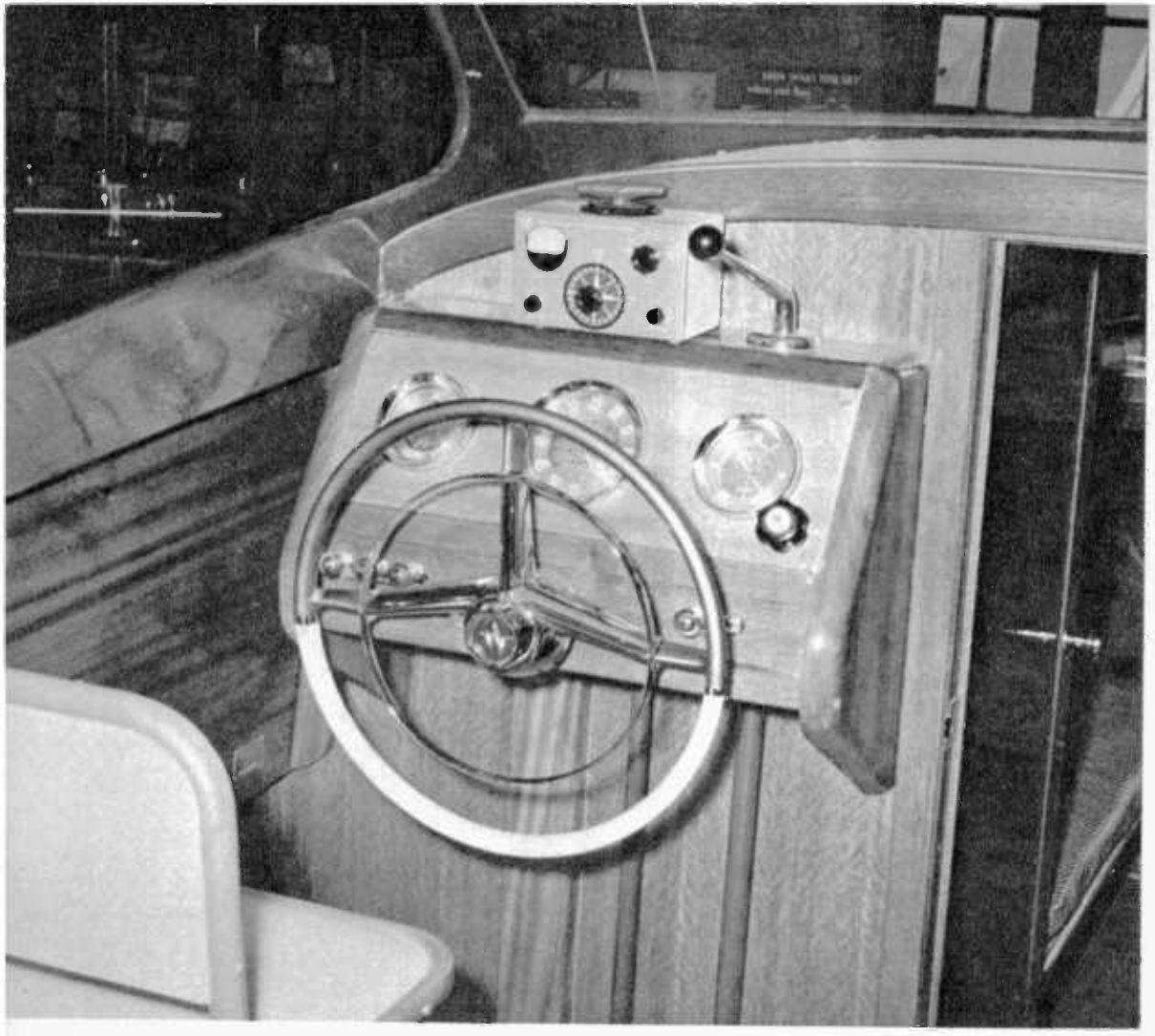


RDF EQUIPMENT

Fog bound? Lost on a lake?

What you need is a Radio Direction Finding kit

ANYBODY who has ever used a small table model radio set has noticed that some stations are weak when the cabinet faces in a certain direction but become strong when it is turned a little. In other words, the receiver is "directional." The position of minimum signals is always much more sharply marked than that of loudest signals.

The self-contained loop antenna in the set is responsible for this effect, which has long been used in radio direction finders ("RDF") for marine, aeronautical and military purposes. Commercial RDF equipment is generally complicated and expensive, but a brand-new RDF kit brought out by Heath is both simple and inexpensive. Within the limits of its size and circuitry, it is a very interesting and useful piece of equipment for owners of small boats.

It must be understood, of course, that RDF by itself is not the complete answer to that fog-bound question. "Where are

SITTING inconspicuously on the instrument board of a small boat (photo left), the Transistor Radio Compass is within easy reach of the pilot. It provides music, entertainment and news, as well as weather information vital to any cruising plans.

we?" It must be used as part of other navigational techniques to meet particular local conditions.

Heath calls its Model DF-1 the "Transistor Radio Compass." It is essentially a sensitive six-transistor broadcast band receiver, with the addition of a rotatable loop antenna sticking through the top of the case and a tuning meter to give sharp readings of maximum and minimum signal strength. Mechanically and electrically, the set is a straightforward assembly project, and is the work of a couple of evenings for any constructor with the experience of one previous electronics kit to his credit. The finished instrument is compact and presents a very attractive appearance. Measuring only 7¼ inches wide, 5 inches high and 4 inches deep, it is completely self-contained.

Loop Adjustment

For normal reception of local radio stations, the loop is adjusted, by means of a right-angle drive from the center control knob on the panel, to give loudest signals. This condition coincides with a maximum swing of the meter needle to the left or "TUNE" side of the scale. If the tuning knob is left alone and the loop now turned for minimum signal, as shown by the swing of the meter needle to the right or "NULL" side of the scale, the pointer of the center or "HEADING" knob shows the line of direction of the broadcasting station in relation to the boat. Note: the *line of direction*, not the specific direction. This distinction is necessary because any loop antenna gives *two* identical minimum or null readings 180 degrees apart. (In larger commercial RDF's, a "sensing" antenna, usually a vertical rod, is connected temporarily to the loop to establish the true directional reading of the latter and to eliminate the back reading.) If a boat owner tries to "home" on a certain station and overlooks the double-reading effect, he is quite likely to find himself going in the wrong direction. However, if he carries an ordinary magnetic compass, too, he knows generally where up and down and sideways are, so can make the necessary correction.

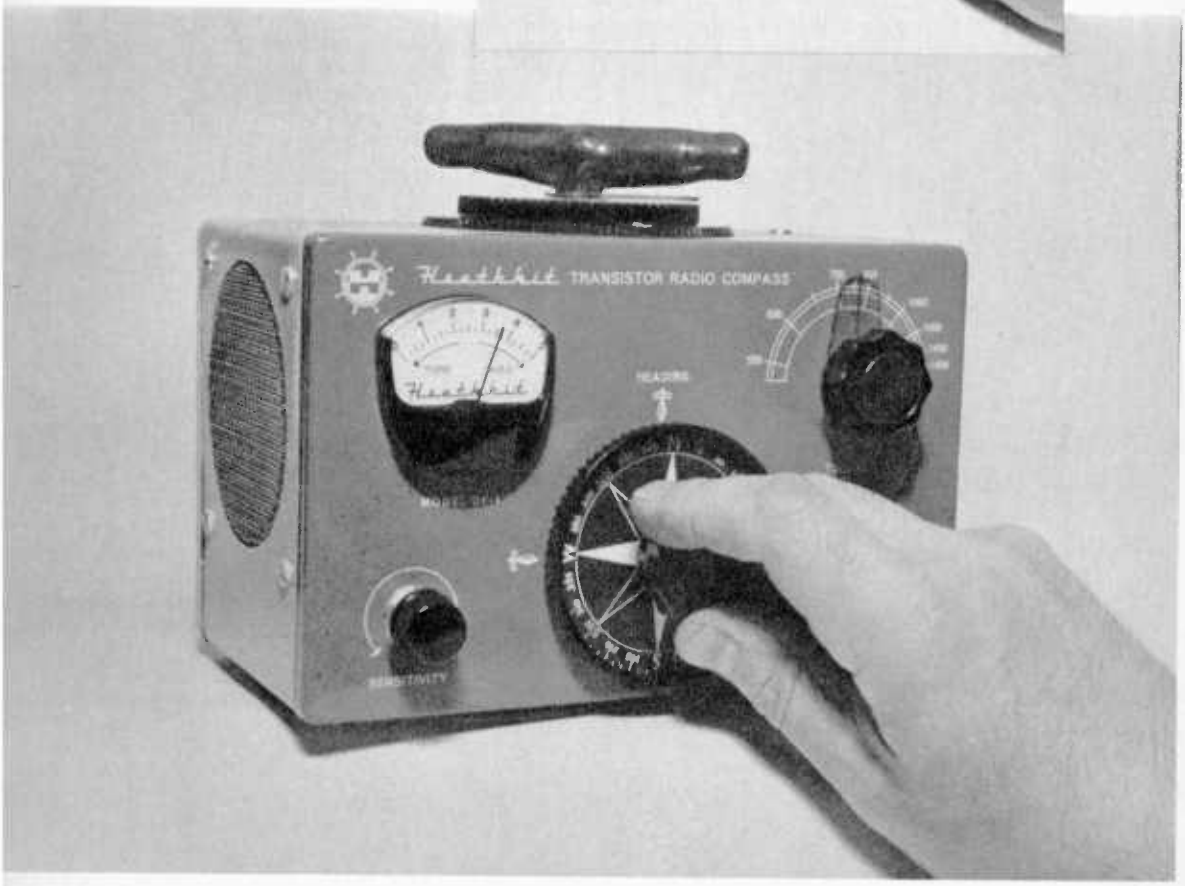
At any event, he must have charts of the waters he is plying, and the pinpoint

locations, frequencies and operating schedules of the local radio stations. Starting from his anchorage, he can plot his course pretty accurately through a combination of visual observation of land marks and the sun, and RDF and compass readings. If the sky should cloud over suddenly and a storm arise, or if land disappears from sight, he knows what combination of RDF and compass bearings will get him back to shore.

That's how RDF equipment works. •

A BROADCASTING station has been tuned in and the loop antenna (top) positioned to give maximum volume and meter needle swung to the left. The center knob controls the loop movement through a right-angle drive inside unit.

THE UPPER right tuning dial has been left alone, but loop has been turned for minimum signal strength, as shown by "null" meter reading. Note loop position.



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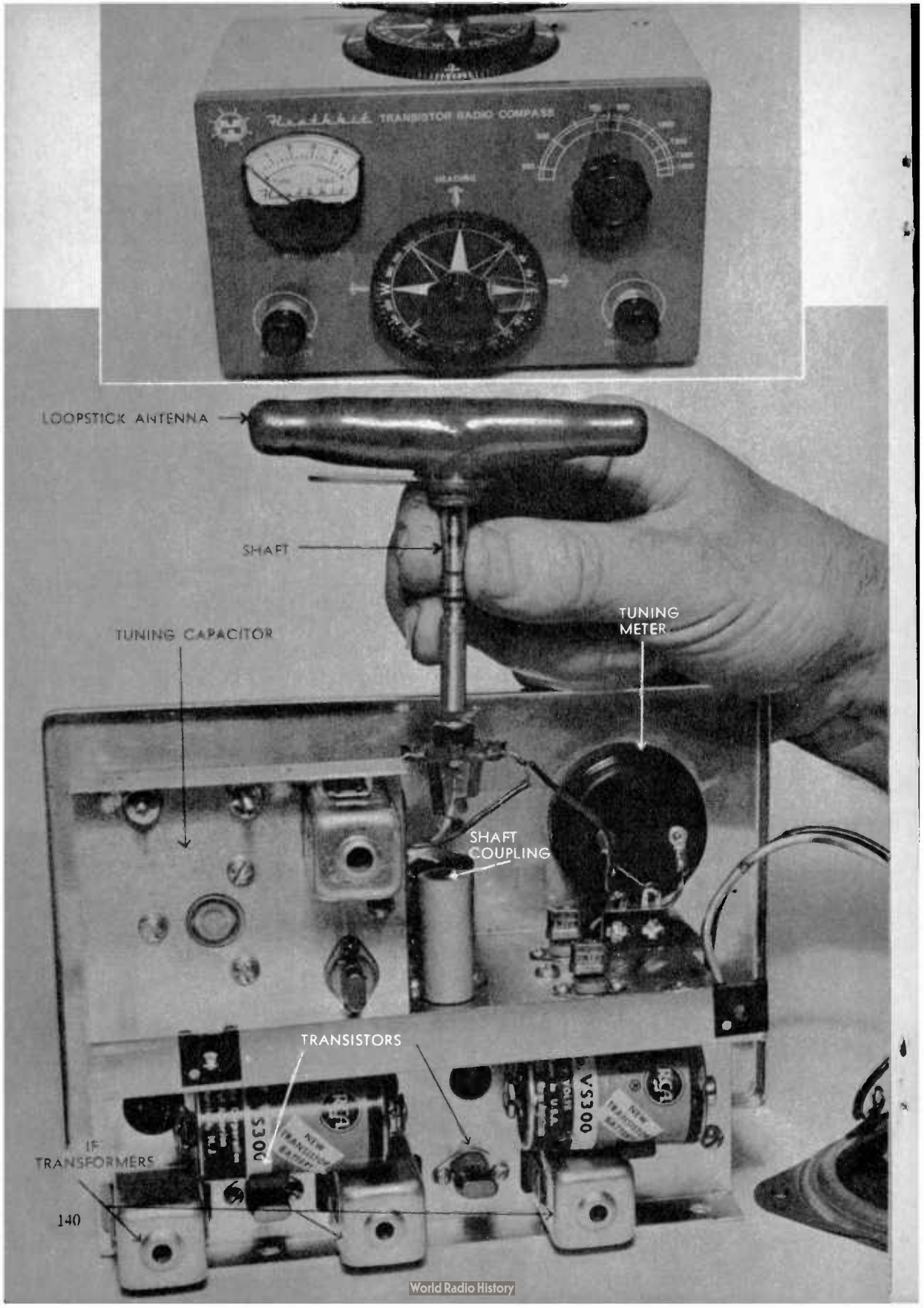
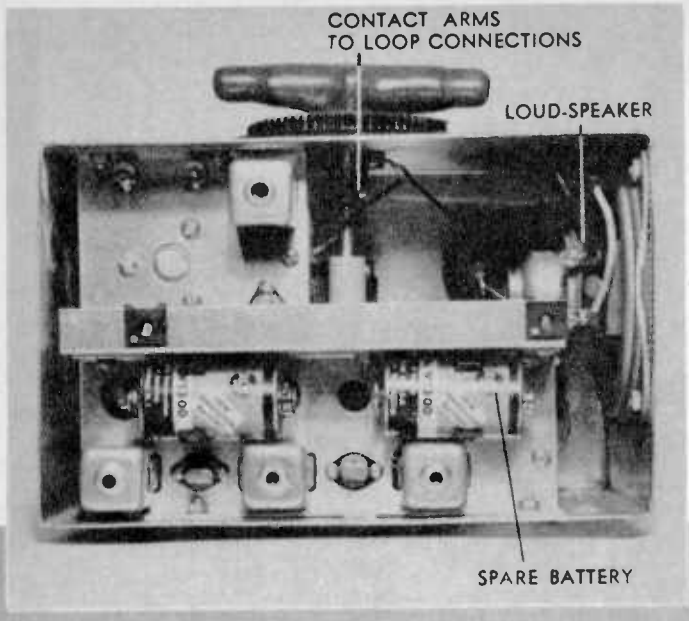


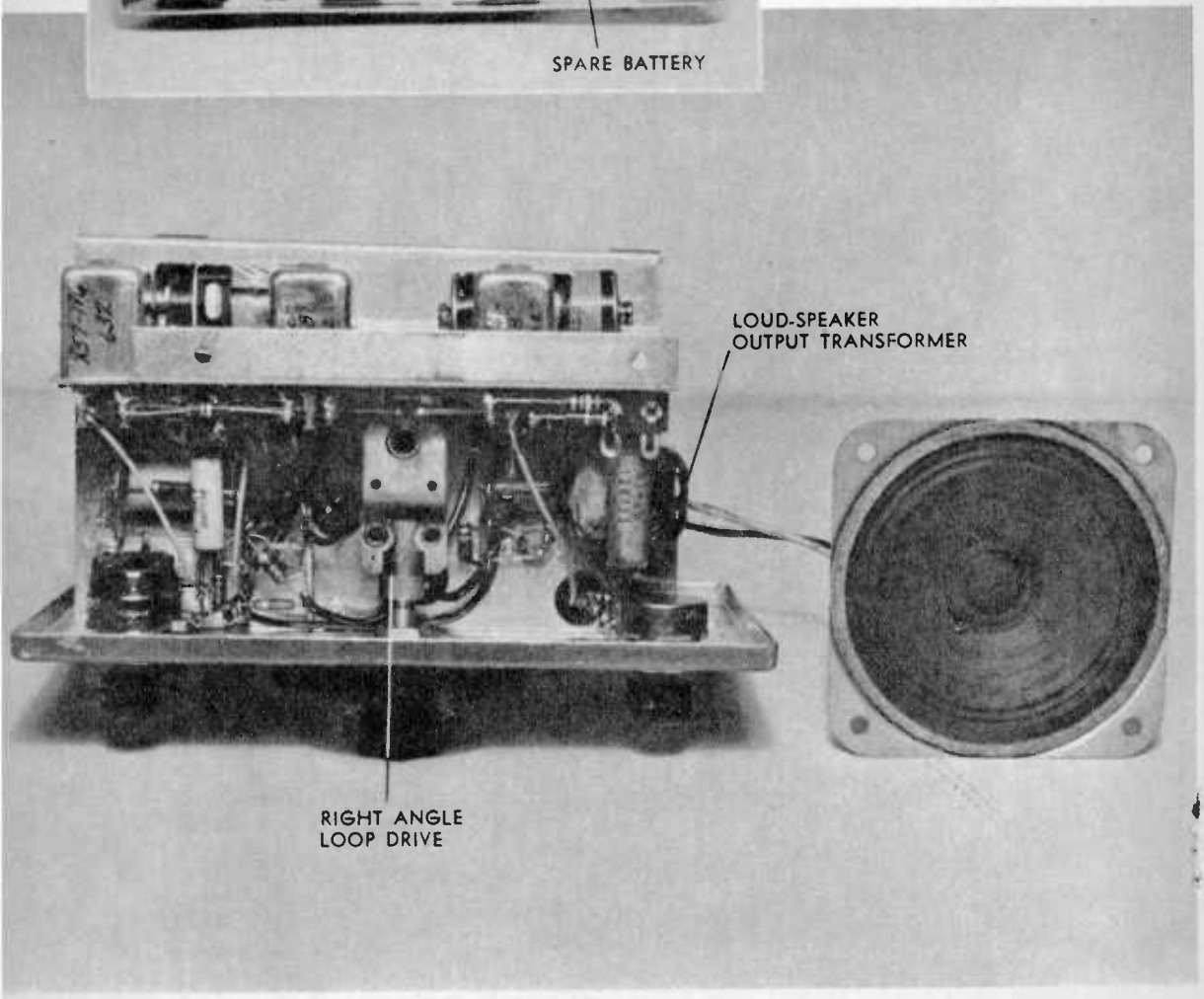
DETAILS of the RDF unit. Upper left, tuning meter. Upper right, tuning knob and scale. Lower left, sensitivity control. Center, drive control for loop. Lower right, on-off switch and volume control. Compass scales, under "Heading" knob and loop-stick, are adjusted to match reception conditions on the boat to the local broadcasting stations.

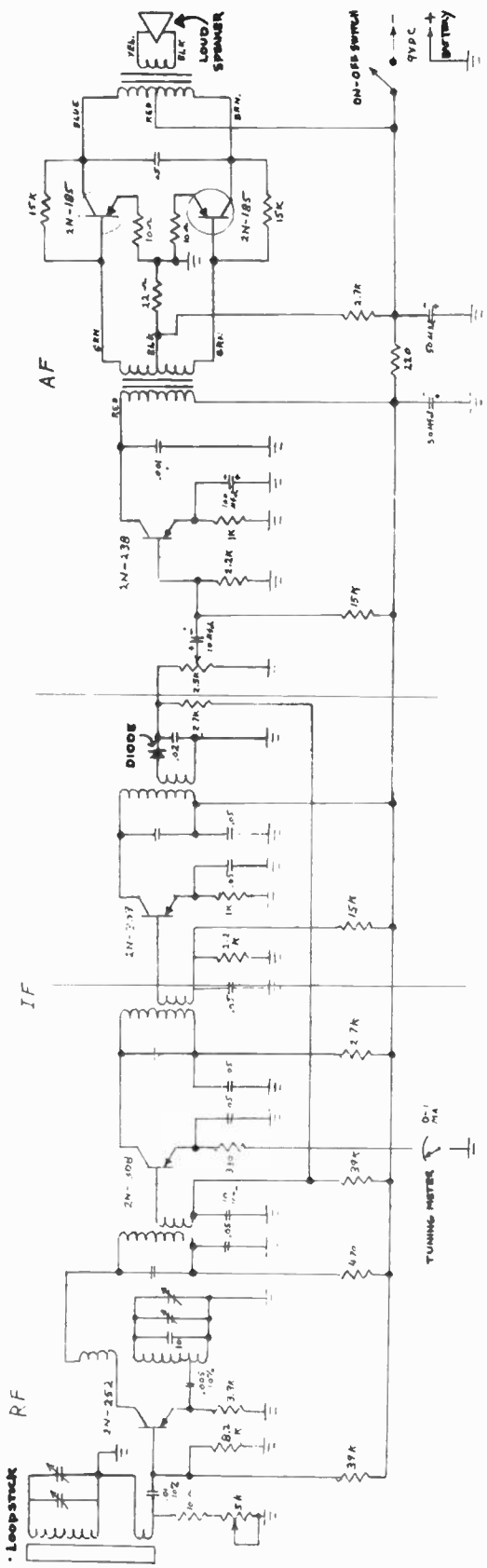
THE ROTATABLE loop antenna has an end fitting like that of a telephone plug, and turns in a sleeve in the top of the cabinet. This photo shows how the chassis looks when it is removed from cabinet.



THE RDF UNIT with the back cover removed to show the mounting of the antenna (center) and of the loud-speaker in the end of the cabinet. Only the left-hand battery is connected; the other is a spare.

BOTTOM VIEW of the chassis is shown in the photo below. Complete circuit diagram of the Heathkit DF-1 is shown on opposite page. The 5K (5,000) ohm variable resistor at the extreme left is the "Sensitivity" control on the front panel. The 2.5K (2,500) ohm potentiometer following the diode is the "Volume Control." Study diagram.





THE HAM OF THE YEAR IS A "SHE"

[*Continued from page 37*]

rearranged his living habits to enable him to spend from 10 p. m. to 5 a. m. handling messages for Navy personnel in "Operation Deepfreeze"; designed a super high speed electronically-controlled machine tool.

Great Kills, S. I., N. Y.—Harry L. Fendt, W2PFL, 169 Wiman Ave.—On July 14, answered emergency call from Belgian Congo requesting special drug to stop bleeding, and with a New York doctor located the drug and placed it on an airplane, thus saving the life of a two-year-old boy; on Nov. 13, answered a call from a ship in the Atlantic Ocean requesting medical assistance for a seaman who had collapsed, and handled a direct phone link between a doctor who prescribed treatment and the ship's captain; during the past 10 years he has handled many messages for servicemen and their families; teaches those who wish to obtain radio amateur licenses.

New York, N. Y.—George W. Bailey, W2KH, 61 East 66th St., executive secretary of the Institute of Radio Engineers—Has an impressive past record of service to amateur radio and, this year also was cited by the IRE "For sustaining service to amateur radio, and administrative leadership." He is a former president of the American Radio Relay League.

West Springfield, Pa.—Sam E. Baker, W3FIQ, RFD 1—Handled requests for emergency supplies and other essential information for three days between outlying areas and an emergency radio center in Erie, Pa., during a heavy snow storm that paralyzed vehicular traffic and disabled telephone lines in that area during the Thanksgiving holiday.

Warren, R. I.—C. Newton Kraus, WIBCR, Brownell and Emery Streets—Has handled hundreds of written messages, press dispatches, more than 200 telephone call relays, and official U. S. Navy business for "Operation Deepfreeze" personnel in the Antarctic. This used up more than 1100 hours of his personal time during 1956.

Black Hawk, S. D.—Mrs. Martha Shirley, WOWZL, P. O. Box 41—Mrs. Shirley operated for 24 hours during a two-day sleet storm that isolated two towns in South Dakota. In November she operated in a blizzard emergency for four days and three nights while home alone and snowbound. She has organized and regularly directs network for gathering of weather reports from isolated areas, providing otherwise unobtainable information.

Syracuse, N. Y.—Group citation to the "Operation Deepfreeze" committee of the Radio Amateurs of Greater Syracuse. The committee of 14 amateurs have delivered more than 3500 messages to and from Navy personnel in Antarctica with the cooperation of the Red Cross. The men work in three-hour shifts from 11 p. m. to 5 a. m. every night. •

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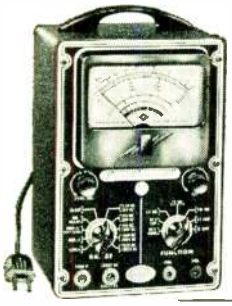

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OUTPUT VOLTS: 0 to 15/30/150/300/1,500/3,000 Volts
D.C. CURRENT: 0 to 1.5/15/150 Ma. 0 to 1.5/15 Amperes
RESISTANCE: 0 to 1,000/100,000 Ohms 0 to 10 Megohms
CAPACITY: .001 to 1 Mfd. 1 to 50 Mfd. (Good-Bad scale for checking quality of electrolytic condensers.)
REACTANCE: 50 to 2,500 Ohms 2,500 Ohms to 2.5 Megohms
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