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DYNAMIC FIELD. With each passing month, it becomes more and more evident that electronics is an amazingly dynamic field. Announcements of new inventions and discoveries are being made at an ever-increasing rate. All of these developments will have far-reaching effects on the electronic industry and on our everyday lives. Some of them would have been almost inconceivable ten years ago. For example, the concept of molecular electronics (see page 89) could come only after extensive research and experimentation in the field of solid-state physics. The maser, too, (page 41) is based on lengthy work in the same field.

In some cases, scientific discoveries are important to electronics. Recent exploration of the upper atmosphere, for instance, has revealed that there is a radio "pipeline" about 5000 feet above the South Atlantic Ocean which could dependably carry radio and TV signals between South America and Africa. At least three other radio ducts are known to exist. These "pipelines" will probably be put into commercial use within ten years. Since the ducts can handle a very broad transmission band, they offer a means of achieving world-wide TV hookups, and thus are an alternate to the communications satellite system discussed in last month's issue.

Another revolutionary advancement announced recently is thermoplastic recording (see page 53). Although this system is still in the developmental stage, its design simplicity suggests that here at last is a video recorder suitable for home use.

Just stop a minute and think how electronics will be affecting your life in 10 or 15 years. Barring a nuclear war, you'll sit in your living room and watch TV from all over the world. If you want to preserve a program, you will record it on your video recorder. If you want to see a TV program while you're out on a fishing trip, you will take along your molecular electronic pocket TV set. And you'll be able to call your wife from hundreds of miles away with your personal radio-telephone.

NEW STEREO TAPE SYSTEM. The persistent rumors about a new stereo tape cartridge system from CBS Laboratories are apparently true. No public announcement has been made yet, but CBS is expected to unveil a tape cartridge player soon that can change tape cartridges like a record changer changes records. The system uses special 1/8' tape manufactured by Minnesota Mining and Manufacturing Co. (Scotch tape) and operates at a speed of only 1-7/8 inches per second. We'll just have to wait to see (and hear) how the system works. Offhand, it seems that the slow speed will limit the frequency response, but maybe CBS will manage to pull a rabbit out of its hat.
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<td>Paul D. Bernard, 408 First Ave., N.E., Walltown, S. D.</td>
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Sylvania Semiconductor Division, Woburn, Mass.

Pepped-Up "Pocket Regen"
- I have found that making a few revisions in the circuit of the "Pocket Regenerative Receiver" (August, 1959) can convert it into a radio which requires no antenna or ground. First, you replace the standard transistor antenna coil with a tapped, variable transistor antenna coil and increase the number of turns on the coil to 25 or 30. Then you substitute a G.E. 2N169A transistor for the 2N35 and replace the 9-volt battery with an Eveready AA 1½-volt penlight cell.
- I constructed the unit in a 1⅝" x 1⅝" x 2¼" pill box. The current drain is 2 µA, and I have had very good results on locals in the Baltimore area.

ROBERT BARD
Baltimore, Md.

Avoiding Mercury Vapor
- I enjoy your publication greatly, but feel that I should draw your attention to the suggestion by Bob Coulter in the January Tips and Techniques that mercury be used to lower the melting point of solder. Since mercury vapor is a deadly poison and the heat of a soldering iron is more than sufficient to vaporize mercury used in this manner, I recommend that this technique be avoided at all times. Solders with lower melting points are commercially available, and the slight premium paid for them is well worth the convenience they provide.

J. E. SCHILAIKJER
New York, N.Y.

Our thanks go to Reader Schilaikjer and to many others for setting us straight on the dangers of this technique. We second the suggestion that the user purchase commercially available solder which has the desired melting point.

Ham vs. Hi-Fi
- I note from time to time that your ham readers seem to want more ham articles and less hi-fi, and your hi-fi fans want less ham material and more hi-fi. Personally, I think you publish a very good balance of material.
- In many cases, so-called "hi-fi" articles can profitably be read by hams. For example, you ran an article some time ago about an audio notch

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April, 1501

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April, 1960

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Letters (Continued from page 10)

filter for reducing turntable rumble; I found this item excellent for getting rid of heterodyne interference and even static on my ham receiver.

Yours is about the only magazine left with good how-to-build articles. Keep it that way.

C. E. Hoover, W0KWW
Ames, Iowa

Calling All "BC'ers"

For about a year now, I have been logging stations on my broadcast-band receiver, and in that time I have managed to receive over 200 stations from 32 states and 4 Canadian provinces, along with stations from Mexico and Cuba. I have been able to interest a couple of my friends in this hobby to the point where they are just as enthusiastic about "BC'ing" as I am. But there doesn't seem to be any organization for "BC'ers," perhaps because the short-wave clubs feel that there isn't a large enough interest in this branch of radio to do anything about it.

I assure you that once a person gets interested in this hobby, he's hooked for good. I get more of a thrill listening to some station in Denver than I do listening to the Australian Broadcasting Corporation's morning broadcast. And I'm sure that there must be at least a couple of thousand other people who agree with me and wish there were some organization solely for those who find pleasure in BC logging.

Other P.E. readers who are interested in logging and making reports to AM stations are hereby requested to drop me a line, telling me about their logging activities and including suggestions on how to get such a club started.

J. D. Leitch
8 Skipton Rd.
Box 1004, R.R. 3
Ottawa, Ont., Canada

A Computerman Comments

The story of Jim Stewart ("Meet the Man Who Out-Thinks Univac," December, 1959) is a familiar one to me and to my co-workers. We use slightly different titles here, and work for another major computer manufacturer, but we have much in common. Although it is true that Jim's job of "roving trouble-shooter" is a unique one, his hours and methods are familiar to us all. We use the same "logic and educated guesswork."

I was gratified to see your article explaining our job; so many people are unaware of this type of work, its qualifications, satisfactions, and headaches. I was happy, also, to see the fact brought out that men without a college degree can still qualify for a rewarding, challenging, and dignified field in electronics.

John W. Boudreau
Customer Engineer
IBM Corporation
Sierra Vista, Arizona

Hi-Fi Modulators

Being a charter subscriber to Popular Electronics, I feel I am entitled to a continent once in a while. I am by no means an engineer, but I do enjoy my living in electronics. Experimenting and construction are my basic hobbies.

Each month I read Herb Brier's column (Across Always say you saw it in—POPULAR ELECTRONICS
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Los Angeles 37, Calif.

April, 1960

A-107

AmericanRadioHistory.com
We are pleased to announce that as a result of the further exploration of the 6CA7's capabilities its power output rating has been raised to 60 watts in a distributed load circuit. This was achieved by increasing the screen grid voltage to 500V. The screen voltage rating now equals the plate voltage rating, thus greatly simplifying the design of power supplies.

Class AB, Audio Amplifier
Distributed Load Connection
Typical Operation
(Fixed Bias—Two Tubes Push Pull)
Plate Supply Voltage ............... 500 V
Grid No. 2
Supply Voltage .......(See Note) 500 V
Grid No. 1 Bias .......(approx.) -44.5 V
Plate to Plate Load Resistance ....7000 Ω
Plate and Grid No. 2 Current
(Zero Signal) .................... 2x57 mA
Plate and Grid No. 2 Current
(Max. Signal) .................... 2x112 mA
Input Signal Voltage (rms) ....... 32 V
Power Output ...................... 60 W
Harmonic Distortion ............ 2.5%
NOTE: Screen voltage is obtained from taps located at 43% of the plate winding turns. An unbypassed resistor of 1KΩ in series with each screen grid is necessary to prevent screen overload.

Letters (Continued from page 12)

the Ham Bands) and I think he does a nice job for the beginners (and old-timers, too). But since there are so many beginners who are looking to his articles for guidance, I thought a word or two about the following subject would be in order.

In the January issue, Mr. Brier brings up the possibility of using a hi-fi amplifier to modulate a transmitter. In an emergency, yes. But for continued use on the ham bands, no, no, no! With the crowded conditions that exist on the bands, we definitely have no place for hi-fi modulators. On the contrary, let's eliminate them completely.

Let's use the bare minimum of frequency response in the speech amplifiers and modulators, thereby concentrating power more closely around the carrier. Don't spread your modulation power for 15 kc. on both sides of the carrier, occupying a total of 30 kc., when you can get by nicely on one-fifth that amount of bandwidth, do it with less modulation power, and make it more pleasant for us all.

James L. Lanterman, W5UJN
Ardmore, Okla.

Stabistor Correction

In the article entitled "The Stabistor Diode," which appeared in your January issue, the maximum current ratings for the SG-22 and SM-72 stabistors were transposed. The correct maximum current rating for the SG-22 is 150 milliamperes; the SM-72 is rated at 2000 ma.

K. J. Shaughnessy
Stoneham, Mass.

CB Calling Frequency

In your December issue, Tom Kneitel made the suggestion in his On the Citizens Band column that one CB channel be set aside to be monitored by both CB'ers and SWL's. As Tom pointed out, this would be a big help to motorists looking for overnight accommodations in a strange town and to those who experience mechanical trouble along the way. I've talked to a number of people about it and everyone thinks very highly of the idea.

I'm looking forward to more articles on Citizens Band subjects. I would especially like to see something on improving the efficiency of mobile antennas.

Joe E. Brooks, 8WØ853
Jackson, Miss.

See this month's On the Citizens Band for additional info on CB calling frequency. Tom Kneitel promises to go into the subject of mobile antennas in a future column.

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April, 1960
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An ideal book for the non-technical person who would like to learn about electricity and electronics, this volume is written and organized clearly and logically. The author manages to communicate a great deal of information very easily.

Starting with atoms and electrons, the book covers d.c. circuits, a.c. circuits, magnetism and electromagnetism, electric and electromagnetic generators, electric motors, transformers and rectifiers, and electric waves. The material is clear and to the point, with review questions appearing at the end of each chapter.

Highly recommended as a basic introduction to electricity and electronics.

"FUNDAMENTALS OF ELECTRONICS" by E. Norman Lurch. Published by John Wiley and Sons, Inc., 440 Fourth Ave., New York 16, N. Y. 631 pages. $8.25.

By coincidence, this book picks up where the preceding one leaves off. Even more interesting, it has the same good qualities: excellent organization and clear writing. The two books together provide a solid grounding in electronics.

This big (631 pages) and comprehensive volume assumes that the reader has a knowledge of basic electrical theory, including a.c. circuits and d.c. circuits. It begins with two-element electron devices (including vacuum tubes and semiconductors), and then works its way step by step to various types of amplifiers, oscillators, etc. The incorporation of transistors into the mainstream of electronic devices (instead of putting them in a separate section) is a somewhat new, but very logical, technique. Thus, the reader learns about vacuum tubes and transistors at the same time...
Jacques Bernoulli, the great Swiss mathematician, pondered a question early in the 18th century. Can you mathematically predict what will happen when events of chance take place, as in throwing dice?

His answer was the classical Bernoulli binomial distribution—a basic formula in the mathematics of probability (published in 1713). The laws of probability say, for instance, that if you roll 150 icosahedrons (the 20-faced solid shown above), 15 or more of them will come to rest with side "A" on top only about once in a hundred times.

Identical laws of probability govern the calls coming into your local Bell Telephone exchange. Suppose you are one of a group of 150 telephone subscribers, each of whom makes a three-minute call during the busiest hour of the day. Since three minutes is one-twentieth of an hour, the probability that you or any other subscriber will be busy is 1 in 20, the same as the probability that side "A" of an icosahedron will be on top. The odds against 15 or more of you talking at once are again about 100 to 1. Thus it would be extravagant for the Bell System to supply your group with 150 trunk circuits when 15 are sufficient for good service.

Telephone engineers discovered at the turn of the century that telephone users obey Bernoulli's formula. At Bell Telephone Laboratories, mathematicians have developed the mathematics of probability into a tool of great economic value. All over the Bell System, the mathematical approach helps provide the finest telephone service using the least possible equipment. The achievements of these mathematicians again illustrate how Bell Labs works to improve your telephone service.
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Bookshelf (Continued from page 16)

-saving him from having to "unlearn" and modify parts of vacuum tube theory when he begins to study transistors.

Recommended as one of the very best books available covering the broad field of electronics at an intermediate level. Review questions and problems appear at the end of each chapter.


As most readers of Popular Electronics will realize, John T. Frye, the author of this book, also writes our monthly "Carl and Jerry" series. From these and other articles, Mr. Frye has gained a well-deserved reputation as being a writer who knows what he is talking about. This book, a revised and enlarged version of an earlier book on radio servicing, is the result of author Frye's long years of experience in the field. Probably the most practical, useful, and best-written volume yet to appear on servicing radio receivers, it is rather long—over 220 pages of smallish type without any unnecessary illustrations—and very complete. It is a pleasure to read, and anyone whose hobby or profession is radio servicing will want to have a copy.

"MASTER RECEIVING-PICTURE TUBE SUBSTITUTION GUIDE BOOK" by H. A. Middleton. Published by John F. Rider Publisher, Inc., 116 West 14th St., New York 11, N. Y. 343 pages. $7.45.

With the stream of new tube types continuing to pour out of the tube factories at an increasing rate, a tube substitution book...
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April, 1960

19
Bookshelf  (Continued from page 18)

is always a good investment for a service technician or electronic experimenter. This is one of the most complete ones yet to appear. It lists over 5100 receiving tube substitutions and 825 picture tube substitutions, with American equivalents for 320 European tubes also given. If any circuit changes are required for substitution of a tube, they are fully outlined. If the circuit changes necessitate changing the tube socket, a diagram of the socket is provided.

Recommended as a valuable aid to servicing and building electronic equipment.

"ENCYCLOPEDIC DICTIONARY OF ELECTRONICS AND NUCLEAR ENGINEERING" by Robert I. Sarbacher. Published by Prentice-Hall, Inc., Englewood Cliffs, N. J. 1426 pages. $35.00.

This enormous book is obviously not intended for the casual reader, but for engineers, technical writers, libraries, and schools. With over 14,000 entries and 1400 illustrations, it seems to be quite complete and up to date. The definitions and explanations are very clear, and higher mathematics is called upon only when necessary.

Recommended as an invaluable reference book for people with serious interest in these fields.

Miscellaneous Literature

Designed for the first-class Citizens Bander, a handy reference guide to the most commonly used "10" series of signals is available from Vocaline Company of America, 10 Coulter St., Old Saybrook, Conn. The guide is free for the asking, but the company requests that you include your call letters to authenticate usage.

The mysteries of stereo high-fidelity are explained in an attractive 36-page booklet offered by Allied Radio, 100 N. Western Ave., Chicago 80, Ill. Intended for the beginner in stereo, it was prepared under the direction of Edward Tatnall Canby. "This Is Stereo High-Fidelity" is a good introduction to the subject and is available for 25 cents. Stock number is 37K387.

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Tips and Techniques

BROOM-CLIP "VISE"
Fasten down a broom clip like the one shown to a scrap piece of wood. It will come in handy for holding wires or parts while you solder them. A broom-clip "vise" will hold almost any size part securely as you apply the solder.—Charles Lang, San Francisco, Calif.

COPPER CLIPS ABSORB HEAT
Solid copper alligator clips make efficient heat sinks to protect heat-sensitive components while soldering. You'll insure rapid heat conduction if you remove the teeth with a file to keep the contact points clean and bright.—Myron Bookwalter, Spokane, Wash.

LIGHT CLAMP IS MIKE STAND
Attach your tape-recorder mike to a photographer's light clamp and you can clamp

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FIBER FUSE CLIPS 15c ea. 12 for $1.65 PP.


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AmericanRadioHistory.Com
**Tips**

(Continued from page 22)

the mike to a chair or other convenient object. First remove the light-socket assembly from the clamp. Cement a round bottle cap—the metal cap from an Aerosol spray can works perfectly—to the back of the mike with a plastic cement such as Duco. Then attach the clamp to the bottle cap. This stand gives you a much better chance of accurate sound pickup and leaves your hands free, too.—James Clifford, Detroit, Mich.

**SPRING GIVES PLIERS POWER**

Hook a coil spring between the handles of a pair of pliers and you have a handy vise for holding small radio parts while soldering. You can also use the spring-operated pliers as a heat shunt by clamping them onto the wire lead between the part and the soldering iron.—Joseph Carroll, Brooklyn, N.Y.

**EASY MINIATURE TUBE REMOVAL**

Removing miniature tubes from crowded chassis can be speeded up by installing a

(Continued on page 28)
UNCONDITIONAL MONEY-BACK GUARANTEE

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<td>LAFAYETTE WOOD CHANGER BASE</td>
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<td>2+ LAFAYETTE SK-58 FAMOUS FREE EDGE</td>
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April, 1960
Tips  

(Continued from page 24)

simple tube puller beneath each tube before placing the tube in its socket. Tie an eight-inch piece of strong nylon thread into a circle and pass the loop under the base of

the tube. Plug the tube into its socket with the loop in place, and fasten the other end of the loop to an i.f. transformer or any other handy spot with a piece of tape. A gentle tug on the free end of the loop will quickly remove the tube.—Ronald S. Newbower, Gloversville, N. Y.

COAT-HANGER HANDLE FOR VOM

Why chance dropping a handle-less VOM or multimeter when you can give the instrument a wire handle in a few minutes’

time? Take a wire coat hanger, straighten it out, clip about 12” from it, and bend the 12” length into a handle that will fit into two small holes carefully drilled in either side of your meter’s case.—John A. Comstock, Wellsboro, Pa.

INEXPENSIVE LIGHTNING ARRESTER

An old automobile spark plug can be turned into a simple and effective lightning arrester for your receiving antenna. To make the arrester, solder a piece of heavy wire (No. 12 or 14) to the threaded barrel of the plug and connect the wire to the antenna lead. Solder a second wire to the post of the plug on the porcelain and run this wire to a good ground. Incidentally, a six-foot pipe driven into the earth often makes a better electrical ground than the water-pipe system. Corroded pipe joints may form high-resistance paths—and lightning charges follow paths of least resistance.—Kent A. Mitchell, Hagerstown, Md.

SHOCK-ABSORBING METER FEET

If your volt-ohm-miliampmeter doesn’t already have resilient rubber feet to help absorb mechanical shocks, you can add some made of Duro plastic rubber. Three layers of the liquid rubber are usually sufficient; remember to allow plenty of drying time between applications.—Charles Lang, San Francisco, Calif.

SPRING HOLDS POWER CORD

If your tape recorder has a detachable power cord, a screen-door spring screw fastened to the inside of the recorder’s lid makes for neat cord storage. Just coil up the cord and store it behind the spring.—Jerome Cunningham, Chicago, Ill.
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April, 1960

AmericanRadioHistory.Com
The introduction of the "Traveler," an all-transistor transceiver for use on the Citizens Band, has been announced by International Crystal Mfg. Co., Inc., 18 North Lee, Oklahoma City, Okla. Weighing less than five pounds and requiring no a.c. power supply, the unit is ideal for portable applications. The 12-transistor circuit includes a noise limiter and squelch, and two crystal-controlled receiving and transmitting channels. The "Traveler" can be operated from standard dry cells, rechargeable batteries, or from 117 volts a.c. (with accessory power supply).

STEREO MICROPHONE
A dual-element microphone for use in making stereo recordings has recently been announced by North American Philips Co., Inc., High Fidelity Products Div., 230 Duffy Ave., Hicksville, Long Island, N.Y. The Norelco EL-3752/01 microphone employs the moving-coil principle and has dual cardiod pickup patterns. Sensitivity is high, with the output only 50 db down at 1 volt, at an input pressure of 1µbar/cm². The output impedance is 25,000 ohms. Price, including 16' of shield-
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April, 1960
ed cable and a three-conductor telephone plug, $39.50.

**STEREO AMPLIFIER**

Introduced by Lafayette Radio, 165-08 Liberty Ave., Jamaica 33, N.Y., the Model LA-235 stereo amplifier delivers 17½ watts per channel in stereo operation or 35 watts in mono use. Frequency response is from 20 to 20,000 cps ±1 db at normal listening levels. Distortion at full output is less than 1% harmonic and less than 2% IM. The LA-235 features five sets of inputs, 8- and 16-ohm speaker outputs, and a blend control to provide continuously variable channel separation. Price, $69.95.

**SUBMINIATURE SWITCH**

Development of a high-current subminiature toggle switch has been announced by ALCO Electronic Products, Inc., 3 Wolcott Ave., Lawrence, Mass. Measuring only ½" x ¾" x ½", it is rated at 5 amperes at 115 volts a.c.; voltage breakdown is 1000 volts a.c. Price: s.p.d.t. model, $1.65; d.p.d.t. model, $2.15.

**TRANSISTOR STEREO AMPLIFIER**

Twenty-five watts output per channel is obtainable with the all-transistor stereo amplifier announced by Transis-Tronics (TEC), Inc., 1650 21st St., Santa Monica, Calif. The Model S-25 has separate treble
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April, 1960
products

(Continued from page 32)

and bass controls for each channel, seven sets of inputs, and a phase reversal switch. Frequency response is from 20 to 20,000 cps ±1 db at 25 watts. This unit can also be employed as a 50-watt mono amplifier and can be operated from either 117 volts a.c. or 12 volts d.c.

AUDIOMIXER

Input and output impedances of 500,000 ohms are provided by the Model VC-220 two-channel audio mixer available from Olson Radio Corp., 260 South Forge St., Akron, Ohio. The input jacks accommodate either standard ¼” phone plugs or RCA-type phono pin plugs. The output terminates in an RCA-type phono pin jack. Size, 4” x 2¾” x 1⅜”. Price, $3.00.

STEREO RECEIVER

The Madison Fielding Model 440 single-chassis stereo tuner-amplifier, introduced by Crosby Electronics Corp., Syosset, N. Y., comprises a stereo AM-FM tuner and two

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products

(Continued from page 34)

20-watt amplifiers. Sensitivity on FM is 2 microvolts for 20 db quieting; AM sensitivity is 80 microvolts per meter. Each amplifier section provides full output with less than 1% harmonic distortion, and the input facilities accommodate all standard stereo program sources. Price, $325.00.

**FM TEST OSCILLATOR KIT**

A new kit-built oscillator designed specifically for use with FM receivers is available from the Heath Company, Benton Harbor, Mich. Model FMO-1 features fixed-frequency outputs at 90, 100, and 107 mc., a 10.7-mc. sweep oscillator with variable sweep width from 200 kc. to over 1 mc., a 10.7-mc. crystal marker, a 10-mc. calibrating crystal and a switched 400-cycle signal for radio-frequency modulation.

**STEREO RECORD CHANGER**

Designed for use with both monophonic and stereo records, the Model GS-400 record changer announced by Glaser-Steers Corp., 155 Oraton St., Newark 4, N. J., automatically changes records intermixed in
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37

AmericanRadioHistory.com
any sequence. Features include a four-pole motor, a quick-change cartridge holder, a muting switch, and a one-piece aluminum tone arm. Price, less cartridge, $47.50.

**FM TUNER**

An FM tuner, the Model 580, is being offered by the J.W. Miller Co., 5917 South Main St., Los Angeles 3, Calif. Sensitivity is 1 microvolt for 20 db quieting and the frequency response is from 15 to 25,000 cps. Features include a tuned r.f. stage, per-

meability tuning, shielded oscillator stage, and dual limiters. The Model 580 has a.f.c.

with a defeat switch and the audio output is of the cathode-follower type. Size, 9"w x 4"h x 7"d. Price, $69.50.

**TRANSISTORIZED PAGING UNIT**

The “Transi-Page,” a transistorized portable paging unit, has recently been developed by Raven Electronics Mfg. Co., 2130 W. Carroll Ave., Chicago 12, Ill. The ten-pound system incorporates an 8" trumpet-type speaker, a 5-watt transistor amplifier, and a heavy-duty dynamic microphone. Although the “Transi-Page” is designed primarily for on-the-go paging, it can be used in any p.a. application. A 25' extension cord and a connector are included for operation with 12-volt car or boat batteries. Price, $99.50.

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By MILES DILLARD

Maser-operated radic telescope at the Naval Research Laboratory has a range of more than seven billion light years.

April, 1960
ON FEBRUARY 10th of last year, eight scientists gathered at MIT's famous Lincoln Laboratory near Boston. They carefully checked over the powerful research radar installed there, then angled its huge dish antenna sharply into the afternoon sky. At exactly 2:21 p.m., a pulse shot out from the antenna in the direction of the planet Venus. Just under five minutes later, an echo so faint as to be hardly recognizable came back to earth. Man had made his first direct contact with the planets. The scientific breakthrough that made it possible for an electronic signal to complete the 55-million-mile round trip from Earth to Venus was the invention of the "maser." This amplifying device effectively makes radar sets up to 100 times more sensitive than they were before, vastly extending their range. The world's first true "atomic amplifier," the maser owes its amazing sensitivity to the fact that it actually harnesses the tremendous internal energy of the electron's spin.

The "solid-state maser," to give it its full name, is an odd but deceptively simple-looking gadget. Its heart is a strip of synthetic ruby which is suspended in a tank of liquid helium and maintained at the almost unbelievable temperature of nearly 460°F below zero! Add a few lengths of waveguide—electronic plumbing to direct the radio waves in and out—and you've got the whole assembly.

While the maser's most publicized triumphs to date have been associated with radar, its accomplishments have by no means been limited to this field. Searching Space. Columbia University's Dr. Charles H. Townes, who invented the maser, and scientists at the Naval Research Laboratory near Washington have built a maser-operated 50-foot radio telescope which has a range three and one half times as great as the best light telescopes—over seven billion light years! This has opened up for exploration a total volume of space about 40 times greater than that seen by the 200-inch Mount Palomar telescope and earlier radio telescopes.

The great sensitivity of the new 50-foot "space eye" is already enabling astronomers to learn something about the surface of Venus for the first time. This has been perhaps the most mysterious of all the planets because it is eternally obscured by
Three Bell Labs scientists, Harold Seidel, H. E. D. Scovil, and George Feher, are shown here with one of their brain-children, an early solid-state maser.

thick clouds. But the maser telescope can pick up its feeble surface radiation easily, and astronomers now know far more about it than ever before. They have recently learned, for example, that the surface of Venus is a sizzling 585°F—far too hot for the existence of life as we know it.

But this is just the beginning. Dr. Frank D. Drake of the National Astronomy Observatory at Green Bank, West Virginia, predicts that within about a year a radio telescope with three times the range of the 50-foot unit at the Naval Research Laboratory and ten times the range of earlier radio telescopes will allow scientists to "see" the actual surface of Venus and to determine for the first time its speed of rotation—that is, the length of its days.

This new instrument is already under construction at the West Virginia observatory site. Its gigantic dish antenna will be 600 feet in diameter; two football fields would fit end to end across its span. Not only will it "see" nearby planets more clearly, but its tremendous sensitivity will enable it to probe 30 to 40 times as much space as can now be explored with the 50-foot telescope. Its range may extend as far as 80 billion light years! Astronomers think they will even be able to observe the "edge of space," where radiation emitted at the time of the formation of the universe may perhaps be detected or where space may actually be seen to curve.

"Such observations," says Dr. Townes, "will quite possibly indicate whether present ideas of an expanding universe are correct, as well as providing a means of checking other cosmological theories."

One of the maser's most obvious applications is in the field of satellite communications. Since tons of fuel must be burned for every pound of satellite put into orbit, scientists use every conceivable trick to design the lightest possible equipment for space probes. With maser amplifiers one hundred times as sensitive as older types in ground listening posts, smaller and lighter transmitters can be installed in satellites. Smaller transmitters also use lighter batteries, saving more weight.

**Thermal Noise.** The maser—this weird piece of frigid hardware—is able to perform its many tricks because its unique principle of operation virtually eliminates that old bug-a-boo, thermal noise.

Why is this so important? Let's take a
The inventor of the maser, Dr. Charles H. Townes (above left), of Columbia University, and J. P. Cedarholm of IBM inspect a gas maser clock which is used in scientific research.

look at the maser's use in radar and find out. Figure 1 shows a radarscope with an echo from a nearby airplane. The echo is strong and clear. But notice the wiggly lines along the bottom of the scope trace. Radar operators call this irregular pattern "grass." Engineers call it thermal noise.

If there were no thermal noise, the scope trace with the same echo would look like Fig. 2. Here, the transmitter pulse and the echo is unchanged; the only difference is that there is now no "grass," or thermal noise. It makes little difference whether or not the thermal noise is there, as long as we get a strong echo from a nearby target.

But what about that echo from Venus? By the time a signal travels 55 million miles, there isn't much of it left. On a maser radarscope, the trace would look like Fig. 3. Without the maser, it would look like Fig. 4. Where is the echo? Completely blanked out by thermal noise.

How does the maser do away with thermal noise? To answer this question, let's quickly review the cause of thermal noise.

If you could look inside the tubes and wires of your hi-fi set, for example, you would see streams of electrons rushing...
along in orderly groups. This flow of electrons is the "signal" that eventually comes out of the speaker as music or speech. But here and there a few electrons, stirred up by the heat present in any circuit, scamper around aimlessly. This random movement generates a small but measurable current of its own, which comes out as noise. It is called thermal noise, or thermal agitation, since it is caused by heat: the more heat, the more noise.

You can actually hear thermal noise on your hi-fi amplifier, just as you can see it on a radarscope. With no signal applied to your hi-fi set, turn up the volume control and put your ear next to the speaker. The hissing sound you hear is thermal noise greatly amplified. Although such noise is rarely objectionable in hi-fi amplifiers, it seriously limits the range of radar, as we have seen.

Since the maser does not depend on electron flow, there is little random noise created. And even the few stray electrons that would normally wander about are much less likely to do so when the maser is dipped in a chilling bath of liquid helium. At temperatures close to absolute zero (−473°F), random electron movement becomes

(Continued on page 122)

**HOW THE MASER WORKS**

The heart of the solid-state maser is a strip of semiconductor material—usually synthetic ruby—placed in a resonant chamber into which are piped the signal to be amplified and the so-called "pump" signal.

Scientists tell us that materials such as synthetic ruby contain electrons spinning at different rates, or to be more accurate, at different "energy levels." Under normal conditions, most electrons are at the lowest energy level, which is called "Energy Level 1." Fewer electrons are at Energy Level 2, and still fewer at Energy Level 3. When an electron "falls" from a high level to a lower one, it gets rid of its excess energy by radiating that energy in the form of microwave signals.

To illustrate how the maser works, a mechanical analogy can be used. This analogy describes the operation of the "3-level maser," the most common type.

Let us represent Energy Level 1 by a tank of water. Energy Level 2 by a row of buckets suspended above the tank, and Energy Level 3 by a still higher row of buckets. Valves in the bottom of the buckets on Energy Level 3 are arranged so that they automatically keep the buckets on Energy Level 2 full.

Each bucket on Energy Level 2 has a sensitive valve on its bottom which can be opened by the slightest touch. The system also has a pump which pumps water from the tank, keeping the buckets on Energy Level 3 full, which in turn keeps the buckets on Energy Level 2 full.

The maser is now ready to operate. Tiny drops of water shooting into the system from the outside will hit the valves on the bottom of the buckets on Energy Level 2, releasing large amounts of water. These small drops of water represent small incoming signals, which in actual masers cause the electrons on Energy Level 2 to drop to Energy Level 1, and thereby radiate their excess energy. The amount of energy they radiate is far more than the amount needed to trigger them. Therefore, a small signal coming into the maser is amplified into a large one.

Because of complex technical considerations, it is easier in practice to "pump" electrons up to Energy Level 3 and let them drift down to Energy Level 2 than to pump them directly to Energy Level 2. The "pump" used in an actual maser is an oscillator operating at a frequency higher than the signal frequency to be amplified. In practice, the cavity in which the maser is placed must be resonant at the signal and pump frequencies.

The gas maser is a "2-level maser," which operates on a slightly different but similar principle. The word "maser" stands for "Microwave Amplification by Stimulated Emission of Radiation."
Among other things, stereo has brought us back to the integrated amplifier system—preamplifier, amplifier, and power supply all in one compact chassis. One of the neatest integrated stereo systems on the market today is the PACO SA-40 kit (PACO Electronics, Inc., 70-31 84th St., Glendale 27, L. I., N. Y.). The unit incorporates two 20-watt amplifiers, a separate preamplifier for each, and a common power supply. At its price of $79.95 ($129.95, factory-wired), the SA-40 is a good buy.

Features. Versatility is one of the unit's outstanding features and seems to have been foremost in the minds of its designers. With the number of inputs available—fourteen in all—you can connect virtually anything to the completed amplifier. An Input Selector chooses between auxiliary inputs 1 and 2, phono inputs 1 and 2, tape head, and microphone. A Mode Switch selects type of operation—stereo, stereo-reverse, monophonic, or separate-channel—and also provides for balancing the loudspeaker systems used. Balance, Loudness, Bass, Treble, Equalization, Rumble, Speaker System Selection, and a separate On-Off Switch make up the remaining operating controls.

A Parallel-Separate switch on top of the chassis determines whether the two power amplifiers operate separately or in parallel. With the power amplifiers operating in parallel—and thus supplying a combined output of 40 watts—an auxiliary external power amplifier can be connected to the left preamp section to drive the other channel.

Each power amplifier incorporates 25 db of inverse feedback around its voltage amplifier, phase inverter, and output stages, as well as the output transformer itself, cutting hum and distortion by nearly 20 times. Equalization networks for both tape and phono are also of the inverse-feedback type. Large capacitors (100 µf.) make power supply regulation good, an important feature in view of the use of fixed bias on the output tubes.

Mechanically, two a.c. outlets (one switched, one unswitched) at the rear of the chassis will supply power to the associated equipment. Provision is also made at the rear of the chassis for connecting the amplifier chassis to a waterpipe ground—one of the most foolproof ways of reducing hum to an imperceptible level.

Comment. It would be wrong to look upon the SA-40 as a construction kit for the experienced kit builder. The instruction manual is thorough and has been carefully worked out to guide the newcomer to kit building. And while the project is extensive—you can count on at least 20 hours of construction time—it isn’t difficult.

The completed SA-40 offers nearly all that could be asked for in an integrated stereo system—neatness, compactness and versatility.
Here's an unusual amplifier that should appeal to the hi-fi experimenter. It's unusual because the output is taken from the cathode and not from the plate of the output tube as you would expect. A similar circuit appears quite often in hi-fi preamplifiers where you probably know it as the cathode follower.

This amplifier was designed to work from a high output cartridge or tuner. You'll need about .1 volt or more to drive the unit to its full output which is in the region of 1 watt. For a simple stereo system, two of these units would be ideal.

The author built his model on a 5" x 7" x 2" chassis he had on hand, and the power supply was built on a separate chassis of the same size. (If you wish, you can build both on a single larger chassis with no ill effects.) Although the circuitry is noncritical, all grid leads should...
Amplifier is shown wired for use with an 8-ohm speaker, but you can connect a 4-ohm speaker by wiring the 4-ohm tap on transformer T1 to terminal strip.

**HOW IT WORKS**

Audio signals from a crystal or ceramic phonograph cartridge are applied to triode V1a through simple treble-boost circuit Cl-R1. Amplified signals are taken from the plate of this triode and fed to volume control R5. The desired portion of the audio is tapped off R5 and applied to the grid of triode V1b where it is again amplified, and finally applied to V2's control grid. The signal is then taken from the cathode of V2 and coupled to the speaker through output transformer T1. Resistor R9 biases V2 in normal fashion.

The power supply is a standard full-wave rectifier with a choke-input filter consisting of C11 and C5. Paralleled resistors R11 and R12 operate as a bleeder and as a discharge path for capacitor C5.

Treble boost circuit Cl-R1 can be omitted from amplifier if desired and J1 connected directly to the grid of V1a.

be kept short and away from leads carrying a.c. power and heater current. It's generally best to wire the heater and power leads first, and then proceed with the rest of the wiring.

A cable is used to interconnect the two chassis, with an octal plug and socket serving as cable connectors. Mount the socket—but not the plug—on the power supply chassis. If the plug were on the power supply, you would be liable to get a bad shock at the plug pins with the supply turned on. If you want a smaller unit, you can sub-
**Choke-input filter** in power supply lowers B+ to proper voltage for V2. Capacitor C5 must be large since it filters output of supply and also serves as audio bypass for V2.

Substitute a 12AU7 for the 6SN7 tube (V1) and a 6AQ5 for the 6V6 tube (V2). No circuit changes would be necessary.

Transformer T1 is not a standard output transformer. It is a line-to-voice-coil unit with a primary impedance of 500 ohms and a 4- and 8-ohm secondary.

A simple boost circuit, C1-R1, equalizes the phono cartridge output. These parts can be eliminated if no boost is required and J1 can be connected directly to the grid of V1a.

**Power-supply bleeder** uses two resistors (R11 and R12) for better heat dissipation. Octal socket SO1 mates with plug P1 on the interconnecting cable.
Transistorized Electronic Fence Controller

Inexpensive unit keeps animals in, pests out!

By R. L. WINKLEPLECK

AN ELECTRONIC fence controller, or "charger," is a useful device for keeping animals either in or out of an enclosed area. It supplies a pulsed high-voltage output to a length of bare fence wire and thus delivers an annoying jolt to any animal that touches it. And, in addition to being ideal for keeping livestock within desired boundaries, the fence controller can also be connected to such things as garbage cans—to prevent dogs or pranksters from knocking them over.

No moving parts are used in the transistorized fence controller described here. There is nothing to wear out except the battery; and—thanks to the circuit's high efficiency—battery replacement should be infrequent. The controller complies fully with safety regulations; it will give a stinging shock, but it can cause no serious harm to anyone coming in contact with the charged wire.

You can build the unit, ready for action, for just a shade over ten dollars.

Construction. The fence controller fits in a 3" x 5" x 7" Minibox. First, assemble the transistor circuitry on a 2" x 5" perforated phenolic circuit board. Then wire the components point-to-point, using solder lugs or "flea" clips where necessary. Attach completely wired phenolic circuit board to the mounting bracket on the spark coil.
or to any other convenient point. Spark coil T\textsubscript{1} may be a 6- or 12-volt model depending on the voltage of the battery you decide to use.

Connect the high-voltage output of T\textsubscript{1} to the stand-off insulator on the top of the box with auto ignition wire. Battery and ground connections are made to the three binding posts on the bottom of the box. As a final touch, fasten a bracket to the box so that you can mount it on a fence post.

Test the finished controller by connecting a 6- or 12-volt "hot-shot" or storage battery to the positive and negative binding posts, being sure to observe polarity. Check for a spark between the stand-off insulator and the ground binding post by scratching a well-insulated wire between these terminals. Don't use bare wire or you may be knocked off your feet.

After the unit is checked out, spray the circuit board and the outside of the box with an insulating spray lacquer to guard against dirt and moisture.

**Operation.** String single- or double-stranded bare wire around the area to be enclosed. Use insulators...
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BATTERY

conducts heavily shown, C2 tinte switch ducts.

biases and the collector vibrator circuit OR 12V.

it biases R4, T1-6- R6 R2-2200 R1-100,000 Q4 Q3
Q1-20-0., QI, C2 BI

Transistors -R3, -82 -2N441 transistors
-2N256 -100-µf., Q4
Q2

Q1

HIGH POWER TRANSISTOR (Delco)
R1-100,000 ohms
R2-2200 ohms
R3-82,000 ohms
R4, R5-220 ohms
R6-82-ohm, 1-watt resistor
R7-82 ohms
T1-6- or 12-volt automobile ignition coil (see text)
1-3" x 5" x 7" Minibox (or equivalent)
1-2" x 5" perforated phenolic circuit board

HOW IT WORKS

Transistors Q1 and Q2 operate as a multivibrator, Q3 and Q4 as common-emitter amplifiers. Capacitor C1 is feedback capacitor in multivibrator circuit.

(ceramic or plastic) to fasten the wire to the fence posts; the wire should be at a level roughly two-thirds the average height of the livestock. Then mount the controller on a fence post, preferably in a spot where it will be well protected from the weather.

Connect the controller's stand-off terminal to any convenient point along the wire; auto ignition wire is best for this purpose if the wire is very long. The controller's ground terminal is connected to a pipe or rod driven at least three feet into

the ground. When the battery is connected, the fence will immediately become "alive."

Use a lightning arrester to prevent damage to the controller. Connect the arrester between the porcelain stand-off insulator and ground. The gap on the arrester should be wide enough (about ¼") to keep the normal output of the controller from jumping the gap.

To turn off the controller, disconnect either battery lead. Animals soon learn to respect and to avoid a charged fence; once they have been shocked they will often be wary of it for weeks after the power is disconnected.

To keep the neighbor's dog from knocking over your garbage can, just set the can on insulating blocks and connect the controller to it as described above.

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AmericanRadioHistory.Com
Dr. Glenn's Magic Wrinkles

Young GE scientist devises new ultra-wide-band recording system for use in video recording, data storage, missile guidance, etc.

The 35-mm. slide looked ordinary enough—except that it had no picture on it. Held up to the light, it was perfectly transparent. But when it was slipped into a conventional-looking projector, a picture in brilliant color flashed on the screen! Movie film which also looked clear was run through a home-type projector, and moving pictures appeared on the screen—some in full color, others in black and white.

This is thermoplastic recording, the invention of a young General Electric scientist, Dr. William E. Glenn. Thermoplastic recording—TPR—paints an image on film in the form of a series of microscopic wrinkles that can't be seen under normal...
conditions. But they break up beams of light projected through them into black and white or brilliantly colored pictures.

**New Concept.** TPR is the first completely new principle in recording to come along since magnetic tape, and it seems destined to make an even bigger splash. The reason: thermoplastic recording combines most of the advantages of tape and film recording with a number of its own.

Here are some of TPR's most important features:

- It can record anything that can be represented by an electrical signal: TV pictures; sound; computer, radar, or sonar images.
- Both recording and playback are instantaneous.
- It provides an image that can be viewed optically or projected on a screen, but it needs no chemical processing.
- Recordings can be used, erased, and reused, again and again.
- Duplicate recordings can be reproduced by stamping, like phonograph records—a much faster and cheaper process than tape re-recording.

- TPR has fantastic bandwidth capabilities (up to 50 megacycles) and resolution. It can cram a staggering amount of information into a small space.

For example, television pictures can be recorded on a tape one-tenth of an inch wide which moves at the astonishingly slow speed of only five inches per second. A half-hour TV program can be put on a reel that would fit in your vest pocket.

At the system's present degree of refinement, the contents of the entire *Encyclopedia Britannica* could be recorded on a reel only a few inches in diameter, at a rate of one volume per minute. Dr. Glenn says that eventually it should be possible to store the same amount of information on a reel the size of a spool of thread.

By using a binary digit system, recorded information can be compressed even more. Since up to forty million “bits” of information can be put on each square inch of film, the contents of a dozen full-length novels could be recorded on one square inch of film, in binary form.

The ability to store vast amounts of in-
Fig. 3. Video recordings are reproduced through a modified slide or movie projector. No modulation of the film's surface results in no light reaching the screen. A surface ripple, however, such as that at point "A," will diffract the light between the bars, allowing light to reach the screen.

Dr. Glenn tests his prototype thermoplastic recorder. He estimates that he could halve its size by rebuilding it. Diagram of the TPR recorder is at left.

formation is becoming more and more important in this age of rapid scientific progress. Many research and development projects, for instance, are hampered because truly comprehensive collections of reference material are available in only a few major libraries.

With TPR, it will be possible to store all of the information in New York's famous Engineering Societies Library—one of the nation's finest collections of technical and scientific information—in a cabinet the size of an ordinary office desk. Techniques used in present-day computers would make it possible to locate any piece of stored information within a few seconds. Consequently, every company or university could have a relatively inexpensive, readily accessible source of information of the sort now available in only a few places in the world.

Preserving the Wrinkles. Dr. Glenn got the idea for thermoplastic recording while working on a refinement for the Eidophor TV projection machine (see Popular Electronics, May 1959). It occurred to him that if there were some way to catch and "freeze" the wrinkles that made up the picture, such a system would have tremendous advantages over conventional recording methods. Thermoplastic recording grew out of this concept.

In TPR, an electron beam sweeps back and forth across a recording film, laying down a pattern of electrons proportional to the signal being recorded. In principle, this is exactly the way an electron beam creates an image on a TV picture tube. (See Fig. 1).

The recording film is composed of three layers. Over a relatively thick base (approximately as thick as a movie film) is a much thinner strip of an electrically conducting plastic; above this is the thermoplastic layer which has a low melting point. (See Fig. 2).

As the tape moves past the electron beam where it collects the electron pattern, it crosses an electronic heater which induces a current flow in the middle layer. This heats the top thermoplastic layer above its melting point. While the thermoplastic is (Continued on page 132)
Find the brightest bulb

In each of the circuits below, all of the bulbs have the same voltage and wattage rating. In every circuit, however, ONE of the bulbs lights brighter than the rest. Which one is it?

By ROBERT P. BALIN

1 (C) 2 (C) 3 (D)

4 (A) 5 (E)

6 (A) 7 (E) 8 (A)

9 (C) 10 (E)

Answers on page 120

POPULAR ELECTRONICS
EACH MONTH, more and more transistorized consumer products are developed as replacements for vacuum-tube designs. In view of this trend, a radio kit recently introduced by the Heath Company (Benton Harbor, Mich.) takes on special significance. Dubbed "Your Cue," Heath's TCR-1 is frankly designed as a transistorized table-model clock radio. If desired, the set can be converted into an attractive "portable" by fitting it in an optional leather carrying case.

Battery-operated, and hence completely shock-proof, the TCR-1 is as at home in the kitchen or bathroom as it is in the living room, den, "rec" room, bedroom, or office. With no dangling cord to plug in, the set can be placed anywhere rather than near an electrical outlet.

Basically a six-transistor superhet using p-n-p types in the common-emitter arrangement, the TCR-1 boasts a number of circuit innovations as well as several interesting operating features. It tunes the AM broadcast band from 535 to 1620 kc. and has a standard 455-kc. i.f. Its audio amplifier can deliver a maximum of 300 mw. to its 4" x 6" loudspeaker, more than ample for good room volume. Radio battery life is from 100 to 500 hours, depending on whether standard penlight or mercury cells are used. A separate battery powers the clock; operating life is approximately four months, using a mercury cell.

Referring to the block diagram of Fig. 1, the set features a high-gain built-in loop antenna and a tuned r.f. amplifier ahead of its converter stage. This is in contrast to the more common practice of having the

Fig. 1. The trend to transistors has now reached the clock radio with this all-transistor circuit by Heath. One battery powers the radio, another powers the clock.
antenna coupled directly to the converter, and it insures better image rejection and overall sensitivity.

Although a single i.f. stage is employed, adequate selectivity is assured by the use of a double-tuned i.f. transformer. The d.c. component of the detected i.f. signal is coupled back to the r.f. amplifier for automatic gain control (a.g.c.); the r.f. stage amplifies the a.g.c. voltage which is then applied to the i.f. stage.

The audio signal from the detector is applied through the receiver's volume control and waken to either music or an alarm. In addition, an earphone jack is provided for personal listening.

From the builder's viewpoint, the TCR-1 is fairly easy to assemble. A conventional chassis and point-to-point wiring techniques are used. The instruction manual furnished is clear and well illustrated with pictorial diagrams.

"MOBIDIC." In the field of computer design, too, the transistor has virtually supplanted the vacuum tube. Few—if any—computers in current manufacture or in the design stage use tubes. Most use transistors, diodes, and other solid-state amplifying and control devices.

One of the most versatile of military computers is Sylvania's transistorized "MOBIDIC" (Mobile Digital Computer)—pronounced, naturally, "Moby Dick." This computer is used extensively by the army for routine business calculations as well as for such battlefield work as logistics, combat surveillance, tactical operations, scientific and analytic computation, map compilation, and determining artillery target assignment.

Readers' Circuits. The circuits in Fig. 2 were submitted by readers from opposite ends of the continent. John Gottcent of 173 Warwick St., Brooklyn 7, N. Y., sent in the circuit given in Fig. 2(A), while the one shown in Fig. 2(B) is the work of Larry
Gorney, K6EBX, of 1536 E. Ave., Q-11, Palmdale, Calif.

At first glance, the two circuits appear similar. Both employ a diode and two transistors; both are designed for operation on a 3-volt battery, both tune the AM broadcast band; both use modified direct-coupling between stages; both require an external antenna for optimum performance; both employ standard magnetic earphones and, finally, both can be assembled using standard commercial components. But with all these similarities, the two circuits are nonetheless very different in operation.

Referring, first, to Fig. 2(A), we see that John’s receiver consists of a conventional LC tuned circuit followed by a two-stage RC-coupled audio amplifier which uses $p-n-p$ transistors in the common-emitter arrangement. Coil $L_1$ is a standard ferrite loopstick antenna coil (such as Lafayette No. MS-11), $C_1$ a common 365-$\mu$F. tuning capacitor, and $R_1$ a familiar 1-meg-ohm volume control with s.p.s.t. switch ($S_1$). Capacitors $C_2$ and $C_3$ are 0.5-$\mu$F. and 0.01-$\mu$F. units, respectively; 200-volt paper tubulars may be used. Any of several diodes can be employed—the popular 1N34 or, if you prefer, a 1N48, 1N68, or CK705. Transistors $Q_1$ and $Q_2$ are both G.E. Type 2N107’s. The 3-volt battery, $B_1$, is made up of a pair of penlight cells connected in series.

In operation, signals picked up by the antenna are selected by tuned circuit $L_1-C_1$ and applied to the diode detector. From here, the detected audio signal is amplified by $Q_1$ and coupled through $R_1$ and $C_2$ to $Q_2$. Additional amplification is supplied by the second stage, with $Q_2$’s output driving the pair of magnetic earphones. Capacitor $C_3$ serves as a high-frequency bypass across the ‘phones.

Note that no effort has been made to supply a separate source of bias current for $Q_1$’s collector. This current is obtained through $Q_2$’s base-collector resistance; hence, $Q_2$’s leakage resistance will play an important part in overall circuit operation. In some cases, it may be necessary to interchange $Q_1$ and $Q_2$ (identical types are used) or to try different $p-n-p$ types for $Q_2$ until best performance is attained.

Larry’s circuit, in contrast, takes advantage of the complementary characteristics of $p-n-p$ and $n-p-n$ types of transistors to achieve direct-coupling between stages. Referring to Fig. 2(B), $Q_1$ is a popular $p-n-p$ type (Raytheon’s CK722), while $Q_2$ is Sylvania’s familiar $n-p-n$ type, the 2N35.

As in the first circuit, $L_1$ is a ferrite loopstick antenna coil and $C_1$ a standard 365-$\mu$F. tuning capacitor. $L_2$ is an “extra” winding added to $L_1$ and consists of 10 to 15 turns of 22- to 28-gauge enamel wire wound on $L_1$’s form about $\frac{1}{4}$” from the coil itself. Larry used a type 1N34A diode, but other general-purpose units will work as well. Capacitor $C_2$ is a 0.05-$\mu$F. paper or ceramic capacitor; working voltage is not critical. Resistor $R_1$ is a 220,000-ohm, $\frac{1}{2}$-watt carbon resistor, and $R_2$ a common 500,000-ohm potentiometer. Any s.p.s.t. switch can be used for $S_1$—toggle, slide, rotary, or push-button. As before, the 3-volt battery, $B_1$, may be made up of a pair of penlight cells connected in series.

In operation, r.f. signals picked up by the antenna system are selected by tuned circuit $L_1-C_1$, detected by the diode, and coupled through $C_2$ to common-emitter amplifier $Q_1$. Enough r.f. “spills” through

(Continued on page 118)
THE Dual-1006 is a four-speed stereo record changer that has few equals on the market today. It is one of just two or three record changers whose performance can be compared with that of separate tone arms and turntables. In terms of operation and reliability, the Dual-1006 leaves little to be desired.

The excellent performance of this West German unit results from several factors. First of all, a high-quality four-pole motor is used which has little vibration and noise. In fact, the motor is so quiet that the listener practically has to wrap his ear around it to hear it. And, in contrast to most changers, touching the base plate while the motor is running reveals only a barely detectable vibration.

A somewhat more elaborate idler-wheel system than is customary couples the motor to the turntable. While most changers employ only a single idler wheel, the Dual-1006 uses two idler wheels arranged in series. This provides an extra stage of mechanical filtering and helps prevent motor vibrations from reaching the turntable.

Problems of wow and flutter are largely overcome by the use of a heavy (for record changers) turntable which weighs 3¾ pounds. An even heavier turntable weighing 5¾ pounds is an optional accessory for extra-fussy listeners.

This changer has a number of other features that are quite unusual. For instance, the design of the tone arm is such that the Dual-1006 will track with stylus pressures as low as two grams. Incidentally, the unit has a built-in stylus pressure gauge calibrated from 2 to 10 grams.

Perhaps the most unusual aspect of the unit's operation is its system for intermixing records of different sizes. After a record is dropped, the arm swings to the inside of the record. Then it skates across the surface of the record on a pair of tiny wheels until it reaches the edge of the record. At this point, it rises in the air, the little wheels retract into the cartridge shell,
Record-indexing sequence of the Dual-1006. After record is dropped, arm swings to center of record (above). It then skates on tiny wheels across the record until it reaches the edge, at which point it rises in the air. The wheels then retract (below) and the arm comes down in the lead-in groove.

and the arm comes down in the lead-in groove. This operation is diagramed above. The user will probably be unnerved the first time he sees the arm scoot across one of his most treasured records, but the process is harmless.

Records can be played manually as well as automatically. A separate manual spindle is included as standard equipment with the unit.

The Dual-1006 seems to be soundly designed and constructed, and it should provide years of eminently satisfactory service. It is imported and distributed by United Audio Products, 12 West 18th St., New York 11, New York.

April, 1960
GIANT ANTENNA REFLECTOR

This huge antenna reflector, an integral part of the BMEWS missile-warning system, is shown under construction in the Arctic. Built by the D. S. Kennedy Co. under a General Electric subcontract, the structure measures 165' high and 400' long and can withstand a 6" coating of ice in winds up to 185 mph. The BMEWS system is being built at a total cost of about a billion dollars and is expected to provide a 15-minute warning in case of a missile attack on the North American continent.

AUTOMATIC POST OFFICE

Electronically controlled miniature post offices like this one are being installed in busy areas throughout France. Each consists of a telephone booth, a mailbox, and a stamping machine which automatically puts the correct postage on a letter and returns the proper change to the customer. (Authenticated News)

SOUND TRUCK

A completely self-contained mobile audio system is available from Sound Triumph Co., 8145 Keystone, Skokie, Ill. Its transistorized amplifying equipment operates directly from the truck's 12-volt battery and has an output of 160 watts. There is a continuous-play tape cartridge deck, a four-speed record player, and a wireless microphone. Cost, including truck, is under $5,000.
Few inventions have had as profound an effect on their fields as the tape recorder has had on communications. Tape recording changed the radio industry, just as it is now changing television. It revolutionized the recording industry and indirectly laid the foundation for the development of high fidelity in the home.

Tape has provided every man with a simple means of recording the events around him which can be expressed in sound. In millions of homes, the tape recorder has taken its place alongside the camera as an instrument of artistic expression as well as a means of providing entertainment and a record of family life.

The Recording Process. Tape recording is extremely simple in theory. The recording head of a tape recorder is a nearly circular electromagnet with a very small gap. The electromagnet consists of a coil wound over a laminated core; electric currents through the coil cause magnetic fields to build up across the gap. The recording tape consists of a thin film of billions of iron-oxide particles on a plastic base, held in place by a bonding agent.

Suppose we pull the tape across the gap of the recording head at a speed of 30 inches per second while we energize the magnet with an alternating current of 60 cycles per second. Each half-cycle of the signal will produce a magnetic field across the head gap. This, in turn, will cause the iron-oxide particles on the tape to arrange themselves lengthwise on the tape, becoming miniature bar magnets.

Negative half-cycles of the input signal...
A tape deck is the simplest type of tape-playing equipment. The Telelectro 800 (upper left) and the Viking 85 (lower left) are suitable for reproducing four-track tapes through a separate stereo system. Matching electronic units are available which enable the user to make mono or stereo recordings in the home.

Because the particles are fixed to the base, the pattern will remain on the tape indefinitely. Now suppose we run this same tape through the tape machine again, but this time without energizing the electromagnet. As the magnetized areas on the tape pass by the gap, they will produce fluctuating magnetic fields across the gap which, in turn, will induce small currents in the coils of the head's winding. These currents are replicas of the original signal, but much weaker in strength. We could, if we wished, use the same head for both record and playback, but the more professional machines generally use two or more separate heads, each designed for a specific purpose.

Frequency and Tape Speeds. If we think about this process a bit, two things will become apparent. First, the lower the frequency of the signal that energizes the recording head, the wider the magnetized areas, or bars; and the higher the frequency, the narrower the bars. This is obvious because at 60 cycles, for example, each half-cycle would magnetize the tape for 1/120 of a second. Traveling at a speed of 30 ips, about .25 inch of tape would pass over the gap in 1/120 of a second, and thus each bar would be about ¼" wide. But at 600 cycles, the magnetizing field would last only 1/1200 of a second. Only .025 inch of tape would pass over the gap in that time, and hence each bar would be .025" wide. At 6000 cycles, the field would last only 1/12,000 of a second, and the bars would be only .0025" wide.

It also follows that the slower the tape
Two popular tape decks with built-in preamplifiers are the Heathkit TR-1A (left) and the Bell T-238 (above). Both are two-speed units (3¾ and 7½ ips) and each will take 7" reels.

travels across the recording head's gap, the narrower the bars will be at any given frequency. For example, at 15 ips, the 60-cycle bars would be ¼" wide. At 7½ ips, they would be only ⅛" wide.

The important concept to be drawn from these data is that at the higher frequencies the individual magnets on the tape become shorter and shorter, and thus tend to cancel each other—particularly at the slower tape speeds. This means that a reduction in tape speed reduces the high-frequency response of a recorder—assuming that the width of the head gap remains the same.

Rising Response. The other thing that becomes apparent is this: if we use energizing signals of the same amplitude in recording, a 60-cycle signal will produce less output in playback than that produced by a 600-cycle signal and much less than that produced by a 6000-cycle signal. How come? Well, remember that the voltage output of any generator is determined by the total number of magnetic lines of force which are cut by a magnetic field (and vice versa).

Since the magnetic fields of high frequency signals cross the recording head's gap more rapidly than do those of low-frequency signals, in playback, the 6000-cycle bars will produce stronger signals in the playback head than the 60-cycle bars. This

"Built-in" construction is typified by the Norelco EL 3536 (upper right) and the Tandberg Model 5 (right). Designed for portability, these units also offer three speeds, self-contained playback amplifiers, and a built-in speaker for one channel.
means that a signal recorded at a constant level will nevertheless play back with a 6-db-per-octave boost as the frequency increases.

The rising response continues to about 3000 cycles, at which point losses in the playback head cause the high-frequency response to drop off. As you might expect, this characteristic of a rising response and subsequent drop-off necessitates special equalization circuits for proper playback. They will be discussed in a future article in this series.

**Playing Times.** The German tape recorders brought to this country after the war operated at 30 inches per second. It is easy to get good high-frequency response at this speed; however, a 1200' roll of tape will give only 7½ minutes playing time at 30 ips. The initial solution to this problem was to reduce the speed to 15 ips. The gap of the playback head had to be narrowed, but it was still not difficult to get response to 15,000 or even 20,000 cycles. Using a 10' reel with 2400 feet of tape yielded 30 minutes' playing time, a convenient length for both broadcasting and recording.

Even so, the 15-ips speed provided only 15 minutes' playing time on the 7" tape reel used by most home recordists. The next step, therefore, was to halve the speed again to 7½ ips. By employing improved heads with narrower gaps, it was possible to get a response to 15,000 cycles at this speed in the best tape recorders, and to 10,000 cycles in recorders for non-professional uses. The 7" reel, together with the 7½-ips speed, allowed 30 minutes of recording time.

For less critical purposes (voice, dictation, etc.), high-frequency response can be sacrificed, and still lower speeds have come into use—3¾ ips, 1¾ ips, and even 1½ ips.

There are two other approaches to extending the playing time at a given speed. One way is to make the tape thinner, so that more of it can be put on a reel of a given size. We currently have two types of long-play tapes—one that permits 1800 feet of tape to be put on a 7" reel (extending the playing time by 50%), and a super-thin one that allows 2400 feet to go on a 7" reel (doubling the playing time).

The other way to extend playing time in-
The capacitor was invented in 1745 by experimenters who were looking for a way to "condense" and store that newly discovered curiosity, electricity. Although many of their ideas were wrong, they came very close to doing what they set out to do! Today's modern capacitor comes in thousands of different sizes, shapes, and colors. It is of vital importance in the operation of everything from the family car to guided missiles; yet it does exactly the same thing and works on the same principle as its remote ancestor discovered in a laboratory at the University of Leyden over two centuries ago.

By KEN GILMORE
Storing the Charge  
- What Is a Capacitor?

A great bolt of lightning crashes to earth with an ear-splitting clap of thunder. This is perhaps the most dramatic demonstration of capacitance at work.

A guided missile streaks into the heavens on a column of flame. Without capacitors doing hundreds of different jobs in its guidance, control, and firing systems, it would never leave the ground.

Your radio and television sets bristle with capacitors used in dozens of different ways. Radio and TV broadcasting stations use thousands of them.

Neither your electric refrigerator nor your car would start without capacitors; your fluorescent lights would remain dark.

Capacitors set off photographers' flash bulbs, help deliver electric power efficiently to your home, automatically start water fountains and open doors as you approach them.

What is this strange phenomenon of capacitance that surrounds us on every hand? How does it work? What causes it? What does it do?

The answer sounds almost too simple. A capacitor is a device that can store an electrical charge. Because of this seemingly modest accomplishment, it can perform an astonishing variety of jobs and is one of the most important of our electrical and electronic servants.

Capacitive Operation  
- How a Capacitor Works

Did you ever walk across a carpet on a cool, dry day and feel a spark jump from your fingers to the door knob as you reached to open the door? Whether you knew it or not, your body was one part of a charged capacitor; the walls of the room—including the door and the door knob—were the other part. You built up the electrical charge by walking across the rug. The friction between your
shoes and the rug deposited excess electrons on your body, each one helping to build up a higher and higher negative charge. Simultaneously, a positive charge of exactly the same strength was accumulating on the walls.

When you got close to the door, the capacitor was discharged. The excess electrons in your body leaped across space between your fingers and the door knob to neutralize the charge.

The capacitor formed by your body and the room is very different from the ones used in radio, but it works in exactly the same way. A radio capacitor is usually made of two or more metal plates, parallel to each other, but not touching. They are charged, not by rubbing them across a carpet (it could be done that way, but there is a better method), but by connecting them to a battery with a switch as shown in the diagram below.

With the switch open, there is no charge across the plates. When the switch is closed, the battery's positive terminal begins to attract free electrons from the plate connected to it, while at the same time the negative terminal starts to force large numbers of excess electrons into the plate connected to it. More and more electrons pile up on the plate, making it continuously more difficult for the battery to force any more on to it. Thus, one plate takes on a negative charge, the other a positive charge.

Soon, the battery has moved all the electrons it can. The flow stops; the capacitor is fully charged. If it were now disconnected and the voltage across it measured, by a very high impedance meter, it would equal the battery voltage.

The capacitor actually stores the energy in its dielectric, that is, in the insulating material between the metal plates. The dielectric can be air or any other insulator.

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Practical capacitors are manufactured with dozens of different kinds of dielectrics.

This theoretical view shows how the charge is stored. In an uncharged capacitor, the number of free electrons in either plate is the same. The electrons in the molecules of the dielectric can be seen orbiting around their nuclei.

When a charge is applied, the picture changes. The negative plate now has all of the free electrons. Since it is a basic law of electricity that like charges repel each other, and unlike charges attract, the orbiting electrons in the dielectric are repelled by the negative plate and attracted by the positive one. They move as far toward the positive plate as they can, which stretches the molecules of the dielectric out of shape. These misshapen molecules are like springs under tension: they try to pop back to their normal shape.

As long as the charging voltage is applied, they can do nothing. But if a conducting path is supplied between the two plates, the dielectric molecules will snap back, pushing the excess electrons out of the negative plate, and discharging the capacitor.

The voltage storing ability of a capacitor is called capacitance. You may sometimes hear it called capacity, but capacitance is grammatically correct.

Of what practical use is a capacitor’s ability to store a charge? Photographers use it in one of the simplest and most obvious ways. In one type of flash gun, they charge a capacitor, then connect a flash bulb across its charged plates. All the electrons stored on the negative side try to rush to the positive plate at one time, through the flash bulb. This surge of current fires the bulb. (See the circuits at the top of the next page.)

Why not connect the battery directly to the bulb? This could be done if a large enough battery were used. Such a heavy-duty battery could deliver enough current to fire the flash bulb. But a far lighter, more compact unit weighing only a few ounces can be made to do the same job with the help of a capacitor.

A battery capable of putting out only a trickle
of current—far less than would be required to set off the bulb—can be used. Over a period of time, the trickle builds up a powerful charge across the capacitor, in the same way that a tiny stream of water can eventually fill a large tank. When the capacitor is fully charged, it can deliver a surge of current even more powerful than the heavy battery, and thus easily fire the flash bulb.

**Positive and Negative**

A great deal has been said about “positive” and “negative” charges. But did you ever stop to think why one pole of a battery is called positive and the other negative? It’s all a mistake, really, because the one we call negative is actually positive, and the one we call positive is……. But maybe we should start from the beginning.

Old Ben Franklin made the original mistake. Nobody knew for sure in which direction current flowed. So Franklin guessed. He named one pole positive, the other negative, based on the reasoning that current went *from* the positive pole, which he visualized as having an excess of current, *to* the negative pole, which had a shortage.

He had a fifty-fifty chance of guessing right, but luck was against him. Many years later it was established that current actually flows in the other direction. By that time, positive and negative terminology was firmly established and it was decided that no change would be made.

Whether the labels are right or wrong, polarity is an important consideration in many capacitor circuits. For example, the electrolytic capacitors used in power supplies will be ruined if they are connected with the wrong polarity.

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Capacitors in Power Supplies

Capacitive "filters" are frequently used in power supplies to smooth out the pulsating d.c. output from an a.c. rectifier circuit, thus allowing 117-volt house current to be converted into direct current.

Without a capacitive filter, a power supply produces pulsating direct current. The current flows in only one direction, but not steadily. A picture of pulsating d.c. from a full-wave power supply looks like this:

![UNFILTERED RECTIFIER OUTPUT](image)

But radio and TV receivers need a source of pure d.c. that rises to a certain voltage level and stays there.

A capacitor connected across the power supply gives just this effect. As the voltage rises to maximum, the capacitor becomes charged. When the power supply voltage falls to zero again, the capacitor begins to discharge, and helps keep the voltage near its maximum level until the following power supply surge, which charges the capacitor again for the next cycle.

You may notice that the voltage does not remain exactly at the maximum level during the capacitor discharge. But if circuit components of the proper values are selected, it stays close enough so that the difference is unimportant.

It is easy to tell when the filter capacitor (or capacitors) in your radio are going bad. As the capacitor starts to fall down on the job, the ripple gets bigger and bigger. Soon it begins to affect the operation of the whole set, and you hear a loud hum. As it gets worse, speech and music become distorted or garbled; then a heavy hum is about all you can hear.
The two examples of capacitor use mentioned so far—photo flash and filter—deal with d.c. voltages and currents. But a capacitor’s function in a.c. circuits is perhaps even more important. To understand how it works, let’s take a look at the two plates and battery setup again. Only, this time, they are connected by a double-pole, double-throw switch, that is, a switch that can quickly reverse the polarity of the charging current applied to the capacitor.

![Diagram of capacitor circuit with switch]

With the switch thrown to the left, the capacitor charges. Open the switch, and the capacitor retains its charge.

The switch is now thrown to the right. This connects the capacitor to the battery again, but with the polarity reversed; the negative plate is now connected to the positive battery terminal and vice versa.

The electrons quickly flow through the battery from the negative plate to the positive one, discharging the capacitor. It then charges again, but this time with opposite polarity. The ammeter shown connected in series with one plate will indicate current flow during this process.

With the switch to the left, the meter will show a current flowing while the capacitor is charging. When the switch is reversed, the meter indicates a current in the opposite direction while the capacitor discharges its old charge and takes on the new one. If the switch is thrown back and forth fast enough, the meter will show current flowing at all times—first in one direction, then the other.

Thus, it is clear that even though direct current cannot flow in a capacitor circuit (except during a brief charging period), alternating current can be made to flow continuously by alternately charg-
ing and discharging the capacitor. To put it another way, a capacitor “blocks” d.c., but “passes” alternating current. This ability is put to work in countless ways. Here, for example, is a simplified amplifier circuit that demonstrates the effect.

![Amplifier Circuit Diagram]

The signal is introduced into the tube’s grid circuit, is amplified, and leaves through the plate circuit. For the tube to work, the plate must be kept at a high positive voltage—say 200 volts—while the grid must be slightly negative.

Since electron tubes usually operate with a high positive voltage on the plates and a low negative voltage on the grid, the problem obviously arises: how can the tubes be coupled together plate-to-grid without disturbing their respective d.c. operating levels?

The capacitor is made to order for this job. Since the signal to be amplified is a.c., it will pass through a capacitor easily, while the d.c. operating voltage will be blocked.

A capacitor used in this way is called a coupling or blocking capacitor. Either name is correct.

A capacitor’s ability to pass a.c. while blocking d.c. is also useful in another kind of hookup. For example, signals frequently appear where they aren’t wanted. A capacitor can “short” such an unwanted signal to ground while leaving the circuit’s d.c. voltage unaffected. This is called “bypassing.”
The capacitor was invented back in October, 1745, by Dean E. G. von Kleist of the Kammin Cathedral in Pomerania. A few months later—in January, 1746—Pieter von Musschenbroek, a professor at the University of Leyden, made the same discovery all over again. Somehow, Musschenbroek got the credit, and early capacitors were called Leyden jars after his university. You may have seen one around a physics laboratory; they’re still used at times to demonstrate the principle of capacitance.

The Leyden jar is simply a bottle with about three-quarters of both the inside and outside surfaces covered with metal foil. The two pieces of foil are insulated from each other by the glass dielectric. A brass rod goes through a stopper and makes contact with the inside foil.

Early experimenters used a jar because they were looking for a way to “condense” and store electricity. Since they thought of electricity as a fluid, they figured a jar would be just the thing to hold it. The name condenser, which is still frequently used instead of capacitor, comes from these early attempts to condense electricity.

Musschenbroek and his associates discovered that if they touched the brass rod of the Leyden jar to an “electric machine” (they had a crude...
electrostatic generator), the jar retained a charge. You could get a shock by holding the outer foil with one hand and touching the rod with the other. Since they couldn't think of much to do with the Leyden jar except stand around and shock each other, they didn't have any need for an accurate system of measuring the stored charge, or the capacitance, of the jar.

As the science of electricity progressed, it became obvious that a system of measurement was needed. So a basic unit of capacitance was decided on. It was named the farad, after Michael Faraday, one of the great electrical pioneers.

A farad represents a specific amount of "storing power" or capacitance. In actual use, the farad turned out to be far too large a unit, so practical capacitors are usually rated in microfarads (mf)—one millionth of a farad, and in micromicrofarads (mmf)—one millionth of a microfarad. (According to one system of notation, a "µ" is substituted for "m" in the abbreviation. Thus, "mf." becomes "µf." and "mmf." becomes "µµf." The meaning in either case is the same.) To put it another way:

1 mf. (or µf.) = 0.000 001 farads
1 mmf. (or µµf.) = 0.000 000 000 001 farads

**Capacitor Variables**

The capacitance of any capacitor is determined by four factors. Let's take a look at each one.

1. **Size of plates.** Large plates can hold a greater charge (more electrons) than small plates.
2. **Separation of plates.** The closer together the plates are (without touching), the greater the charge they can store.
3. **Number of plates.** The more plates, the greater the capacitance.
4. **Dielectric constant.** Every different dielectric material has its own dielectric constant. Air has an arbitrarily assigned constant of 1. Mica has a constant of about 7. This means that mica will store about seven times the charge that air can handle, with all other factors the same. Paper has a dielectric constant of about 5, and some types of ceramic over 1000! Different substances have different constants because each molecule has a different "natural elasticity," which allows some to store vastly...
greater amounts of energy than others (see page 70). Among frequently used dielectrics are plastics of various kinds, air, mica, and paper.

Here are some of the more common types of capacitors, classified according to dielectric material.

*Paper capacitors* are made of long strips of aluminum foil, wrapped tightly in a roll, separated by a paper dielectric. To make the paper a better insulator (to prevent breakdown of the capacitor when high voltage is applied to its plates), it is usually impregnated with oil, wax, or plastic.

*Plastic capacitors* are similar, but use thin sheets of plastic—Mylar and others—as a dielectric. They have the same uses and are about the same size as paper capacitors.

*Metallized paper capacitors* are another variation of the same basic type. Instead of strips of aluminum foil, this capacitor's plates are microscopically thin layers of metal deposited by an evaporation technique on the dielectric paper. Because the plates are so thin, the capacitor can be rolled into a very much smaller package than a standard capacitor of the same capacitance.

All of these variations of the paper capacitor are widely used in coupling, bypass, and tone control circuits. They are usually tubular, and range in capacitance from about 250 µf to 1.0 µf or more. They have voltage ratings up to about 1600 volts—that is, they can withstand 1600 volts without the voltage breaking through the dielectric and destroying the capacitor. Most used, however, are capacitors in the 400-600 volt range.

Minor differences exist between the various types. Plastic capacitors can be built more easily to withstand higher voltages. Metallized ones, as

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mentioned earlier, are smaller, and they cost more. With these exceptions, the three types are generally interchangeable.

The printed band around one end of these tubular capacitors tells you which lead is connected to the outer layer of foil. In general, the lead so marked should be connected to the “low” side of the circuit. To put it another way, connect it to ground if possible, or to the side of the circuit electrically closest to ground potential. The band does not indicate the polarity of the connections. When a capacitor is used this way, the outer layer of foil serves as an electrostatic shield, so that the capacitor’s operation will not be affected by other stray fields within the circuit.

Oil capacitors also use a layer of paper as a dielectric; the paper is impregnated with a special type of oil that gives it both a high capacitance and a high voltage rating. They are usually used as high-voltage power supply filters. Capacitance varies from 1.0 µf. to 20.0 µf. or more.

Oil capacitors are usually sealed in a heavy can, and may have a rating of 1000 volts or more.

Mica capacitors are made of a number of flat strips of metal (tin, copper, aluminum, etc.) separated by sheets of mica. Alternate plates are hooked together, and the whole assembly is molded into a block of plastic or ceramic material.

They range in capacitance from about 10 µf. to .01 µf. Mica is an unusually good insulator, so capacitors with a mica dielectric can be built with ratings up to 5000 volts or more, and are used in high-voltage transmitting circuits.

Ceramic capacitors, a newer type, use sheets of ceramic as a dielectric. The plates are normally vapor-deposited silver. A ceramic capacitor generally has only two plates—one on either side of a ceramic disc, or one on the outer and one on the inner surface of a ceramic tube.

Since ceramic has a very high dielectric constant, up to 1200, relatively large values of capacitance can be obtained with small capacitors. Also, the insulation quality of ceramic is excellent, so these units can easily be designed to operate at several thousand volts. They are widely used in television, military and satellite communications equipment, and other critical circuits.

Advanced manufacturing techniques have
brought the cost of ceramics down to about the same range as paper. They have one disadvantage: they are not as readily available in the larger common values.

Electrolytic capacitors pack the largest amount of capacitance into the smallest space. They come in sizes up to several thousand microfarads, with working voltages up to about 600 volts. The cans an inch or more in diameter and four to six inches long that are mounted on top of almost every radio and TV chassis are electrolytic capacitors. They are usually used as power supply filters.

Electrolytics have extremely high capacitance values because the dielectric is only a few millionths of an inch thick. The capacitor is manufactured by dipping an aluminum sheet into an electrolytic solution, and setting up a current flow from the solution to the aluminum. The action of the current builds up a layer of oxide on the plate. When the layer is completely formed, the aluminum is ready to become the positive plate of a capacitor. The dielectric—the oxide coating—is already in place. The unit is sealed in a can filled with a conducting liquid which becomes the negative plate of the completed capacitor.

This is a description of the so-called “wet” electrolytic. There is also a “dry” electrolytic. The only difference is that the “wet” uses an actual solution, while the “dry” has a saturated layer of gauze between the plates. In actual use, the wets have almost disappeared, because drys are more convenient to manufacture, store, and use.

Electrolytics, like most other components, are getting smaller and smaller in this age of miniaturization. A recently developed type—the etched aluminum electrolyte—packs even greater capaci-
tance into a smaller volume by using a plate that has been roughened by chemical etching. A greatly magnified cross section of the etched aluminum would compare with the usual polished surface like this:

![Etched Aluminum Cross Section](image)

Obviously, the etched plate has a far greater surface area exposed to the electrolyte, and consequently has greater capacitance. The etched aluminum capacitor is now on the market, but is considerably more expensive than the ordinary electrolytic. Its extra cost is, of course, well worth the difference in such diverse applications as hearing aids and missiles, where weight and size are very important.

Electrolytics have several disadvantages. One is that leakage current is larger than for any other type. The other is that the electrolytic has a positive and a negative terminal. Therefore it cannot be used where the polarity changes (in a.c. circuits, for example). Great care must be taken to see that it is properly connected. Even a few seconds exposure to the wrong polarity voltage can ruin an electrolytic, or even cause it to explode.

*Variable air capacitors* are used in every radio for tuning in different stations.

One of the sets of plates is fixed to the frame, and is called the stator. The other set, which moves, is called the rotor. Naturally, as in all capacitors, the two sets of plates are close together but do not touch. Capacitance is varied by changing the amount the plates mesh. (There are fixed air capacitors, but they are rare.)

Variable air capacitors come in sizes from a fraction of a µuf. to 1200 µuf. or more. Those used in low-voltage receiving circuits may have 10 to 30 plates separated by less than a hundredth of an inch. Large transmitting types can have 80 to 100 plates, separated by a half inch or more.

Variable air capacitors are frequently *ganged*. This means that several independent capacitors are arranged along one shaft so that they rotate together. In this way, several circuits can be tuned simultaneously.
Although we have only mentioned fixed mica, paper, oil, ceramic, and plastic capacitors, there are variable capacitors which use some of these dielectrics, too. But most variable capacitors have air as the dielectric. The one common exception to this is the small mica "trimmer" capacitor found in most radio receivers. These units, with a capacitance of only a few µµf., are adjustable with a screwdriver. They are used in making minor adjustments in circuits where the amount of capacitance is critical. The local oscillator in a superheterodyne receiver, for example, is tuned to an exact frequency with a mica trimmer.

Only the principal types of capacitors have been listed so far. There are many others: vacuum, glass, vitreous-enamel, polystyrene, tantalum, Milinex, and even one with the jaw-breaking name of polytetrafluorethlene. Each has its own advantage and special uses. And some, like tantalum, are becoming more popular.

The many ways mentioned so far in which capacitors are used hardly scratches the surface of the jobs to which this versatile component is suited. Every radio, television, or communications transmitter or receiver, for example, must operate on a certain predetermined frequency. The signal sent out by the transmitter must oscillate, or vibrate, at a precise rate—so many times a second. Receivers must be tuned to this exact frequency to pick up the signal. Capacitors play an important part in circuits which determine operating frequency. Vary the capacitance, and the frequency changes. When you tune your radio, you are adjusting the capacitance of the tuning circuits.

Another important duty of the capacitor is waveform-shaping. The most common waveshape is the sine wave.

The electrical power that comes into our homes is in this form; this is also the shape of an ordinary oscillator's output. But for certain uses—radar, television, telemetering, to name only a few—waveforms of many shapes must be produced.

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These and thousands of other waveshapes can be formed by hooking capacitors together in different combinations with other components.

**Heavenly Charges**

Oh, yes, one more thing. What does capacitance have to do with lightning? In stormy weather, air currents rise swiftly. Particles of water vapor in clouds are swept past other stationary particles, and a charge accumulates by friction, just as it does when shoes rub across a carpet. The charge on the clouds, small at first, builds up rapidly. At the same time, a similar—but opposite—charge builds up on the ground under the cloud. As the cloud races across the sky, the charge moves along the ground with it—it can be measured with the proper equipment.

Higher and higher builds the charge, as more particles of water vapor rush by, each adding to the charge. First, it can be measured in volts, then millions, next trillions of volts from cloud to earth. Finally, the giant capacitor—the cloud forming one plate, the earth the other—“breaks down.” The charge arcs over the insulating dielectric (air) and a blinding flash lights up the heavens. The mammoth capacitor discharges in a brilliant flash of lightning.

Capacitance—the simple ability of two bodies to store an electrical charge—is thus responsible for one of our most useful electrical components, and at the same time, for one of nature’s most spectacular displays.
A nearly everyone in electronics makes use of crystals every day—here's why these rock-like plates play such an important role in keeping the world in tune

By JIM KYLE, K5JKX/6

An amateur radio operator, an airline pilot, a police radio dispatcher, a broadcast-station announcer... sound like a hodge-podge of job holders? Maybe so, but they have at least one thing in common. All make daily use of the peculiar properties of quartz crystals—thin, glass-like plates that keep the world in tune.

Crystals are found in almost all commercial and ham radio equipment, but few of their users know how they work. Before we examine the details of crystal operation, let's take time out to define our terms. There are three important words involved: resonance, damping, and piezoelectricity.

Resonance means the frequency at which an object will vibrate most easily. Every object has a resonant frequency. Musical instruments—the piano, for instance—are based on this principle. When you strike a key, a hammer hits the piano string, which then vibrates at its resonant note.

Damping means the suppression of an object's tendency to vibrate. The more highly damped an object is, the less readily it will vibrate. In the piano, for example, stepping on the loud pedal removes the damping from the strings. Stepping on the soft pedal damps the vibrations even more than usual.

Finally, piezoelectricity is a property shared by several substances. It means that the substance generates a small voltage across its opposite sides if it is stretched or squeezed. In addition, applying a voltage to opposite sides of a piezoelectric material will deform the substance as long as the voltage is present.

How a Crystal Works. Let's assume that we have a crystal of some piezoelectric substance, and a means of making electrical contact to its opposite sides. Since the crystal has mass, it will have a resonant frequency. If it's jarred—mechanically excited—it will vibrate at that frequency. And if the crystal's damping is light, it will continue to vibrate at its resonant frequency for some time.

But remember that our crystal is piezoelectric. By definition, this means that it will develop a voltage across its opposite sides whenever it's stretched or squeezed. The electrical contacts we've connected to those sides will allow us to utilize that voltage.

If the crystal's size is such that the resonant frequency falls within the r.f. spectrum—and this is ordinarily the case—we have a generator of r.f. energy. But our generator must be jarred to be put into operation, and it will operate only until the vibrations die out. For it to be of use to us, we must make our crystal operate continuously.

The addition of a special vacuum-tube or transistor circuit to amplify a portion of
Fig. 1. In a typical oscillator circuit, turning the oscillator on develops a voltage between its cathode and grid, and this voltage shocks the crystal into vibration at its resonant frequency. The vibration in turn develops an alternating voltage across the crystal terminals, which is amplified by the tube. The LC circuit is tuned near the crystal frequency and presents a high impedance in the tube’s plate circuit. Consequently, a portion of the amplified voltage is fed back to the crystal and maintains oscillation.

The crystal’s developed voltage and then feed it back to the crystal will keep the crystal operating indefinitely. Such a circuit is called an oscillator and is used to “jar” the crystal electrically at the proper instant to keep its vibrations going. Before looking at several types of oscillator circuits, let’s consider the reason for using a crystal at all.

**Why Use Crystals?** Since oscillators can be built without using a crystal—the ordinary superheterodyne radio receiver and the ham’s VFO are good examples — the question arises, “Why bother with crystals?”

Actually, a crystal has only one major advantage over a well-built variable oscillator—stability. A crystal’s resonant frequency is determined primarily by its physical size. This means that the frequency of a crystal is relatively unaffected by outside influences.

There are, however, two outside influences which can change a crystal’s frequency. One is widely known, the other almost ignored.

The first enemy of crystal stability is heat. Like any substance, a crystal will change in size slightly as it heats or cools—and its frequency is determined mainly by its size. Thus, changes in temperature will be reflected as a drift in frequency.

The effect can be serious. In commercial applications, a crystal is usually kept in a tiny oven, thermostat-regulated to maintain an even temperature. Amateur and experimenters’ crystals, in contrast, are designed to remain at a fixed frequency under reasonable temperature variations. But overloading the crystal in an effort to extract the last measure of power from the circuit can push its temperature into the “unreasonable” region.
Even more serious than the heating problem—and far less widely known—is the matter of shunt capacitance. In an ideal situation, the crystal will “see” no load at all across its terminals. But such a circuit is impossible in practice, since the crystal must feed an oscillator in order to operate. And, with the oscillator connected, some capacitance is unavoidable.

This capacitance acts as a load on the crystal, slowing down its rate of vibration and thus lowering its resonant frequency slightly. Depending upon the capacitance in the circuit, a crystal will produce higher or lower frequencies than that specified. Since this effect cannot be avoided, crystal manufacturers assume a standard value of shunt capacitance and build their crystals to give specified frequency when working into that load. For most amateur crystals, the design value is 32 µF.

Since manufacturers can’t be expected to know the capacitance involved, most of them refuse to guarantee extremely close accuracy unless they can calibrate the crystal in the actual circuit to be used.

**Oscillator Circuits.** There are a number of circuits that can be used as oscillators. All have two things in common—a means of amplifying the crystal’s output, and a way of feeding some of that output back to keep the crystal oscillating. A typical oscillator circuit (Fig. 1) makes use of the tube’s grid-cathode voltage to place the crystal in operation. Because the crystal is in the grid circuit, the tube amplifies its output.

Some oscillator circuits are designed to give output only at the fundamental frequency of the crystal—the frequency of the crystal itself. Others are built to provide the fundamental and integral multiples of the fundamental frequency as well. Such multiples are known as harmonics and have frequencies of two, three, four, or more times the fundamental frequency.

Still a third variety of crystal oscillator is the “overtone” circuit. A major difference between it and a harmonic oscillator is that the overtone circuit produces only one output frequency—the third, fifth, or other odd harmonic. A harmonic oscillator, in contrast, produces the entire gamut—the fundamental, the desired frequency, and other harmonics, too.

The Pierce circuit shown in Fig. 2 is typical of a fundamental-frequency oscillator.

*Continued on page 128*
Variable A.C. Supply

Inexpensive Olson Radio T-266 kit
places line voltage control at your fingertips

VARIABLE a.c. voltage supplies have helped put more than one kit or construction project on the road to proper functioning. What's more, they can be a valuable aid in radio-TV trouble-shooting.

The T-266 supply kit shown here is available from Olson Radio Corp., 260 S. Forge St., Akron 8, Ohio, for only $15.95. An evening's work should complete it, with plenty of time left over for equipment testing. The supply uses an autotransformer to vary its output between 0 and 150 volts. It is fused for safety and has a built-in volt-meter connected across its output.

In use, the variable supply is plugged into an a.c. line, and the equipment is plugged into the variable supply. With the equipment connected in this manner, the on-off switch on the supply will also turn the equipment on and off. And, once connected, you have an a.c. supply that stands ready to vary its output over a 150-volt range at a twist of the control knob.

The T-266 has two a.c. outlets to permit powering two pieces of equipment at the same time. Both outlets supply the same voltage, since the two are in parallel. Total current capacity is 300 watts, so the drain imposed by the equipment under test shouldn't exceed this amount.

A variety of testing operations is possible. By adjusting the supply voltage to a receiver, for example, pin-pointing defective resistors and capacitors is often a matter of turning a knob. So, too, is detecting a defective oscillator or making circuit voltage checks under the specified a.c. input voltage. You can also use the supply for checking induction motors.

This handy supply has a function other than servicing and testing. If you've ever hooked an a.c. voltmeter across your a.c. line, you may have watched the voltage variations with interest. And if you haven't run a check or two on the a.c. line voltage in your area, you may be in for a surprise. You can't blame the power companies, since most of them do the best they can. The simple fact is that varying line loads result in varying line voltages; in some areas, it's not unusual for line voltages to waver from a low of 105 to a high of 125 volts during a single 24-hour period. For these reasons, your line voltage is probably not the 117 volts engineers assume for equipment design purposes. But feeding equipment with an honest 117 volts is a simple matter with this variable a.c. supply. Again, voltage control is simply a matter of a twist of the knob.

The T-266 kit as supplied was complete in every respect. Instructions were easy to follow. The completed supply is compact (measuring 8" x 4½" x 4½"), and, with its grey finish and balanced panel layout, attractive. The T-266 would seem a desirable adjunct to the experimenter's or serviceman's test bench.
Build your own

Miniature tester spots troubles in home appliances

By FORREST H. FRANTZ, SR.

CHECKING on appliance power consumption from time to time is a wise precautionary measure. With a wattmeter, power-consumption trouble-shooting is a snap.

The wattmeter described here can be constructed in a few hours at a cost of only five to ten dollars. A rheostat-type range control permits calibration of the unit with full scale readings of 200, 500, and 1000 watts.

The entire unit was built in a 5" x 2¼" x 2¼" aluminum box with a wall-mounting three-way outlet attached to the side of the box. Resistor $R_1$ was made from a length of Nichrome heater-element wire cut to correct length for a resistance of one ohm. The precise resistance can be measured with a Wheatstone bridge or the lowest ohms scale on a VTVM. If it's more convenient to buy a 1-ohm, 10-watt, wire-wound resistor, you can use a commercial unit instead of making your own.

Testing and Calibration. To test the wattmeter, turn potentiometer $R_2$ to its approximate mid-point. Plug the wattmeter into an a.c. outlet, and plug a lamp containing a 100-watt bulb into the outlet on the wattmeter. Turn the lamp on and rotate $R_2$ until the meter reads 0.5 ma. Place a mark opposite the knob pointer on the metal box. Label this mark "200," since this is the calibration point for the 200-watt scale.

Now rotate $R_2$ until the meter reads 0.2. Mark this point
**PARTS LIST**

D1, D2—1N54A diode
M1—Miniature 0-1 ma. meter
(see text)
R2—10,000-ohm, wire-wound potentiometer (Clarostat series 43 or equivalent)
R3, R4—1000-ohm, 1/2-watt resistor
l—5" x 2/4" x 2/4" aluminum box (Cinch-CU-2104A or equivalent)
l—Slugged terminal strip (Cinch-Jones 200S or equivalent)
l-Line cord and plug
l—Wall-mounting three-way outlet
l—pointer knob
Misc. screws, washers, nuts, wire, rosin-core solder

Watch polarity of both meter and diodes when wiring wattmeter. Resistor R1 can be made from Nichrome wire or purchased from a supply house.

**HOW IT WORKS**

Meter M1 is a 0-1 d.c. milliammeter. Diodes D1 and D2 with resistors R3 and R4 form a rectifier bridge that converts the a.c. at the bridge input to d.c. for the meter. Potentiometer R2 is connected in series with the bridge circuit input. These components form an a.c. voltmeter that measures the a.c. voltage drop across R1.

Deflection of the meter is directly proportional to the power consumption for a given setting of R2. With R2 adjusted to a low value, the meter will be deflected full scale for relatively low power consumption. As power consumption increases, the voltage drop across R1 increases. Therefore, R2 is set to a higher resistance value for testing appliances with higher current drains.

The meter reading in each case (between 0 and 1) multiplied by the range setting (200, 500, or 1000) is the power consumption for the appliance being tested.

on the case opposite the pointer and label it "500"—the 500-watt range.

Next, plug a 300-watt load (a 300-watt 3-way lamp is ideal) into the meter receptacle in addition to the 100-watt bulb already connected, and adjust R2 until the meter reads 0.4. Mark the case as before and label this range "1000."

This completes calibration and you’re ready to make measurements. But before you begin, here’s a note of caution: the Nichrome resistor (R1) tends to heat on loads over 500 watts. Therefore, don’t leave loads of 500 to 1000 watts connected to the wattmeter for more than a few seconds at a time.

**Operation.** To check appliance power consumption, simply plug the wattmeter cord into an a.c. outlet and plug the appliance into the receptacle on the wattmeter. As with any meter, it's a good idea to set the range control at maximum and then decrease the range if necessary.

There's probably something wrong with the appliance if the wattmeter indicates 25% or more power consumption above the appliance rating. A short or leakage path is the most common fault. And if the appliance consumes only 75% or less of its rated power, or if the readings are erratic, it's likely that there's a poor connection within the appliance.
A five-watt audio amplifier less than the size of a dime and a two-stage video amplifier much smaller still... these are among the first products of an exciting new era, the age of...

Molecular Electronics

At a press conference in Washington recently, a demonstrator connected an ordinary phonograph to a pair of tiny wafers that fitted easily into the palm of his hand. Then he hooked two leads from the wafers to a 15" loudspeaker. When he flipped a switch, music filled the room.

The two little discs that did the man-sized job of amplifying the weak signal from the record player into a hefty five watts of power are striking examples of some of the first triumphs of "molecular electronics," a startling new design concept that promises to revolutionize the entire electronics industry.

Molecular electronics is not just a new advance in miniaturization. It is a radically different approach to electronic design that provides amplifiers, oscillators, and other complete, operating electronic circuits.

By

J. K. Locke

April, 1960
without tubes, transistors, resistors, or capacitors.

Although molecular electronics is hardly out of the laboratory, it is already clear that equipment using its principles will be far smaller, lighter, more reliable, and ultimately cheaper than anything available today. One example will illustrate its advantages.

A transistorized i.f. stage for a TV set can be built today to fit into a match box. But molecular electronics has made possible the production of a device that contains two such stages and is only a fraction of the size of a single transistor! (See photo on page 89). And the molecular electronic unit operates on only a fraction of a volt—much less than the power required for transistors.

As far as complexity is concerned, a transistorized circuit has perhaps a dozen components and 35 soldered connections, while a comparable molecular electronic circuit only has about two parts and four connections.

Integrated Circuitry. The concept of molecular electronics was developed during the search for better ways to miniaturize electronic equipment. While great strides had been made in designing smaller and smaller individual components, it was obvious that far greater miniaturization and reliability could be achieved if all the necessary electronic properties could somehow be built into a single, solid block of semiconductor material.

As solid-state physicists gained better understanding of the structure of materials and the flow of electrical charges in them, it became possible to design simple “function blocks” containing, for example, both capacitance and resistance. Later, n- and p-type materials were added to produce amplification as they do in transistors and tunnel diodes. Finally, scientists were able to produce single bits of material that would function as complete electronic circuits.

The various electrical properties such as resistance, capacitance, and amplification
Multiple-junction systems attached to the dendritic ribbon above are complete multivibrator circuits smaller than the point of a pencil. These are some of the first molecular electronic circuits to be produced by entirely automatic machinery. Engineers hope that complete amplifiers, radios, and other more complex circuits will soon be produced automatically.

are not localized in any one spot in these function blocks. They are, instead, distributed throughout the material. Molecular function blocks—even those as complex-looking as the five-watt audio amplifier with its concentric rings (shown on page 90)—are not put together from a number of different parts. Instead, they are cut from a single tiny chunk of semiconductor material. The block is then etched, alloyed and treated until the desired results are obtained.

Automatic Production. Engineers are working on the design of machines that will turn out completed circuits automatically. Although only the simplest circuits are now produced by automatic machines, great strides have been made. For example, a method of drawing ribbons of semiconductor (Continued on page 116)
JUST what is a signal generator? Technically, any collection of wires, tubes, resistors, and other assorted electronic gadgetry hooked together to produce an electrical signal could bear this title. But, as it’s commonly known, a signal generator is an electronic instrument producing an amplitude-modulated r.f. sine wave for test purposes. To avoid confusion, special-purpose instruments—sweep generators, color-bar generators, audio generators, markers, and so on—are known by their special names, although they, too, are technically signal generators.

Let's take a close look at the standard r.f. signal generator to see how it works.

![Diagram of signal generator](image)

**Fig. 1.** Signal generator design varies, but a typical unit includes these functions. The a.f. input jack permits alternate source of modulation.

Figure 1 shows the block diagram of a typical instrument. An r.f. oscillator produces the basic signal. A tuning section (part of the oscillator circuit) allows us to vary the output over a wide range of frequencies. A self-contained a.f. oscillator supplies an a.f. signal to modulate the r.f. signal produced by the r.f. oscillator. A mixer-buffer tube combines the r.f. and a.f. signals and isolates the r.f. oscillator from its load. And, finally, an attenuator circuit controls the output signal level to suit the job at hand.

**R.F. Oscillator.** Since the key to any generator is its oscillator, let's take a moment to discuss what an oscillator is and what it does. Simply stated, an oscillator is an amplifier with enough positive feedback to set up self-sustaining oscillations. In Fig. 2, the familiar Colpitts oscillator circuit, tuned circuit \( L_1-C_1-C_2 \), is tuned to the desired frequency of oscillation. For
feedback purposes, both grid and plate are connected to opposite ends of the tuned circuit through capacitors $C_3$ and $C_4$.

The amplified voltage from the plate circuit is fed back to the top of coil $L_1$ in phase with the voltage already in the circuit. Because the two voltages are in phase, each complements the other. The increased voltage at the top end of $L_1$ is reflected as an increased voltage at the opposite end, as shown which would tune from, say, 100 to 290 kc. But by substituting another coil in place of $L_1$, the same circuit could be made to tune from 280 to 1000 kc. A third coil could extend the range still further, and so on. Figure 3 shows such a circuit as used in the Heath LG-1 signal generator.

One final detail: $C_3$ in Fig. 3 is a trimmer capacitor for calibrating the dial. Once set, it needn’t be changed again unless parts which, you’ll remember, is connected to the grid. This results in an increased grid input voltage which, since the tube is an amplifier, brings about an even greater signal at the plate. Obviously, our feedback is positive, and, when the amount of feedback becomes large enough, oscillation will occur at a frequency determined by the values of $L_1$, $C_1$, and $C_2$.

Usually, a somewhat more complicated circuit than that shown in Fig. 2 is used in order to cover a wider frequency range. For example, an oscillator could be built as an r.f. oscillator as discussed above is all that is needed for many jobs. But its usefulness can be greatly increased by adding two more circuits—the audio oscillator and the mixer-buffer stage already mentioned.

A simplified diagram of the audio oscillator in the EICO Model 324 r.f. generator appears in Fig. 4. The values $L_1$, $C_1$, and $C_2$ were chosen so that the oscillator would operate at about 400 cps. The a.f. output are replaced, or aging causes frequency drift.

**A.F. Oscillator.** An r.f. oscillator as discussed above is all that is needed for many jobs. But its usefulness can be greatly increased by adding two more circuits—the audio oscillator and the mixer-buffer stage already mentioned.

A simplified diagram of the audio oscillator in the EICO Model 324 r.f. generator appears in Fig. 4. The values $L_1$, $C_1$, and $C_2$ were chosen so that the oscillator would operate at about 400 cps. The a.f. output

April, 1960
Fig. 4. Audio oscillator in EICO 324 supplies signal to both mixer-buffer stage and separate output jack. Audio signal is necessary for testing and aligning AM receivers.

Fig. 5. Mixer-buffer stage in Knight generator combines output of r.f. and a.f. oscillators and serves to isolate the r.f. oscillator from its load.

Fig. 6. Attenuator in EICO 315 generator is typical. Potentiometer RI provides fine control; four-position switch S1 furnishes coarse control.

is connected to the mixer-buffer and an a.f. “out” jack on the front panel. This dual connection enables the 400-cps signal to serve two purposes. It can be taken directly from the front panel for trouble-shooting a hi-fi amplifier or the audio stage of a radio. And, since it is also used to modulate the r.f. output of the main oscillator (in the same way that voice and music signals modulate broadcast-station signals), it equips the signal generator with a modulated r.f. signal for aligning and trouble-shooting AM receivers.

**Mixer-Buffer.** The circuit used to combine the separate r.f. and a.f. signals in a signal generator is known as a mixer-buffer. (See Fig. 5 for the mixer-buffer stage used in the Knight R. F. Signal Generator.) This circuit acts somewhat like a funnel: two separate signals are “poured” in, and one well-mixed signal—a combination of the two—comes out.

As you might guess from its name, the mixer-buffer stage does more than mix r.f. and a.f. As a “buffer,” it also serves to isolate the r.f. oscillator electrically from its load (radio, amplifier, or other device under test). Such a stage is necessary because an oscillator is really a rather delicate circuit. An oscillator can be “detuned”—tuned away from its operating frequency—very
How to Convert a Radio to an AM Tuner

Simple rewiring job plus low-cost transformer adapts standard a.c.-d.c. radio for use with your hi-fi system

By DAVE GORDON

CHANCES ARE that you have an old a.c.-d.c. radio around somewhere that's doing nothing but gathering dust. Here's how to turn that old five-tuber into an AM tuner you can play through your hi-fi system.

Basically, the conversion consists of installing an isolation transformer to prevent shock hazards and removing the radio's present audio circuitry. While the results may not be precisely hi-fi, in most cases you'll be surprised at the quality attained. The complete conversion can be made for about three dollars.

The particular model converted by the author had a tube line-up consisting of a 12BE6, a 12BA6, a 12AT6, a 50C5, and a 35W4. However, radios using 12SA7, 12SK7, 12SQ7, 50L6, and 35Z5 tubes can be handled in a similar manner.

Begin the conversion by removing the set's speaker, output transformer, and 50C5 or 50L6 output tube. Then install the isolation transformer (Lafayette TR-91, supplied with line cord), 125-ohm, 10-watt resistor, and an audio cable as shown on the schematics. When mounting the transformer, be certain to locate it away from any filter capacitor since it runs quite hot.

Before rewiring the set, disconnect all leads to the on-off switch on the rear of the volume control. Connect the primary of the isolation transformer to the on-off switch terminals as shown; you will have to cut into the transformer's line cord to make this connection. In wiring the isolation transformer primary, do not ground either of the switch terminals or you will defeat the purpose of the transformer and allow a shock hazard to exist.

Connect one of the transformer's two secondary leads to the chassis. The other lead is connected to the rectifier tube (35W4 or 35Z5).

Locate the 125-ohm resistor on top of the chassis since it will also get hot in opera-
tion. Run two insulated leads from this resistor through any convenient hole in the chassis and connect them to the heater terminals on the socket of the 50C5 or the 50L6.

At least one jumper should be connected between floating ground and the chassis to reduce hum. The jumper can be connected at the proper volume control lug or between the 12AT6 or 12SQ7 heater and the chassis, as shown in the diagrams, or two jumpers can be used. Choose whichever connection results in the least hum.

**To complete the conversion**, connect a 3' or 4' length of shielded output cable to the set's volume control as shown; disconnect the lead already connected to the center lug of the volume control, but do not disturb any of the other leads. If you want to use the volume control on your hi-fi set instead of the one on the receiver, you can connect the output cable to a 220,000-ohm, 1-watt fixed resistor instead. This alternate connection is shown at right.

The output cable should be terminated in a standard RCA phone plug or any other suitable plug. Listening tests made by the author against a commercial AM tuner revealed that the length of shielded output cable used caused no detectable roll-off of the tuner's treble response.

The converted set can be put back in its original cabinet. Or, you can mount it in a new cabinet and add a vernier tuning dial. But whether you do it plain or fancy, a small investment in time and money will pay off with a fine-sounding and fine-performing AM tuner.

**Modified detector** circuit shows added output cable and jack or plug, with a jumper connected between floating ground lug on the volume control and the chassis. One or both jumpers must be connected; use the combination which gives the best results.
THE OTHER DAY a local ham called me on the telephone and said, "Herb, I just received a radiogram from a ham in the W5 call area and I delivered it by telephone. The woman asked me to take a reply, but what do I do with it?"

"Put it in standard amateur message form, report it into a traffic net, and start it on its way. Or give it to me, and I'll take care of it," I replied.

"Well, Herb, the woman was so tickled to get the message—it was from her son—that it made me feel good to deliver it. So, if you don't mind, I'd like to finish the job by handling the reply myself, if you'll brief me on how to do it."

**Message Forms.** This is the way many hams get their introduction to the message-handling phase of ham radio. Besides being fun and a public service, it is the best possible training for supplying emergency communications in any disaster that disrupts normal communications channels. Consequently, all hams should know at least the rudiments of message-handling.

The following is a sample message in standard message form:

```
Nr. 1 W9EGQ 12 Gary Ind. 530 pm March 15. Miss June Jones, Women's Residence, Northeastern College, Rockford, Ill. Phone Wo-12345. I will arrive at 400 pm Saturday. Have your dancing shoes ready. Tom.
```

The message is divided into four parts: preamble, address, text, and signature. The

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**Ham of the Month**

Our Ham of the Month for April is James "Stu" Craig, W3DBZ, 7406 Dorcas St., Philadelphia, Pa. Stu is 22 years old and got his start five years ago at a demonstration of ham radio in a high school "open house."

Before he left the demonstration Stu had decided to become a ham. Two weeks later, he was copying the code at 8 wpm on an old broadcast receiver with a short-wave band. Within a month, WN3DBZ was born!

Stu's first station consisted of a converted ARC-5 "surplus" transmitter and a used National NC-57 receiver. Although he made many contacts as a Novice, he kept studying, and two months later passed his General Class examination.

Besides his intense interest in ham radio, Stu keeps bees! He started this hobby in junior high school, with the encouragement of his English teacher, and he soon had four hives. As his reputation spread, Stu would often be called on by the police, the humane society, and others to remove swarms of bees from public places. This little chore is especially interesting when the friendly bees sometimes turn out to be hornets, yellow jackets, or wasps!

If you live around Philadelphia, listen to "Jimmie Craig's Saturday Nite Dance Time" on Radio WJMJ. Yep. That's our boy, W3DBZ. And when he isn't hamming, raising bees, or MC'ing his radio program, you'll find Stu working at the General Atronics Corp. research laboratory. He is also a part-time radio engineer at WJMJ. The rest of the time he just loaf.
last three items are self-explanatory and are the responsibility of the person sending the message, but you prepare the preamble. It consists of your message number, starting with number one; your call letters; the “check” or number of words in the text of the message; place of origin; and the time and date the message is filed. The preamble is transmitted unchanged by all hams who handle the message.

Some hams omit the check, although it provides a simple way to tell if words have been added or omitted in the text. When handling a message under unfavorable conditions, punctuation is included in the text of the message. It should be spelled out, comma, period, etc., and counted in the check. Some operators use “X” or “x-ray” as a substitute for other punctuation.

**Relay to Destination.** Some messages are transmitted directly to their destinations over long distances. However, most of them are relayed from station to station in traffic nets until they are delivered. There are literally hundreds of these ham traffic nets. Most of them operate in the c.w. and phone sections of the 3.5- to 4-mc. ham band in the late afternoon and early evening hours, although there are some on all ham bands from 160 through 2 meters.

If you have a message to send, the easiest way to get it on its way is to tune across the ham bands until you hear a net handling message. Listen to it for a few minutes to find out the call letters of the net control station (n.c.s.) and how the net is operated. Then call the n.c.s. and report your traffic.

Suppose, for example, you are K9OVC, have a message for Los Angeles, and hear Bob, W9JOZ, calling “CQ QIN” on 3656 kc., the Indiana c.w. net frequency. You would call “W9JOZ DE K9OVC K.” Bob would reply “K9OVC DE W9JOZ QRU? K.” You would send “QTC 1 Los Angeles.” Bob would then probably reply “R QRF,” and, in a few minutes, he would tell you to whom to send your message.

If you have only an occasional message to send, it doesn’t make much difference which traffic net you report into. All organized traffic nets are interconnected. Therefore, once your message gets into the system, it is routed to its destination.

If you want to become a regular traffic man, you can join your own state c.w. or phone net. If you don’t know its operating schedule or frequency, write or—better yet—send a message to the American Radio Relay League, Inc., 38 La Salle Road, West Hartford, Conn., and request a copy of the latest ARRL net directory, which lists all the registered ham traffic nets in the United States and Canada. Also, ask for a copy of the special “QN” signals used on most c.w. nets in addition to the regular Q signals.

Remember when you report into a net that the net control station is “boss” during net sessions. In exchange for handling your traffic, the net will expect you to accept for delivery by mail, telephone, or in person, any messages whose destinations are close to your station. Also, the FCC requires that you keep on file for one year all messages which you handle by ham radio.

**Restrictions.** In the United States and its possessions, there are no restrictions on the messages you may handle, as long as they are not obscene and you receive no compensation for handling them. However, international regulations forbid the handling of third-party communications of any kind with foreign countries, whether by messages, “phone patches,” or other means, unless special agreements have been negotiated between the governments involved.

Such agreements are in effect between the United States and Canada, Chile, Costa Rica, Cuba, Ecuador, Liberia, Mexico, Nicaragua, Panama, Peru, and Venezuela.* With these countries, we may exchange unimportant messages that would not ordinarily be sent by commercial communica-

* On January 6, 1960, the United States and Haiti signed an agreement in Port au Prince permitting the exchange of third-party communications between the two countries via ham radio. The agreement went into effect February 5.

**Tim Hiteman, K8LCV, Parma Heights, Ohio.**
PARTS LIST

C1—140-µf. midget variable capacitor (Bud 1856 or equivalent)
C2—390-µf. silver-mica capacitor
C3—270-µf. mica capacitor
C4, C5, C6, C8—0.005-µf. disc ceramic capacitor
C7—“Gimmick” capacitor or 1.2- to 10-µf. variable capacitor (Cardwell PL-6000 or equivalent—see text)
L1—13 turns of #20 wire, 1” dia., spaced 1/16” between turns, tapped four turns from grounded end (part of B & W 3015 Miniductor)
L2—1-mh. r.f. choke
R1—100,000-ohm, 1/2-watt resistor
R2—47,000-ohm, 1/2-watt resistor
V1—6AU6 tube
I—3” x 4” x 5” aluminum box
I—Vernier dial (Millen 10039 or equivalent—see text)

Simple tuner for single-sideband reception is actually an electron-coupled oscillator which restores the suppressed carrier. It can be operated from a small power supply or the power can be taken from the receiver’s accessory socket.

You can improve the reception of those monkey-chatter single-sideband suppressed-carrier (SSB) signals on your ham receiver by using the simple tuner shown here. It will work on all ham bands up to 29.7 mc. and operates by restoring the suppressed carrier before the signal enters the receiver. Thus, the SSB signal can be tuned in the receiver like a conventional AM signal.

The one-tube electron-coupled oscillator in the tuner operates in the range between 3.5 and 4.0 mc, with strong harmonics up to 30 mc. Little power is required by the tube and only one connection to the receiver antenna is necessary.

The complete tuner is built into a two-panel 3” x 4” x 5” aluminum box with all components mounted on one panel. Connect coax cable such as RG-59/U between “gimmick” capacitor C7 and receiver antenna.

(Continued on page 126)
AN INCREASING NUMBER of inaccurate reports have been received recently by the Far East Network (Japan). According to Mr. Henry Yaskal, Directorate of Engineering for the FEN, reports have also been received for stations which are out of existence. In a letter to your Short-Wave Editor, Mr. Yaskal said, in part:

"We receive reports from short-wave listeners and radio amateurs of many countries. They have a genuine interest in radio and take great pains to be accurate. We consider their reports to be of great value and are happy to send them our QSL Cards. It would be unfair to them if we also sent cards to those people forwarding unverifiable or down-right dishonest reports."

A second letter from Mr. Yaskal was accompanied by an original report that had been sent to him by one of our POP'tronics Monitors. The report listed the day and time that the station was "heard" and gave program data. But a check into the station log for that particular day indicated that the program "heard" was, in fact, scheduled for another day of the week. Further, the log showed that the station was actually off the air on that one day for antenna maintenance. Further investigation proved conclusively that the Monitor making the report had copied the program information from a previous listing in this column, added a "date" to the report and sent it in.

(Continued on page 135)
It's COMPACT!
It's PORTABLE!
It's TRANSISTORIZED!

A completely new, truly portable, all transistor Transceiver for the Citizens Radio Service. Weighs less than five pounds.

Small but mighty . . . The Traveler packs 12 transistors and a walloping big signal! The perfect communicator in the home, the office, as well as outdoors. Inconspicuous atop the desk. Adjust the special shoulder strap, and it becomes your companion in the field.

Three types of power supplies. (1) Rechargeable battery, complete with charger. (2) Standard dry cell. (3) 115 VAC.

Due to extremely efficient design, the International Traveler provides greater output than any other Citizens transistor transmitter currently on the market.

Special High Frequency transistors are utilized in the transmitter. The receiver's dual conversion superhetrodyne RF circuits use special High Frequency transistors. Provides microvolt sensitivity.

Other features: Noise limiter and squelch, two channel crystal controlled transmitter, two channel crystal controlled receiver.

Your choice . . . Portable case with mobile mounting bracket adjustable shoulder strap, complete with whip antenna and microphone . . . or if you prefer, a beautiful "hand rubbed" wood case* complete with microphone.

Available soon at your International dealer or write for details.

*115 VAC only

INTERNATIONAL CRYSTAL MFG. CO., INC.
18 NORTH LEE  OKLAHOMA CITY, OKLAHOMA
HI-FI RATED 25/25 WATT STEREO AMPLIFIER-PREAMPLIFIER KIT

A complete 25/25 watt stereo power and control center (50 watts mono) . . . 5 switch-selected inputs for each channel . . . new mixed center speaker output . . . stereo reverse and balance controls . . . special channel separation control . . . separate tone controls for each channel with ganged volume controls . . . all of these deluxe features in a single, compact and handsomely styled unit! Five inputs for each 25 watt channel are provided: stereo channel for magnetic phono cartridge (RIAA equalized); tape head input; three high level auxiliary inputs for tuners, TV, etc. There is also an input for monophonic magnetic phono cartridge, so switched that monophonic records can be played through either or both amplifiers. The automatically mixed center speaker output lets you fill in the "hole-in-the-middle" found in some stereo recordings, or add extra monophonic speakers in other locations. Nearly all of the components are mounted on three circuit boards, simplifying assembly and minimizing possibility of wiring errors. 30 lbs.

New Heathkit Stereo Hi-Fi Components . . .

plus Exciting New Kits for the Ham, Technician,

Boating Fan and Hobbyist

MANUAL STEREO RECORD PLAYER KIT

Made by famous Garrard of England, the AD-10 is a compact 4-speed player designed to provide trouble-free performance with low rumble, flutter and wow figures. "Plug-in" cartridge feature. Rubber matted heavy turntable is shock-mounted, and idler wheels retract when turned off to prevent flat spots. Powered by a line-filtered, four-pole induction motor at 16, 33⅓, 45 and 78 rpm. Supplied with Sonotone STA4-SD ceramic stereo turnover cartridge with .7 mil diamond and 3 mil sapphire stylus. Mechanism and vinyl covered mounting base preassembled, arm pre-wired; just attach audio and power cables, install cartridge and mount on base. With 12" record on table, requires approximately 15" W. x 13" D. x 8" H. Color styled in cocoa brown and beige. 10 lbs.
ECONOMY STEREO' PREAMPLIFIER KIT

Although these two new Heathkit models are designed as companion pieces, either one can be used with your present stereo system. The preamplifier (AA-20) features 4 inputs in each stereo channel and gives you a choice of 6 functions. It will accommodate a magnetic phonograph (RIAA equalized), a crystal or ceramic phonograph, and two auxiliary sources (AM-FM tuners, TV, tape recorders, etc.) and is completely self-powered. The six-position function selector switch gives you instant selection of "Amplifier A" or "Amplifier B" for single channel monophonic; "Monophonic A" or "Monophonic B" for dual channel monophonic using both amplifiers and either preamplifier; "Stereo" and "Stereo Reverse". 8 lbs.

HI-FI RATED 14/14 WATT BASIC STEREO AMPLIFIER KIT

Two 14-watt high fidelity amplifiers, one for each stereo channel, are packaged in the single, compact, handsomely styled amplifier (AA-30). Suitable for use with any stereo preamplifier or with a pair of monophonic preamplifiers, it features individual amplifier gain controls and speaker phase reversal switch. Output terminals accommodate 4, 8 and 16 ohm speakers. 21 lbs.

HI-FI RATED 14/14 WATT STEREO AMPLIFIER KIT

A tremendous dollar value in the medium power class, this top-quality stereo amplifier-preamplifier combination delivers full 14 watts per stereo channel (28 watts monophonic) to drive your stereo system with ease, while versatile controls give you fingertip command of its every function. In addition to "stereo" and "stereo reverse" functions, the SA-2 provides for complete monophonic operation. Inputs on each stereo channel accommodate "magnetic phono" (RIAA equalized), "crystal phono", "tuner" and high level auxiliary input for tape recorder, TV, etc. Other features include a speaker phase-reversal switch, clutched volume controls, ganged tone controls, filament balance controls, and two AC outlets to accommodate accessory equipment. Handsomely styled in black with inlaid gold design. 23 lbs.

UTILITY RATED 3/3 WATT STEREO AMPLIFIER KIT

Your least expensive route to stereo, the SA-3 delivers 3 watts per stereo channel (6 watts monophonic), adequate for average living-room listening. The high level preamplifier has two separate inputs for each channel and is designed for use with ceramic or crystal cartridge record players, tuners, tape recorders, etc. Featured are ganged bass and treble tone controls, clutched volume controls, channel reversing switch, speaker phase reversal switch and mono-stereo function selector switch. Attractively styled with satin-black cabinet. 18 lbs.

MIXED LOWS STEREO CROSSOVER NETWORK KIT

The AN-10 makes it possible for you to convert to stereo or improve your present stereo system by using just one bass "woofer": saves buying a second bass speaker, permits using more economical "wing" speakers, improves the bass response of any stereo system. Delivers the non-direction bass frequencies of both channels below 250 cps to a single woofer and passes the higher frequency stereo channels to a pair of wing speakers. Rated at 25 watts per channel. Matches 8 or 16 ohm woofers, 8 ohm high frequency speakers, or Heathkit SS-1-2-3 speaker systems. 10 lbs.

TURN PAGE FOR MORE HIGH QUALITY DO-IT-YOURSELF KITS
HEATHKIT® GIVES YOU MORE IN THESE TEN WAYS:

1. Building a Heathkit is easy—Check-by-step instruction manuals make it virtually impossible for you to fail.
2. Building a Heathkit is quick—No complicated, technical jargon for you to decipher; at your leisure, a Heathkit takes only a few evenings to assemble.
3. Building a Heathkit is economical—Mass production and purchasing economies are passed directly along to you, our customers.
4. Building a Heathkit is educational—As you build, you learn about electronics, more about the component units and where and when to add them.
5. Building a Heathkit is fun—Nothing quite equals the sense of achievement you receive when you successfully complete a Heathkit unit and “tune-in” for the first time.
6. Your Heathkit is Guaranteed—Every Heathkit unit is guaranteed to meet advertised performance specifications... or your money will be cheerfully refunded.
7. Your Heathkit is available on Convenient Credit—Your time payment plan makes it possible for you to order now... pay later.
8. Your Heathkit is Tops in Quality—The very finest in electronic equipment comes to you in kit form from the Heath Company.
9. Heathkit Dealers can Serve you Locally—Carefully selected Heathkit representatives are available in most localities.
10. Heathkit Service is Customer Service—Our staff of technical experts is always ready to answer your questions or help you if you have any difficulty.

TEN-TRANSISTOR
“MOHICAN” GENERAL COVERAGE
RECEIVER KIT (GC-1)

An excellent portable or fixed station receiver. Many firsts in receiver design, ten transistor circuit, flashlight battery power supply and new ceramic 1P transistors. The amazing miniature transistors used in the GC-1 replace transformer, inductive and capacitive elements used in conventional circuits for shaping bandpass; offers superior time and temperature stability, never need alignment, provide excellent selectivity. Telescoping 54" whip antenna, tuning meter, flywheel tuning and large slide-rule dial also featured. Covers 550 kc to 30 mc in five bands. Electrical handspread on five additional bands cover amateur frequencies from 80 through 10 meters. Operates up to 400 hours on 8 standard size "C" batteries. Sensitivity: 10 uv, broadcast band; 2 uv, amateur bands, for 10 db signal-to-noise ratio. Selectivity: 3 kc wide at 6 db down. Measures 6½" x 12" x 10". 20 lbs.

HEATHKIT XP-2. Plug-in power supply for 110 VAC operation of GC-1. 2 lbs. $9.95

6-TRANSISTOR PORTABLE RADIO KIT
(XR-2 Series)

Unsurpassed quality and styling are combined in these handsome sets to provide you with superb and dependable portable entertainment wherever you are—wherever you go! Choose the gleaming, two-tone molded plastic model or the handsome simulated leather-and- plastic combination—both feature a gracefully curved grille in smart beige plastic. The XR-2P complements the handsome grille with a mocha colored case of high-impact plastic, while the XR-2L encases the beige grille in sultan color Sur-U-Lon simulated leather. Vernier tuning control gives you smooth, precise station selection. Six Texas Instrument transistors are used for quality performance and long life; a large 4" x 6" PM speaker with heavy magnet provides "big set" richness of tone. Ready to play after simple assembly— transformers prealigned. Six flashlight batteries used for power (500—1,000 hrs.) (Batteries not included).

Order Direct by Mail or
**ORDERING INSTRUCTIONS**

Fill out the order blank below, giving us your name and address in the space provided at right. Include charges for parcel post according to weights shown. Express orders are shipped delivery charges collect. All prices F.O.B. Benton Harbor, Mich. A 25% deposit is required on all C.O.D. orders. Prices subject to change without notice. Dealers and export prices slightly higher.

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**FREE CATALOG!**

Over 150 items of stereo, marine, amateur and test equipment are illustrated and described in the complete Heathkit Catalog.

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Please send my free copy of your complete catalog.

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**New! One switch operation**

"**HYBRID**" PHONE PATCH KIT (HD-19)

Transfer calls from ham rig to telephone by flipping a single switch! Allows voice control (VOX) or manual operation. VU meter monitors output to 600 ohm line and serves as null depth indicator. Separate receiver and transmitter gain controls. Provides better than 30 db isolation between receive and transmit circuits. All leads filtered to minimize RF feedback. Matches receivers with 3 to 16 ohms impedance. 4 lbs.

**NEW 100 KC CRYSTAL CALIBRATOR KIT (HD-20)**

This versatile ham aid provides marker frequencies every 100 kc between 100 kc and 54 mc. Use to calibrate all types of communications equipment. Features transistor circuit dependability, battery power portability, and crystal control accuracy. .005% crystal supplied. 1 lb.

**Two brand new models**

**HEATHKIT 10 & 6 METER TRANSCEIVERS**

Complete ham facilities at low cost! Ideal for beginning and veteran hams for local net operations. Transmitter and receiver are combined in one easy-to-use instrument. Features neat, modern styling, press-to-talk transmit/receive switch, built-in AC power supply, variable receiver tuning, variable gain control, and amplifier metering jack. Operates mobile using vibrator power supply. Microphone and two power cables included. Handsomely styled in two-tone mocha and beige. Less crystal.

**VIBRATOR POWER SUPPLIES:** VP-1-6 (6 volt). VP-1-12 (12 volt). 4 lbs. Kit; $8.95 each. Wired; $12.95 each.

**MUTUAL CONDUCTANCE TUBE TESTER (TT-1)**

The impressive list of its features make this tube tester a fine value. Tests Gm (amplifiers) from 0-24,000 micromhos, Emission, Leakages, Grid current (1/4 microampere sensitivity), Voltage regulators (built-in variable DC power supply), Low power Thyatron and Eye tubes. Features 300, 450, and 600 ma constant current heater supplies, life test, Hybrid tube test, built-in switch operated calibration circuit. Large easy-to-read meter, and constant tension free-rolling roll chart mechanism. Individual selector switches allow testing any tube type, regardless of basepin connections, protecting against obsolescence. Assembly simplified by 7 wiring harnesses and transformer terminal board. Assembly skill of technician or higher recommended, time 40 hours average. Black leatherette case with white trim, nylon feet, removable top. 27 lbs.

**EDUCATIONAL KIT (EK-1)**

Teaches, as you build, the basic "yardsticks" of electronics—opens up fascinating areas of study for youngsters and adults alike. The combination kit and text-workbook gives you a practical demonstration of the principles of voltage, current and resistance; the theory and construction of direct current series and parallel circuits, voltmeter, ammeter and ohmmeter circuits and the application of ohms law to these circuits. The completed meter is used to verify ohms law and the maximum power transfer theorem, one of the most important theorems in electronics. The finished kit, a practical voltm-ohm-milliammeter, may be used in a variety of applications. Procedures for checking home appliances and automobile circuits included with the kit. The EK-1 will serve as a prerequisite to following Heathkit Educational kits. Get started NOW in this new and exciting series of "learn-by-doing" educational kits. 4 lbs.

*The convenience of Local Heathkit Sales and Service costs but a few dollars more.*

**See Your Heathkit® Dealer**

April, 1960
El Torero Electronico

A S CARL STEPPED through the open door of the electronic laboratory he shared with his pal, Jerry, in the basement of the latter's home, his ears were assailed by a loud, piercing, unwavering tone. It was coming from a hi-fi speaker in one corner of the room, and Jerry was crouched over some electronic equipment directly in front of the speaker.

"What are you doing?" Carl shouted. "This is no day to be messing around in-
vice for translating sound into electricity without worrying about the actual efficiency percentage of the device. Measuring actual sound power is real tricky even when you have elaborate sound-measuring equipment and a sound-deadened room. By measuring the voltage developed across the eight-ohm voice coil of this speaker by my 1000-cycle tone, I'm setting the electrical power fed into the speaker at exactly one watt. I figure the speaker has an efficiency of between five and ten per cent; so I estimate that the sound power output is only around one-fifteenth of a watt or thereabouts.

"This transducer I'm trying first is a sound-powered phone. As you can see, it's mounted exactly a foot away from the speaker and directly in front of it. These sound-powered phones are designed to be transducers of sound into electrical energy and electrical energy into sound. When two of the units are connected together, sound striking the diaphragm of either moves an attached coil in a strong magnetic field, producing currents in the coil. These induced currents travel along the connecting wires and flow through the coil of the other unit, causing it to vibrate its diaphragm and produce sound again. Notice that all the power used—and you can carry on conversations up to twelve miles with a pair of these phones—is produced by sound waves.

"Any other transducers I use, such as

April, 1960
Can you think faster than this Machine?

GENIAC® set up to do a problem in check valve research. Be careful before you answer. GENIAC, the first electrical brain construction kit is equipped to play lectures, cipher and encipher codes, convert from binary to decimal, reason in syllogisms, as well as add, subtract, multiply and divide. Specific problems in a variety of fields—actuarial, biology, electronics, physics, etc.—can be set up and solved. Problems that are completely explained with templates in the manual. This covers 125 circuits and shows how new ones can be designed. You will find building and using GENIACS a wonderful experience: one kit user wrote us: "This kit has opened up a new world of thinking to me." You actually see how computing, problem solving, and game play (bic-lactics, him, etc.) can be analyzed with Boolean Algebra and the algebraic solutions, transformed directly into circuit diagrams. You create from over 400 specially designed and manufactured components a machine that solves problems faster than you can express them.

--- MAIL THIS COUPON ---

SCIENCE KITS, Dept. PE-46, Oliver Garfield Co., Inc. 108 E. 16 St., N. Y. 3, N. Y.

Please send me:
1. GENIAC Electrical Brain Construction Kit and Manual.
   $19.95 (East of Mississippi)
   $20.95 (Elsewhere in United States)
   $21.95 (Outside the United States)

Returnable in seven days for full refund if not satisfied.

Enclose full payment. My name and address are attached.

CITIZENS BAND TWO-WAY RADIO KIT

FREE with this unit, shock mounted CB mobile antenna. $8.95 Val.

- HANDSOME TWO-TONE CABINET
- ASTATIC CERAMIC MICROPHONE
- PLATE MODULATED TRANSMITTER
- PLUG IN 3RD OVERTONE CRYSTAL
- SUPER REGEN RECEIVER PLUS RF AMPLIFIER
- FCC FORM 505 INCLUDED
- HIGH Q CERAMIC COILS
- SPECIFY CRYSTAL FREQUENCY
- PLUS TUBES, PARTS, ETC.
- 3 MODELS—6 Volt—12 Volt—110 Volt

$39.95

Order direct or write for name of nearest distributor

GROVE ELECTRONIC MFG. CO.
4103 W. BELMONT CHICAGO 41, ILL.

Always say you saw it in—POPULAR ELECTRONICS

sound-powered units working on a slightly different variable-reluctance principle, speakers, crystal units, etc., will be mounted in the same position as this moving-coil unit. They will be subjected to the same dynes per cm² of sound power as long as I keep one watt of 1000-cycle tone feeding into the speaker. This will allow me to compare relative efficiencies by simply taking into account the pickup area of my transducer and noting the electrical power developed across a resistive load. Of course, impedances between the transducer and the load must be carefully matched to develop maximum power. That's what I'm doing now."

"Sounds like a real neat idea, but let's save it for a rainy day," Carl suggested. "Come along and help me try out my brand-new radio-controlled plane. The thermometer is up to 75 out there, and the buds are bursting like popcorn."

JERRY NEEDED little urging, and a half hour later the boys were parking their bicycles along a narrow dirt road running alongside a large pasture with a single tree growing in the center of it.

Carl's plane was not a sleek modern aircraft. Instead, it was a sturdy old-fashioned biplane model of the sort he had seen crop-dusters using in the South. The large wing area permitted it to stay in the air at slow speed, and an oversize engine gave it lots of power for hedge-hopping tactics. Carl had spent a great deal of time—and no little money—designing the most responsive and complete remote control possible for maximum maneuverability. It was his intention to fit a smoke emitter in the plane and give a realistic demonstration of dusting procedures at a model airplane meeting coming up in a couple of months.

Carl handled the controls, and Jerry hand-launched the plane. Right from the start it performed beautifully. Carl first sent it high above the pasture to test it out; but when he saw how quickly and smoothly
A happy reel of spirited classics
... available in a special Audiotape bonus package

DETAILS OF THE PROGRAM
"High Spirits" includes these bright selections:
Strauss Frisch ins Feld
Strauss from Fledermaus Waltz
Beethoven from Symphony No. 1 in C
Tchaikovsky from Capriccio Italian
Bizet from Carmen Suite
Berlioz .Rakoczy March

DETAILS OF THE OFFER
This exciting recording is available in a special bonus package at all Audiotape dealers. The package contains one 7-inch reel of Audiotape (on 1½-mil acetate base) and the valuable "High Spirits" program professionally recorded on standard Audiotape. For the entire package, you pay only the price of two boxes of Audiotape, plus $1. And you have your choice of the half-hour two-track stereo program or the full-hour monaural or four-track stereo versions. Don't wait. See your Audiotape dealer now.

Like your classics bright and melodic? Do you enjoy music of the toe-tapping variety? Then "High Spirits" is just for you. This reel of sparkling classics shows you how vibrant and colorful music can be when it's recorded on Audiotape.

The makers of Audiotape have not gone into the music business. They are simply using this reel to allow Audiotape to "speak for itself."

"High Spirits" is available RIGHT NOW from Audiotape dealers everywhere. (And only from Audiotape dealers.) Ask to hear a portion of the program, if you like. Then, take your choice of a half-hour of two-track stereo, a full hour of four-track stereo, or an hour of dual-track monaural sound—all at 7½ ips. Don't pass up this unusual opportunity to put yourself in high spirits.


AUDIOTAPE

April, 1960
NOW YOU CAN HAVE YOUR CHOICE OF CENTURY'S UNIQUE
VACUUM TUBE VOLT METERS

Model VT-10
LINE OPERATED

WITH LARGE EASY-TO-READ 6" METER
featuring the sensational new
MULTI-PROBE (Patent Pending)

No extra probes to buy! The versatile
MULTI-PROBE does the work of 4 probes
1 DC Probe 2 AC-Ohms Probe
3 Lo-Cap Probe 4 RF Probe

No longer do you have to cart around a maze of entangled
 cables, lose time alternating cables or hunting for a misplaced
 probe. With just a twist of the MULTI-PROBE tip you can set
 it to function as either a DC Probe, AC-Ohms Probe, Lo-Cap
 Probe or RF Probe.

LINE OPERATED
Ideal for use on the test
pencil. Designed to run cool
even under continuous
operation. Line isolated.

BATTERY OPERATED
Completely portable... in-
valuable wherever line con-
nection is undesirable or
unavailable. Unique cir-
cuity assures low battery
drain.

FUNCTIONS OF VT-1 and VT-10

DC VOLTMETER... will measure D.C. down to 1.5 volts
full scale with reading, and give accurate
readings of scale divisions as low as .025 volts...
will measure low A.C. and oscillator bias voltages from 3 volts or less
up to 1500 volts with consistent laboratory accuracy on all
ranges... Zero center provides for all balancing measure-
ments such as discriminator, ratio detector alignment and
high-frequency balancing.

AC VOLTMETER... True Peak-to-Peak measurements
as low as 3 volts of any waveform including TV sync, deflection
voltages, video pulses, distortion in hi-fi amplifiers, AGC and
time V.T.V.M. gates... Scale divisions are easily read down to
.1 volt... Measures RMS at 1300 ohm circuit loading of a
V.T.V.M. Unlike most other V.T.V.M.'s there is no loss in
accuracy on the lowest AC range.

ELECTRONIC OHMETER... Measures from 0 to 1000
megohms... Scale divisions are easily read down to .2 ohms
...Will measure resistance values from 2 ohms to one billion
ohms... Will detect high resistance leakage in electrolytic
and by-pass condensers.

RF AND LO-CAP MEASUREMENTS... With these extra
VT-1 functions you can measure voltages in extremely high-
impedance circuits such as sync and AGC pulses, driving saw
tooth voltages, color TV gating pulses, mixer output levels
T.F., stage-by-stage gain and detector inputs.

FEATURES OF VT-1 and VT-10

- New advanced pentode amplifier circuit
- Large 6" 100-micrometer scale, many
times more sensitive than meters used in
most V.T.V.M.'s
- Simplified multi-color easy-
to-read 4-scale meter
- No heat operated, assures stability and accuracy
- Amplifier rectifier circuit with frequency compensated
attenuator...a feature found only in costly
laboratory instruments
- Meter completely isolated
- Hand-crafted circuitry eliminates
the headaches of printed circuitry
- Resistors used for permanent accuracy
- Rugged gray hammertone steel case provides
necessary shielding and eliminates plastic
case drawbacks of cracking or melting
- Deep brushed long lasting etched aluminum
panel... Matching cover protects instrument
face...snaps on and off instantly.

Model VT-10
TERMS: $14.50 within 10
days. Balance $11
monthly for 4 months.

$58.50 Net

Model VT-1
BATTERY OPERATED

TERMS: $14.50 within 10
days. Balance $11
monthly for 4 months.

$58.50 Net

SPECIFICATIONS OF VT-1 and VT-10

- DC Volts... 0 to 1.5/6/30/150/300/600/1500
- AC Volts (RMS and Peak-to-Peak) ...0 to
3/12/60/300/1200 volts
- Ohms... to a billion ohms, 10 ohms center
scale... RX1/10/10K/100K/1M
- RF... Peak reading demodulator sup-
pplied for use on all DC ranges
- Zero Center... available on all DC volt
ranges with zero at mid-scale
- Decibels... from -10 DB to +10/22/
36/50/65 based on the Dbm unit. 0dB:
LMW in 600 ohms
- Impedance... 11 megohms DC, 1 meg-
ohm AC, 10 megohms Lo-Cap
- Input Capacity... 130 m mf, RMS, 250
m mf, Peak-to-Peak, 25 m mf, Lo-Cap

Model CT-1
IN-CIRCUIT CONDENSER TESTER

Here is an IN-CIRCUIT CONDENSER that DOES THE WHOLE JOB! The CT-1 actually steps in and takes over where all other in-circuit condensers fail. The ingenious application of a dual bridge principle gives the CT-1 a

10 DAY FREE TRIAL ON CENTURY INSTRUMENTS OF YOUR CHOICE

See for yourself at no risk why thousands of servicemen all over the country selected CENTURY test equipment above all others. Send for instruments of your choice without obligation, try them for 10 days before you buy... only then, if satisfied,
pay in easy-to-buy monthly installments — without any financing or carrying charges added.

in-circuit checks:
- Quality of condensers even with circuit short resistance...
  (This includes leakage, shorts, opens, inter-
tempts)
- Value of all condensers from 200 m mf, to .5 m mf.
- Quality of all electrolytic condensers (the ability to
  hold a charge)
- Transformer, socket and wiring leakage capacity

out-of-circuit checks:
- Quality of condensers... (This includes leakage,
  shorts, opens and intermittents)
- Value of all condensers from 50 m mf, to .5 m mf.
- Quality of all electrolytic condensers (the ability to
  hold a charge)
- High resistance leakage up to 300 megohms
- New or unknown condensers... transformer, sock-
et, component and wiring leakage capacity

OUTSTANDING FEATURES

- Ultra-sensitive 2 tube drift-free circuitry
- Multi-color direct scale readings for both quality and
  value... in-circuit or out-of-circuit
- Simultaneous readings of circuit capacity and circuit
  resistance
- Built-in hi-leakage indicator sensitive to over 300
  megohms
- Cannot damage circuit components
- Electronic eye balance indicator for even greater
  accuracy
- Isolated power line
- Deep brushed long lasting etched aluminum panel
- housed in sturdy gray hammertone finish steel
case... comes complete with test leads

Model CT-1
TERMS: $9.50 within 10
days. Balance $5 month-
ly for 5 months.

$34.50 Net

always say you saw it in—POPULAR ELECTRONICS
THE CRT DOES ALL THIS RIGHT IN THE CARTON, OF THE CARTON OR IN THE SET

For quality of every black and white and color picture tube, employing the time proven dynamic cathode emission test principle.

For inter-element shorts and leakage up to one megohm. Separate short test provided for each element in the picture tube.

For life expectancy.

Will clear inter-element shorts and leakage.

The "SHOT" (high voltage controlled pulse) method of reactivation provided by the CRT-2 will restore picture tube to new life in instances where it was not possible before. The high voltage is applied without danger of stripping the cathode as you always have perfect control of the high voltage pulse.

The "BOOST" method of reactivation also provided by the CRT-2 is used effectively on tubes with a superficially good picture but with poor emission and short life expectancy. It will also improve definition, contrast and focus greatly and add longer life to the picture tube.

THE CRT-2 DOES

TESTS, REPAIRS AND REACTIVATES

- ALL BLACK AND WHITE PICTURE TUBES (including 110° tubes)...
- ALL COLOR PICTURE TUBES

CHECK THESE EXCLUSIVE FEATURES

- THE MULTI-HEAD (Patent Pending) ... A SINGLE PLUG IN CABLE AND UNIQUE TEST HEAD
- WATCH IT REACTIVATE THE PICTURE TUBE - You actually see and control the reactivation directly on the meter as it takes place. This allows you for the first time to properly control the reactivation voltage and eliminates the danger of stripping the cathode of the oxide coating. It also enables you to see whether the build-up is lasting.
- CONTROLLED "SHOT" WITH HIGHER VOLTAGE FOR BETTER REACTIVATION - Stronger than any found in other testers - high enough to really do the job - yet controlled to avoid damage to the picture tube.
- UNIQUE HIGH VOLTAGE PULSE CIRCUIT - Will burn out inter-element shorts and weld open circuits with complete safety to the picture tube.

Model CRT-2

**$57.50 Net**

TERMS: $13.50 within 10 days. Balance $11 monthly for 4 months.

THE-CRT-2

Model FC-2

**$9.50 Net**

TERMS: $2.50 within 10 days. Balance $1 monthly for 4 months.

PICKTUR TEST ADAPTER

INCLUDED WITH FAST-CHECK

Enables you to check in triplicate picture tubes (including the new short-neck 110 degree type) for cathode emission, shorts and life expectancy... also to rejuvenate weak picture tubes.

THE FAST-CHECK TUBE TESTER

Simply set two controls ... insert tube ... and press quality button to test any of over 900 tube types completely, accurately... IN JUST SECONDS!

The FAST-CHECK enables you to cut servicing time way down, eliminate unprofitable call-backs and increase your dollar earnings by merely showing your customer the actual condition and life expectancy of the tube. The extra tubes you sell each day will pay for the FAST-CHECK in a very short time.

RANGE OF OPERATION

- Checks quality of over 900 tube types, employing the time proven dynamic cathode emission test. This covers more than 99% of all types in use today, including the newest series-string TV tubes, auto 12-plate volt tubes, O24s, magic eye tubes, gas regulators, special hi-fi tubes and even foreign tubes.
- Checks for inter-element shorts and leakage.
- Checks for gas content.
- Checks for life-expectancy.

Model VF-10 Vacuum Tube Volt Meter...

Model VF-1 Battery Vacuum Tube Volt Meter...

Model CT-1 In-Circuit Condenser Tester...

Model CRT-2 CRT Tester-Reactivator...

Model FC-2 Fast-Check Tube Tester...

MAIL FREE TRIAL COUPON TODAY!
it answered every electronic command, he brought it down until it was skimming only a few feet above the fresh green sod. "What a sweet-flying job!" he chortled happily. "Watch this, old buddy; watch me put it in a tight circle around that tree."

The little plane lifted easily to the top of the tree and went into a tight banked left turn. At this moment there was a terrific rumbling roar right in the boys' ears, and Carl was so startled that he dropped the control box. Standing in front of the boys, with only the fence between, was a red-

eyed black bull emitting a low earth-shaking bellow through his flared nostrils.

"Wow!" Jerry exclaimed shakily; "what a beast! I'm sure glad that fence is there. He must have sneaked up on us while we were watching the plane."

"Where is the plane?" Carl asked as he snatched up the control box and anxiously scanned the empty sky. "Oh, oh!" he groaned. "There it is in the tree."

Sure enough, the little plane was resting in the upper branches of the tree with its motor still snarling away. Carl cut the motor off with the control box, and the two boys tried to drive the huge animal away by shouting at him and waving their arms. But this only seemed to add to the bull's ill temper. Finally they went down the road a short distance and hid in the side-ditch.

The bull eventually calmed down and wandered over to the far side of the pas-
In a few minutes Carl had inched his way back down to Jerry's level with the plane in his hands. "Not hurt a bit!" he gloated. "When I dropped the control box, the plane must have pulled up in a stall and then pancaked into the tree. We're lucky."

"Oh, we're lucky, all right!" Jerry exclaimed sarcastically. "We have a choice: we can either sit up here in this tree and freeze to death tonight or we can let that bull make shish kebab out of us on his horns."

"It's not that bad—I hope," Carl comforted. "We'll get out of this some way. He'll get tired after a while and wander away. Let's be quiet and see if he doesn't forget us."

The boys remained absolutely still for half an hour, but the bull did not calm down. He circled around and around the tree, pawing the earth and throwing great clogs of soft turf up over his back while slobber runs from his bellowing mouth.

"Gee, what a grouch!" Carl finally exclaimed as he looked anxiously at the sun touching the horizon. "I never realized what 'bull-headed' really meant until now. He's not going to cool off. We've got to think of something else."

"You might jump out of the tree and..."
“Hold it, honey lamb. I found the JENSEN CARTRIDGE!”

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dragged the bright fabric over the back of the startled bull. As it flipped off his horns in front of his eyes, he charged fiercely after it. Carl throttled the motor down until the plane was almost stalling and flew a zigzag course that kept the red cloth tantalizingly in front of the animal’s nose until he was led into a far corner of the pasture; then both boys leaped to the ground and ran for the closest fence.

Carl, as he ran, still kept an eye on the little plane and used the control box to keep it flying. The bull was so engrossed with his new “enemy” that he did not notice the boys’ escape at all. When they were safely across the fence, Carl brought the little plane sailing to them. He handed the control box to Jerry and had him put the plane into a tight circle while he caught the dangling piece of red cloth and broke the thread; then he took over and brought the plane in for a smooth landing on the narrow dirt road.

“WELL,” Jerry observed, getting astride his bicycle; “that’s that, and we’d better be getting home or we’ll miss supper.”

“Yeah,” Carl agreed as he shot a malevolent look at the snorting bull, once more just on the other side of the fence; “and I just hope we have beefsteak!”

April, 1960
Molecular Electronics
(Continued from page 91)

Molecular material called "dendrites" directly from the molten mass has already been perfected. These ribbons are of exact size and thickness, with optically perfect surfaces. They are practically ready for use as they emerge from the furnace, and there are virtually no rejects.

By contrast, semiconductors are normally made in the form of ingots which must be x-rayed, oriented, sawed, lapped, etched, and polished before they are ready to use. In addition, this "old" method results in a high percentage of rejects.

A dendritic ribbon to which tiny multiple-function systems have been automatically attached is shown on page 91. Here a series of multivibrators has been created directly on the dendrite. The individual circuits need only be clipped apart and leads attached. Soon, complete amplifier circuits will be produced the same way. The dendrite ribbon will be snipped into different lengths to give amplifiers of different gains—the longer the strip, the greater the amplification!

Eventually, engineers hope to "grow" complex electronic equipment—complete receivers, for example—automatically and continuously from a pool of semiconductor material. These receivers are still far in the future, but they would be unbelievably cheap and trouble-free by today's standards. Because of the low power consumption of molecular electronic function blocks, a single battery would last for years.

Military Significance. As might be expected, the first application for molecular electronics will be in the military and space fields. The savings to be realized in weight, size, and power consumption are of paramount importance here.

Of even greater significance is the tremendously improved reliability that can be achieved through the use of these amazing devices. To see why, consider the example of a giant rocket designed for hurling our satellites into orbit.

The rocket's electronic "innards" are made up of 20 or 30 thousand separate parts and perhaps 75 thousand connections. If just one of these parts or connections fails, we suffer another missile failure. With molecular electronic equipment, only one-tenth to one-twentieth the number of parts and connections is needed. Consequently,

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there is much less chance that a part or connection will go bad under strain, and the promise is that missile firings will be far more successful than ever before.

Molecular electronic units for military use are now being developed by Westinghouse under a U.S. Air Force contract. Although it takes time to design and test circuits, set up production lines, and train personnel, the first of these units will be going into action within about three years.

**Consumer Use.** It is hard to say when molecular electronic products will be available for the consumer market. But it is a certainty that such devices will be on sale some day. Because they will be produced by continuous, automatic, low-cost production methods, their price is bound to become so low that conventional tube and transistor circuits—with their separate resistors, capacitors, inductances, and complex soldered connections—will be on the way out, except possibly for highly specialized uses.

Molecular electronic devices will open up exciting new fields with their combination of high performance, small size, and low cost. For example, the wrist radio—*à la* Dick Tracy—will become commonplace. The personal telephone—a tiny gadget to strap on your wrist or carry in your pocket—will become possible. With it, you will be able to call anybody in the world who is similarly equipped.

A flat-screen TV set that hangs on your wall like a picture will become a reality. Rapid advances in electroluminescence have already come close to making practical a screen only a fraction of an inch thick. Molecular electronics will make it possible to pack the rest of the TV circuitry into a hollow corner of the frame!

There are endless speculations possible on the changes molecular electronics will bring—the probable developments in communications already mentioned are only a few. But who can say what revolutions in medicine, industry, business, government, and other phases of human endeavor will come about?

As with most truly revolutionary advances, molecular electronics will bring about profound changes impossible to predict. We'll be looking forward to them eagerly, however. For certainly, molecular electronics, whatever its contributions, will help shape a better and more exciting world for us all.

April, 1960

---

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PE-4
Transistor Topics
(Continued from page 59)

the detector and \( Q_1 \) to permit feedback
winding \( L_2 \) to provide regeneration,
increasing circuit gain and improving selectivity. Transistor \( Q_1 \)'s base bias is furnished
through \( R_1 \). The amplified audio signal is
applied through regeneration-volume control
\( R_2 \) to \( Q_2 \) which, like \( Q_1 \), is connected
as a common-emitter amplifier. Finally,
\( Q_2 \)'s output drives the magnetic earphones.

Either of these circuits can be assembled
on a conventional chassis or on a Bakelite
or fiber mounting board. Follow good wir-
ing practice, keeping the signal leads short
and direct and observing all d.c. polarities.
Don't install batteries or turn the circuit on
until you have double-checked all connec-
tions for wiring errors and accidental
shorts.

Both circuits give optimum performance
when used with moderate-length (25' to
100') external antennas; a ground connec-
tion is optional. In strong signal areas, a
shorter antenna may give satisfactory re-
results. Moderate-impedance (500- to 2000-
ohm) magnetic earphones should be used.
In the second circuit—Fig. 2(B)—try inter-
changing \( L_2 \)'s connections, as in any regen-
ratively circuit, using the connection which
gives maximum gain.

Product News. With the Citizens Band
"booming," Radio Manufacturing Engi-
nears, Inc. (RME), Washington, Ill., has
introduced a fully transistorized, hand-held
transceiver for use in the Class D Citizens
Band. This compact instrument, about the
size of the familiar "Walkie-Talkie," in-
corporates seven transistors and one diode.

Webster Electric Company (1900 Clark
St., Racine, Wis.), manufacturer of "Tele-
talk" intercoms and "Ekotape" recorders,
has introduced a line of transistorized d.c.
to d.c. power converters. A typical unit,
Type 2D12, has an input rating of 12.6 volts
at 3 amp. and can supply 250 volts d.c. at up
to 100 ma.

Lafayette Radio (165-08 Liberty Ave.,
Jamaica 33, N. Y.) has issued the second edi-
tion of its popular Semi-Conductor Di-
rectory. This useful publication, supplied
free on request, has been expanded to 36
pages and lists the latest in diodes, recti-
fiers, and transistors.

That's it for now, fellows—we'll be back
next month with more news.

Lou
Test Instruments  
(Continued from page 94)

... easily by being coupled too closely to its load. If the coupling is too tight, it may actually stop oscillating. A regenerative receiver, for example, will sometimes refuse to oscillate when it isn't optimumly coupled to its antenna. For this reason, too, almost every transmitter has a buffer stage between its oscillator and power amplifier. 

The buffer eliminates this loading effect by isolating the oscillator and its load from each other. By carefully selecting the capacitors and other components that couple the oscillator and buffer together, the designer can make certain that the oscillator is relatively independent of its load. 

The designer of the Knight circuit in Fig. 5 chose a cathode-follower stage as a buffer to minimize loading effects further. As you probably know, a cathode follower delivers its output signal from its cathode rather than its plate. This results in a very low output impedance, which further minimizes stray capacitance effects.

**Attenuator.** The final circuit in any r.f. signal generator is the attenuator. This circuit is very much like a faucet on a water pipe: its job is to supply any amount of "juice" from a trickle to a torrent. It does this by varying the output voltage from zero to the maximum voltage the generator can produce. For many uses, exact output voltage control isn't necessary. But in some cases—measuring receiver gain is one—the attenuator must be capable of controlling...
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the output very precisely and indicating its level accurately.

Figure 6 shows the attenuator circuit of the EICO Model 315. Switch $S1$ is the
"coarse" or "multiplier" control which selects the general range of output levels.
Potentiometer $R1$ is the fine control which allows continuously variable output voltage within the selected range. The resis-
tance values for the "coarse" control have been chosen so that the output of
switch position 2 is about 10 times as large as position 1, output of position 3 is 10 times
as large as position 2, etc.

Some signal generators have considerably more complex attenuator circuits. Expensive
laboratory instruments designed for high precision work, for example, have attenuators
which include sensitive meters. They indicate the output level far more accurately than is needed for ordinary serv-
vice or experimental work. Such attenuators are also designed to minimize stray capacitance effects, improve the linearity
of the output over the entire range, and keep the output impedance constant
throughout the entire frequency and output level ranges.

At the other extreme, very inexpensive instruments may have only a single vari-
able resistor for an attenuator. While such control is not very precise, it does allow
the output to be varied and is adequate for most everyday purposes. Naturally, r.f. and
a.f. sections, mixers, and other features also vary widely from one instrument to an-
other.

Prices on signal generators run from
under $20 (kits) to as high as about $150 (fully wired). Your choice will depend on
just what you want the instrument to do.

Next month: details on the most common
use of the standard r.f. signal generator—
aligning a receiver.

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Answers to "brightest bulb" problems on page 56.
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(Continued from page 45)
comes virtually non-existent. A radar echo from Venus, minute signals from a star six billion light years away, or a feeble message from a satellite with a small, lightweight transmitter can come right in without competing with amplifier noise.

**Spinning Electrons.** When Dr. Townes invented the maser in 1954, he was not looking for a new type of amplifier. In the process of using radio waves to study the structure of gas molecules, he discovered that the energy of the spinning electrons in the gas could be tapped under certain conditions, and that it would give off microwave radiation similar to radar waves. Eventually he found a way to make the electrons radiate large amounts of energy when stimulated by small amounts, a reaction similar in some ways to a vacuum tube's action in controlling a large current flow with a small signal. Thus, a new amplifier working on an entirely new principle was born.

Dr. Townes' first instrument was a "gas maser," as opposed to the solid-state maser mentioned earlier. One of its first applications was in the world's most accurate atomic clock. Because the energy radiated by the maser's electron spin-vibrates at an extremely constant rate, he was able to build a clock, regulated by these vibrations that was accurate to within one second in a hundred years! With similar clocks, scientists are now measuring the rotation of the earth so accurately that soon we will know if it is actually slowing down, as many think.

The gas maser has also been used to confirm Einstein's theory of relativity concerning the velocity of light. Earlier attempts had been hampered by the lack of a timing device of sufficient accuracy. The maser clock enabled scientists to prove conclusively that the theory was correct.

Although the gas maser operated perfectly in atomic clocks and a few other devices, it was not a particularly efficient amplifier, so investigators began looking around for other materials to which the principle of the maser could be applied. A team of Bell Telephone Laboratories scientists, headed by Dr. H. E. D. Scovil, constructed a series of successful designs which used semiconductor solids, some of them similar to those used in transistors. So far,
synthetic ruby has proved to be one of the more effective materials, and many of today’s atomic amplifiers are made of this material.

**Future Applications.** The maser seems likely to be cast in a starring role when National Aeronautics and Space Administration and Bell Telephone scientists try to transmit high-frequency signals from coast to coast and across the Atlantic by bouncing them off satellites. (See “Communications Satellites—Key to World-Wide TV,” POPULAR ELECTRONICS, March, 1960.) Specially designed maser amplifiers and powerful antennas are now under construction at Bell Labs in New Jersey. And when world-wide TV becomes a reality, the maser will play an important part.

If the space probe scheduled to be fired into orbit around Venus this year is successful, scientists on earth will listen to its cryptic messages with maser receivers. And, of course, masers will be on hand when man himself takes the big step into space and wants to communicate over vast distances back to his home planet.

New uses, some based on startlingly original concepts, are proposed regularly. For example, work has begun on the development of masers operating at frequencies so high that they are actually visible light. Techniques for generating infrared and visible light rays and for transmitting them like radio waves—although still far in the future—may open up entirely new applications for the maser.

Are masers likely to show up in our home TV and radio receivers? Well, there are some tremendous technical problems that have to be solved first. For example, the earth gives off feeble radiations which can jam the super-sensitive maser. Maser devices that have been successful so far overcome this problem by using sharply directional antennas pointed up and away from the earth’s radiation. Consequently, maser-operated home television receivers seem unlikely until the day comes when our TV stations broadcast from satellites.

Although at this time we can only guess where future developments may lead, we can be sure that the maser and its applications will grow increasingly valuable—both here on earth and in the empty vastness of space when man leaves his planet to explore the stars.

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April, 1960
Inside the Tape Recorder
(Continued from page 66)

at a price disadvantage. Tape answered back, though, with new heads that allowed four tracks to be placed side by side on a single tape. However, even four-track stereo tape usually costs more per minute of playing time than does a stereo disc, but many audiophiles feel that the results so far as quality is concerned are worth the difference in price.

Types of Recorders. For semi-professional and home use, tape recorders are available in either two-track or four-track models. Present stereo tape recordings are four-track recordings. The older two-track stereo tapes, as well as all monophonic tapes, can also be played back on the four-track tape machines. Hence, four-track machines are preferred by those who want to reproduce commercial stereo and monophonic tapes, since such machines can handle all present and past types of commercial tapes (except the long-obsolete stereo tapes for "staggered-head" machines).

The simplest types of tape machines are the tape decks which permit tape playback only and have no facilities for recording. They are inexpensive and are used with preamplifiers which equalize and amplify the signal as it comes from the heads of the deck. Decks are available in either two- or four-track types.

Most people, however, like to be able to make recordings as well as play back commercial tapes. Hence, they want a machine that permits recording as well as playback. These machines, too, can be separated into general types: those that permit only monophonic recording and those that permit both monophonic and stereo recording. The ones which permit four-track stereo or monophonic recordings are, of course, the most versatile—and the most expensive.

Tape recorders and decks usually offer a choice of at least two speeds—and sometimes three speeds. Semi-professional and home machines generally offer 7½-ips and 3½-ips and sometimes 1¾-ips speeds. Since it is likely that 3½-ips tapes will eventually be available in prerecorded reels, a machine that has both 7½-ips and 3½-ips speeds is a prudent buy. Furthermore, the 3½-ips speed is an economical speed for home recording, and the quality is good enough for voice and acceptable for some musical re-
cording. As a rule, the 7½-ips speed is suitable only for voice work.

Home-type recorders usually take 7" or smaller reels only. Semi-professional types also accommodate 10½" reels, which hold twice as much tape as 7" reels and give twice the recording and playback time. The semi-professional machines are more complicated, more versatile, yield higher performance, and cost a great deal more than home types—usually well above $300 in monophonic versions, and above $400 in stereo versions. They offer better frequency response, less wow and flutter, usually take 10½" reels, permit more exact editing of the tape, and are more precisely and sturdily built.

During the past year, tape cartridges have been introduced which require no threading and can be slipped on a suitable player as easily as a disc recording is put on a turntable. These cartridges, however, come only in the 3½-ips speed and are four-track types. They can only be used on special tape-cartridge recorders which cannot play the four-track 7½-ips reel-to-reel stereo tapes issued by other record manufacturers. The quality of the tape cartridges is slightly inferior to that of the 7½-ips tapes because of the slower speed.

Manufacturers have a very wide choice of features and facilities which they can incorporate into a tape recorder. Consequently, there are dozens of different types of recorders available, and the buyer is free to choose the one that best fits both his needs and his purse.

Next month we will continue our discussion by examining in detail the basic mechanical systems of modern-day magnetic tape recorders.

April, 1960

---

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Across the Ham Bands
(Continued from page 99)

Antenna terminal. Capacitor C7 is formed by twisting two lengths of insulated wire together for an inch or so. For more control, use a midget 1.2- to 10-µf variable capacitor for C7 such as the Cardwell PL-6000. For best operation, it may be necessary to cut off a portion of the capacitor's plates to lower the minimum capacity. Insulate C7 from the aluminum box, and connect its shaft to a small front panel knob with an insulated flexible coupling.

A midget vernier dial (not visible in the photo) is desirable for precise tuning of capacitor C1. If you don't want to invest in a vernier dial, use as large a knob as you have on hand.

Power the tuner with a separate power supply or "rob" the power from your transformer-operated (a.c.) receiver. You'll need 6.3 volts a.c. at 0.3 ampere and a few milliamps of B+ at 150 volts.

In operation, switch the receiver BFO off and tune in the desired sideband signal on the receiver for maximum output. Adjust tuning capacitor C1 until the signal becomes intelligible. Coupling capacitor C7 should also be adjusted for best performance on each signal.

News and Views

Steve Russell, KN8NHC, 715 Dwillard Drive, Kalamazoo, Mich., probably has the "N" knocked out of his call letters by now. As a Novice, he worked 38 countries in five continents and 46 states, 43 confirmed, in 900 contacts. A Heathkit DX-40 running 75 watts, feeding separate antennas for 80, 40, and 15 meters, and a 22-year-old SX-16 receiver did the trick. Steve has a 25-wpm code certificate and is glad to help prospective hams. . . .

Roger Warren, KN9UHH, 8715 Guilford Ave., Indianapolis, Ind., was formerly K3EWM. In three months with his new call, he has worked 46 states and 30 countries in the six continents using a modified DX-40 and VF-1 VFO. Roger also has three antennas: a Hy-Gain 14-AV vertical on the roof, a 2-element 15-meter beam, and a 150' wire fed through an antenna tuner which was described in Across the Ham Bands. Oh, yes, he got a Hallicrafters SX-101 receiver for Christmas. . . .

Mark Rowland, KN5ST, 1717 East 31st St., N. Little Rock, Ark., operates on 15 and 40 meters. His Heathkit DX-35 and Hallicrafters S-85 receiver have accounted for 650 contacts in 48 states—he needs Montana and Nevada—and all continents except Europe. This record was compiled with two 15-meter antennas eight feet high and a 40-meter dipole. By now, he should have a 3-element 15-meter beam in operation. Mark likes to re-work hams who...
promise to QSL, then don’t, to find out why.

Mike Swink, 8009 Beverly, Prairie Village 15, Kansas, worked all continents—85 countries—and WAS on phone in Dallas, Texas, where he operated as KSHWY. His tools were a Globe Champ transmitter, a National NC-173 receiver aided by an RME DB-23 preslector and separate ground-plane antennas, plus a home-brew 10-meter beam. Now he is starting all over again as KOYVR. . . . Jim Zientara, KMANTV, 1560 Lake Ave, Whiting, Ind., is a lucky ham. He admits he has practically no electrical noise at his location! He must have lots of room, too, because he has four antennas and is planning on a 20-meter beam and a vertical for 80 and 160 meters. He receives on a Hallicrafters SX-101A and transmits on a Heathkit DX-100. You can usually find him either handling traffic on 160 or 75-meter phone or chasing DX on 20-meter c.w. . . . Joe Hauptly, K2CZM, 2245 Western Market St., Pottsville, Pa., calls attention to the typographical error in the January Across the Ham Bands which made the General Class code test speed 12 wpm instead of the correct 13 wpm. Joe uses a Heathkit DX-20 to drive a Globe LA-1 amplifier to about 175 watts on 20-meter c.w. He uses the DX-20 “barefoot” on 40 meters, and receives on a Hallicrafters SX-43. His record is 41 states and “some” DX. Joe offers to schedule anyone needing Pennsylvania, “if anyone needs Pennsylvania.” And he would like to schedule Hawaii. “But who wouldn’t?” he asks.

Bob Wilhelm, WA2AYI, 239 Third Ave., Garwood, N. J., Membership Chairman EASN, invites you to report into the Eastern Area Slow Speed Net, which meets daily at 1800 EST on 3748 kc. Normal speed is 10 to 15 wpm, but they slow down for Novices. The net teaches traffic-handling procedures, and members receive the semi-monthly bulletin “QNC.” Write to Bob for more details. . . . Dale Cochran, K4YBS, 1830 Patton Dr., Eastpoint, Ga., uses a Heathkit DX-100B transmitter and a Hammarlund HQ-129X receiver, a trap dipole antenna, and a 2-element 15-meter beam. He worked 18 counties as a Novice and now has 42 counties. He needs Hawaii and Vermont for WAS. . . . Earl Spencer, K4FQU, 1413 Davis Drive, Ft. Myers, Fla., was a Novice for eight months and worked 45 states and nine countries with a Johnson Adventurer transmitter feeding a 40-meter dipole. His receiver is an Allied Knight R-100. Since getting his General as a Christmas present, Earl has built a screen modulator for his Adventurer transmitter and uses it to drive a Globe LA-1 linear amplifier, giving him about 70 watts output on phone. . . . Bill Berry, K6UNS, 1660 Chatsworth Blvd., San Diego 7, Calif., says he was the last Novice in California to receive a “KN” before the FCC started issuing “WV” calls.

That uses up our space. See you all next month. As always, keep your letters, pictures, “Ham of the Month,” and construction ideas coming. 73,

Herb, W9EGQ

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April, 1960
Crystals

(Continued from page 85)

tor. It operates at the crystal’s fundamental frequency, without tuning or other adjustments.

One of the most popular harmonic-oscillator circuits is shown in Fig. 3. This is the Colpitts or “grid-plate” circuit. As shown, it produces useful power output up to the fourth harmonic of the crystal’s fundamental frequency, if an LC circuit in the output is tuned to the desired output frequency.

There are many types of overtone oscillator circuits. The one shown in Fig. 4 is recommended by International Crystal engineers for use with their overtone crystals in the 15-60 mc. range.

All three of these circuits are stable. Crystal heating—if operating voltages are kept within the limits shown—poses no problem. If you keep in mind that a crystal is intended to control frequency and not to produce power, you’ll have no trouble. Keep power input to the oscillator as low as possible, and let other stages of the equipment provide power output.

In both the Pierce and Colpitts circuits, shunt capacitance affects the crystal’s operating frequency. Values shown for the Colpitts circuit result in about 32 µuf. across the crystal. In either circuit, a small variable capacitor can be connected in parallel with the crystal to adjust the output frequency slightly.

Since the overtone circuit operates differently, additional capacitance across its crystal will have little effect on frequency. If the capacitance is excessive, though, it may keep the oscillator from functioning.

Controlling the frequency of a radio transmitter is but one application of the quartz crystal. Although it operates in a completely different way, a crystal is electrically the same as an extremely efficient LC (or “tank”) circuit. For this reason, a crystal can replace a tank circuit in any low-power installation.

But the major use of quartz crystals today is in transmitter frequency control. Here, they provide precision channels at low cost and enable efficient use of the limited radio spectrum. In fact, these rock-like plates make radio as we know it possible. Their purpose? Keeping the world in tune!
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On the
Citizens
Band

By TOM KNEITEL, 2W165

MANY STATIONS have adopted the APCO “10” signals, that is, the code developed by the Associated Police Communication Officers, Inc. Use of the “10” code saves transmission time and will very often enable you to get your message through some pretty rough noise. Here are some of the commonly used “10” signals.

10-1 Receiving poorly
10-2 Receiving well
10-3 Stop transmitting
10-4 O.K.—acknowledged
10-5 Relay message
10-6 Busy
10-7 Leaving the air
10-8 In service
10-9 Repeat message
10-10 Transmission completed—subject to call
10-11 Speak slower
10-12 Visitors present
10-13 Advise weather/road conditions
10-18 Complete assignment quickly
10-19 Return to station
10-20 What is your location?
10-21 Call me by telephone
10-22 Stand by
10-24 Trouble at station
10-25 Can you contact ______?
10-30 Does not conform to rules and regulations
10-31 I have an emergency message
10-36 Correct time
10-45 Await message
10-92 Your transmission’s poor
10-98 Assignment completed
10-99 Cannot read you
10-101 (Unofficial) Switch to Channel No. ______

Copies of this list should be at your base station and in all mobile units. You, too, can sound like “Highway Patrol!”

The long-awaited “Executive” unit is finally available from International Crystal, and it’s as versatile as you could want a CB set to be. It has three transmit channels, and a dual-conversion superhet receiver with two crystal-fixed positions. The receiver is fully tunable across all 23 CB channels.

The “Exec” is decked out in a fancy bronze-colored cabinet with gold and red trim. But the external features are just the “plus” of the unit; “it’s what’s in back that counts.” And what’s in the back really does count. In fact, you can almost knock a horse over with the signal.

We ran a test with Bill Edwards, 2W4Q6, and made a solid contact for a good 10-mile haul. This was within New

Always say you saw it in—POPULAR ELECTRONICS
York City, being blocked by an adjacent 16-story steel-frame building and using only a mobile whip at street level. Just think, if we fed the “Exec” into a “dual ground plane,” we could probably raise Saturn (oops—no DX’ing on CB).

By the way, “Exec’s” are sold only through dealers and are not available directly from International Crystal.

Speaking of dual g.p.’s, many of you have written asking for information on this antenna, which seems to be gaining popularity by the minute. It’s a nine-element monster; a vertical radiator sticks up on top, four “drooping” radials surround the vertical radiator at its base, and four horizontal radials are a quarter-wave below the “drooping” radials. The antenna has a low angle of radiation and will add 3 db to your signal. Esso makes it.

Just for the record, you are not allowed to “pull-out and plug-in” crystals to change frequencies. You must have a properly filled-in Transmitter Identification Card (FCC Form 452-C) attached to each CB transmitter. And you should not try to soup up your rig by substituting “hot shot” audio tubes, capacitors, and other gizmos.

And never, never let an unqualified person poke around your rig’s innards for any purpose whatsoever. A ham is not qualified to tune a CB transmitter. Neither is a TV serviceman. Nor is Uncle Elbert who might be a whiz at finding water with a bent twig, and can fix a TV set better than “any of those service guys.” Fooling around with your unit cancels the manufacturer’s warranty.

Last month’s news-flash about the unofficial selection of two CB channels (9 and 13) for marine use was probably welcome news for the many sportsmen who have wanted to stick a rig aboard the ol’ “Nellie Belle” but didn’t know which channels to utilize. Choosing the two channels was no easy task. For one reason or another, just about every one of the 23 CB channels was a problem child—1 was too low, 11 was too jammed, 23 was loaded with R/C, 8 was too crowded in Podunk, and so on.

The main thing is—let’s all cooperate and get the most out of these two channels by using them properly. This also holds true for land stations utilizing Channel 9, which is now the unofficial national CB calling channel.

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PE-460

Dr. Glenn’s Magic Wrinkles
(Continued from page 55)

in a liquid state, the charged areas are electrostatically attracted to the base, wrinkling the surface. A few thousandths of a second later, the tape cools, re-hardens, and the wrinkles are “frozen” into a permanent pattern. (For re-use, the tape is heated again, and normal surface tension smooths out the wrinkles.)

Reproduction. “Playback” is through any conventional slide projector or movie projector which has undergone a simple modification. The playback system is shown in Fig. 3. If the film has no wrinkles and thus is perfectly flat, the line light sources and bars are arranged so that they exactly cancel each other. No light gets through to the screen.

But a single ripple on the film, as at point “A,” will diffract the top beam (shown in the diagram by the dashed line). This beam will then miss the bars and shine on the screen. Therefore, a single ripple will appear as a single line of light across the screen. And a series of ripples arranged in a pattern to form a picture will diffract the beams in such a way that they project a replica of the ripple pattern on the screen.

The color projector operates on a similar, but more complex, principle. The ripples here are designed to break the beams into a color spectrum in the same way a prism turns a beam of sunlight into many hues. A system of bars screens out all the unwanted colors.

Compact and Simple. TPR equipment promises to be significantly smaller and simpler than any recording device that can even begin to approach its capabilities. The prototype machine constructed by Dr. Glenn is built into a standard relay rack 6” tall and 18” wide. But this is an experimental machine. According to Dr. Glenn, simply rebuilding the same machine in more compact form would reduce it to about one-half its present size. Or, to put it another way, it would be smaller than many of today’s studio-type sound tape recorders. Further development will no doubt reduce the size still more. And although General Electric won’t predict future price tags for TPR equipment, there is every indication that it should cost far less than today’s complex video recorders.

What might reductions in size and price bring about? First, of course, every TV
station would be able to afford TPR equipment. Every university, industry, advertising agency, or organization that now uses movie film would consider changing to this more convenient—and perhaps cheaper—form of recording images. Howard A. Chinn, chief engineer of CBS Television, predicts that even movies may someday switch to TPR. Using this system, a director would handle entire productions from a central console, watching all scenes from several camera angles and editing the film as he goes.

As a possibility for the more remote future, a portable TPR system might be designed making use of a vidicon or similar lightweight camera, with a complete recorder so compact that it could be carried by the operator! The volume-storage capabilities of the machine would make it possible to record hours of material in one "take."

Tremendous Potential. Defense planners are excited about the possibilities of TPR in a number of fields. For example, satellites used to record Signal Corps messages from one ground station and play them back thousands of miles away would be able to handle far more information with TPR—video signals, for instance.

Missile guidance by "map-matching" techniques is another possible use for TPR. In this system, a "movie" of the path a missile is supposed to follow is played back by TPR inside the missile during its flight. At the same time, an optical system scans the earth below and the stars above. An electronic "brain" compares the pictures from the tape and the optical system. If there is any difference, it acts to bring the missile back to the correct flight path as indicated by the tape.

TPR will extend the range and reliability of radar by a method known as "optical correlation." Briefly, both the outgoing signal and the returning echoes are recorded, then compared for similar characteristics. Sometimes when returning signals are very weak, true echoes cannot be separated from background noise. With optical correlation, they are easily identified.

Large-screen displays of radar, sonar, and infrared signals will become possible. At present, when large numbers of people want to view these images simultaneously, they must use either hand-plotted boards or

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FEATURES

- Dual channel, crystal or ceramic phono and tuner inputs; ganged gain control; balance control; speaker reverse switch; two separate tone controls; monaural-stereo switch; transformer power supply for complete line isolation.

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Each frame of a thermoplastic recording is less than a quarter of an inch wide and fits inside a paper clip. This photo was obtained by lighting the film from an angle, making it possible to view the film's surface modulation, or wrinkle pattern.

photographic enlargements. Either method involves delay. But with TPR, a recording of a radarscope can be made and the playback projected on a large screen a fraction of a second later.

With military TPR going into action within a year and commercial versions likely to appear shortly afterwards, the typical consumer wants to know when thermoplastic recording will be available for home and hobby use. Not any time soon, to be sure. As with any new system that works on an entirely different principle, a great deal of refinement and simplification must take place before it becomes practical.

For instance, even though video recording has been around for several years, home video tape recorders are not available. Undoubtedly the same thing will be true of TPR. Even so, it seems to be better suited for the consumer market, since it will probably be cheaper and simpler than magnetic tape video recording.

You may not have your own personal TPR machine for a few years, but you will soon begin to feel the effects of this new medium. As it plays back the television programs you watch, records the information you need on the job, and helps defend our country, Dr. Glenn's thermoplastic recording, with its "magic wrinkles," will play an important part in the life of our nation.
Short-Wave Report
(Continued from page 100)

hoping to receive, in return, a verification from the station.

We cannot condone this method of sending reports to stations. It is, to put it mildly, an act of bad faith on the part of the Monitor. The report serves no purpose whatever to the station receiving it and can only result in the SWL hobby acquiring a bad reputation. As we have pointed out before, reports to stations must be accurate. They must be based only on actual listening time. And they should also include certain other items which will help stations to know, without doubt, that you actually heard them. Our Verification Leaflet lists suggested methods for preparing reports.9

Incidentally, upon receiving Mr. Yaskal's second letter, we immediately contacted the Monitor in question, whom we knew only as being one of our newer members. In return we received his assurance that the report had been sent in haste and without due consideration of the possible consequences and, further, that such a report would never again be sent.

SWL News. Did you get your copy of the 1960 World Radio Handbook yet? It's available for $2.70. The summer supplement can be obtained at a later date for $1.00. The WRH Bulletin is available (via air mail) for $1.50 for three months or $5.65 for one year, and the booklet entitled "How To Listen To The World" is priced at $1.00. All orders should go to Gilfer Associates, P. O. Box 239, Grand Central Station, New York 17, N. Y., and not to Your Editor or to Popular Electronics.

We've received many replies to our query in the January column regarding the full name of Mr. Lord and his sailing ship. Phillips Lord was the name and the schooner was the "Seth Parker," operating on 8840 kc. with the call letters KNRA.

A new publication in the SWL-FM-TV field is "DXing Horizons," published monthly by Robert B. Cooper, Jr., 820 Tully Rd., Modesto, Calif. Its Short-Wave Editor is Ken Boord, 948 Stewartstown Rd., Morgantown, W. Va., and its FM Editor is Bruce Elving, 920 Laramie St., Manhattan, Kan.

* The Verification Leaflet, as well as other leaflets listing clubs, publications, time zone conversion, and reporting codes can be obtained from your Short-Wave Editor. Please send your request to P. O. Box 254, Haddonfield, N. J., enclosing a postage stamp to help defray postal expenses.

April, 1960

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sas. The TV column is currently being
handled by staff members of the magazine.

The Universal Radio DX Club has
announced the appointment of C. M. Stan-
bury, II, Box 218, Crystal Beach, Ontario,
as Eastern Short-Wave Editor. Mr. Stan-
bury is known to many as an expert in the
commercial and utility station category,
especially in the 2000- to 4000-kc. range.

Current Station Reports

The following is a resumé of the current reports.

Afghanistan—Kabul has been noted on 5975
kc. from 0800 s/on to 0830 s/off with native
musical numbers and vocals and ID’s in sev-
eral languages including English. Reports go
to: Technical Department, Radio Kabul, Ka-
bul. (WPE4BC, WPE9KM)

Bogotá—A station in R. Raqueta Pinto,
Av. Almirante Barroso 81, Rio de Janeiro,
9515 kc. Reported opening at 0600. The exact
schedule is requested. (WRL)

Bulgaria—Sophia, 9700 kc., has Eng. to N.A.
at 2000-2030 and 2300-2330 with a “Mailbag”
period on Thursdays and Sundays and a DX
program on the first Friday of each month.
A daily concert is aired from 1800 to 1830. An-
other Eng. period is noted at 1430. Reports
are made to: English Language Broadcast, Radio
Soja, Bulgaria. (WPE4BEI, WPE8KE, WPE-
9DN, WPE9EW)

China—Yunnan has moved from 9992 to
10,034 kc. Fair at 0740 with native language
program, it fades rapidly by 0800. (WPE3NF)

Colombia—HJKP, La Voz de Bogota, Bogota,
5960 kc., has “Sunday Evening Show” in Eng.
and Spanish on Sundays at 2100-2230. A new
station is R. El Sol Cali, 6118 kc., noted at
2300 with music and commercials. (WPE9KM)

Czechoslovakia—Czechoslovakia operates to N.A.
and the Near East at 1930-2000 on 9550, 11,745,
and 11,840 kc., at 2200-2300 on 9550 and 11,745
kc., at 0000-0330 on 9665 and 11,840 kc., and
at 0330-0430 on 11,840, 15,185, and 21,450 kc.
The 7340-kc. outlet was used for several weeks
recently. A program for SWL’s is broadcast on
the first and third Thursdays of each month
at 1930 and 0000 and on the first and third
Fridays at 2200 and 0330. (WPE1GO, WPE1-
HA, WPE1YI, WPE24FK, WPE2BDU, WPE2-
BVP, WPE3AWB, WPE4AMC, WPE4BC,
WPE4BEI, WPE4EC, WPE5AG, WPE6EZ,
WPE7QN, WPE8HF, WPE9CT, WPE901,
VE1PE2U)

Danmark—Copenhagen operates to N.A.
daily in Eng. on 9520 kc. at 2030-2130 and
2200-2300. (WPE8AGL)

Ecuador—“Caribbean Call,” a feature of

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African Station Report

At the end of World War II, in 1945, there were only four independent states in Africa: Egypt, Liberia, Ethiopia, and South Africa. Now the ever-growing rolls of freedom have expanded to include Morocco, Tunisia, Guinea, Ghana, Sudan, and Cameroon. Added to these are the French Autonomous (self-governing) Republics of Malagasy (Madagascar), Gabon, Congo, Central African Republic, Chad, Niger, Dahomey, Ivory Coast, Voltaic Republic, Senegal, Mauretania, and the Comoro Islands. Slated for independence in 1960 are Togoland (April 27), Somalia (July 1), and Nigeria (Oct. 1). The following is a list of some of the African stations which have been heard recently; the numbers in bold face are the frequencies in kilocycles.

3322—CR7BW, Lourenco Marques, Mozambique, was noted from 1632 to 1702 s/off with pop dance music, dual to 4840 kc.

4815—Ouagadougou, Upper Volta, logged from 1620 to 1631 s/off with pop music and French announcements.

4855—VQ7LO, Nairobi, Kenya, heard with 1500/closing; not dual to 4885 kc.

4875—Cotonou, Dahomey, which moved here from 4870 kc., closes at 1600; also noted s/on at 0030 but not too strong.

4955—R. Mali, Dakar, French West Africa, has moved to this spot and is strong at 0307/closing.

4981—UFAC, Elizabethville, Belgian Congo, now closes Saturdays at 1600 with a march number; audible from 1530 with instrumental dance music and French anmats. Elizabethville is also tuned on 5951 kc. (a move from 5933 kc.) at 1450 with native vocals.

5040—Libreville, Gabon, 5040 kc., is audible some days from 1530, mostly with native music. Closing seems to be 1600 weekdays, 1700 Saturdays.

5045—Lome, Togo, has moved from 5036 kc., and is good at 0105 and 1600 in French.

6608—Benghazi, Libya, normally s/off at 1615, may run longer on holidays.

This special report was compiled by Charles Sutton (CS) and George Cox (WPE3NF).

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on 11,795 and 9640 kc., and at 2200-0115 (Eng. at 2300-2320) on 11,495 and 11,795 kc. A xmn in to the Near East with ID's in several languages, including Eng., is noted at 0930-1240 on 17,875 kc. (WPEIBY, WPEIHA, WPE4MM, WPE8ANI, WPE0ADY, VE2PEIH, VE7PE2Y) According to QSL Card, Bayerischer Rundfunk (Bavarian Broadcasting) is on 6085 kc. at 2330-0350 and 0430-1900 on Mondays, Wednesdays, and Fridays, at 2300-1900 Tuesdays, Thursdays, and Saturdays, and at 0000-1900 Sundays. (WPE1BM)

SDR, Muhlaeker, 6030 kc., is noted at 0120-0145 with violin recital, at 0145-0200 with a piano recital. German news follows, then more classical music. (MM)

Ghana—Accra carries Eng. at 1630-1715 on 4915 kc. and at 0100-0115 on 3368 kc. Careful tuning is a "must" on both channels. (WPE3-FZ, WPE8BCW)

Goo—R. Goo is scheduled at 2030-0430 and 0600-1230 with Eng. at 0130-0330 and 0930-1030 on 4650 and 9610 kc. A new 50-kw. xmtr may be in operation by the time you read this, watch for it in the 49-, 41-, and 16-meter bands. (WPEIBY, WRH)

Haiti—R. Lumiere, 4VO, Aux Cayes, is now operating on 6093 kc., dual to 3322 kc., at 0650-2130 on Sundays and at 0530-0800 and 1700-2130 Monday through Saturday, with best reception at 0530-0700 and 2000-2130. Another new outlet is 4VAB, R. Caribe, Port-au-Prince, 6025 kc., noted with good signal at 0635 with music and 0645 with news. (WPE2LH)

4VRW, R. Haiti, Port-au-Prince, has been noted irregularly on Sundays on 10,150 kc. with French music at 1730-1800. (CS)

4VEH, Cap Haitian, has Eng. at 0445-0600, 0800-1000, 1500-1715 (Sunday), at 2000-2200 (Saturday, Sunday, Monday) and at 2200-2300 (Sunday, Monday) on 9770 and 6000 kc. (WPE1KR, WPE8AGB, DC)

Hungary—Budapest is scheduled currently at 1900-2000 and 2200-2330 on 11,910 and 9833 kc. to N.A., and at 0700-0800 on 21,685 kc. to Australia/New Zealand. (PG)

India—Delhi has Eng. at 1445-1545 on 17,790, 15,105, 11,710, and 9590 kc. and Eng. and Burmese at 1930-1950 on 15,280 and 11,895 kc. (WPE9DN)

All-India Radio's Hyderabad outlet on 4988 kc. has been tuned at 0743 with native language news and at 0745 with native music. (WPE3NF)

Indonesia—Djakarta was found on 9595 kc. (YD6P) at 0930-1010 with music and frequent ID's. They are asking for reports. (WPE4BC)

Iran—R. Teheran may now be operating 24 hours daily on 3780, 7288, and 9680 kc. The 9659-kc. channel will also be in use from 1515

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**SHORT-WAVE ABBREVIATIONS**

amnt—Announcements
Eng.—English
ID—Identification
IS—Interval signal
kc.—Kilocycles
xmn.—Transmission
xmrtn.—Transmitter

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FOR REPAIRING ALL ELECTRICAL APPLIANCES and AUTOMOBILE CIRCUITS

As an electrical trouble shooter the Model 70:
- Will test Toasters, Toaster Ovens, Broilers, Heating Pads, Clocks, Fans, Vacuum Cleaners, Refrigerators, Lamps, Fluorescents, Switches, Thermostats, etc.
- Measures A.C. and D.C. Voltages, A.C. and D.C. Current, Resistances, Leaks, etc.
- Will measure current consumption while the appliance under test is in operation.
- Incorporates a sensitive direct-reading resistance range which will measure all resistances commonly used in electrical appliances, motors, etc.
- Leakage detecting circuit will indicate continuity from zero ohms to 5 megohms (5,000,000 ohms).

As an Automotive Tester the Model 70 will test:
- Both 6 Volt and 12 Volt Storage Batteries + Generators + Starters + Distributors + Ignition Coils + Spark Plugs + Carburetors + Engine Breakers + Cigarette Lighters + Stop Lights + Condensers
- Directional Signal Systems + All Lamps and Bulbs + Fuses + Heating Systems + Horns + Also will locate poor grounds, breaks in wiring, poor connections, etc.

**INCLUDED FREE**

This 64-page book—practically a condensed course in electricity. Learn by doing.

Just read the following partial list of contents: What is electricity? + Simplified version of Ohms Law + What is wattage? + Simplified wattage charts + How to measure voltage, current, resistance and leakage + How to test all electrical appliances and motors using a simplified trouble-shooting technique. + How to trace trouble in the electrical circuits and parts in automobiles and trucks.

Model 70 comes complete with 64 page book and test leads

$15.85

Only

Superior’s New Model TV-50A GENOMETER

**Signal Generators in One!**

- R.F. Signal Generator for A.M.
- Bar Generator
- Marker Generator
- R.F. Signal Generator for F.M.
- Cross Hatch Generator
- Audio Frequency Generator
- Color Dot Pattern Generator

This versatile All-Inclusive GENERATOR Provides ALL the Outputs for Servicing: A.M. Radio + F.M. Radio + Amplifiers + Black and White TV + Color TV

R.F. SIGNAL GENERATOR: The Model TV-50A Generator provides complete coverage for A.M. and F.M. alignment. Generates Radio Frequencies from 100 Kilocycles to 60 Megacycles on fundamentals and from 60 Megacycles to 180 Megacycles on power harmonics.

VARIABLE AUDIO FREQUENCY GENERATOR: In addition to a fixed 480 cycle sine-wave audio, the Model TV-50A Generator provides a variable 360 cycle to 20,000 cycle peaked wave audio signal.

MARKER GENERATOR: The Model TV-50A includes all the most frequently needed marker points. The following markers are provided: 189 Kc., 282.5 Kc., 456 Kc., 600 Kc., 1000 Kc., 1400 Kc., 1600 Kc., 2000 Kc., 2500 Kc., 3510 Kc., 4.3 Mc., 5 Mc., 16.7 Mc. (3379 Kc. is the color burst frequency).

BAR GENERATOR: The Model TV-50A projects an actual Bar Pattern on any TV Receiver Screen. Patterns will consist of 4 to 16 horizontal bars or 7 to 20 vertical bars.

DOT PATTERN GENERATOR (FOR COLOR TV): Although you will be able to use most of your regular standard equipment for servicing Color TV, the one addition which is a "must" is a Dot Pattern Generator. The Dot Pattern projects on any color TV Receiver tube by the Model TV-50A will enable you to adjust for proper color convergence.

The Model TV-50A comes absolutely complete with Sendead leads and operating instructions. Only $47.50

USE APPROVAL FORM ON NEXT PAGE

We invite you to try before you buy any of the models described on this and the following pages. If after a 10 day trial you are completely satisfied and decide to keep the Tester, you need send us only the down payment and agree to pay the balance due at the monthly indicated rate.

Moss Electronic, Inc.

Dept. D-721, 3849 Tenth Avenue, New York 34, N.Y.

Printed in U.S.A.

Popular Electronics
TRY FOR 10 DAYS before you buy! then if satisfactory pay in easy, interest free, monthly payments. See coupon below.

SUPERIOR'S NEW MODEL 83 C.R.T. TESTER Tests and Rejuvenates ALL PICTURE TUBES

ALL BLACK AND WHITE TUBES
From 50 degree to 110 degree types— from 8" to 30" types.
- Model 83 is not simply a relabeled black and white C.R.T. Tester with a color adapter added; Model 83 employs a new improved circuit designed specifically to test the older type black and white tubes, the new type black and white tubes and all color picture tubes. Model 83 provides separate filament operating voltages for the older 6.3 types and the newer 8.4 types.
- Model 83 employs a 4" air-damped meter with quality and calibrated scales. Model 83 properly tests the red, green, and blue sections of color tubes individually—for each section of a color tube contains its own filament, plate, grid, and cathode.
- Model 83 will detect tubes which are apparently good but require rejuvenation. Such tubes will provide a picture seemingly good.

Model 83—C.R.T. Tube Tester
Total Price $38.50
Terms: $8.50 after 10 day trial, then $6.00 monthly for 5 months if satisfactory. Otherwise return, no explanation necessary.

ALL COLOR TUBES
Test all picture tubes—in the carton—out of the carton—in the set! but lacking in proper definition, contrast and focus. To test for such malfunction, you simply press the rej. switch of Model 83. If the tube is weakening, the meter reading will indicate the condition. Rejuvenation of picture tubes is not simply a matter of applying a high voltage to the filament. Such voltages improperly applied can strip the cathode of the oxide coating essential for proper emission. The Model 83 applies a selective low voltage uniformly to assure increased life with no danger of cathode damage.

Housed in handsome portable saddle-stitched Texon case, complete with sockets for all black and white tubes and all color tubes. Only

Model TW-11—Tube Tester
Total Price $47.50
Terms: $11.50 after 10 day trial, then $6.00 monthly for 6 months if satisfactory. Otherwise return, no explanation necessary.

STANDARD PROFESSIONAL TUBE TESTER
- Tests all tubes, including 4, 5, 6, 7, Octal, Lockin, Hearing Aid, Thyratron, Microphones, Sub-minuters, Nobs, Sub-miners, Proximity Fuse Types, etc.
- Uses the new self-cleaning Lever Action Switches for individual element testing. All elements are numbered according to pin-number in the R.M.A. base numbering system. Model TW-11 does not use combination type sockets. Instead individual sockets are used for each type of tube. Thus it is impossible to damage a tube by inserting it in the wrong socket.
- Free-moving built-in chart provides complete data for all tubes. Printed in large easy-to-read type.

NOISE TEST: Phone-jack on front panel for plugging in either phones or external amplifier detects microphonic tubes or noise due to faulty elements and loose internal connection.

EXTRAORDINARY FEATURE—SEPARATE SCALE FOR LOW-CURRENT TUBES Previously, on emission-type tube testers, it has been standard practice to use one scale for all tubes. As a result, the calibration for low-current types has been restricted to a small portion of the scale. The extra scale used here greatly simplifies testing of low-current types.

Housed in handsome, saddle-stitched Texon case. Only

Moss Electronic, Inc.
Dept. D-721 3849 Tenth Ave., New York 34, N.Y.

Please send me the units checked off approval. If completely satisfied I will pay on the terms specified with no interest or finance charges added. Otherwise, I will return after a 10 day trial positively cancelling all further obligation.

Model 70—Total Price $15.85 $3.85 within 10 days. Balance $6.00 monthly for 3 months.

Model TV-S5A—Total Price $47.50 $11.50 within 10 days. Balance $6.00 monthly for 6 months.

Model TW-11—Total Price $47.50 $11.50 within 10 days. Balance $6.00 monthly for 6 months.

Model 83—Total Price $58.50 $8.50 within 10 days. Balance $6.00 monthly for 5 months.

Model 77—Total Price $42.50 $12.50 within 10 days. Balance $6.00 monthly for 5 months.

Model 79—Total Price $38.50 $8.50 within 10 days. Balance $6.00 monthly for 5 months.

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NO INTEREST OR FINANCE CHARGES ADDED! If not completely satisfied, you are privileged to return the Tester to us, cancelling any further obligation.

SEE OTHER SIDE
CUT OUT AND MAIL TODAY!
Superior’s New Model 77 VACUUM TUBE VOLTMETER

With NEW 6" FULL-VIEW METER

Compare it to any peak-to-peak V. T. V. M. made by any other manufacturer at any price!

- Extra large meter scale enables you to print all calibrations in large easy-to-read type.
- Employs a 12AU7 as D. C. amplifier and two 9000’s as peak-to-peak voltage rectifiers to assure maximum stability.
- Meter is virtually burn-out proof. The sensitive 400 ohm 77-VACUUM METER...___.
- For necessary.
The model 77 is indispensable in Hi-Fi Amplifier servicing and a must for Black and White and color TV Receiver servicing where circuit loading cannot be tolerated.

As an ELECTRONIC OHM-METER: Because of its wide range of measurement leaks, capacitors show up glaringly. Because of its sensitivity and low loading, intermittent are easily found, located and repaired.

As an AC VOLTMETER: Measures RMS values if sine wave, and peak-to-peak values if complex wave. Pedestal voltages that determine the “black” level in TV receivers are easily read.

Model 77—VACUUM TUBE VOLTMETER... Total Price... $42.50
Terms: $12.50 after 10 day trial, then $6.00 monthly for 5 months if satisfactory. Otherwise return, no explanation necessary.

SUPERIOR'S NEW MODEL 19 SUPER-METER WITH NEW 6” FULL-VIEW METER

A Combination VOLTM-OMH MILLIAMMETER

Plus CAPACITY, REACTANCE, INDUCTANCE & DECIBEL MEASUREMENTS

Also Tests SELENIUM & SILICON RECTIFIERS, SILICON & GERMANIUM DIODES

The model 19 represents 20 years of continuous experience in the design and production of SUPER-METERS, an exclusive SICO development. It includes not only every circuit improvement perfected in 20 years of specialization, but in addition includes those services which are "musts" for properly servicing the ever-increasing number of new components used in all phases of today’s electronic products.

SPECIFICATIONS:
- D.C. VOLTS: 0 to 7.5/15/75/150/750
- A.C. VOLTS: 0 to 15/30/150/300
- 1,500/3,000
- 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: 0.1 to 1 Mfd., 1 to 50 Mfd.
- REACTANCE: 50 to 5,000 Ohms. 2,500 Ohms to 2.5 Megohms. INDUCTANCE: 0.1 to 7 Henrys. 7 to 7,000 Henrys.
- DECIBELS: —6 to +15. +14 to +38. +34 to +58. The following components are all tested for QUALITY at appropriate test potentials. Two separate BAD-GOOD scales on the meter are used for direct readings. All Electrides, germanium rectifiers to 1000 Ma. MPD, All Germanium Diodes. All Selenium Rectifiers. All Silicon Diodes. All Silicon Rectifiers.

Model 19 comes complete with operating instructions, probe leads, and streamlined carrying case. Operates on 110-120 volt 60 cycle. Only...

SUPERIOR'S NEW MODEL 19 SUPER-METER WITH NEW 6” FULL-VIEW METER

The model 19 represents 20 years of continuous experience in the design and production of SUPER-METERS, an exclusive SICO development. It includes not only every circuit improvement perfected in 20 years of specialization, but in addition includes those services which are "musts" for properly servicing the ever-increasing number of new components used in all phases of today’s electronic products.

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- D.C. VOLTS: 0 to 7.5/15/75/150/750
- A.C. VOLTS: 0 to 15/30/150/300
- 1,500/3,000
- 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: 0.1 to 1 Mfd., 1 to 50 Mfd.
- REACTANCE: 50 to 5,000 Ohms. 2,500 Ohms to 2.5 Megohms. INDUCTANCE: 0.1 to 7 Henrys. 7 to 7,000 Henrys.
- DECIBELS: —6 to +15. +14 to +38. +34 to +58. The following components are all tested for QUALITY at appropriate test potentials. Two separate BAD-GOOD scales on the meter are used for direct readings. All Electrides, germanium rectifiers to 1000 Ma. MPD, All Germanium Diodes. All Selenium Rectifiers. All Silicon Diodes. All Silicon Rectifiers.

Model 19 comes complete with operating instructions, test leads, and streamlined carrying case. Operates on 110-120 volt 60 cycle. Only...

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NO INTEREST OR FINANCE CHARGES ADDED!
If not completely satisfied, you are privileged to return the Tester to us, cancelling any further obligation.

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