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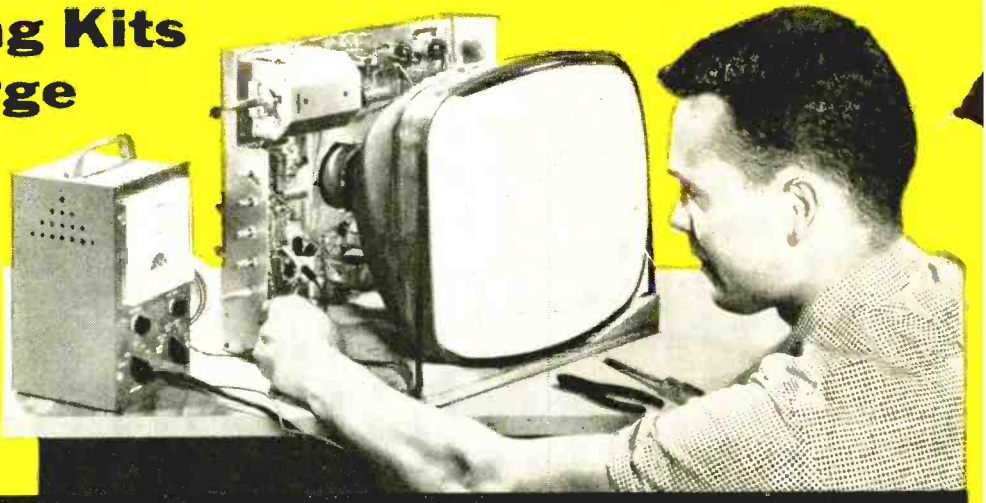

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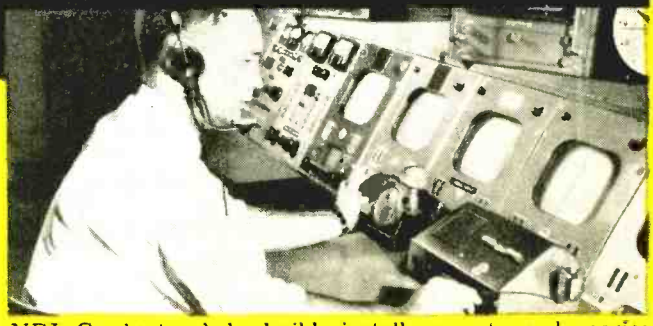

NRI Graduates help build, install, operate and service electronic equipment for the "Space Age" we live in—equipment used in offices, factories, the military. Others are inspectors, laboratory technicians, etc., or work with the Government and Armed Forces.

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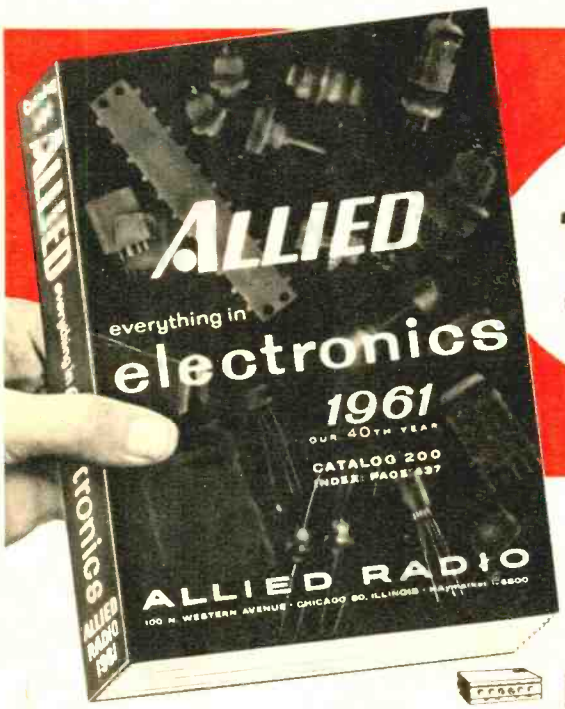

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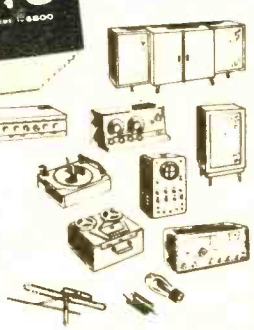

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ELECTRONICS ILLUSTRATED

January, 1961 Vol. 4, No. 1

A Fawcett Publication

CONTENTS

16 PAGE FEATURE

FEATURE ARTICLES

BUILD-IT PROJECTS

ELECTRONICS ILLUSTRATED is published monthly by Fawcett Publications, Inc., Fawcett Place, Greenwich, Conn. W. H. Fawcett, Jr., President; Gordon Fawcett, Secretary and Treasurer; Roger Fawcett, General Manager; Roscoe K. Fawcett, Circulation Director; Donald P. Hanson, Assistant General Manager.

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Are you the kind of guy who loves to "tinker" with things?

And are you completely satisfied with your present kind of work, income, prospects? If these questions "hit home," here's a big fact to realize: OVER 400 MILLION electrical appliances are in use in American homes — and are increasing by 76 MILLION a year! Men trained to service them are cashing in on this "Electrical Appliance Boom" — making $3 to $5 an hour, spare time or full time. It will pay you to send for the FREE BOOK telling how you can quickly and easily get into this profitable field.

YOU'RE NOT TOO HAPPY in your present job — right? Not enough money. Work not interesting enough. Don't like the people you work with.

What you *really* enjoy is puttering around the house, getting things shipshape. Fixing that doorbell or squeaky hinge. Putting a new washer in that leaky faucet. Getting the motor of that balky power lawn mower to run smooth as silk.

And sometimes you wonder, "Why can't I do something like this all the time? Why can't I get PAID for doing what I really enjoy — instead of what bores me? Why can't I start some sort of little home business that would be fun and profitable?"

This is "Made to Order" for You

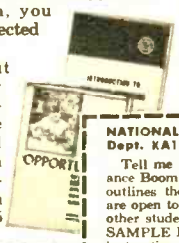
If that's the kind of fellow you are, here's a little business that's "made to order" for you. Servicing Electrical Appliances. No big investment or elaborate equipment needed. A few simple hand tools are all you need — and a corner of your basement or garage to work in.

Plenty of money to be made — $3 to $5 an hour, in spare time or full time. At that rate, you may soon find it will pay you to open up your own Appliance Repair Shop. Then you're completely your own boss. Maybe even end up having other fellows work for *you!*

Why the Boom in Appliances Means Money in Your Pocket

In addition to the 400 MILLION electrical appliances *already* in use in American homes, this year alone will see sales of 76 million *new* appliances! For example, 4,750,000 new coffee makers, 2,000,000 new room air conditioners, 1,425,000 new clothes dryers. And now that Americans have become so absolutely dependent on these electrical aids, they are dependent on the men who can service them. As a trained Appliance Service Technician, you will be needed – respected – well paid.

Don't worry about how little you may now know about electricity. That's where we come in. We'll train you at home, in your spare time, using methods proven successful for over 45 years. We start from scratch, TELL you clearly and SHOW you in pictures everything you need to know. Your training will cost you less than 20¢ a day – and you can earn while you learn.



EARN WHILE YOU LEARN

with this APPLIANCE TESTER—Yours at No Extra Charge

Your NRI Course comes *complete* with all the parts to assemble a sturdy, portable Appliance Tester that helps you earn while you learn. Easy-to-follow manual tells how to assemble and use the Tester *right away*. Locate faulty cords, short circuits, poor connections, etc. in a jiffy; find defects in house wiring, measure electricity used by appliances; many other uses.

With this Tester you save time and make money by doing jobs quicker, making sure appliances operate correctly after repairs.

CASH IN ON THE BIG BOOM IN ELECTRICAL APPLIANCES

The coming of the auto created a multi-million dollar service industry, the auto repair business. Now — with 400 MILLION electrical appliances in American homes — the same thing is happening in *that* field. No wonder that men who know how to service them properly are making $3 to $5 an hour — in spare time or full time!

FREE BOOK *and Sample Lesson*

Our 24-page Free Book will open your eyes to a whole world of new opportunities. Tells how you can "cash in" on America's "Electrical Appliance Boom" – the money our students are making, what they say about us.

Free Sample Lesson shows how simple and clearly illustrated our instruction is – how it can quickly prepare you for a profitable future in this big field. Just mail coupon, letter, or postcard to: *National Radio Institute, Dept. KA1, Washington 16, D.C.* (No obligation – and no salesman will call on you.)

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"In one month I took in approximately $648 of which $510 was clear. I work only part time. I do a lot of service calls on ranges, dryers, and other major appliances . . . . The NRI course has been priceless to me."—*Earl Reid, RFD 1, Thompson, Ohio.*

Business A Success

"Since taking your course I have opened up a small repair shop. At present I am operating the shop on a spare time basis – but the way business is growing it will be a very short time before I will devote my full time to the shop." – *J. G. Stinson, 1506 Poinsettia St., Long Beach, Cal.*

More Than Doubled Cost of Course

"I had practically no knowledge of any kind of repair work. Now I am busy almost all my spare time — and have more and more repair work coming in. I have my shop in basement. I have made more than double the cost of training." — *John D. Pettis, 172 N. Fulton, Bradley, Illinois.*

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Tell me how I can "cash in" on the "Electrical Appliance Boom." Send me your illustrated FREE BOOK that outlines the whole NRI Course, tells what opportunities are open to me, answers my questions, describes success of other students, and much more. Also send me the FREE SAMPLE LESSON so I can see how clear and easy your instructions are. I am particularly interested in:

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Electronics in the news

Meals by Remote Control

This is about the time each year that the giant appliance manufacturers unveil their annual "house of the future" and invite all housewives to take a peek. Well, Westinghouse is right on time with its new "Experimental" kitchen of the future which this time has cold cabinet drawers, each drawer at a different temperature, instead of a refrigerator of the conventional kind. These drawers are cooled by thermoelectric elements.

The kitchen has a method of operating the oven, heating the air conditioning units and other appliances by *telephone*. When the home owner leaves the house, she sets the special control unit to "automatic." Then from any dial phone in the U. S. she dials her home number and a special numerical code for any appliance and specific setting.

—o—

Electronics and Beer (!)

A critical problem resulting from a labor agreement has just been solved by electronics. Automatic controls at the Ruppert breweries in New York have made possible the continuation of that company's normal four-brew schedule for each eight hours when a labor contract change from eight-hour to seven-hour shifts went into effect.

—o—

Good Bye to "Hello" Girls?

Look for person-to-person long-distance telephone calls to go automatic in the near future. So successful have been the little publicized experiments with direct person-to-person dialing between New York City and Poughkeepsie, N. Y., that the American Telephone and Telegraph Company is sold on extending the service. The days of the long-distance operator are numbered!

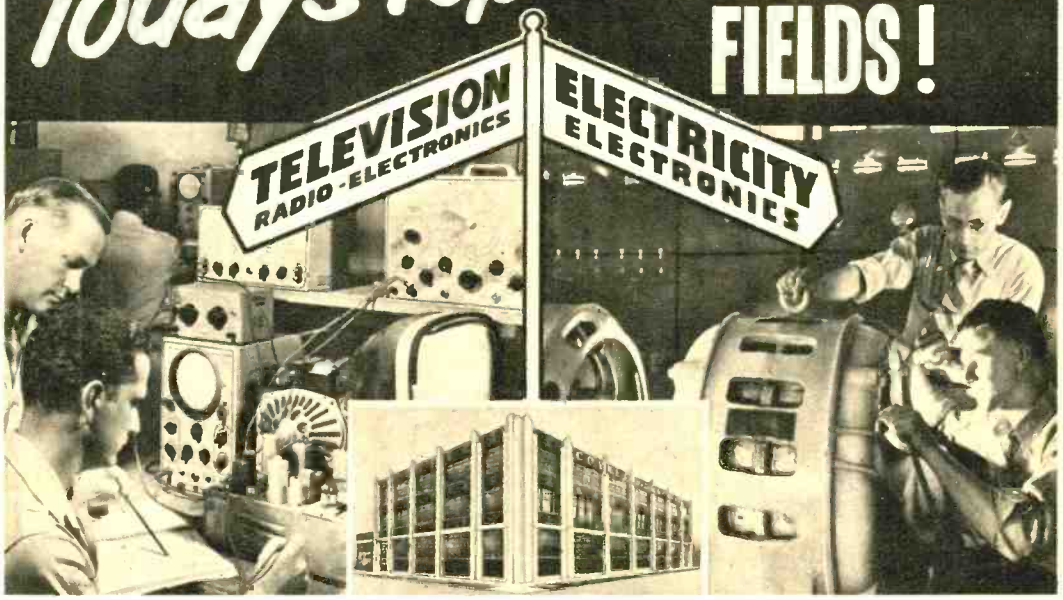
And talking about the telephone—it may soon be possible to use the telephone as an interpreter during a direct call from the U. S. to a foreign country. According to Dr. Edwin Schneider, Vice President for Research of Sylvania, the basic computer mechanism for automatic translation of a telephone call is already in existence, although primitive. The problems are greater than for translation of printed matter.

—o—

Bullet-Proof Sign

A new type of electric sign that remains lighted even after it has been punctured by bullets (public signs are a favorite target for vandals) was displayed recently by Sylvania Electric, Inc. The signs are for indoor and outdoor use and its "Panelescent" elements (thin phosphor-coated metal sheets), may take any shape desired. These lamps will operate for more than five years without maintenance. When connected to a source of power, a slow movement of electrons through the semiconductor base excites the phosphor, which emits light.

Train in New Coyne Shop-Labs for Today's Top OPPORTUNITY FIELDS!



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. . .News

Turntable for the Turnpikes

Now any car owner can have the kind of music he wants when and where he wants it with the new Norelco "Auto Mignon" record player. This unit, which bears a strong rememblance to the "trap door" record players that were on the U. S. market about six or seven years ago, plays only 45-rpm records and uses the car's auto radio amplifier and speaker. The record player draws 50 milliwatts and works off six- or twelve-volt batteries. It costs $57.50. You can get more information from North American Philips Company, 230 Duffy Avenue, Hicksville, Long Island.

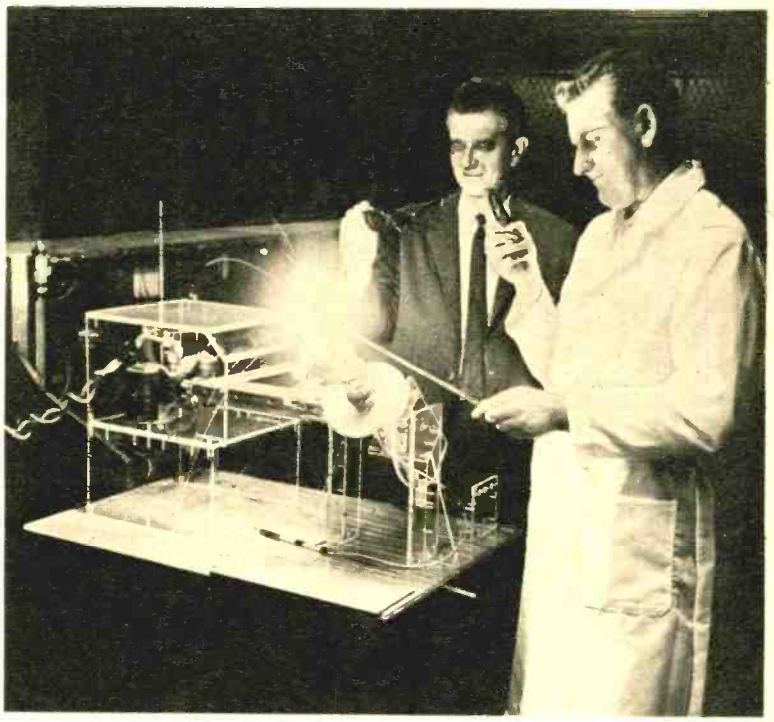
—o—

Power from the Sun

Sunflower I is the esthetic-sounding name for the 3000-watt solar generator currently being developed for the National Aeronautics and Space Administration (NASA). This system will be designed to generate the power for one year continuously and will fit into the nose cone of an advanced space vehicle. First reports have it looking like an automobile headlight reflector with a large petal-like foldable sunlight collector. Fully extended it will measure about 32 feet across. The sun's heat will boil liquid mercury, whose vapor will drive a turbogenerator, a modified version of the Snap-2 unit previously described *in EI.* The mercury vapor is cooled, condensed, recycled to keep Sunflower going as a "closed system."

. . . News

"Plasma Torch" Produces Heat Without Fuel



The "Plasma Torch," a device that uses a radio-frequency field to generate heat approaching the temperature of the sun, yet without consuming any fuel or electrodes whatsoever, has been built by Amperex Electronic Corporation, Hicksville, N. Y.

The "Torch" operates by using the energy of a high-frequency electromagnetic field to dissociate and ionize gas molecules into their component atoms (the gas in this form is called a plasma), and then allowing them to recombine into their original state. When recombination occurs, the absorbed energy is liberated in the form of heat.

The electromagnetic field is created by a coil or coaxial cable. In one unit that uses a coil the energy is generated by the Amperex type 5866, a standard $20 transmitting triode operating at 27 mc with an output of 250 watts. Another unit uses a coaxial cable, the energy for which is generated by the Amperex type 7292 magnetron which operates in the S Band (2450 mc) with a 1-kw output.

Amperex engineers have been using ordinary nitrogen as found in compressed air for their experiments. As the piped nitrogen passes through the coil or coaxial cable it is converted into a plasma. Recombination occurs when the nitrogen leaves the field, just past the point where the plasma escapes from the nozzle into the open air. Since it is never consumed, the nitrogen, or any other suitable gas, can be used again and again. Temperatures in excess of 3000 degrees C have already been achieved and experiments are now under way to reach 5700 degrees C, the temperature of the sun's surface.

A unique characteristic of the "Plasma Torch" is that none of its parts ever heat. In fact, if the system is suddenly turned off and the nozzle touched, it is found to be cold. The whole unit, therefore, can last indefinitely. The only component that will eventually have to be replaced is the electron tube or magnetron.

Important and diverse applications in a variety of industries are foreseen: investigation of missile reentry, spraying high melting point metals and ceramics, petroleum cracking, welding, etching, machining, chemical purification and processing.

Any simple plasma source also has great value in research. Rocket fuels of the future may consist of compounds of normally-inert rare gases (argon, xenon, etc.) that have been stripped of their outer-shell electrons and made to combine with other elements. If this "stripping" can take place it will be only at the superhigh temperatures found either in nuclear explosions or in "plasma jets." Needless to say the plasma jet is a more convenient heat source in the laboratory.

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Invisible Light Counts Traffic

The Traffitrol Detector, an infrared traffic counter, has just made its appearance at busy street corners as an aid to traffic engineers studying intersection problems. An infrared beam projects downward onto the traffic lane or lanes and is reflected from the pavement into a receiver lens. When vehicles break the

beam they are detected and counted.

Single units of the Traffitrol may be purchased from the Minneapolis-Honeywell Regulator Co. for $450 for those of you who are convinced that you have a traffic problem in your driveway.

—o—

More Radar Protection

The first of three super long-range radar stations of the U.S.'s early warning system (BMEWS) has just gone into operation at Thule in Greenland. This radar will provide at least 15 minutes of warning to U. S. and Canadian air defense and C. D. forces if a ballistic missile hurtles its way across the top of the world. These missiles now travel at about 15,000 miles per hour, so this new radar station has a range of about 3000 miles. Two additional stations are now being built to protect our flanks; one in Alaska and the other in England. These are expected to be operational in the summer of 1961. Recent BMEWS developments promise to deliver warning in a matter of seconds.

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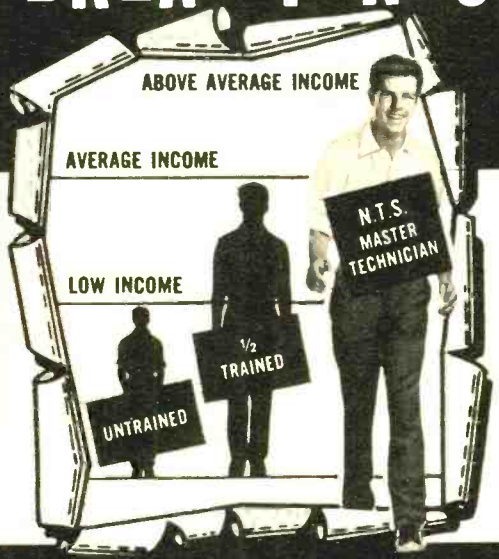

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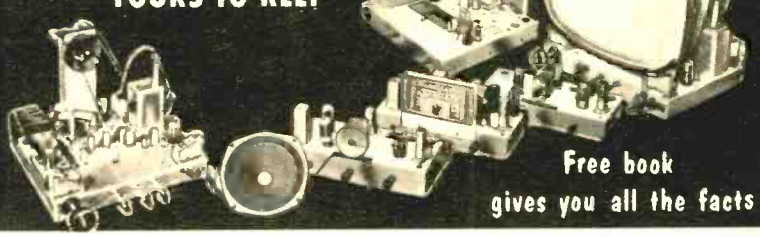

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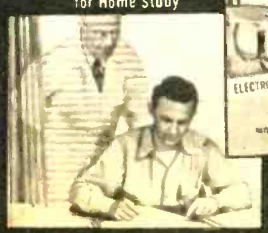

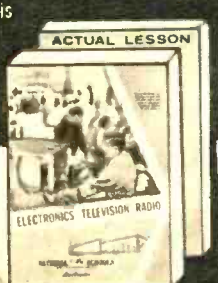

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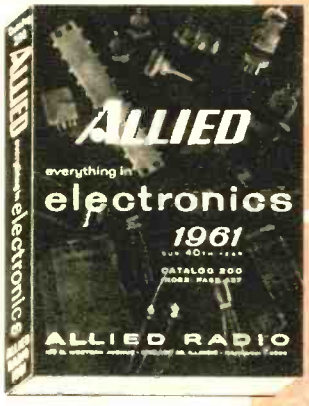

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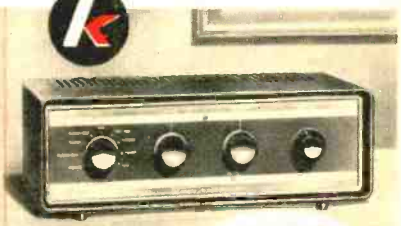

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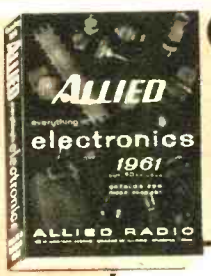

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. . . News

Slide-Out Album

New Quick-See end table record storage cabinet has a slide-out album file for flip-through record selection. Cabinet in various finishes is $49.95.

Individual slide out Quick-See album and tape files are also available for installation in your own cabinet, or

shelves. Nine different models, designed to fit most any storage area, hold up to 125 twelve-inch albums, 150 forty-five rpm's or 30 tapes. Prices start at $6.95. Kersting Manufacturing Company, 504 South Date Ave., Alhambra, California.

—o—

"Anti-Skating" Tone Arm

Another tone arm that has just been introduced and features something called "anti-skating" is the Fairchild "500," which sells for $55 including the SM-2 stereo cartridge. According to the manufacturer, who conveniently defines the term for us, skating is the force which tends to pull an arm toward the center of a record and is produced by the friction between the stylus and the walls of the groove (and possibly the inertia of the arm). In any case, this leads to an unbalance between the stereo channels. In other possible recording systems this might not be a problem, but in the system actually in use (45/45) the information for each channel has its own groove wall, and the playback stylus must evenly distribute its pressure on both walls.

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You will learn how to build radios, using regular schematics; how to wire and solder in a professional manner; how to service radios. You will work with the standard type of punched metal chassis as well as the latest development of Printed Circuit chassis.

You will learn the basic principles of radio. You will construct, study and work with RF and AF amplifiers and oscillators, detectors, rectifiers, test equipment. You will learn and practice code, using the Progressive Code Oscillator. You will learn and practice trouble-shooting, using the Progressive Signal Tracer, Progressive Signal Injector, Progressive Dynamic Radio & Electronics Tester, Square Wave Generator and the accompanying instructional material.

You will receive training for the Novice, Technician and General Classes of F.C.C. Radio Amateur Licenses. You will build 20 Receiver, Transmitter, Square Wave Generator, Code Oscillator, Signal Tracer and Signal Injector circuits, and learn how to operate them. You will receive an excellent background for television, Hi-Fi and Electronics.

Absolutely no previous knowledge of radio or science is required. The "Edu-Kit" is the product of many years of teaching and engineering experience. The "Edu-Kit" will provide you with a basic education in Electronics and Radio, worth many times the complete price of $26.95. The Signal Tracer alone is worth more than the price of the entire Kit.

THE KIT FOR EVERYONE

You do not need the slightest background in radio or science. Whether you are interested in Radio & Electronics because you want an interesting hobby, a well paying business or a job with a future, you will find the "Edu-Kit" a worth-while investment.

Many thousands of individuals of all ages and backgrounds have successfully used the "Edu-Kit" in more than 79 countries of the world. The "Edu-Kit" has been carefully designed, step by step, so that you cannot make a mistake. The "Edu-Kit" allows you to teach yourself at your own rate. No instructor is necessary.

PROGRESSIVE TEACHING METHOD

The Progressive Radio "Edu-Kit" is the foremost educational radio kit in the world, and is universally accepted as the standard in the field of electronics training. The "Edu-Kit" uses the modern educational principle of "Learn by Doing." Therefore you construct, learn schematics, study theory, practice trouble-shooting—all in a closely integrated program designed to provide an easily-learned, thorough and interesting background in radio.

You begin by examining the various radio parts of the "Edu-Kit." You then learn the function, theory and wiring of these parts. Then you build a simple radio. With this first set you will enjoy listening to regular broadcast stations. Learn theory, practice testing and trouble-shooting. Then you build a more advanced radio, learn more advanced theory and techniques. Gradually, in a progressive manner, and at your own rate, you will find yourself constructing more advanced multi-tube radio circuits, and doing work like a professional Radio Technician.

Included in the "Edu-Kit" course are twenty Receiver, Transmitter, Code Oscillator, Signal Tracer, Square Wave Generator and Signal Injector circuits. These are not unprofessional "breadboard" experiments, but genuine radio circuits, constructed by means of professional wiring and soldering on metal chassis, plus the new method of radio construction known as "Printed Circuitry." These circuits operate on your regular AC or DC house current.

THE "EDU-KIT" IS COMPLETE

You will receive all parts and instructions necessary to build 20 different radio and electronics circuits, each guaranteed to operate. Our Kits contain tubes, tube sockets, variable, electrolytic, mica, ceramic and paper dielectric condensers, resistors, tie strips, coils, hardware, tubing, punched metal chassis, Instruction Manuals, hook-up wire, solder, selenium rectifiers, volume controls and switches, etc.

In addition, you receive Printed Circuit materials, including Printed Circuit chassis, special tube sockets, hardware and instructions. You also receive a useful set of tools, a professional electric soldering iron, and a self-powered Dynamic Radio and Electronics Tester. The "Edu-Kit" also includes Code Instructions and the Progressive Code Oscillator, in addition to F.C.C.-type Questions and Answers for Radio Amateur License training. You will also receive lessons for servicing with the Progressive Signal Tracer and the Progressive Signal Injector, a High Fidelity Guide and a Quiz Book. You receive Membership in Radio-TV Club, Free Consultation Service, Certificate of Merit and Discount Privileges. You receive all parts, tools, instructions, etc. Everything is yours to keep.

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- PRINTED CIRCUITRY

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You will learn trouble-shooting and servicing in a progressive manner. You will practice repairs on the sets that you construct. You will learn symptoms and causes of trouble in home, portable and car radios. You will learn how to use the professional Signal Tracer, the unique Signal Injector and the dynamic Radio & Electronics Tester. While you are learning in this practical way, you will be able to do many a repair job for your friends and neighbors, and charge fees which will far exceed the price of the "Edu-Kit." Our Consultation Service will help you with any technical problems you may have.

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

FROM OUR MAIL BAG

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

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

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At no increase in price, the "Edu-Kit" now includes Printed Circuitry. You build a Printed Circuit Signal Injector, a unique servicing instrument that can detect many Radio and TV troubles. This revolutionary new technique of radio construction is now becoming popular in commercial radio and TV sets.

A Printed Circuit is a special insulated chassis on which has been deposited a conducting material which takes the place of wiring. The various parts are merely plugged in and soldered to terminals.

Printed Circuitry is the basis of modern Automation Electronics. A knowledge of this subject is a necessity today for anyone interested in Electronics.

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. . . News

Electronic Target Simulator

Lockheed Electronics Company has taken the wraps off an electronic "magnifying glass" that makes small training targets for fighter planes look like bombers soaring in space. The little black box that does this trick is called a radar augmenter and all it amounts to is an electronic mirror. When it is installed in a small rocket launched from

a plane, one if its two antennas intercepts a radar signal sent out by a pursuing fighter. This signal is amplified and sent out by the second antenna to be picked up by the fighter's radar scope. The scope displays a "large" target. This method replaces the use of a drone plane.

—o—

Fore!

The stewards and judges for the World Amateur Team Golf Championships held in Ardmore, Pa., wore RCA transmitters and receivers on their belts to maintain constant communication with tournament HQ. This mobile radio system was used to assist crowd movement and clear up rules questions as they occurred.

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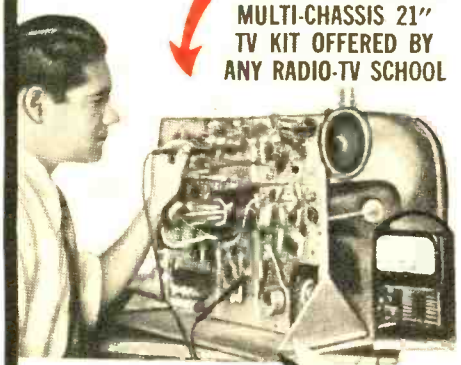

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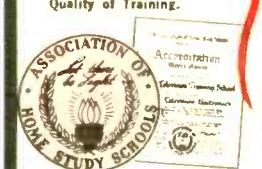

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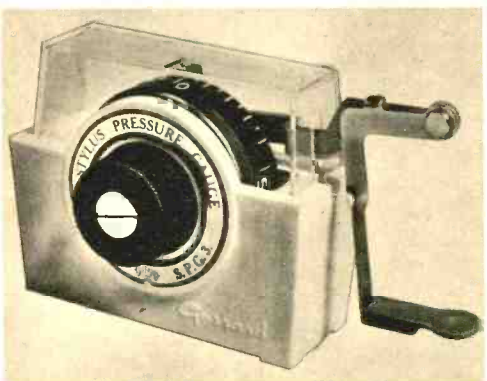
. . . News

Direct-Reading Pressure Gauge

We've come a long way from the simple (but somehow effective) straight bar, lever-type stylus pressure gauge. The new one shown here is by Garrard, a division of British Industries, 80 Shore Road, Port Washington, New York. The

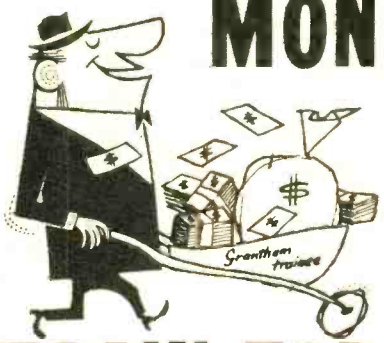


stylus is placed on the protruding arm and the pressure of the tone arm is read directly. The scale is marked off in ½-gram divisions and its accuracy may at any time be calibrated against a 5-gram brass weight furnished with the gauge. Price is $2.95 for the SPG 3.

—o—

New York State has passed a law requiring the labeling of rebuilt TV picture tubes as such. It forbids a tube to be represented or sold as "new" if it contains a single used part, including the glass envelope. A label must be affixed to the rebuilt tube, which may only be removed by the customer after the sale. A nationwide survey had revealed that eight out of ten families thought they were buying brand-new replacement tubes, while industry sales figures showed that only one out of five tubes sold was all-new. This law may, and should, become a model for other state laws. Observance of it should improve customer relations in some service shops. Awareness of the law helps the customer, since he tends to confuse the meanings of "replacement" and "new" and may accept charges for a "new" tube without objecting.

MAKE MORE MONEY



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Grantham training is the easy way to learn more quickly—to prepare more thoroughly—for F. C. C. examinations. And your first class license is the quick, easy way to prove to your employer that you are worth more money.

This correspondence course is directed toward two major objectives—(1) to *teach* you a great deal about electronics, and (2) to prepare you to *pass* all of the F. C. C. examinations required for a first class commercial operator's license. We teach you step by step and have you practice with FCC-type tests which you send to the school for grading and comment. You prepare for your F. C. C. examinations under the watchful direction of an instructor who is especially qualified in this field.

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. . . News

Punched Tape Stores Scores

Musical scores may now be stored on punched tape from which they can be duplicated at will. Furthermore, the same tape can be fed to a computer which can be so programmed that individual performance parts for the instruments of the orchestra may be extracted

from the complete score, eliminating an orchestrator. The machine that does all this has been invented by composers L. A. Hiller, Jr. and Cecil Effinger and is essentially an electric typewriter that produces a punched tape while printing musical notations.

—o—

We hear so much these days of new "break throughs" in research we forget how much is owed to well-known principles. *You* might have devised the *electromagnetic blood flow meter* now being developed by George N. Hoover and Fred R. Johansen of Ohio State University for their studies on biological instrumentation for people in motion. A conductor moving in a magnetic field generates an electric current. Blood is a conductor. Can you figure it out from there?

- For the Experimenter
- For the Boat Owner
- For the Hi-Fi Enthusiast
- For the Ham
- For the Retailer

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1

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Model T-61C (Kit). **Net Price: $ 99.95**

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Model T-61F (Kit). **Net Price: $124.95**

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NEW PACO TK-6 TOOL KIT

For the kit-builder or experienced electronic technician, this complete set of precision-built English and American-made tools can handle any assembly job, large or small. Includes: diagonal cutters; long-nosed pliers; 40-watt soldering iron; two screwdrivers, a pair of wire-strippers, plus see-through carrying-case.

Model TK-6. . . . . **Net Price: $9.95**

4

NEW

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5

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ELECTRONICS ILLUSTRATED published monthly at Greenwich, Conn., for October 1, 1960.

1. The names and addresses of the publisher, editor, managing editor, and business managers are: Publisher, Fawcett Publications, Inc., Greenwich, Conn.; Editor, Charles Tepfer, Chappaqua, N. Y.; Managing Editor, Larry Elsinger, Staten Island, N. Y.; Business Manager, Gordon Fawcett, Greenwich, Conn.

2. The owner is: (If owned by a corporation, its name and address must be stated and also immediately thereunder the names and addresses of stockholders owning or holding 1 percent or more of total amount of stock. If not owned by a corporation, the names and addresses of the individual owners must be given. If owned by a partnership or other unincorporated firm, its name and address, as well as that of each individual member, must be given.) Fawcett Publications, Inc., Greenwich, Conn.; W. H. Fawcett, Jr., Norwalk, Conn.; Marion Bagg, Overland Park, Kansas; Roger Fawcett, New York, N. Y.; V. D. Fawcett, Greenwich, Conn.; M. B. Fawcett, Norwalk, Conn.; Gordon W. Fawcett, Greenwich, Conn.; Gloria Leary, Santa Monica, Cal.; V. F. Kerr, Bakersfield, Cal.; Allan M. Adams and Jack B. Adams as trustees under the trust agreement with Eva F. Roberts dated July 3, 1959, Greenwich, Conn.; H. A. Fawcett, New York, N. Y.; Roscoe Kent Fawcett, Reno, Nevada; M. F. Fawcett, Greenwich, Conn.

3. The known bondholders, mortgagees, and other security holders owning or holding 1 percent or more of total amount of bonds, mortgages, or other securities are: (If there are none, so state.) None.

4. Paragraphs 2 and 3 include, in cases where the stockholder or security holder appears upon the books of the company as trustee or in any other fiduciary relation, the name of the person or corporation for whom such trustee is acting; also the statements in the two paragraphs show the affiant's full knowledge and belief as to the circumstances and conditions under which stockholders and security holders who do not appear upon the books of the company as trustees, hold stock and securities in a capacity other than that of a bona fide owner.

5. The average number of copies of each issue of this publication sold or distributed, through the mails or otherwise, to paid subscribers during the 12 months preceding the date shown above was: (This information is required by the act of June 11, 1960 to be included in all statements regardless of frequency of issue.) 160,437.

GORDON FAWCETT,
Business Manager

Sworn to and subscribed before me this 30th day of September, 1960.

[SEAL] LILLIAN M. KLEIN

(My commission expires April 1, 1963)

. . . News

New Books and Booklets . . .

"The Art of Selecting & Preserving Recordings" is a new 20-page booklet available for 25¢ from Shure Brothers, 222 Hartrey Avenue, Evanston, Ill. Topics discussed include ways to build a basic record library, the elements of musical etiquette when you play records for friends (no, you do not just turn the volume all the way up and wait for the windows to rattle!), and how to handle and store records so they will last.

Two new transmitting antenna catalogs are now available from Hi-Gain Antenna Products, 1135 North 22nd Street, Lincoln, Nebraska. One covers beams, verticals, halos, ground planes, mobile and portable units for amateurs; the other describes antennas for the Citizens Band. These catalogs are sent free.

A pocket-sized 22-page dictionary of computer terms and, incidentally, a short course on computers, is being offered free by the Brown Instruments Div. of Minneapolis-Honeywell Regulator Co., Philadelphia, Pa. The booklet is called "Do You Talk Computerese?"

Where can you get all the parts for any project you see in *EI's* articles? Where can you find the widest selection of hi-fi components, short wave receivers, kits of all kinds, Citizens Band equipment? Have you tried the free 1961 catalogs of the great parts distributors? See their ads in *EI's* pages for handy coupons.

CBS has revised and expanded its Transistor Home-Study Course to include latest information. The Course has ten lessons, a do-it-yourself approach, and includes correction and advisory services. Individual and group rates may be obtained from CBS tube distributors or "Transistor Course," CBS Electronics, 100 Endicott Street, Danvers, Mass.

Write to the Rockbar Corporation, Mamaroneck, N. J. for its free new booklet, "For The Discerning Listener," which describes the Goodman loudspeakers and also includes plans for enclosures.

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Get Your FCC License Quickly

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Name ..... Age.....

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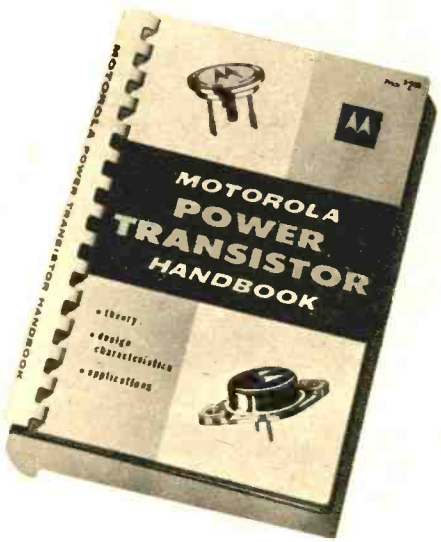
EI 28

. . . News

The Motorola Semiconductor Applications engineers got together long enough to compile a 200-page handbook on power transistor theory and applications. This new book is available from the Technical Information Center, Motorola Semiconductor Products, Inc., 5005 East McDowell Road, Phoenix, Arizona, for $2. It can serve as a source of new circuit ideas for hobbyist and hams as well as hi-fi fans.



If you use coils (and who doesn't at one time or another) then you will be interested in a 28-page catalog describing the complete line of Stancor coils, RF, IF, choke, etc., etc. Included in this catalog, which you can get free, are 79 schematics and complete application information. Write to Chicago Standard Transformer Corp., 3501 W. Addison Street, Chicago 18, Ill.

"Practical Electrical Wiring," by H. P. Richter, is a McGraw-Hill book now in its new and sixth edition that will show you how to plan and carry out all types of wiring (light and power) for homes, labs, farms, etc. This book not only includes on-the-job tips and short-cut suggestions but also tells you the theory behind the practices. It sells for $7.95.

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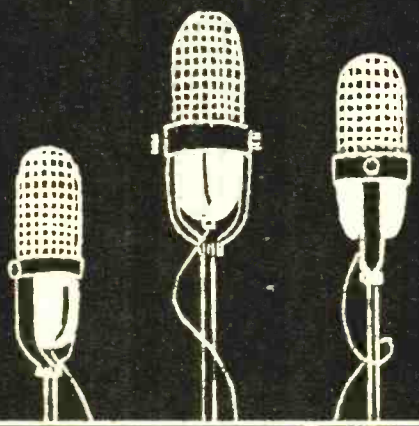
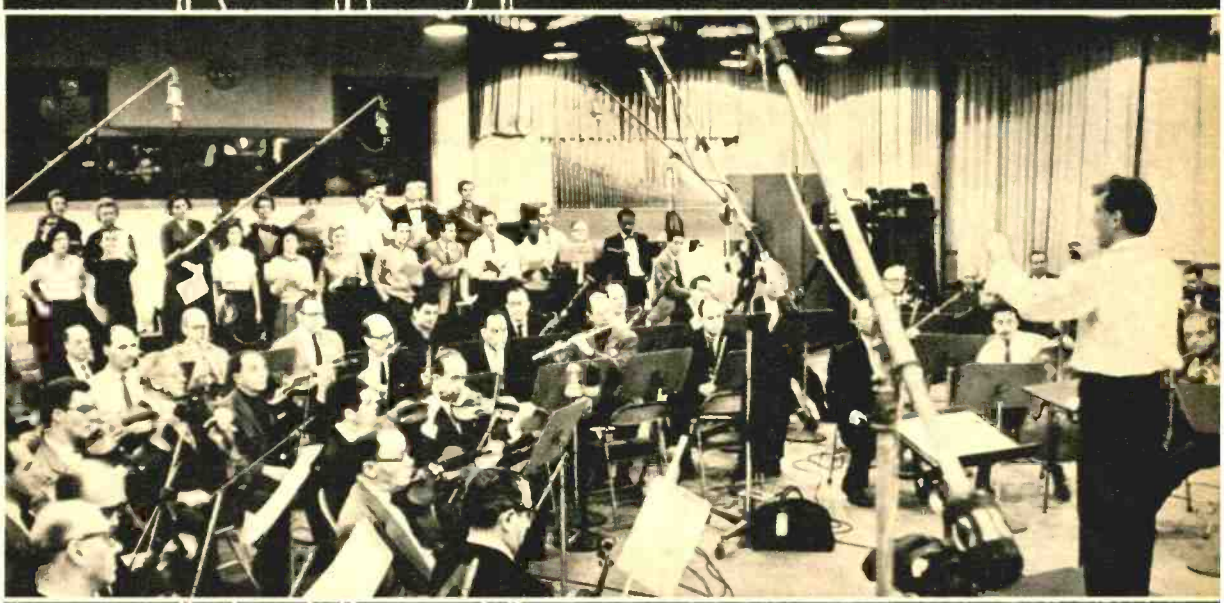
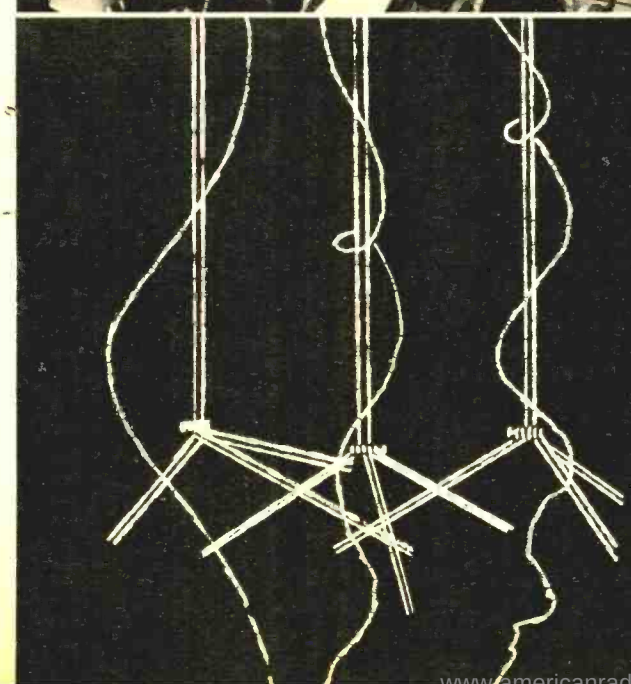
◀ See Page 24 for the BEST BUYS in CITIZENS TRANSCEIVERS, "HAM" GEAR and TRANSISTOR RADIOS.



E I goes to

A Stereo Recording Session

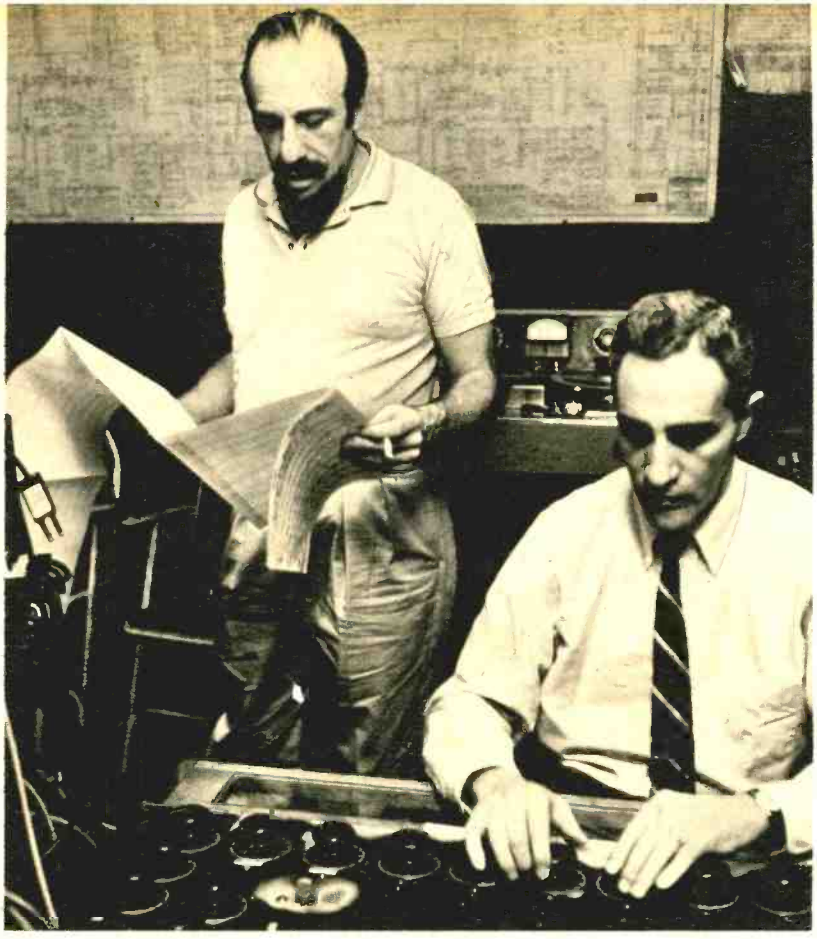




By Sanford Maizel

EVERY new process goes through a major shake-up in its early days, and stereo recording is no exception. There was a time, not at all long ago, when certain record companies thought that the only way to run a stereo session was to separate the orchestra into two completely independent channels with a sound-proof baffle running down the center. While the result was certainly different, those early efforts have hardly become collector's items, and for the very best of musical reasons—they sound strange!

Now the dust has settled and the stereo session is a sober, skillful effort



Mitch Miller, popular recording artist and producer, follows the score with a keen ear during an extended taping session in a Columbia Records studio.

Below, left: "Riding gain" on as many as a dozen mikes around the studio, the recording engineer keeps his eyes on the conductor and his hands on the controls. Below, right: Is the tape good? All men concerned in its production listen critically to an immediate playback in the recording studio.

Making a Columbia Record under perfectionist Leonard Bernstein is shirt-sleeve job for musicians.

to put on tape (and into your microgrooves) a well-rounded, authentic musical performance instead of an elaborate acoustic exercise. The emphasis is now on performance, not on ping-pong. Every aspect of the session is again under the direction of the producer, or A&R man (for "Artists and Repertory") and it is his responsibility to see that the truest possible presentation of the composer's or the arranger's creative intent gets through to you, the listener.

At a recording session at one of New York's most famous studios (a former church auditorium), *EI* watched as Howard Scott, producer of most of the Columbia Masterworks Series, arrived for a session, carrying the carefully annotated score he'd worked on the night before.

His first step, as at all sessions, was to order a thorough check of all the equipment, carried out by the engineers with the help of a tone generator. First they checked the mikes for output level, and

made the necessary compensating adjustments. Then came the tape decks, and again the tone generator was used to measure the frequency response, verify the azimuth and check the tape speed. To give you an idea of the tolerances involved, the tape speed must check out to .004%!

The standard gear at these sessions is a pair of half-inch Ampex tape decks (one acting as safety) operating at fifteen inches per second, plus a single quarter-inch machine. The half-inchers record on three channels, right, left and center, with the center being used later in dubbing to fill in the hole when needed. Since all the channels are on a single tape, they are in perfect synchronization with each other, and make editing that much more precise.

Sometimes the quarter-inch machine is used for the mono version and sometimes an artful blend of all channels is used.

Each of the three channels on the tape is fed by an appropriate microphone. Since this calls for at least three mikes, and since it is often wise to give special support to certain choirs of instruments or soloists for part of the performance, the actual microphone array begins to resemble an overgrown forest. All mikes are fed into an audio console which not only provides complete on-off and volume control, but also permits the engineer, at the behest of the producer, to switch any given mike from right to left to center. In other words, here is another way they use their electronic controls to maintain strict artistic control.

The positioning of the orchestra and the microphones is an art all its own, on which the reverberation or echo effect depends. All things being equal, the larger the hall, the longer the time delay, the more reverb. Actually, most companies add some time delay by the use of echo chambers either at the time of recording or later in the editing. Some current playback equipment is being provided with a special control that can lengthen the time delay and introduce even more echo.

A major factor which may nullify all the good work that goes into a session is humidity. Tests have shown that a strictly controlled humidity level is a must, so modern studios are not just air-conditioned but are moisture conditioned, too.

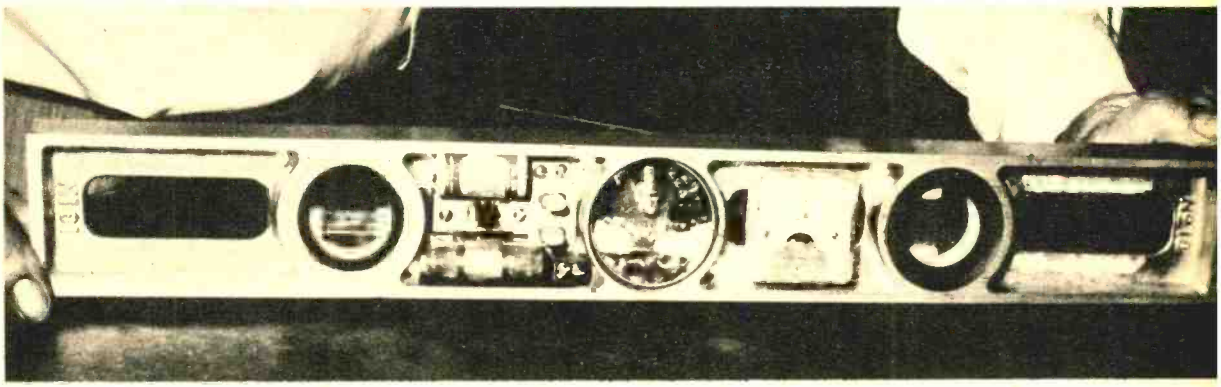
With the musicians assembled, the actual session gets under way after a brief run-through. The producer signals, the tape decks start, the identifying phrase "CO 65, Take One" is put on the tape, and the orchestra starts to play. Now comes the concentration on the prepared score, the trained ear listening for "clams," which occasionally disrupt even the finest performance.

"Takes" vary in length from a few short choruses to a whole movement that may run close to half an hour, but the moment an engineer spots a technical weakness, [*Continued on page* 107]

Cutting and splicing, listening; more cutting and splicing, more listening. These are the duties of the tape editor, a most important man in the recording business. (Photo taken in Columbia Records studio, N.Y.)

a simple invention:

The Electronic Level



Why didn't YOU invent it? Even a blind man can use this superaccurate version of a common tool.

By James A. Collins

EVEN though you're not Matt Dillon when it comes to straight shooting, there is no longer any need to guess when it comes to a precision leveling or surveying job. Anyone can be a dead-eye with the Surber Electronic Level, the only known level in existence which can measure true "zero" level. Even a blind man can use it.

Impossible you say? Let's see. The device is the brain-child of a 40-year-old Wichita Falls, Texas inventor, Curtis M. Surber, who has a remarkable way of looking at problems of this nature—from the limited viewpoint of a blind man.

Though Surber is not sightless, his first thought in approaching this problem was, "How can I make a level that a blind person might use?" Solving the problem seemed to bring forth many possibilities and new applications for the principle involved.

With modesty, Surber said, "The level is really a simple device, and anyone with some electronics experience could conceivably have invented it.

"The traditional level, of course, operates by sight only. When a small bubble in a tube is lined up between two marks on the tube, the carpenter calls it level and lets it go at that.

"My level is much more accurate. In fact it is as accurate as it is possible to get," Surber claims.

Surber's level is exactly like the regular level found in any workshop or lumber yard except it utilizes a battery, switch, wiring, photo electric cells or solar batteries, a light source, and either a transistor audio source (for the sightless) or a meter which can be read by eye.

The light source, a small bulb, is [*Continued on page* 105]

"concert hall" echo

The "Reverb"

Reverberation is all the rage these days. Your phonograph needs a built-in echo chamber for it.

By Lothar Stern Motorola, Inc.

SOMETHING new has been added to high fidelity techniques. It's the reverberation effect—a sort of echo—that attempts to create true concert hall realism in the living room by artificially restoring the characteristics of a large hall, which are normally lost during the recording process.

In the concert hall, the sound from the orchestra reaches the listener not only directly from the instruments but also by way of *reflections* from walls and ceilings. These reflections arrive a split second after the direct sound and give "live" music its "spaciousness and depth." Similar reflections, of course, are also set up in the living room, but because of the smaller dimensions of the room, the feeling of spaciousness found in a concert hall is entirely absent.

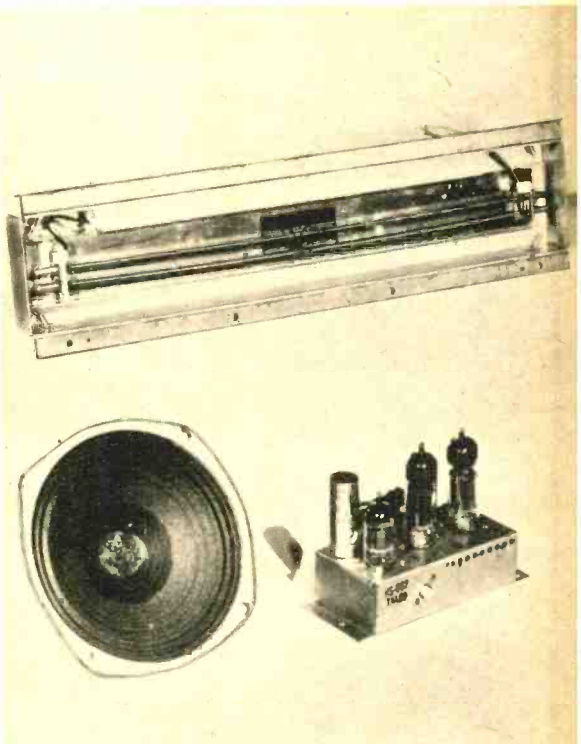
Reverberation devices compensate for the acoustic differences between a

small room and a large hall by delaying a portion of the sound fed to the main loudspeakers, and repeatedly reproducing it at optimum intervals and with decaying amplitude to simulate true concert-hall conditions.

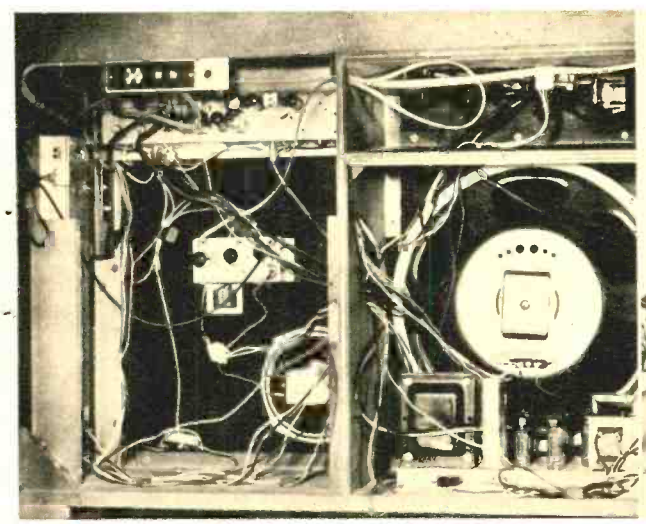
Reverberation can be used with monophonic program material from radio broadcasts and mono records as well as stereo. And, as presently employed, the listener has complete control over the amount of "echo" he wishes to use. By means of a *reverberation control,* he can vary the volume of the delayed sound from zero to some preset maximum level. The apparent size of the living room can therefore be varied at will.

The Boing-g Box

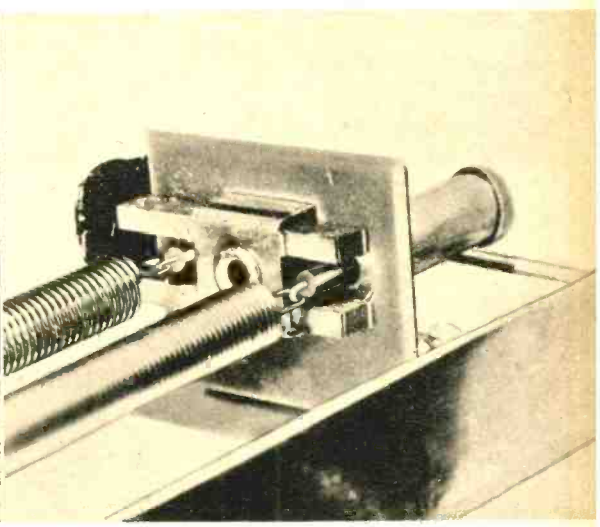
The heart of all current commercial reverberation systems is an electromechanical *delay unit* developed by the Hammond Organ Company. Basically, this consists of a couple of precisely engineered metal springs, terminated on each end by transducers. At the input end, the transducers convert the electrical signal from the main amplifiers into rotary mechanical motion which is transmitted [*Continued on page* 104]



Two-spring delay unit, extra amplifier and extra speaker are used in Motorola's stereo "Reverb" system, to add "concert hall echo."



The "Reverb" system has its own enclosure section in this unit. Spring box is mounted vertically at left; supplementary amplifier is on the front panel. Both stereo grooves feed system.



In this magnified view, small cylindrical magnets drive pair of springs with rotary motion, which travels to pickups at far end of springs. Pickups feed extra amplifier and speaker.

Stereo Omnimeter

Dual microphone sound level meter provides accurate acoustic balance and phasing of your system.

By Harry Kolbe

PRECISE balance of stereo channels with respect to level and frequency are of utmost importance for the full enjoyment of present day stereo systems. However, the sensitivity of the two channels of a stereo power amplifier may differ as much as 3 db or more. And the situation in the preamp may be even worse. For there may be a discrepancy between the frequency response vs. tone control setting of each channel. For example, when the two channels are working simultaneously to produce a stereo sound at, say, 5,000 cps and there is as little as a 3 db difference in output between them, unfortunate things happen to the stereo effect. The discrepancy is large enough to "shift" the apparent location of the first violin section of an orchestra from its position on stage left to stage right. Speaker placement and efficiency, in addition to room acoustics all play a part in the ultimate balance (or unbalance) of your stereo system.

Numerous devices, such as magic eye level indicators, tone generators, and level meters have been incorporated into some of the recent preamps and amplifiers, and are also available as accessories. These devices all suffer from a handicap in that they can

balance the signal going to the speaker, but not the signal coming out of it.

The stereo balancing and phasing problem can be solved once and for all by a simple test device dubbed the Stereomnimeter (SOM). This device consists of an inexpensive sound level meter with *two* pickup microphones which are used to accurately adjust the channel's relative *sound* output.

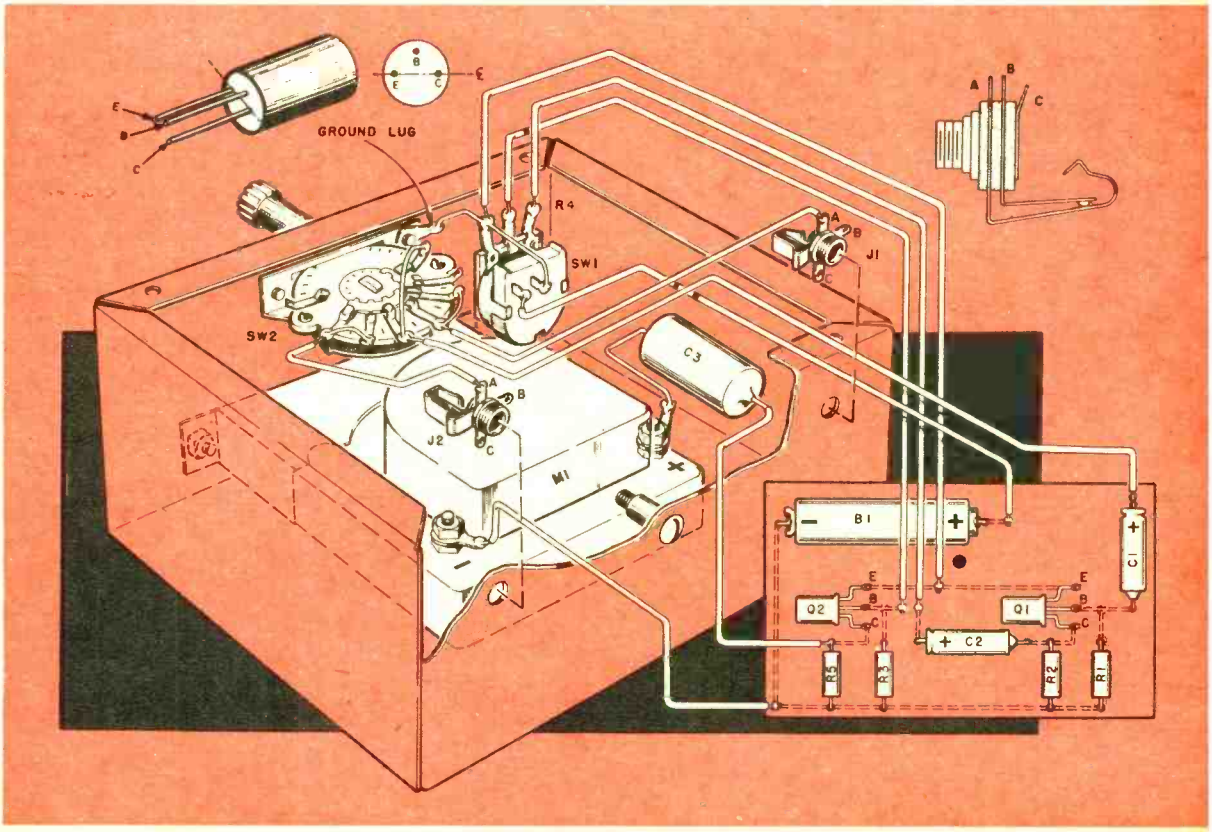
Electronically, the two microphones are connected to the input of a two-stage high gain transistor amplifier (Q1, Q2) whose output feeds a VU meter (M1). A selector switch (SW2) is inserted between the microphones and the amplifier input to permit selection of either left or right channel microphone or both. With SW2 in the center position, both microphones are connected to the transistor amplifier *out of phase* with each other. Therefore if the sound picked up by both microphones is exactly the same and both are equally sensitive, their outputs will be equal and opposite, thereby canceling and presenting no signal to the SOM's amplifier. Used this way, the instrument can check speaker phasing and balance between the channels even when they're producing a complex signal.

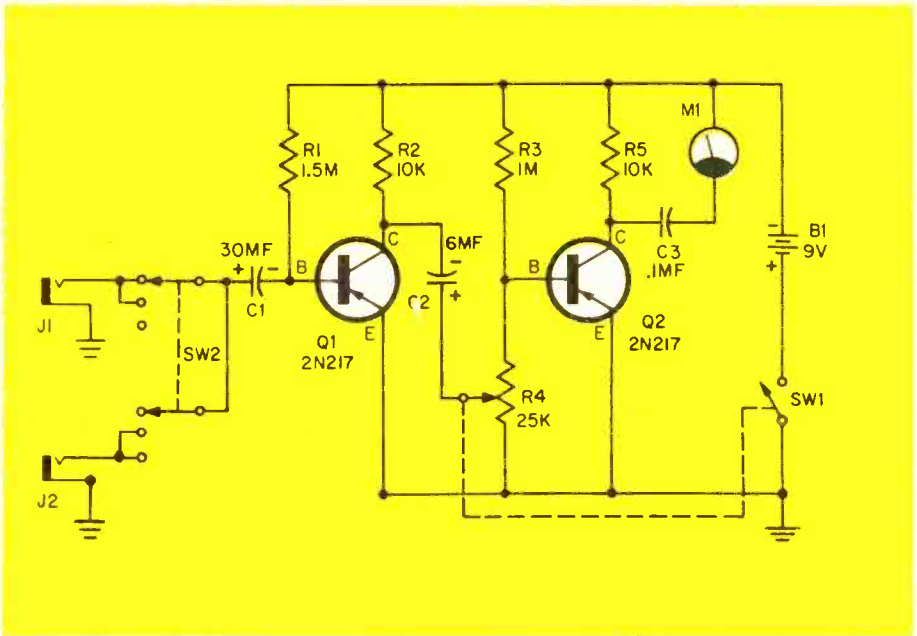
Long two conductor speaker cables are used between microphones and the SOM so that a microphone may be placed in front of each stereo speaker.

Construction

The unit is laid out in two separate preassembled sections. The main section is the aluminum cabinet upon which are mounted the VU meter (M1) SW2, microphone input jacks (J1, J2), and level control (R4). The rectangular meter hole is easily cut out of the soft alumi-

Pictorial of SOM. Carefully follow terminal connections of switches, transistors and input jacks.





Transistors Q1, Q2 amplify signal injected at inputs J1, J2. With SW2 in center position, input signals are out of phase and cancel out each other.

PARTS LIST

R1—1.5 megohms ½ watt, 10%
R2,R5—10,000 ohms ½ watt, 10%
R3—1 megohm ½ watt, 10%
R4—25,000 ohm miniature potentiometer
C1—30 mf, 6 volts miniature electrolytic capacitor
C2—6 mf, 12 volts miniature electrolytic capacitor
C3—.1 mf, 200 volts tubular or disc capacitor
Q1,Q2—2N217 transistor
M1—edgewise VU meter (Lafayette TM-33 or equiv.)
B1—9 volt (RCA type VS-309A)
SW1—SPST switch (on rear of R4)
SW2—DP3T positive lever action switch
J1,J2—Open circuit miniature phone jack
SP1,SP2—2½" PM speaker with 10-ohm voice coil (Lafayette SK-66 or the equiv.) Miniature baffle (Lafayette MS-315)
Cabinet—4"x5"x3" aluminum (Bud AU1028 or equiv.)
Misc.—Perforated phenolic board 2 7/16"x3⅜", metal spacer, hardware, etc.

num by drilling a row of holes to remove most of the metal and then squaring off with a flat metal file. In a similar manner, a slot is cut for SW2 using a small, very thin flat file.

The second section is the transistor amplifier. It is built on a 2½" x 3⅜" piece of perforated phenolic board. Flea clips are used as socket holders for the transistors and as terminal posts for connections to M1 and jacks J1 and J2.

After both sections have been assembled, the amplifier board is mounted with two ⅜" standoff metal spacers to the back panel of the case behind the meter. Now make all the connections.

The PM speakers are cemented into the plastic baffles with Duco cement. Connect the microphone leads to the speakers and jacks. These leads should be connected so that the microphones will be in *opposite* phase. We will check this later.

SOM Calibration Check

Before you start to stereo balance, it's a good idea to first determine the relative frequency responses and sensitivity of the SOM's two speaker-microphones SP1 and SP2. This is best done with a steady tone test record or signal generator feeding *one* channel of the system.

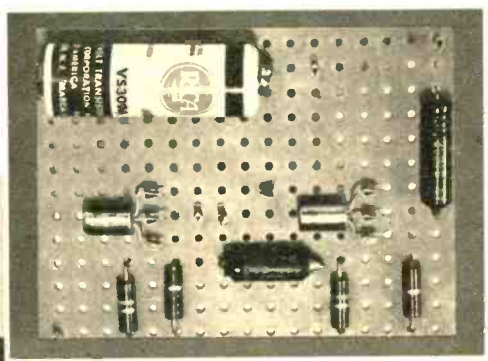
Place *both* SP1 and SP2 directly in front of, and about two feet away from one speaker. Set the generator at 1000 cps and adjust the amplifier so that the tone produced by the speaker is at about normal listening volume. With the SOM selector switch SW2 in the *Left* position, set level control R4 so that the meter reads "O" VU. Now switch SW2 over to *Right* and make note of the reading. They should be equal with the speakers equidistant from the front of the speaker. If you have an audio generator available, check the tester at 2000 cps,

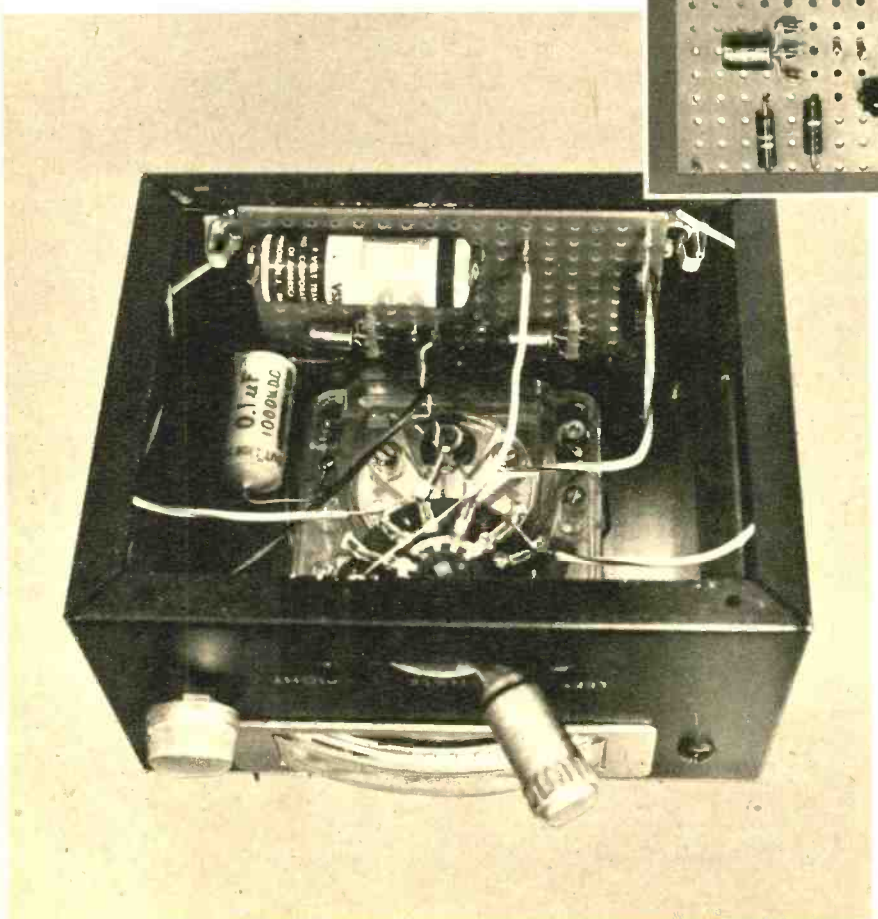
3000 cps, 5000 cps, 7500 cps, and 10,000 cps. With a 1000 cps tone, check for correct phasing of the microphones by switching to the *Center* position. If the meter does not read at the low end of the scale, reverse the leads to the voice coil of SP1. The Stereomnimeter is now ready for use.

Using the SOM

Stereo system balance is accomplished by placing the microphones in front of each stereo speaker. With your preamp set up for monophonic and the signal generator or test record as the program source, adjust the balance controls and tone controls to get the same readings as above. The system should now be balanced over the entire treble range. The Stereomnimeter is purposely designed to fall off rapidly below 1000 cps since the lower frequencies are not important for stereo and would tend to complicate the balancing. Phasing of the stereo speakers is checked by switching SW2 to the center position. Correct phasing is indicated by a reading on the low end of the scale.

Single center screw and spacer holds perforated board. Flea clips are used to mount transistors. Battery is soldered at both ends.





Electronic Brain

Have you any questions on electronics? Send it in and the Electronic Brain will provide the answer.

"Blooming" CRT

When my television set was new, the brightness control had no effect on picture size. Now, turning up the brightness control causes the picture to grow larger and distorted, and at the same time to get dimmer. What causes this?

Bob Rigmore
Lexington, Ky.

The effect you describe is known colloquially as "blooming" and is quite common in certain types of receivers.

It is almost always due to deterioration of the high-voltage rectifier tube. To help you locate your high voltage rectifier tube for replacement purposes, we are listing the types that are commonly found in television receivers.

1AX2, 1X2A, 1B3-GT, 3A3, 3A2
1V2, 1X2B, 1G3-GT, 3B2

Should you decide to replace this tube, leave your set off for at least an hour after use to permit its capacitors to discharge. If you fail to do this, you may get an unpleasant electrical shock.

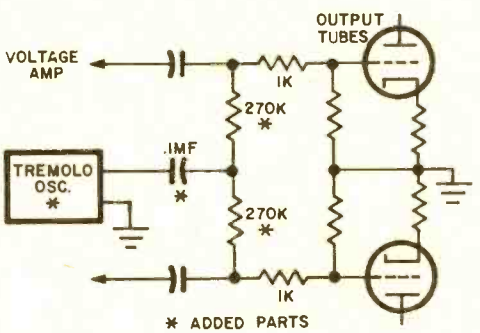
Guitar Amplifier

What produces the tremolo sound in some guitar amplifiers?

Ralph Hammelbacher
St. Croix, Minn.

Tremolo as used in guitar amplifiers is an effect in which the output gain of the amplifier is varied at a low frequency—possibly 5 times per second—by a built-in sine wave oscillator. Many guitar amplifiers use a phase-shift RC type oscillator for this purpose, although any oscillator that can produce a uniform sine wave is suitable.

Several different methods of superimposing the tremolo oscillations on the amplifier signal have been used successfully. One of the better methods involves the application of the oscillator's output to the grids of the push-pull output tubes in the amplifier, as shown in the accompanying sketch. This technique does not introduce loud thumps which are obtained when low-level



modulation of the audio by the tremolo voltages is attempted.

Tremolo oscillators generally contain two basic controls, both of them potentiometers. One governs the tremolo speed, or the number of vibrations per second; the other controls the intensity or depth of the inserted tremolo voltage.

Replacing Rectifiers

Is a series resistor necessary when replacing a selenium rectifier with a silicon of the same rating? The voltage source is a small isolation transformer.

James Wallace
Appalachia, Va.

Small isolation transformers such as those used for hobby equipment are generally rated at 25 to 40 ma maximum. This means that the secondaries are wound with relatively fine wire and that the source impedance is sufficiently high to make a surge resistor unnecessary. This idea is borne out by the fact that a protective resistor was not used in the original selenium circuit as stated in your letter. Silicon rectifiers can withstand much higher peak currents than seleniums, hence a resistor is not required with such a replacement.

"B" Supply Current

How can I go about calculating the current requirements of a portable radio? I want to build one of the power supplies described in the February EI.

John R. Carter
Ottawa, Ontario, Canada

Reference should be made to a standard tube manual in which you will find the current ratings of all the tubes. First, you will want to know the filament current drain. Since your radio utilizes a 1.5-volt filament battery now, the tubes are wired in parallel; hence, you merely add up all the individual current ratings to find the total current.

A very close approximation to the total "B" supply current may be obtained by totaling all the tube's individual plate and screen currents. For the power amplifier (output to speaker), use the "maximum signal" current ratings. You should find that the total drain is from 8 ma to 10 ma for a four-tube radio, and from 9.5 ma to 11.5 ma for a five-tube set.

Mystery CW

While using my signal generator on several occasions, I have heard a CW signal on the set under repair. Why should this happen?

David Nelson
Ajo, Arizona

When two radio frequency signals are fed simultaneously to a non-linear device such as a diode, a vacuum-tube properly biased, or a transistor stage biased near cut-off, an effect called heterodyning will occur. This is similar to the phenomenon of "beats" in sound, and results in the production of sum and difference frequencies. As an example, consider this situation: suppose your radio receiver is tuned to 1,000 kc (middle of the broadcast band) and that a CW station nearby is reaching your antenna with a 3,000 kc signal of reasonable strength. Normally, the mixer selectivity of your receiver is good enough to reject this off-frequency signal. Now, however, suppose that you are feeding your mixer—either directly or indirectly—with 2,000 kc from the signal generator. The SG output will heterodyne the incoming RF signal and produce a strong difference frequency of 1,000 kc. Since your receiver is tuned to this frequency, the CW station will be clearly heard.

Modulator for Crystal Oscillator

I have a 40-meter crystal oscillator using a 6L6 that is directly coupled to an antenna. Can you give me a circuit that will enable me to modulate this oscillator with a 7-watt audio amplifier?

Joel Fentin
Hawthorne, California

There are three *serious* things wrong with what you propose to do.

First, a transmitting antenna should not be coupled directly to the tank coil of a transmitter. Not only does this represent a potential danger with respect to DC shock, but the harmonic radiation may be severe and cause interference.

Second, an oscillator—even crystal-controlled—should not be modulated to obtain an AM signal. The amount of frequency modulation introduced thereby would violate the rules and regulations of the FCC. An oscillator should be followed by an amplifier, if AM is to be used. Better yet, a buffer stage between final amplifier and oscillator is highly recommended.

The two principal systems of modulating an RF carrier are variable or constant input. In most cases the final RF amplifier is modulated, regardless of system used.

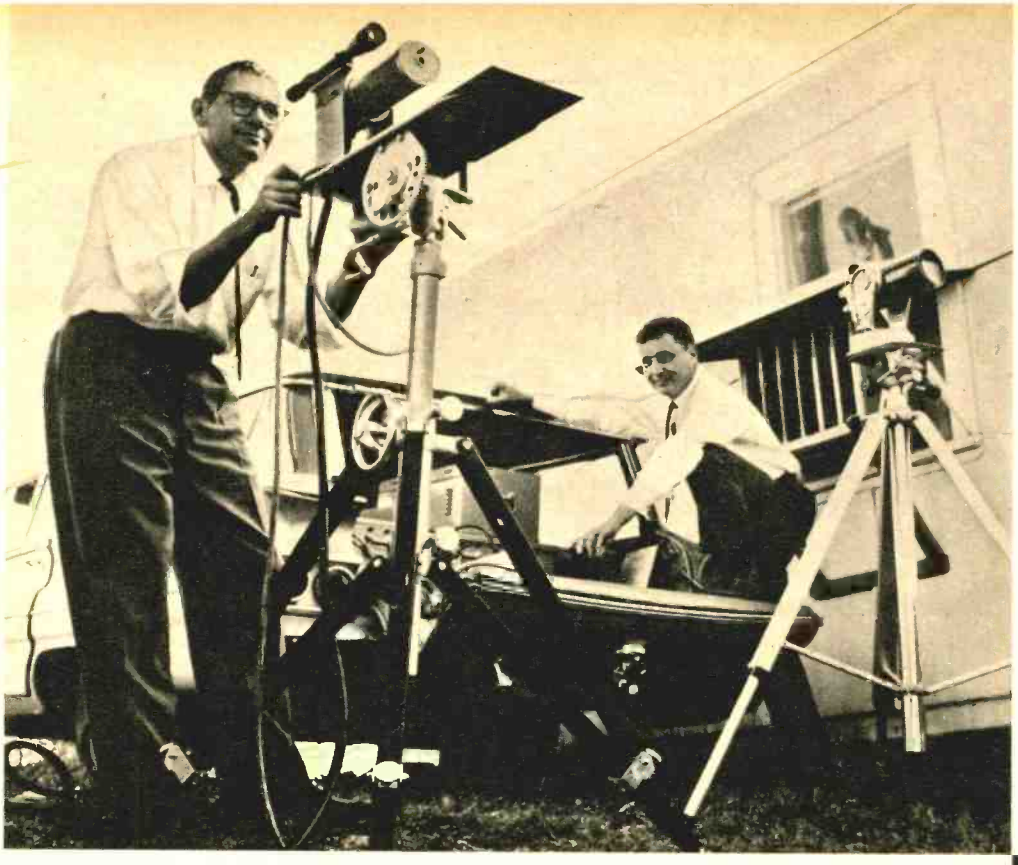
Third, modulation is permitted only in the *General Class phone* segment of the 40-meter band, not in the Novice segment, which is for CW only.

CRT Coating

Is the screen of a television picture tube coated with material similar to that used in scintillation counters?

R. C. Irvine
Valley Stream, N. Y.

Yes. The material used in coating picture tubes is a *phosphor,* or a chemical compound that emits light when struck by electrons. Scintillation counters also contain phosphors, although the chemical composition may not be the same as those used on picture tube screens. In either case, the object is to have a substance that emits light upon impact with sub-atomic particles.



Holmdel, N. J.: Bell Labs scientists aim light maser for 23-mile communication experiment.

Light-Amplifier Breakthrough

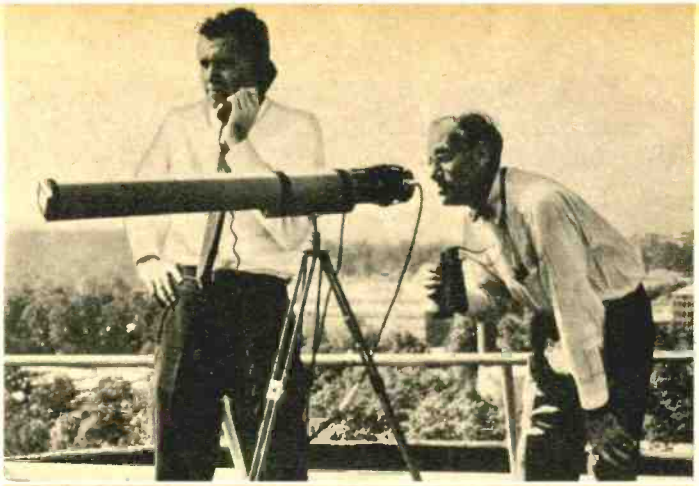
First practical experiments with light maser: "Coherent" light used much like a radio signal.

By N. A. Rosa Feature Editor

MUCH-NEEDED scientific developments have a way of coming along at the right time. As you read in *Electronics Illustrated* for October, 1960, it is now possible to amplify light waves as if they were ordinary radio waves. This has not been done by extending or adapting the usual radio amplification methods, but by a radically different approach. Yet the action in a light amplifier is much the same as in the radically new microwave radio device called the *maser* (*EI*, February, 1959), and the device is called a "light maser," or sometimes "laser."

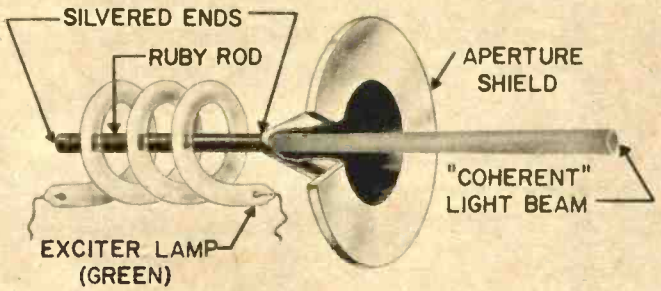
It is much needed because the world will be "all out" of radio channels by 1970 or before.

The light maser produces a "new kind" of light, compared to the light mankind has always worked with. It has many

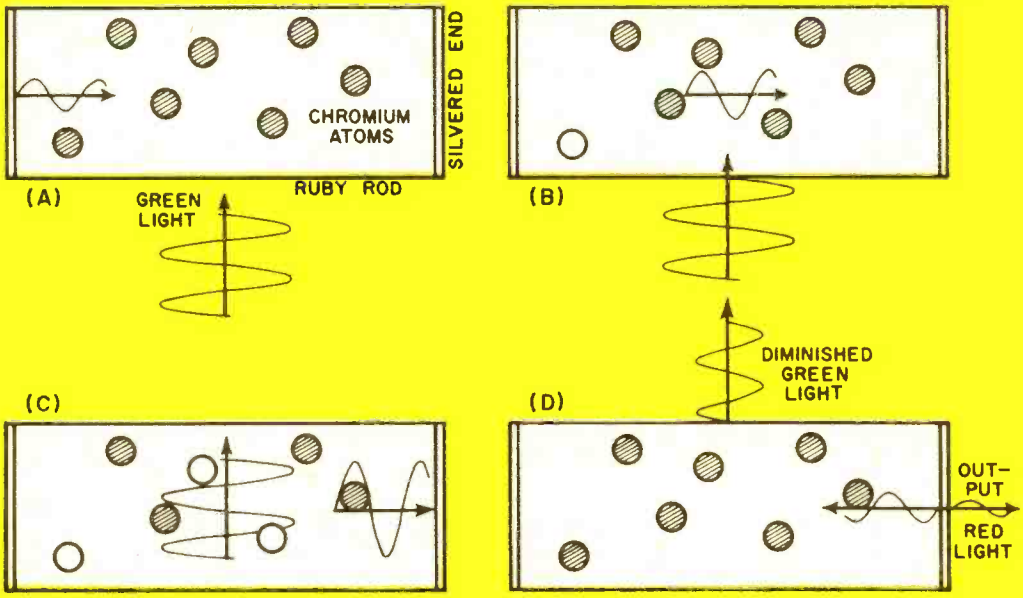


Scientists at Murray Hill, N.J., receive maser beam on phototube. Beam was only 200 feet wide at 25-mile distance, was visible to eye.

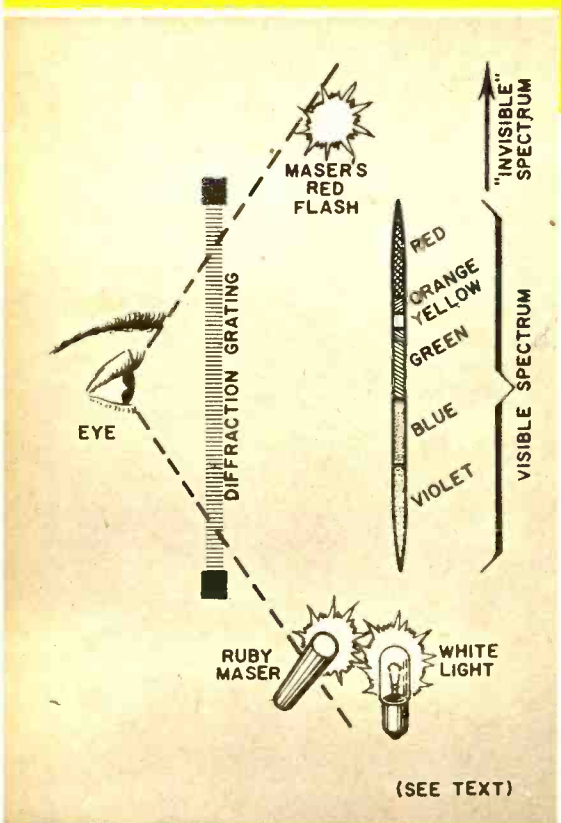
All there is to a light maser is a synthetic ruby rod and a "pump" light. Shield keeps stray light confined, making control of system easier.



Maser's single-frequency radiation being photographed by Dr. A. Schawlow, one of idea's originators, and Dr. C. G. Garrett of Bell Labs.



(A) "Pump" light stimulates ruby's chromium atoms to emit red light. Moving back and forth between silvered ends (B) red light particles jolt other atoms into emitting light. Total red light energy moving along axis builds up (C) and finally penetrates silvered ends (D).



Eye sees "invisible" red ray in experiment with white and maser lights in diffraction grating. Maser beam is so strong it makes eye respond.

of the useful qualities of a good radio signal. For instance:

The light maser's output is *coherent:* all its waves are in *phase,* "marching in step" in the orderly fashion of waves from a radio antenna, or the sound vibrations of a tuning fork. Most light is a jumble of randomly phased waves.

Maser light is *monochromatic:* again like the output of a radio transmitter or a tuning fork, *one frequency* is produced. Even the "single-color" lights we occasionally see put out a broad band of frequencies. White light contains all the frequencies between visible red and visible violet, a band two octaves wide. The difference between truly monochromatic light and ordinary light is like the difference between a pure musical

tone and the chaos of audio frequencies that make up noise. "Noise" frequencies are also incoherent, or out of phase, like the components of ordinary light.

The light maser has more to it. It produces an extremely narrow, extremely intense beam. It is equivalently hotter and brighter than the Sun. To get the same intensity from the familiar Klieg lights of the theater, several billion "kliegs" would have to be used. To get a beam as narrow as that used in the recent Bell Telephone Laboratories communications experiments between Holmdel and Murray Hill, N. J., the reflector-and-lens system of a conventional searchlight would have to be over a hundred feet in diameter.

The output beam of a light maser is only a tenth of a degree wide without optical focusing. The best searchlight beams are two degrees wide. At 23 miles, the distance separating the Holmdel and Murray Hill installations, the beam illuminated a circle only two hundred feet wide. It was visible to the naked eye (although it is in a normally invisible part of the spectrum!) and easily picked up on the phototube "receiver" used for recording and measurement.

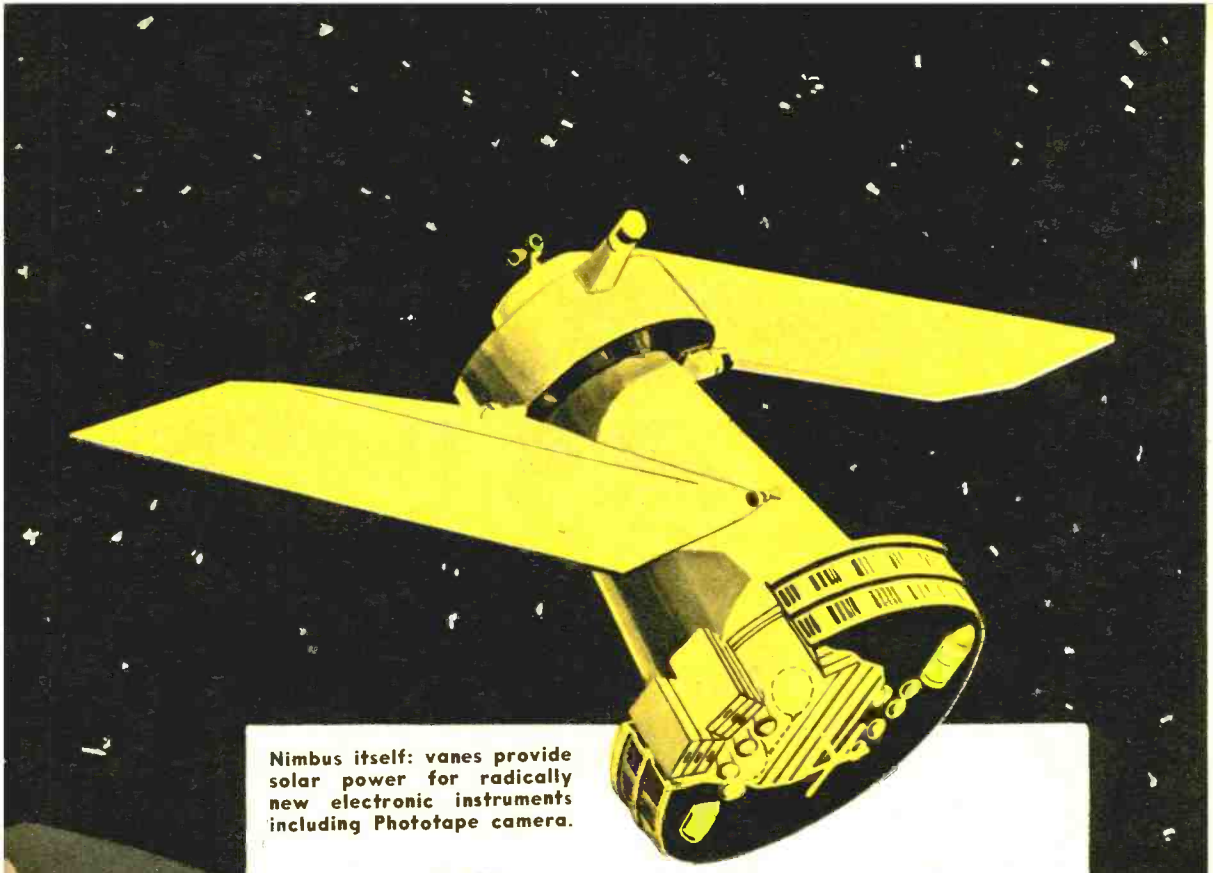
With optical focusing, one light maser beam could carry all the communication and telemetering that would be needed between an exploration base on the planet Mars, and the Earth. For communication with a Moon station, a focused maser beam would illuminate only a few square miles of the Moon's surface.

The light maser's narrow beam makes possible a "light radar" capable of giving much more finely detailed pictures than present "picture" radar, since the things a radar is "interested" in seeing are all larger than a half-wave length of light. With its hairthin beam, an enemy would have a difficult time detecting it, much less jamming it. The scanning

[*Continued on page* 108]

Dr. Theodore L. Maiman of Hughes Aircraft Co., developer of the light maser reported in *EI* for October, 1960. Design is like Bell Labs.

"The works" of a light maser. Light radiates from one end, is absorbed by shield at the other. Ruby ends are polished optically flat.



Nimbus itself: vanes provide solar power for radically new electronic instruments including Phototape camera.

new satellite tv recorder:

Phototape

New video recorder INSIDE the camera tube is "eye" for NIMBUS weather-watching satellite.

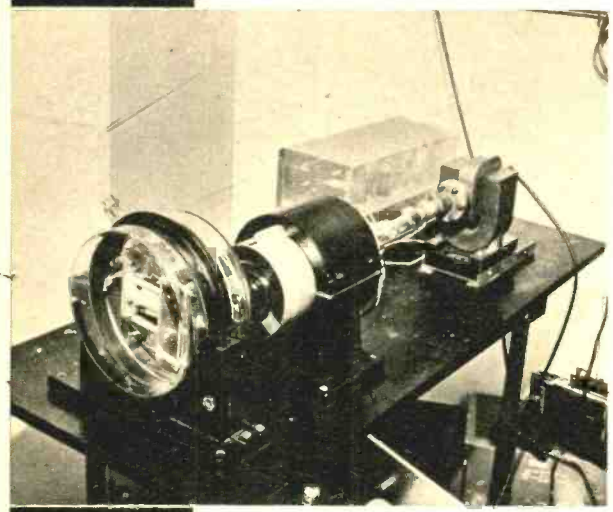
By Hans Huber

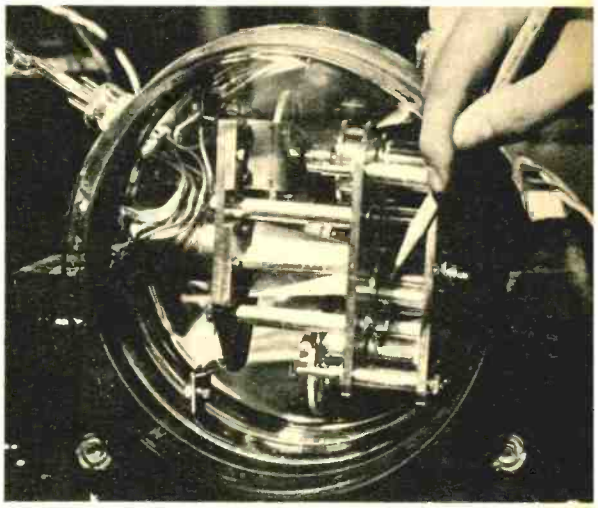
SOMEDAY in the near future, the United States will orbit an all-new weather satellite. Expected to perform tricks even more fabulous than its famous predecessor *TIROS,* our latest weather watcher will be called *NIMBUS,* after the Roman name for the dark gray rain cloud.

It will carry electronic instruments never before seen in space. Or on earth either, for that matter. Among these will be a radically different system of video tape recording.

Developed by RCA's Astro-Electronic Division, *Phototape* is completely unlike conventional magnetic recording. It employs electrostatic principles, as does *thermoplastic* recording (*EI,* April, 1960), but there the similarity ends. It is really a TV camera, but instead of the usual fixed mosaic target found in broadcast cameras, this one has a *moving photoelectric tape* instead.

The entire system, tape transport mechanism and all, *is en-*





The complete Phototape camera-and-recorder system is enclosed in tube's glass envelope. Cloud "pictures" become pattern of electrostatic charges on a moving film-base tape. Scanning electron beam reacts with charges to modulate miniature TV transmitter on command. Right, pencil points to part of tape reel, on which light is focused by means of a lens system, not shown.

closed within the evacuated glass envelope of the camera tube. Because of its unusual construction, RCA doesn't even call it a recorder, but rather a "sealed electrostatic tape camera."

Since the camera stores its own video information directly, it has no need to convert its signals to magnetic recordings. It is therefore much simpler and lighter than the systems now in use.

The base of the tape, shown in Fig. 1, is standard uncoated motion-picture film stock. Over this is evaporated a thin layer of gold. This is called the *signal plate*, and is used to make electrical contact with the next layer above.

On top of the gold is a photoconductive layer. A photoconductor is a material or device whose resistance varies with the amount of light striking it. The material in this case is antimony trisulphide, the same as is used in commercial Vidicon TV camera tubes.

The top layer is polystyrene (an insulating material, which here forms the dielectric of a capacitor) for electrostatic picture storage.

At each edge of the sensitive area of the tape is a metal strip which makes electrical contact with the signal plate. Wiping contactors pick the sig- [*Continued on page* 105]

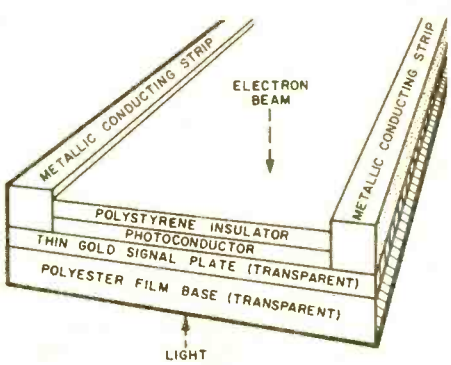
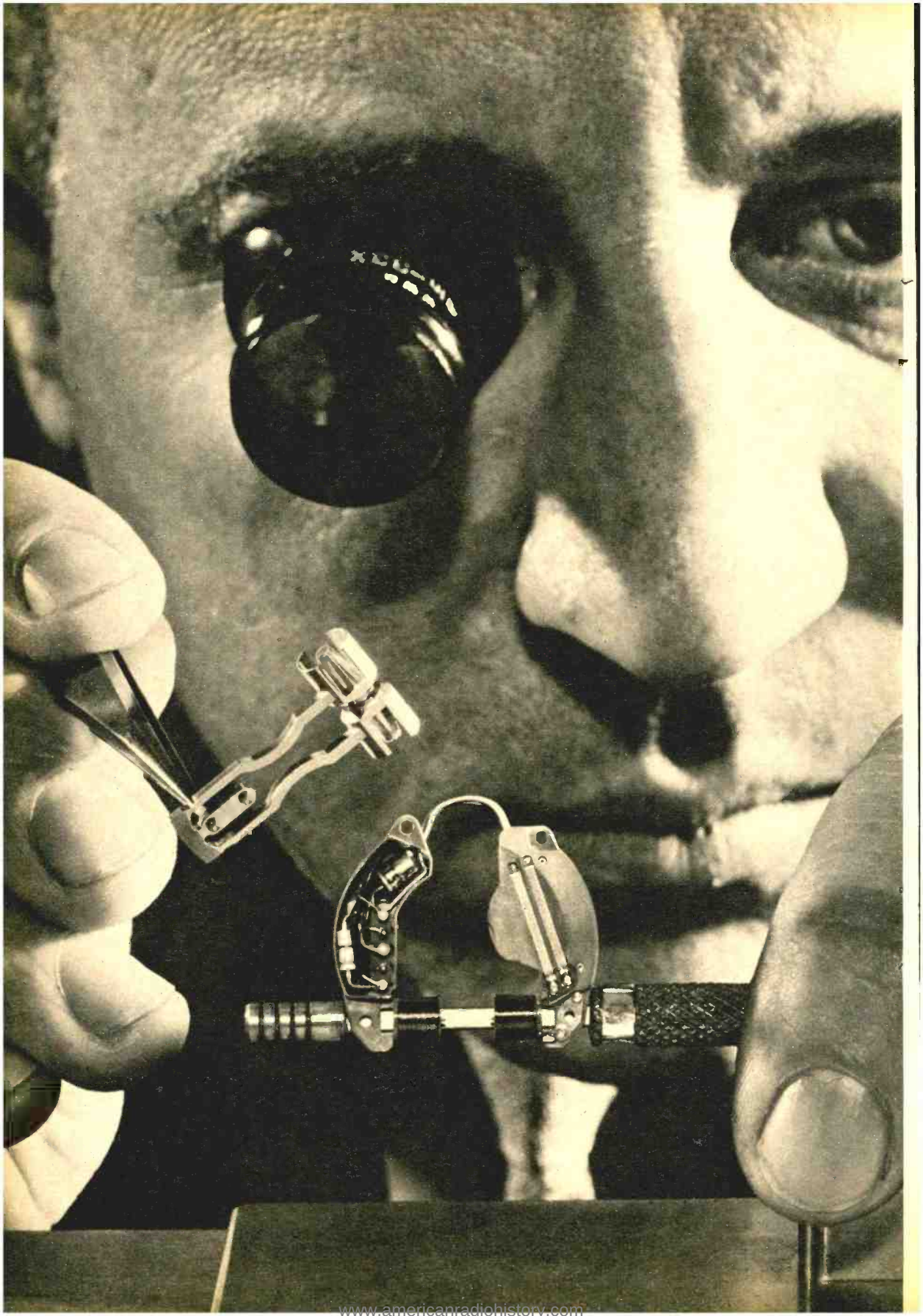


Fig. 1. Phototape consists of conducting and insulating layers on a polyester film base.



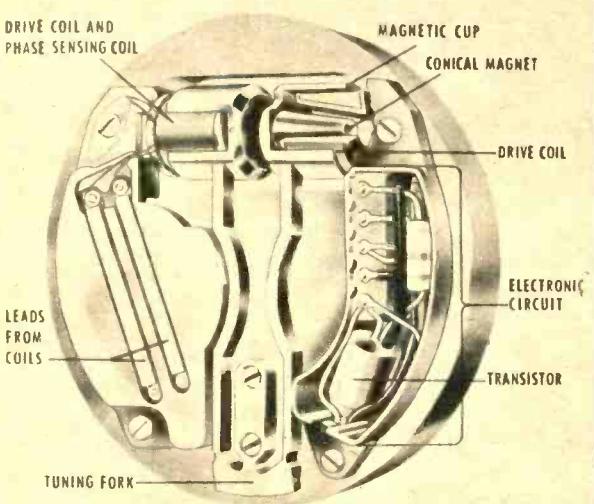
A True Electronic Watch

MICRO-MINIATURIZATION, electronics, and ingenuity have combined to produce something really new in watchmaking: The *Accutron*, Bulova's electronic watch. The Accutron looks ordinary enough on the surface, but a glance at the innards shows a fresh approach. Instead of the usual mainspring, escapement, and winding mechanism, there are a transistor, a tuning fork, and a replaceable miniature 1.3-volt mercury battery.

How Does It Work?

The heart of the instrument is a one-inch tuning fork with an electromagnetic assembly at the tip of each tine. Electrical energy drives the tuning fork to vibrate at its natural frequency of 360 cps. Attached to one tine of the fork is a tiny finger-like index spring. On the tip of the index spring is a jewel that engages ratchet teeth on an index wheel. As the fork vibrates, the jewel-tipped spring moves back and forth with it, advancing the index wheel one tooth for each cycle of the tuning fork. The index wheel, which is about the size of a pinhead and has half the thickness of a human hair, [*Continued on page* 109]

No springs, no escapements and no motor . . . the Accutron is simply a frequency standard. Electromagnetic coil assembly causes tuning fork to vibrate at 360 cycles per second guarantying timepiece's accuracy. Finger-tip size battery (below right) powers the uncomplicated transistorized circuit.



ACCUTRON

EI's Hi-Fi Doctor . . . .

Audio Fact and Fiction—Part One

A few columns ago, I started out on a subject that I tentatively labeled "The Mythology of Hi-Fi." Encouraged by letters from audiophiles, I'd like to pursue it further and try to separate some more audio fact from fiction.

Of all hi-fi components, speakers come first in the myth and half-truth class. Take, for instance, the sacred notion that a multi-speaker system is a *must* for hi-fi. There *is* just enough truth in this to take it out of the myth category, but let's take a closer look.

According to standard hi-fi gospel, only a woofer and a tweeter working together can produce wide-range sound. A speaker designed to move a big chunk of air for good bass response just can't be light enough on its feet to produce good highs. And an agile speaker for highs can't stand the heavy-duty use needed for low frequencies. The piston motion that produces the lows is quite different from the minute vibrations that propagate the highs.

This multi-speaker rule holds up pretty well for all-out systems that aim for ultrasonic highs and earth-shaking lows. But inventive souls have done pretty well with one eight-inch or ten-inch unit in horn-loaded or even bass-reflex enclosures. The medium or small-sized drivers in these systems often come up with cleaner overall response (particularly in the transients) than their big brothers.

The trouble with the multi-speaker theory comes when it is applied to systems designed for a budget-minded audiophile. Here the many eight- and ten-inch speakers from companies like Wharfedale, Lansing, Goodmans, and Stephens usually have an edge on two- or three-speaker systems in the same price range.

The audiophile with high hopes and a small budget will wind up in better shape if he doesn't insist on a cheap separate woofer and tweeter or a cheap coaxial job. When he does insist on a multi-speaker system, it's usually because of the mistaken notion that wide-frequency response and high-fidelity are one and the same.

Actually, it makes little sense to look for all-out frequency response from really low-priced units. Systems at the rock-bottom price level can supply it, but at the cost of a jagged overall response curve, distortion, and a good case of listening fatigue. It pays to concentrate instead on smooth, low-distortion sound that makes for comfortable listening. A lack of extreme highs—the 15,000 cps variety—and real bottom bass below 50 cps is much easier to live with than a system with wide-range distortion.

For the audiophile on a budget, the easy way to all-out fidelity is to start out with an eight- or ten-inch speaker which can later serve as a part of a bigger system. You can later add a matching tweeter and/or woofer, eventually winding up with the original speaker performing as a mid-range unit. Make sure to use the manufacturer's suggested crossover points.

Although it's far from a myth that multi-speaker systems usually have the highest fidelity, I've taken this quick potshot at the subject because it is often the source of fruitless and expensive experimenting for new audiophiles.

and Clinic

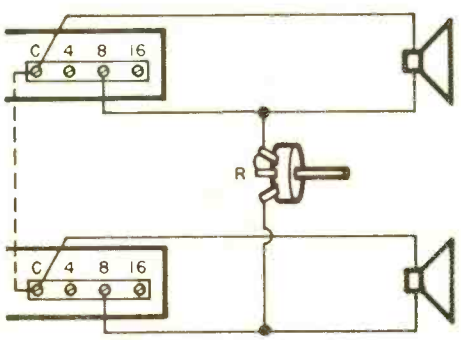
Hi-Fi questions are all answered by mail. If of general interest they will appear in this column.

Stereo Blend Control

My present stereo system does not have a blend control. How can I add one and how does it work?

A. Levine
New York City

The blend control permits the listener to vary the "width" of the sound source presented by a pair of stereo loudspeakers. If your system doesn't have such a control, one can be added. Connect a linear-taper potentiometer (R) as shown. This can even be done right



at the speakers themselves, but make sure that the pot is connected across the "hot" leads. For 4-ohm speakers use a 100-ohm pot, for 8-ohm speakers use a 200-ohm unit. In the minimum resistance position, you will have essentially monophonic reproduction; at the maximum resistance position, the pot is, in effect, out of the circuit; in-between positions vary the overall width of your sound source.

Four or One

Which would you recommend, a speaker system with four separate speakers (woofer, mid-range, and two tweeters) or a more expensive system using a single speaker?

Charles Margolis
Miami, Fla.

It's a mistake to "count" the speakers in the enclosure when trying to select a system. There are advocates of single full-range speakers, two-way, three-way, and four-way systems—and there are advantages and disadvantages claimed for each arrangement. The odds are—if the system using a single speaker costs more than the four speaker system, it will sound better. In any case, speaker systems should be judged by the sound coming out of the enclosure, not by the number of speakers in it.

Speaker Specs

Does frequency response specifications for speakers mean anything any more? My catalogs list a $3.95 tweeter that seems to have the same specifications as a $25 model.

Charles Cooper
Culver City, Calif.

A statement that a speaker has a response of from 40 to 13,000 cycles, for example, tells very little about how it will sound. For all we know it may have a 10 db peak at 10 kc and drop off immediately beyond that frequency. The net result is a "brilliance" of tone, but with an emphasis on distortion and noise from the associated equipment.

Down at the other end of the audio spectrum, a large resonant peak at 70 or 80 cycles causes the speaker to have a jukebox sound. The fundamental frequencies of real bass response would be missing.

In short, frequency response is not the whole story—it isn't even necessarily the most important part of the story. Unless the response is expressed in plus or minus so many db from the lowest to the highest frequency covered, it is meaningless. Other factors such as transient response, damping, dispersion, etc., in the final analysis will prove to be far more important to your ear over a long period and it's an unfortunate fact that these factors are not always subject to quick evaluation or listing in spec sheets.

New Life For Your Record Changer

Part I

By Walter Salm

IF YOU have an aging record changer, don't throw it away just because it has some rumble, wow, needle talk and other assorted ills. A little time spent in routine servicing may give the machine a new lease on life.

Most record changers are well constructed and reliable, but two serious factors operate against them . . . dirt and age. Aging primarily affects the rubber parts, causing them to harden and wear. The worst victim of this problem is the idler wheel which is the rubber disc that transmits the power from the motor drive shaft to the inside turntable rim.

Most other problems concern dirt and adjustments, with the emphasis on the dirt. A good general cleaning agent is carbon tetrachloride, an inexpensive item available at any hardware store. One word of caution however, avoid breathing the fumes from carbon tet or using it in a poorly ventilated room. A healthy record changer is not worth a sick repairman.

Some of the adjustments you'll have to play by ear. If there is some mechanical trouble in the changer that hasn't cleared up after the cleaning and lubrication described, prop up the changer on some wood blocks and watch it cycle. A little observation and experimentation should show the trouble. All those mysterious gears, cams and levers have a purpose and you can discover it with a little patience.

To get into the works of the changer, you'll first have to remove the turntable. Pull off the horseshoe-shaped locking clip on the spindle base; you can pry it loose with a thin screwdriver blade. These clips have a tendency to disappear, but don't fret if yours is missing. It won't affect the operation of the changer one bit. Next step is to remove the turntable by pulling straight up with a slight rocking motion. (Fig. 1.) Clean the inside of the turntable rim with a clean cloth saturated with carbon tetrachloride. All rubber drive elements should be cleaned with alcohol.

Several things happen to the drive wheel (or "idler") with the passage of time. It crystallizes, that is the rubber hardens and can no longer "grab" the turntable rim with the friction needed for positive drive action. The result is "wow" and stalling during the change cycle. You can try roughening the surface of the wheel with coarse sandpaper, but be careful not to remove too much material.

"Flats" (shown in exaggerated form in Fig. 2) are caused by pressure of the wheel against the turntable rim. These flats show up as rumble or "thumps" in the speaker.

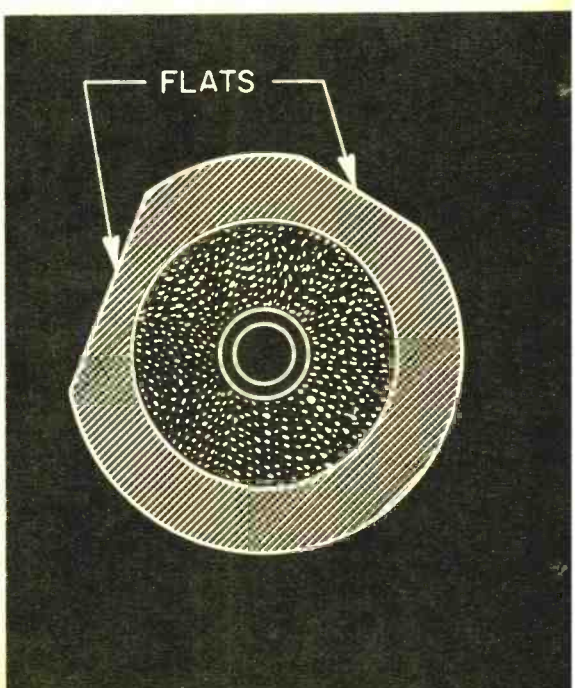
The only *permanent* cure for these conditions is to change the idler wheel. In some record changers, the entire wheel must be replaced. In others, the rubber rim or "tire" can be peeled off the metal core and replaced with a new "tire." (Fig. 3). Because of the effect of age on rubber, it is a good idea to change this wheel every two or three years as a regular maintenance procedure.

To remove the idler, loosen the set screw from top or sides (Fig. 4). Some idler wheels may have a locking clip or cotter pin instead. The other wheel shown in model in the photo is the cycling mechanism drive, which does not have to be removed. Most changers have only one wheel. If the older idler seems to be still serviceable, clean out the center hole with carbon tet. After it has dried, put a spot of oil on it. The same operation should be performed before installation of the new idler wheel. Be careful not to get any lubricant on the rubber surfaces or turntable rim or the turntable will tend to slip.

There are several British and American changers which have drive belts instead of wheels. Under normal conditions these belts are good for about two years of service at most. If one of these models wows or tends to stall in the middle of a change cycle, check the belts

FIG. 1

FIG. 2



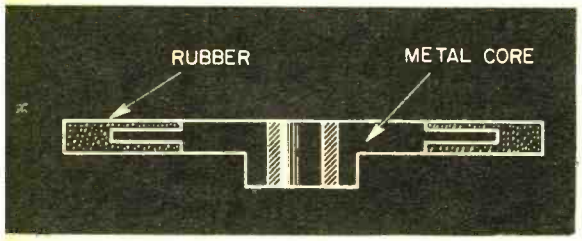


FIG. 3

—they look like ¼" wide rubber bands with about ¾" to 1" internal diameter. The rubber should be "live" and stretch and snap back with plenty of tension. Replacements if required can be obtained from the manufacturer or Walsco Electronics Mfg. Co., 400 So. Wyman Street, Rockford, Illinois. Walsco also has available a complete line of idlers, and drives.

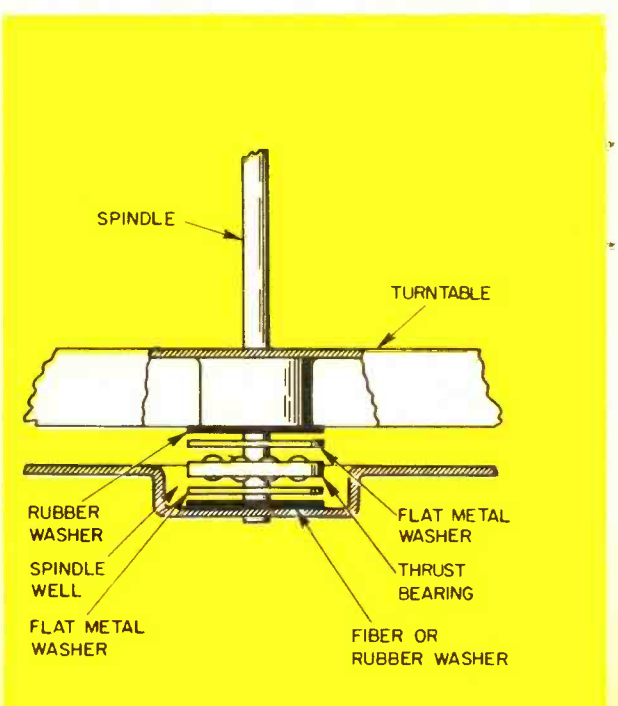
A typical record spindle and bearing assembly is shown in Fig. 5. It is important during reassembly after cleaning to follow the specific order of the washers and bearings in your changer. The thrust bearing must have metal washers at its top and bottom in order to turn freely. Be sure to clean all the parts and lubricate the bearing assembly before reinstallation. When replacing the turntable you may find that the idler wheel will partially obstruct the table. To correct this, push in the idler wheel with your finger or the flat side of a standard screwdriver blade while you lower the turntable. Once the table is in place, the retaining clip can be snapped onto the base of the spindle. It may be necessary to rotate the table by hand a number of times before it engages. Listen for rubbing, scraping or any other noise that might indicate improper assembly. If there are any mechanical sounds present, they may be picked up by the cartridge.

For a final check on the turntable operation, check the speed with a stroboscopic disc. The disc contains several bands of dots or lines which will appear to be stationary when illuminated by a 60-cycle light source, such as a neon lamp plugged into a 60-cycle AC line. Slight backward or forward motion of the lines indicate that the speed is somewhat slow or fast. In a commercial record changer, it is rather unusual for all of the speeds to be exactly up to specification. One-quarter rpm too fast or slow amounts to an error of less than one percent and is not noticeable at 33⅓ rpm. However, a serious error in speed indicates trouble.

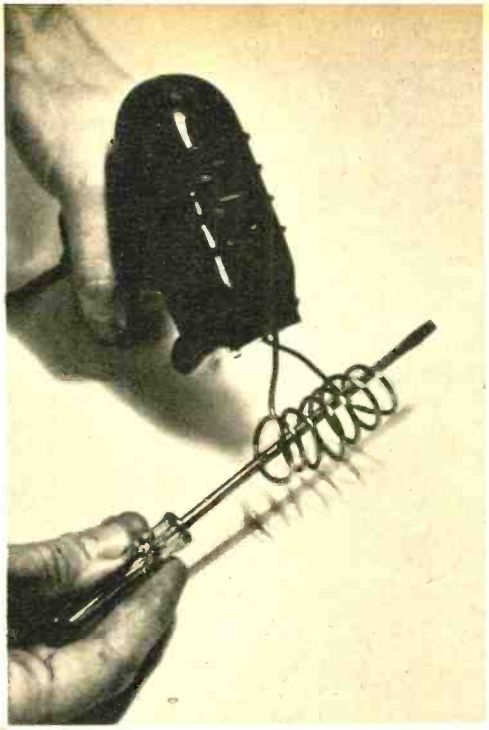
(*To be continued next month*)

FIG. 4

FIG. 5

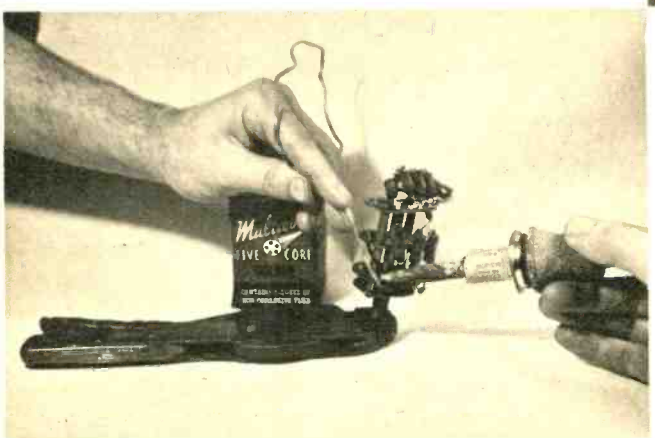


EI's Hot Tips



Gun Converted To Magnetizer

A coil consisting of several turns of #14 gauge solid copper wire can be plugged into your soldering gun in place of the regular tip to convert it to a magnetizing tool. Simply insert tool you want magnetized into coil, squeeze the trigger for a couple of 10-second intervals.



Switch Wiring

When constructing projects or kits, switch wiring can be a problem. Two such problems are keeping the switch steady while you are soldering and making sure that the solder doesn't run down into the switch contacts. These problems can be easily solved if you use one of the many available types of locking pliers as a vise. The switch can then be positioned at any angle and rotated to the best soldering position.

Artist's Brush Aids Soldering

An artist's brush can be very handy for soldering. Especially so if you coil some solder around it as shown. Use the brush to apply soldering paste; also to brush away excess hot solder. The pointed wood handle is good to open clogged solder lug eyes. Finally, the solder around the handle lets you apply solder and the paste all in one easy operation.

Getting on the Air:

the final steps

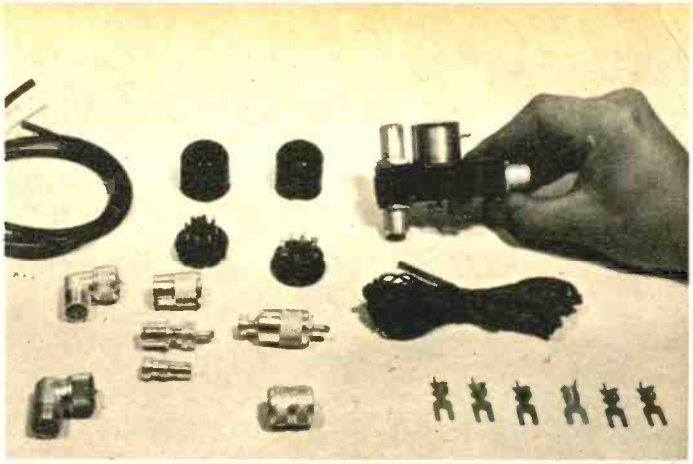
Waiting for a ham license? Don't chew your nails. Put your station in shape to operate efficiently.

By Paul Hertzberg, K2DUX

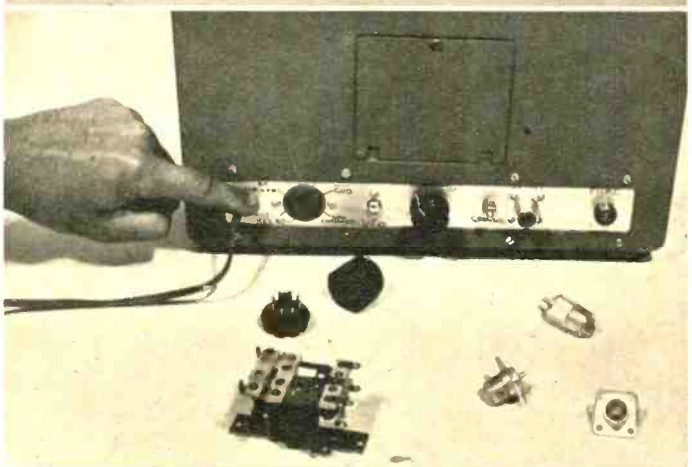
MANY a new ham has tried to put his station on the air using nothing but his transmitter, his receiver, and the antenna. He soon finds that contacts (QSO's) are a nightmare requiring him to have four hands and a teflon-insulated skin. He must switch the receiver to standby, the antenna from the receiver to the transmitter, the transmitter to "transmit" and then switch everything back again each time the conversational ball is tossed. As he frantically slaps switches he gets big and little shocks and tickles because the shack is full of RF energy and the transmitter and receiver chassis have a potential between them. The receiver keeps "getting the wind knocked out of it" for seconds at a time because of overload from the transmitter signal.

These problems are very easily solved for a few dollars and a small investment in time. *Relays* can handle all the switching at one "throw." *Coaxial cable* keeps RF inside the circuits and gets it to and from the antenna with minimum loss. *Proper grounding* eliminates shocks and tickles and their hazards.

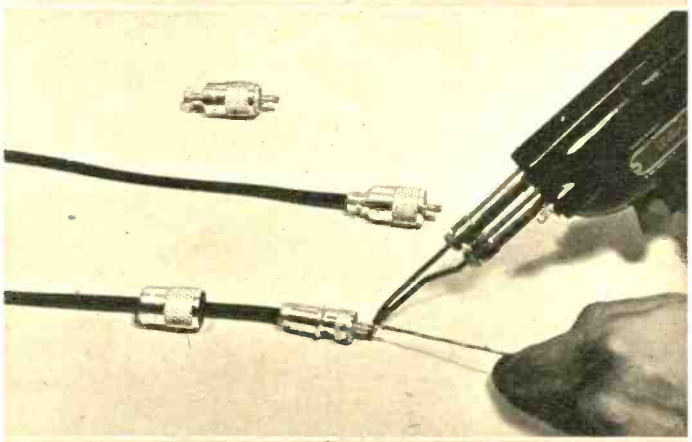
You had your receiver long before [*Continued on page* 102]



The few items needed. Coaxial relay is for antenna switching, receiver disabling. Other relays may be used (see text).



Most newer transmitters have accessory socket for control-relay power and VFO. In front, non-coax substitute relay.



Coaxial cable should be used for all RF leads. True coax fittings are superior to phono plugs, are more easily soldered.

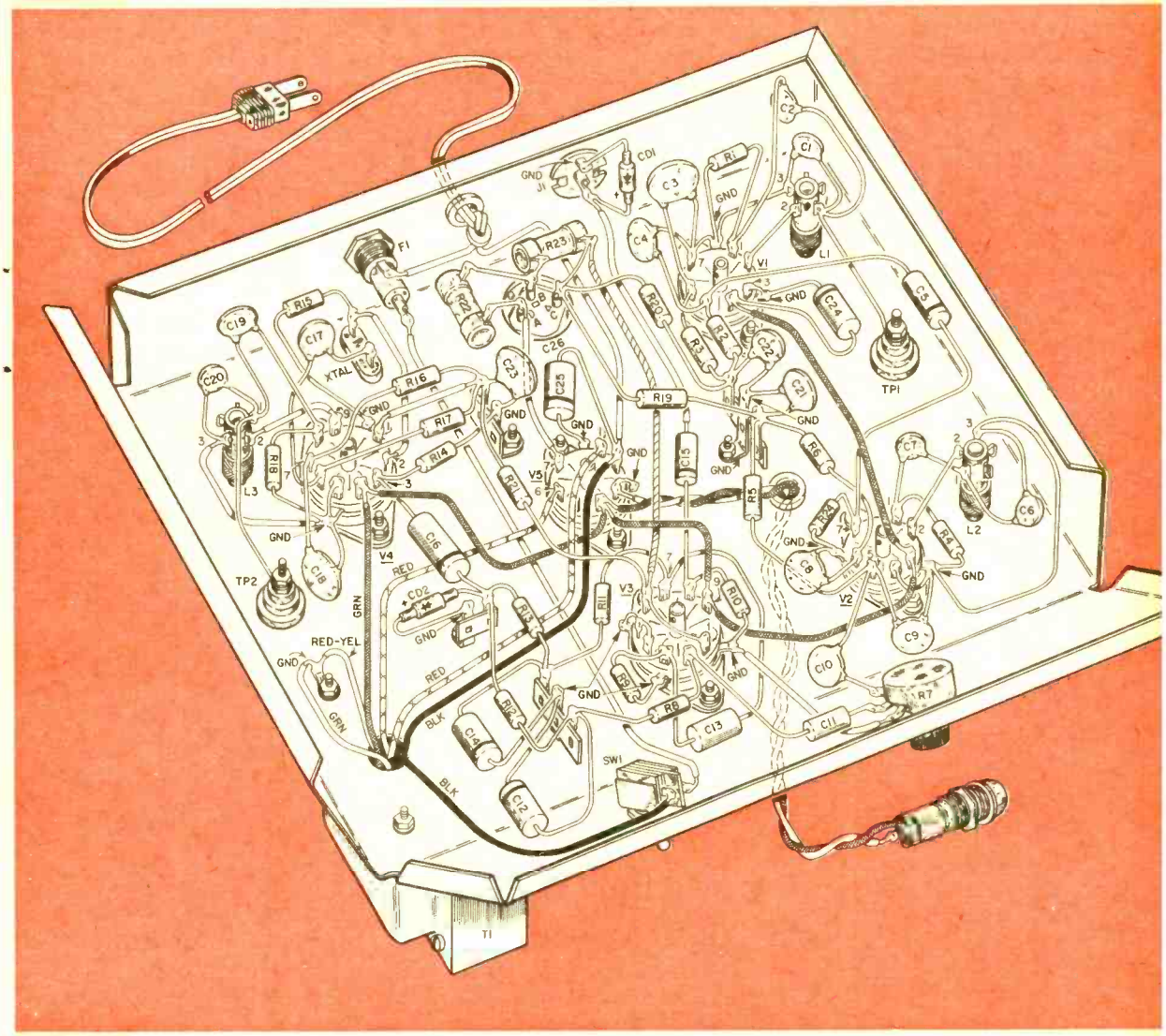
A dummy antenna is essential, and nothing could be simpler: a light bulb. Lug goes to chassis ground by a short lead.

A Professional's Theremin

Souped-up unit works with any PA or hi-fi system.

By Dan Horowitz

RECENTLY we've heard a lot about electronic musical instruments—electronic organs, guitars, vibraharps, etc. But the weirdest and most exciting electronic musical instrument of them all is the theremin. Invented in the early days of radio, it has been used mainly to produce eerie sound effects, but in the hands of experts it has played melodies, and produced sounds similar to a choir of voices or other more conventional musical instruments. For about thirty-five dollars you can build *EI's* version of the theremin and create your own in-



Underchassis view of completed unit. If tube sockets without ground tabs are used, install separate grounding lugs under the socket mounting screws.

eresting compositions for this most fascinating instrument.

Construction

The Theremin can be built easily by anyone with some experience in electronic construction. The layout shown in the pictorial should be followed carefully.

Drill the required holes and mount the components. Then wire up the power supply and filament leads making sure that the latter are dressed close to the chassis. Next wire the oscillator sections (V1, V4) and the audio stage (V3). If desired, the oscillator coils (L1, L2, L3) can be prewired before assembly. On these coils note that the red dot is in the position shown (between

lugs 1 and 2), lugs 4 and 5 are *not* used.

Use shielded tube sockets for V1 and V2 to help reduce oscillator radiation. Any crystal whose fundamental is close to 500 kc will serve. Several crystals marked for use around 26 and 27 megacycles worked well also since their fundamental frequencies are in the desired range.

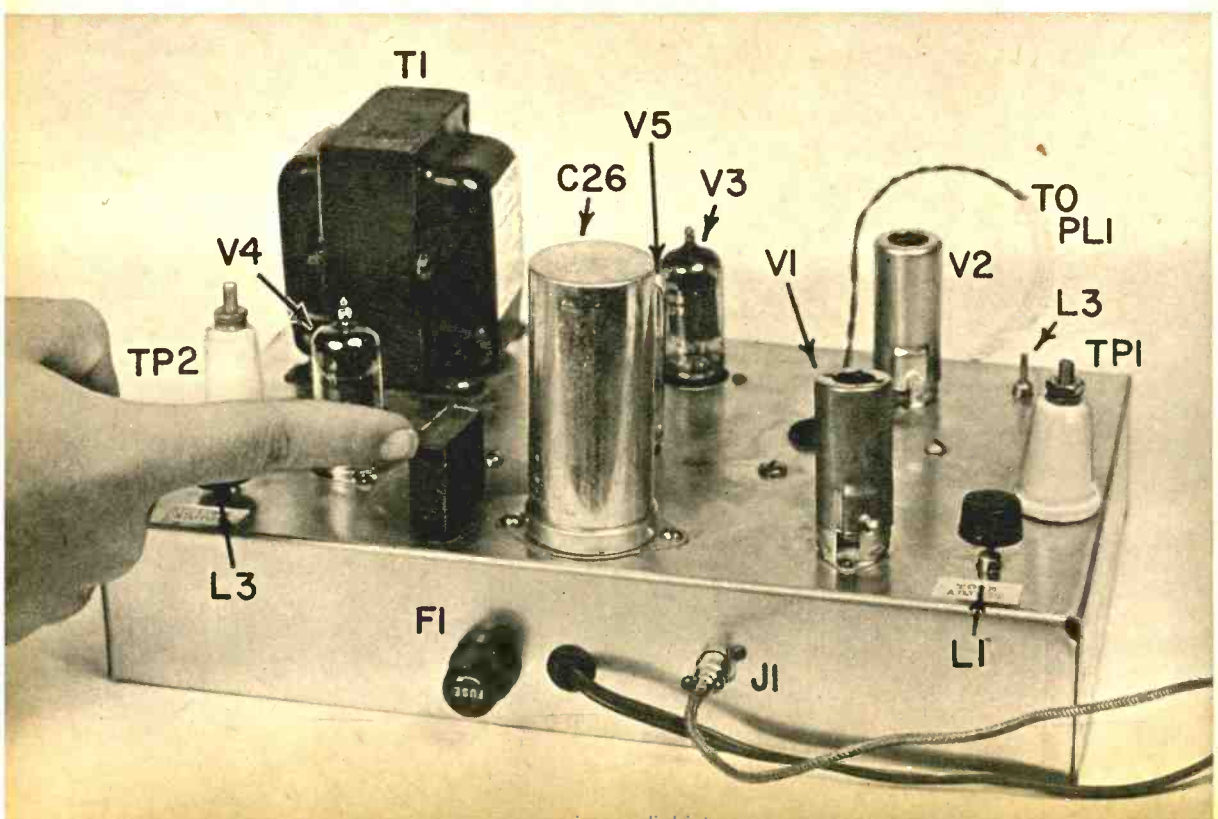
The leads to be connected to the antennas are brought through the chassis by means of porcelain feed-through insulators (TP1, TP2) which also serve as antenna mounts. The antennas are bent from ⅜-inch aluminum or copper tubing. One end of each antenna is hammered flat and drilled so that it may be bolted to the tops of TP1 and TP2. Any shape of antenna will do since it is the surface area that affects its sensitivity. The two antennas should be relatively far apart as shown to prevent interaction.

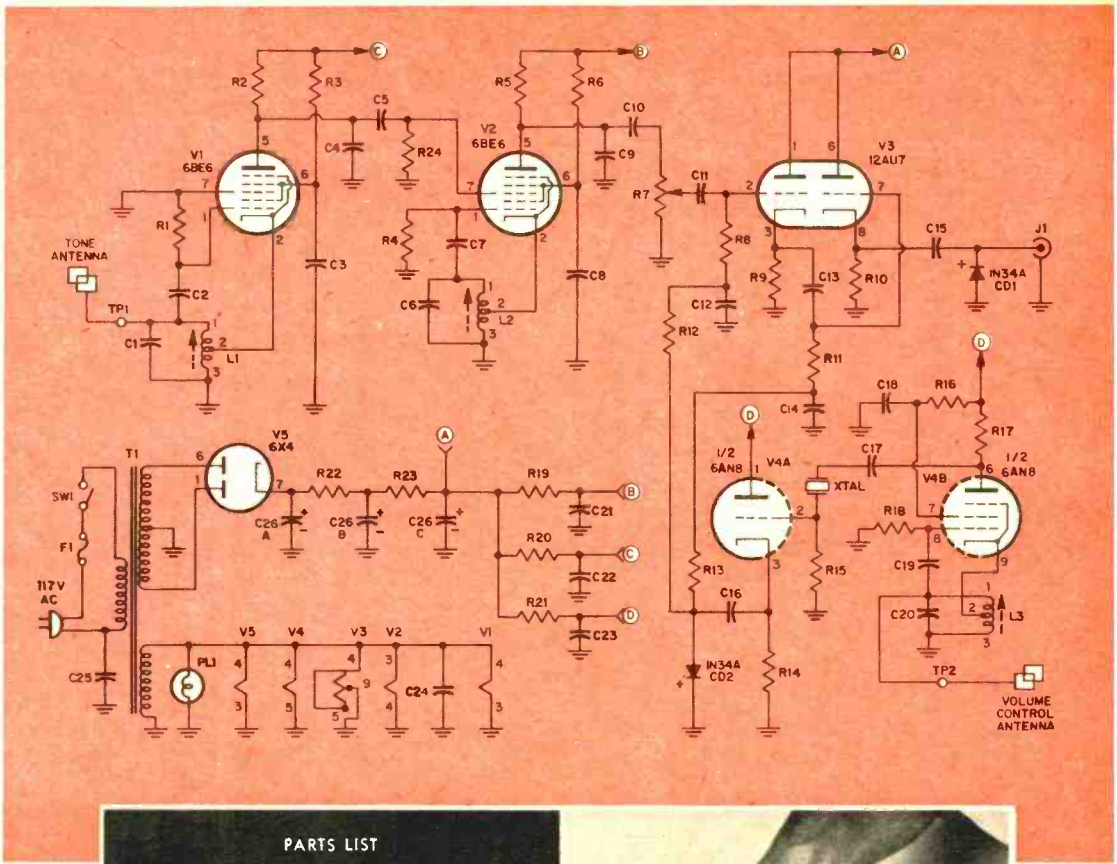
Adjustment

After construction is completed, and the wiring checked out, connect the unit to an audio amplifier; any AC-operated unit, either integrated or basic will do. Connect a shielded phono cable and jack J1 of the Theremin to the tuner or aux input of your hi-fi set. Allow at least 20 minutes for warmup before attempting to make permanent adjustments.

Tone Antenna. This antenna is adjusted by using a small screwdriver to set the slugs of coils L1 and L2. 1) Turn volume control R7 and your external amplifier's volume control, about halfway up. 2) Turn the slug of L2 until about ½ inch of the screw protrudes above the chassis. 3) Rotate the slug of L1 slowly until a high pitched sound is heard. Further rotation of L1 should cause the sound to lower in pitch until it disappears (zero beat), then rise in pitch again and finally disappear. This sequence may occur at several places, but the one that gives the loudest volume is the one to use. 4) Adjust L1 so that with the hand *away* from the tone control an- [*Continued on page* 98]

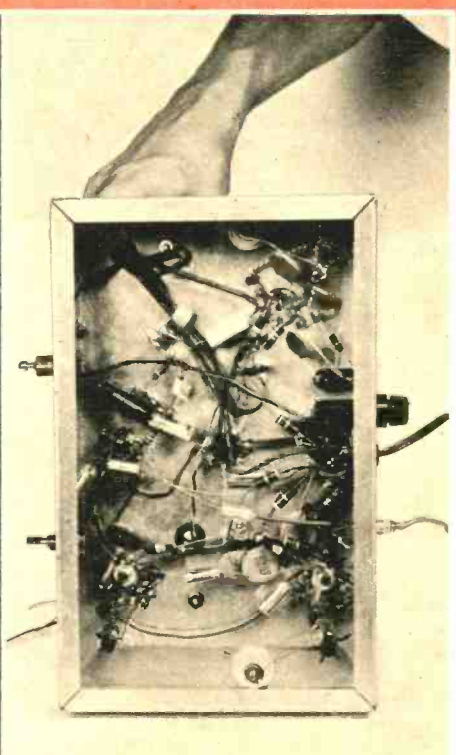
Top chassis component layout. Crystal shown may be surplus unit. Author's layout should be followed to avoid interaction of the various oscillators.





PARTS LIST

Resistors—½ watt, 10% unless otherwise indicated
R1,R4,R18—22,000 ohms
R2,R5,R17—100,000 ohms, 1 watt
R3,R6,R14—47,000 ohms, 1 watt
R7—500,000 ohms potentiometer (audio taper)
R8,R11—680,000 ohms
R9,R10—56,000 ohms
R12,R13,R15—120,000 ohms
R16—270,000 ohms
R19,R20—4,700 ohms, 1 watt
R21—3,900 ohms, 1 watt
R22,R23—1000 ohms, 5 watt
R24—100,000 ohms
Capacitors: All capacitors 600 volt disc or tubular unless otherwise indicated
C1,C6—470 mmf
C2,C7—47 mmf
C3,C10,C11,C13,C15,C17,C21,C22—.01 mf
C4,C19—56 mmf
C5,C9—.005 mf
C8,C12,C14,C16,C18,C23,C24—.05 mf
C20—680 mmf
C25—.03 mf
C26—30-20-20 mf, 3-350-V electrolytic can
V1,V2—6BE6
V3—12AU7/ECC82
V4—6AN8
V5—6X4
F1—1 amp fuse and assembly
PL1—No. 47 pilot lamp and assembly
L1,L2,L3—oscillator coil (Miller 70-OSC)
TP1,TP2—porcelain feed-through insulators
T1—power transformer, secondary: 240-0-240 @ 50ma or higher, 6.3-volt @ 3amp.
CD1,CD2—1N34A Crystal Diode
SW1—SPST toggle switch
Xtal—500 KC (available from Texas Crystals, Crystal Drive, Fort Myers, Florida)
Misc.—Aluminum chassis 7"x11"x2", cabinet, antennas, Xtal and tube sockets



Semiconductor Rectifiers

A short survey of the operating characteristics of these increasingly important components.

By Henry A. Schwartz
Tung-Sol Electric Inc.

THE conversion of alternating current to direct current for use in electrical equipment, has been given a great deal of consideration by Industrial and Electrical Engineers. This particular phase of the electronic art uses the principles of many devices. In this article we will deal with the branch of the industry known as "Metallic Rectifiers."

When dealing with an alternating voltage, we are dealing with a voltage which fluctuates in a sinusoidal manner. That is to say, the voltage starts at zero, increases in a positive direction, through a maximum (peak), back through zero and then repeats the cycle in a negative direction reaching a negative peak. To rectify this alternating current, we must cause the electrons to flow in one direction only.

The Diode Rectifier

The diode is a two-element device which allows electrons to move in one direction only (Fig. No. 1). In the illustration, the plate is connected to the positive side of a battery and the cathode is connected to the negative side. The cathode when heated by a filament releases electrons. The electrons are attracted to the plate, due to the fact that the plate has a charge opposite to that of the electrons.

By replacing the battery and the switch with an alternating voltage source, the positive half of the sine wave (equivalent of switch closed) will cause electrons to flow. The negative half of the sine wave (equivalent of switch being open) will not permit any elec-

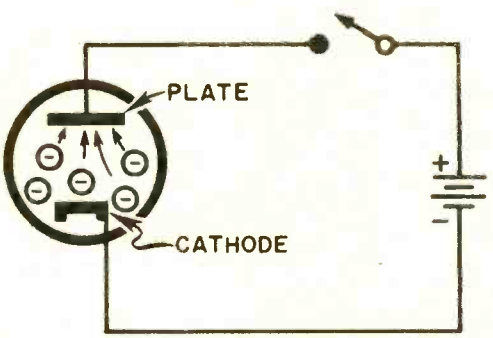


Fig. 1. Operation of ordinary diode tube. The electrons will flow only when switch is closed.

trons to flow. By using this simple diode we can therefore change alternating voltage to direct voltage by allowing electron flow in one direction only.

Semiconductor Rectifiers

A semiconductor rectifier can be used to replace the diode tube. It functions approximately in the same manner as the diode tube. Semiconductor rectifiers have certain advantages over the diode tube:

a) For the same current and voltage capacity they take up less room.
b) Since the semiconductors are metallic in structure, they are less fragile than the glass diode tube.
c) Since there is no need for a filament in the semiconductors, they need no "warm up" time as do the diodes. In high current applications the diode tube can be seriously damaged if plate voltage is applied prior to a sufficient warm up time.

Briefly, the semiconductor provides little or no resistance to the flow of electrons in one direction, and a great deal of resistance to the flow of electrons in the opposite direction. When the plate side (P side) of the rectifier is positive, electrons will flow forward, through the rectifier. When the plate side is negative, no electrons flow.

Semiconductor rectifiers are composed of various types of metals and metallic compounds. Such compositions as selenium, silicon, germanium, copper oxide, and magnesium copper sulfide have been used for these rectifiers. Until very recently, because of the relatively simple manufacturing technique, selenium has been used in most semiconductor rectifying devices.

A high power silicon rectifier with current rating in the 45-150 amp. area. Note the pipe thread base and the heavy output lead at top.

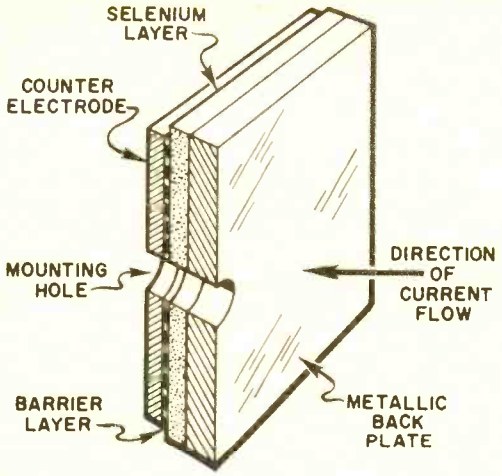


Fig. 2. Cross section of a selenium cell. Proper cell operation depends on selected impurities.

Types and Functions

There are three popular types of semiconductor rectifiers presently in use. The germanium rectifier is constructed of a single crystal of germanium. It is noted for its high efficiency (approximately 98.5%) and its lack of aging. Aging is the term for the changing with time of the electrical characteristics of a particular semiconductor. Germanium is used where the current application is low, i.e.: up to about 100 milliamperes. In higher current applications germanium needs cooling. High surge currents can destroy them.

The seleniums are very strong and withstand shock and vibration. They are capable of being constructed in stacks or groups to handle very high current applications. Selenium is found in power supplies having current characteristics of from 5 through 100 amperes or more.

Up and coming in the semiconductor field is the silicon rectifier which has many additional properties which make it ideally suited for applications in medium power voltage supplies. The silicon is used in applications where currents of 100 ma through 5 amperes are handled. It is much smaller than its larger brother the selenium rectifier, operates in higher ambient temperatures and has good aging characteristics.

Application of Silicon Rectifiers

Like all semiconductors, silicon is rated in terms of forward current and the peak inverse voltage. Consideration must be given to these two factors when selecting a silicon rectifier for application in a particular rectifier circuit.

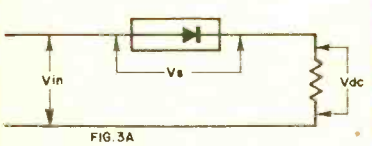
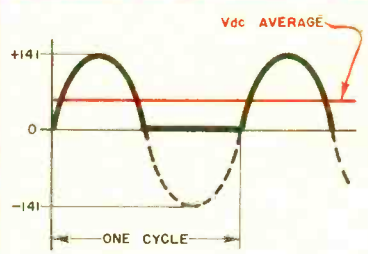


FIG. 3A



Simplest rectifier circuit has current flow during half of each cycle. Because of lack of filtering, the DC voltage is only ⅓ of the AC peak. In addition, the ripple voltage is very high.

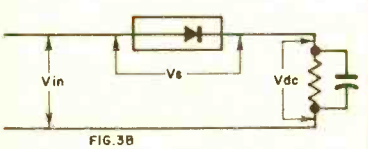
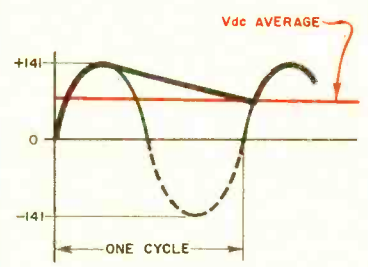


FIG. 3B



A capacitor has been added across the load resistor in the circuit above. This capacitor increases the average DC voltage output to approximately ½ of the peak. The circuit has poor efficiency.

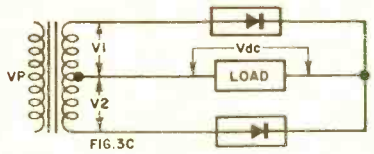
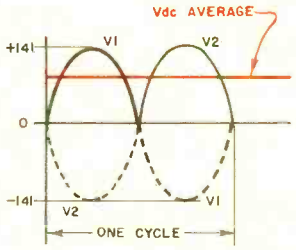


FIG.3C



Centertap transformer rectifier circuit provides full-wave rectification using two diodes. Utilization of both halves of AC cycle results in lower ripple and higher DC output.

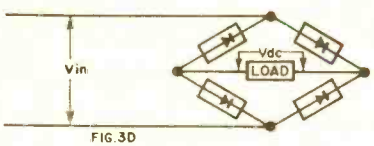
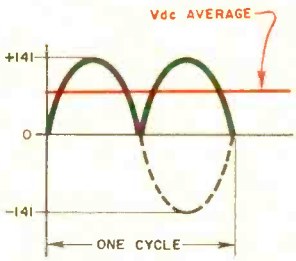


FIG.3D



Full-wave bridge circuit requires no center-tapped power transformer and can use rectifiers with a lower peak inverse voltage. In addition, this configuration may be operated directly from the AC power line.

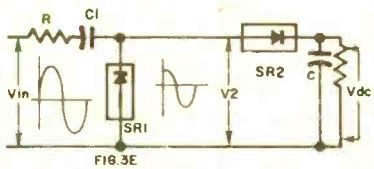
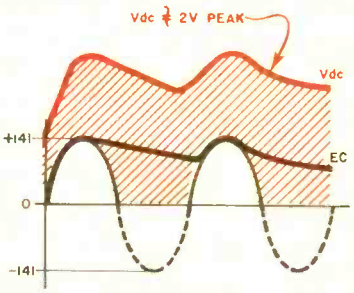


FIG.3E



Half-wave voltage doubler circuit in which the DC output voltage is about twice that of the AC input voltage. This transformerless circuit is found in inexpensive TV receivers.

Referring to the half wave rectifier (Figure 3A—resistor load), we will analyze the voltages in the circuit. V_{in} represents an input voltage whose RMS value is 100 volts. V_{dc} represents the instantaneous DC voltage across the load. V_s represents the voltage drop across the silicon. (Since V_s is of the order of 1 volt we will neglect it in our analysis.) As the voltage V_{in} increases from zero to a maximum positive, electrons flow through the silicon and subsequently through the load resistor. As the voltage, V_{in} decreases from its positive maximum position toward zero, the electrons flowing in the circuit also decrease. When V_{in} reverses phase and goes negative (below the zero axis), the *rectifier does not conduct, therefore instantaneous V_{dc} equals zero.* The maximum inverse (PIV) blocking voltage across the silicon is the maximum negative peak of V_{in}. Since we are assuming an input voltage of 100 volts RMS, the peak input voltage is equal to 1.41 x the RMS = 141 Volts. This would indicate that a half wave silicon rectifier should have a peak inverse voltage rating of not less than 150 volts. If the load resistor, R, were equal to 1000 ohms, then the current (average DC current) flowing in the circuit would be: $I_{av} = V_{dc}av/1000$. In a half wave resistor-loaded rectifier, V_{dc} average is equal to 31.8% of V_{dc} peak. V_{dc} average would equal 44.84 volts. I_{dc} average would therefore be equal to .0449 amperes. Besides considering the peak inverse rating of the silicon we can now select the rectifier with the proper current characteristics. A Tung-Sol type 1N2078 for example, rated at 400 volts

peak inverse blocking voltage and 500 ma average DC forward current would operate adequately in this type of circuit.

Referring to Figure 3B, we have modified the half wave rectifier by adding a capacitor to the load. The same analysis can be made of the circuit as we have just gone through for the simple half wave silicon rectifier. The basic difference is that the capacitor charges during the positive cycle of V_{in} and, assuming a high load resistance, discharges slowly during the negative cycle of V_{in}. At the time that the voltage on the silicon plate is negative maximum due to V_{in}, the voltage on the silicon cathode is positive due to V_{dc}. Therefore the peak inverse voltage is equal to approximately twice the peak of V_{in}.

Full Wave Rectifier

Figure 3C represents a full wave rectifier. The voltages are supplied to the plate side of two silicon rectifiers by means of a center tapped transformer. The voltages supplied to either silicon are out of phase with each other. I.e.: When silicon plate No. 1 is positive, silicon plate No. 2 is negative. When silicon No. 1 has a positive voltage applied, it conducts and current flows through the load resistor back to the center tap of the transformer. The second silicon conducts when it is supplied with positive voltage. From the standpoint of load current there is no "off cycle." Electrons are flowing through the load during all half cycles. The average voltage at the load is equal to .639 of the peak voltage at the load. The inverse voltage is equal to approximately twice peak. By the addition of a proper filtering network the ripple can be reduced and the average voltage at the load increased.

The bridge rectifying circuit shown in Figure 3D provides essentially the same electrical characteristics as the full wave rectifier just discussed. The major difference is the fact that the inverse voltage is *equal* to V peak or approximately half the rating of the inverse voltage of the full wave rectifier. The center tapped transformer is eliminated also.

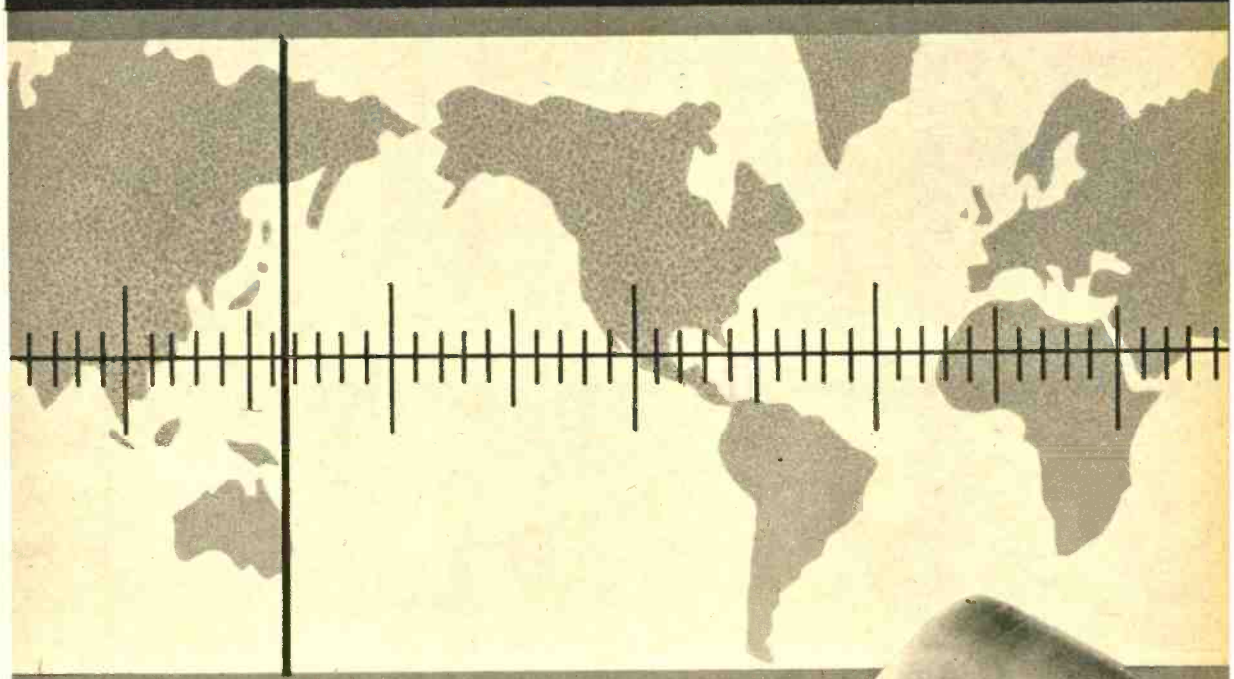
A circuit which is commonly found in the transformerless television receivers is shown in Figure 3E. This is a voltage doubling circuit which does not use a transformer. During the negative cycle, the silicon rectifier SR1 conducts and electrons charge capacitor C1 as shown. If we now consider the sum of the input voltage plus the voltage across capacitor C1 as the supply voltage to silicon SR2, the balance of the circuit is identical to a half wave capacitance loaded rectifier. SR2 receives an input voltage of V_{in} plus V_{c1}. If C1 is selected at approximately twice the value of C, then the voltage developed at C would be approximately twice the average voltage normally developed by a simple half-wave rectifier.

Checking a Diode

DC voltage and current measurements may be made to ascertain forward current while the semiconductor is operating in the circuit by placing a DC ammeter in series with the load. Care should be exercised to select a high reading scale on the meter prior to turning on the circuit. After the circuit is on, a lower range can be selected to clearly read the DC circuit current. This will indicate if the rectifier characteristics change under load. An ohmmeter may be used to determine static (non-energized) conditions of the circuit parameters. Since the semiconductors have a low forward resistance and a high reverse resistance, this can be measured using an ohmmeter by first connecting the positive meter lead to the plate side (P side) and reading the forward resistance (low). By reversing the ohmmeter leads, you may read the reverse resistance (high). A comparison of these readings to the manufacturer's specifications will provide an indication of a defective rectifier whose characteristic (static) are permanently changed. By following standard resistance and voltage analysis, these possible defects may be rapidly located:

Aging (selenium primarily)
Broken junctions (germanium and silicon)
Loose connections (selenium)
Change of characteristics providing poor forward current flow.
Open series resistor.
Open voltage doubling capacitor.

how you can
Tune In The World



Everywhere, strange new music is being beamed at you. It is literally at your fingertips.

By C. M. Stanbury, II

WE keep hearing these days about how small our world is. It is often called a "shrinking" world. Aviation usually gets the credit and blame for this, but the world-shrinking was really done by radio. Now it is small enough to fit into your living room, and the process started in the nineteen twenties, when radio hams proved that the "useless" short waves were really the greatest thing since tom-toms.

Strangely, radio has made it a *big* world again, too. When you actually tune in the world, you will become acutely aware of the immense variety of

Starting out as a "DXer" is easy. All you need is your ordinary broadcast radio. Tune slowly, and you will hear stations from all over the country. Rotate set itself for best pickup.

things that make it up. When you pick up a transmission from some scientific expedition you will *feel* the actual remoteness of some spots on our globe.

How do you get started, tuning in the world? What do you need?

Why not begin by using your ordinary broadcast radio, as is? That's right, nothing to buy, nothing to add to the set, no need even to tear off a box top. Just turn it on, warm it up for half an hour or so, and begin.

The best time is a couple of hours after sunset, especially in the winter months. Adjust the volume for comfortable "local" listening, and start tuning *slowly* across the dial. When you come to a weak signal, stop. Rotate the set itself to take advantage of the built-in loop antenna's directionality. Adjust the volume, and wait for station identification.

Whatever it turns out to be, it is probably farther away by several hundred miles than what you are accustomed to hearing. It may be in Canada or Mexico. You have bagged your first *DX*.

"DX" is the old radiotelegrapher's symbol for "distance," and if you listen to distant stations you are a "DXer."

You probably won't want to stop there. Now that you have caught the DX virus you will want to go after the really distant ones, across the oceans, across the world. For that you must become a short wave listener, or "SWL."

Short Wave

"Everything" is on the short waves, both at home and abroad. Airliners far out over the ocean, calling ahead to airports. Fishing boats at work, talking with each other and their shore base. Radio amateurs, or "hams," by the thousands. Satellites beeping in their orbits, and space probes falling away into the vastness. Internal communications of countries like Brazil and the Soviet Union, with great reaches uncrossed by telephone or telegraph lines. And, of course, international broadcasting.

Practically every country of the

A rare one? Or just a weak U.S. signal coming along a poor transmission path? Careful adjustment of the receiver "develops" the signal. Notice the transmitting equipment here; many a radio amateur, or "ham," started out as a short wave listener, the best way to begin.

Verification cards from DX stations often show the transmitter site, as does this dramatic one from principality of Monte Carlo.

world airs its music, culture, drama, and point of view (in news and propaganda) on the short waves. A great deal of all this broadcasting wattage is beamed at North America, and a generous portion of it is in English. The reasons are obvious, especially when it comes to propaganda. Often, however, a foreign country will simply want to maintain a cultural tie with immigrants here. Therefore, even if a station is broadcasting in a foreign language, it may be aiming its transmission "at you." This makes it easier to hear, but on the short waves you often hear things that are beamed elsewhere, not intended for you, or "us," at all. This is one of the things that makes it interesting.

Everybody is familiar with the idea of the Voice of America (*VOA*), the British Broadcasting Corporation (*BBC*), and our old friend Radio Moscow. These are big propaganda efforts, but they carry entertainment, too.

The smaller nations often provide the most interesting listening. The facilities in some cases are almost makeshift, reminiscent of the early days of radio anywhere. But little countries high on remote mountain ranges, at the edge of great deserts, and on tiny islands all want to be heard.

A by-product of your short wave listening will be the stations' *verification* or "QSL" cards. These are often things of beauty and are worth collecting in themselves. If you are a stamp collector, why, you may get the latest stamp, too. How to go about securing verification cards (also called "veries") is covered toward the end of this article.

As you get to know more about DXing, you may want to specialize. International broadcasting uses only about ten percent of the frequencies of the "short wave" spectrum. The rest is used by the "utilities" mentioned before: aircraft, boats, ships, police, telephone and telegraph facilities—everything that requires *two-way communications*.

Whether you specialize or not, you will have to get acquainted with various "noises" of short wave—code signals

Marv Robbins

There you are, in your room with your short wave receiver, listening to the world. The ace DXer shown here uses a big, complex receiver. You can do very well with something simpler. Distance heard does not depend on cost of set.

National NC-60

This little table model or "bookshelf" receiver, a sixty-dollar investment, is a superheterodyne incorporating a beat frequency oscillator (see text), built-in speaker, headphone jack for your family's sake; standby switch to keep it warmed up; bandspread tuning dial.

and the like. We'll tell you about those in a section dealing with certain little difficulties and obstacles. *Difficulties? Obstacles?* Don't panic, Guv'nor. DXing is a *sport*. We'll let you in on the easy things first. Get your courage up with some beginner's luck, a hole-in-one or two, get you acquainted with the course before we send you out to muck around in the rough.

The Receiver

About all you need in the way of "equipment" is a short-wave receiver. And an antenna, which will turn out to be a piece of wire, more or less.

Now, some fundamentals. Since we keep hearing about "short waves" we can assume that there are "long waves," too. In fact, there are medium waves. And "very short waves." And "ultra short waves." And so on. But we are talking here about short waves: say, from 100 meters (in wavelength) down to 10 meters. Or, in terms of frequency, from 3000 kilocycles to 30 megacycles. One megacycle, as the eager ones in the class now wish to point out, equals 1000 kc, so 30 mc is 30,000 kc.

Now, you need a radio that covers at least 3 to 30 mc. You may have one that covers part of the range: many entertainment-radios have a short wave "band" on them. They also have the dial marked with such fanciful things as "Tokyo," "Paris," "Moscow," and so on. You may have tried putting your dial pointer on the middle of one of these words, or on the initial letter, and have heard nothing that remotely sounds like Tokyo, Paris, Moscow, or even Toledo (Ohio) for that matter.

"Communications" receivers, which cover the short wave, have no city names on them. Just numbers for kilocycles and megacycles, and dial divisions in between.

A really fine communications receiver usually covers 500 kc to 30 mc in six bands. The medium- and lower-priced models cover the range in four bands.

Your receiver may have five or six tubes or it may have thirteen. *You can hear just as far with the five-tuber* as with its big brother.

In fact, you can hear 'round the world with a two-tube *regenerative* set. This old circuit is a perennial favorite of experimenters and of beginning radio constructors. In a "regen," the detector tube amplifies the incoming signal and then feeds some of its amplified output back to its input circuit to be amplified again.

Most "regens" these days come as inexpensive kits. But you may not feel like building anything, and besides, a regen is a bit tricky to operate. So let's go back to the more familiar superheterodyne type of set, which is the standard radio, TV, and radar receiving circuit.

Your minimum cost for a good modern receiver is about sixty dollars, not counting sales taxes or shipping costs. Such a set will have five or six tubes, will cover the standard broadcast frequencies and everything up to 30 mc, will have *bandspread tuning* ("fine" tuning), *automatic volume control, beat frequency oscillator* (*"BFO"*), built-in speaker, headphone jack, *standby* switch, and perhaps a noise limiter circuit.

This is a "minimum" receiver. There are other features you will want as your DXing gets more avid and serious.

For long-wave work, or very-high-frequency work (below 550 kc and above 30 mc respectively) you will need other receivers, or *converters*. A converter is a device that picks up a signal on a frequency not covered by a receiver, *converts* it to one that the receiver normally picks up, and then feeds it to the receiver. The receiver thinks it is picking up what it is supposed to and

Allied Radio Corp

Heath Co. AR-3

A simple regenerative receiver like the 2-tube kit at left will pull in stations from anywhere and everywhere. It may lack some of the fine features of its big brothers, but is a fine beginner's tool. In the hands of an expert, a "regen" can put complex sets to shame. Another kit, at right, is 6-tube basic superheterodyne set. More stable, easier to control than the regen, it is an inexpensive "starting out" project for the do-it-yourself type DXer.

Verification cards, or "QSL's," from distant stations are not only your proof of reception, but are colorful collector's items in themselves. Many DXer's store them in "wallpaper" displays. They can help your stamp collection too.

is quite happy. Using one is simple.

(Editor's note: A good short-wave converter, to be used with an ordinary broadcast receiver, was described in EI *for March, 1960. In a forthcoming issue,* EI *will bring you the* "EI Forty-Niner," *a simple transistor converter that covers the 6-mc international broadcast region and allows you to "sample" short waves.)*

A good receiver has three qualities:

Sensitivity: The ability to respond to weak signals, whether near or far. When conditions are bad, even the signals of 50- or 100-kilowatt propaganda transmitters are feeble. By no means all of the transmitters used on short wave are so powerful. The most interesting DX, and the most worthwhile (at least from the "sporting" point of view) comes from far smaller transmitters. You will soon find yourself ignoring the strong ones and going after the weak ones. The more sensitive your receiver, the better luck you will have.

Selectivity: The ability of a receiver to separate stations operating on closely-adjacent frequencies. The answer to the separation problem is *not* to add bandspread tuning, as is commonly supposed, though bandspread is highly useful with a well-designed, selective set. We'll tell you how and why in a moment.

Signal-to-noise ratio: A receiver tends to generate noises of its own: a steady

hiss of thermal antenna noise and thermal tube noise, and *hum* from the power circuits. Part of the receiver, the *intermediate frequency amplifier,* amplifies signals and noise thousands of times. Each tube in the "IF" amplifier also amplifies the noise of the preceding tubes in that circuit. The problem is met by low-noise circuits ahead of the IF, including a low-noise *radio frequency amplifier.* A good "RF" amplifier builds up the signal to a whopping high value that requires less subsequent amplification and easily overrides noise.

The better the signal-to-noise ratio, the weaker the signals you can work with, especially as there may be other, "outside" noise to contend with.

An RF amplifier also improves the set's selectivity. This in turn improves the noise performance of the receiver, since the set is picking up external noise from a more narrow "slice" of the spectrum.

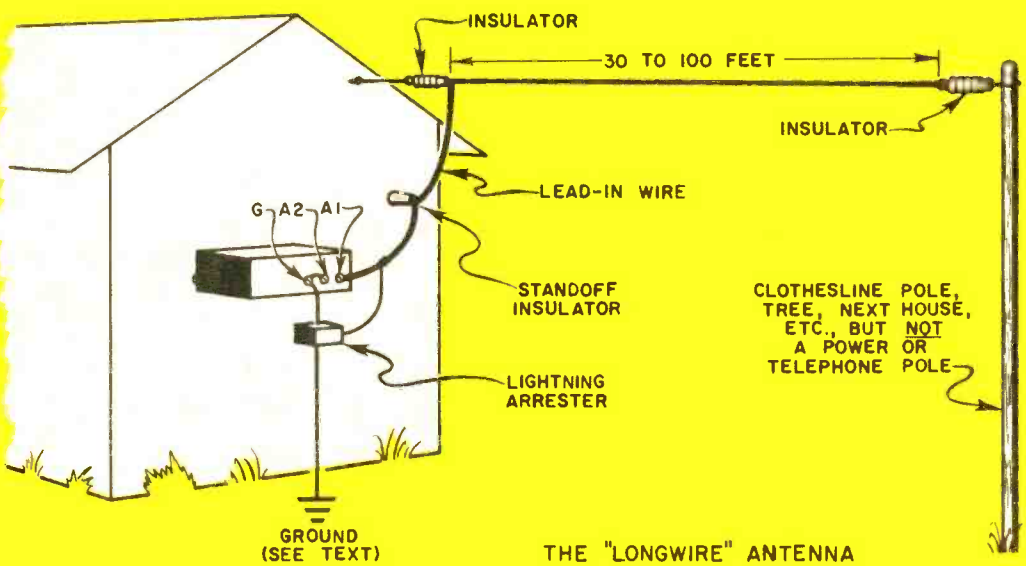
Therefore, if you are going to make more than the minimum sixty dollar investment, you will want to be sure your set has at least one RF stage. A catalogue description will mention it if it has.

Our "minimum" receiver has only one, or possibly two, IF amplifier stages. (Each "stage" is a tube and its associated circuitry.) The better your receiver, the more IF stages it has, each with tuned input and output. The main job of amplifying signals is done by this section.

All communications receivers have a beat frequency oscillator, or *BFO.* This was originally intended simply to enable the receiver's superheterodyne circuit to make code signals audible. It is also essential for *spotting weak carriers.* With the BFO on, even a very weak signal will create a whistle in the loudspeaker as you tune across it. Then you can turn the BFO off and adjust the receiver.

All will have an *automatic volume control,* or "AVC," circuit. With a very strong signal, the AVC generates a biasing voltage on the input grids of the RF and IF amplifier tubes. This effectively

The simplest, most versatile antenna is the "longwire" shown here. Connections to the receiver, inside house, are shown. Text discusses other antennas.



THE "LONGWIRE" ANTENNA

cuts down the amplifying power of the tubes, so that the set does not overload. With a weaker signal, the AVC generates less biasing voltage or none at all. This tends to keep all signals in a comfortable listening range. Without it, strong stations roar out at you as you tune across them, and if you simply turn the volume down you miss the weaker ones.

Automatic Noise Limiter: This "chops the peaks" off outside noise pulses, and allows nothing to come through more loudly than the general volume level you have set for the signal.

Bandspread Tuning: An extra tuning control, which enables you to tune *slowly*. The need for this is not apparent to the neophyte: all his life, he has whisked back and forth across the dial of his standard broadcast radio, catching plenty of stations with no trouble. However, the full excursion of the tuning capacitor on the standard broadcast band covers only a megacycle and a half. On a short wave band, one full sweep of the dial covers many megacycles, *and the signals are no broader.* Also, they are mostly weaker. You can tune across them so fast they make no noise in the speaker.

In a communications set, the *main* tuning dial is used for rough, fast tuning, and as a "bandset" to place the receiver in operation in the frequency segment you wish to use. Then you tune slowly through the segment with the bandspread dial. It has the effect of "spreading" the main dial's divisions over several feet instead of inches.

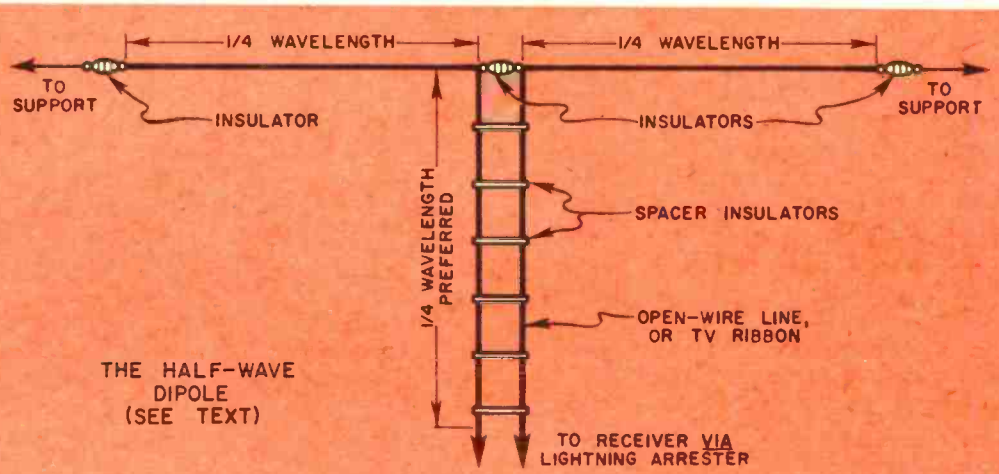
A bandspread dial won't separate stations very well for an unselective receiver, but it does make your tuning easier.

So much for the "minimum" receiver. The more complex receiver has still other features.

Q Multiplier: A device that effectively increases the efficiency of the coils in the IF amplifier. It can help pull a station up out of adjacent-channel interference, or can suppress a heterodyne "beat" whistle by putting a "hole" in the receiver's response right where the whistle is.

Crystal filter: A selectivity control. This filter uses one or more quartz crystals ground to operate at the IF frequency. It has some of the functions of the Q multiplier—peaking up a station or canceling interference. It also enables you to vary the width of the receiver's *passband*—to make its "slot" broader or narrower.

Antenna Tuning: A variable capacitor in the antenna circuit, to match the antenna to the set at the operating frequency, since the antenna is naturally



The simple, efficient dipole antenna has some directionality, works best at its fundamental frequency and some harmonics but tends to act "dead" elsewhere.

When the DXing bug is in your blood, you want fine tools. A communications receiver like this one is priced comparatively with television and hi-fi sets. Its many features are explained in the text. Some sets of this type even have built-in crystal calibrators. It makes a good station receiver if you become a "ham."

efficient (and naturally matched) at only one frequency. A big help.

"S" Meter: Commonly used to measure relative signal strengths, but really designed as a *tuning meter* to help you tune signals in "on the nose."

Standby Switch: The "Standby" position disables the receiver except for tube heaters ("filaments"). With the heaters on, the set is kept warmed up, ready for instant operation, even though the set is otherwise "off." Even where it serves no other function, it keeps the receiver stable, minimizing drift.

Drift: Not a receiver adjunct! An ideal receiver would have no drift, but all are subject to it. Tuning circuits are made up of coils and capacitors. Their electrical value depends in part on their physical *size*, and this changes with changes in temperature. The higher the frequency you are using the more the change in tuning because of the thermal drift. Expensive receivers use temperature-compensating capacitors and resistors in their circuitry, but even with these, a receiver likes a constant "internal climate." Hence the "standby" feature; it keeps the temperature of the inside of the set regulated.

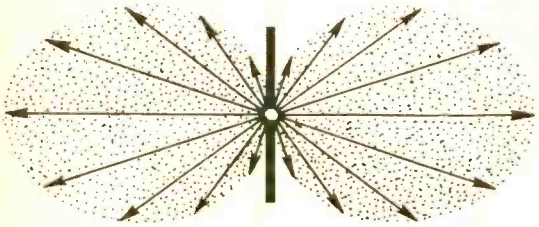
Standby switches are often labeled "Send/Receive." If the receiver is used with a transmitter, as it would be in an amateur station, the receiver is effectively turned "off" during transmissions but is kept warm so it can instantly pick up the reply when the transmission is over. "Send" just means "standby."

Your Antenna

Your antenna may be a few yards of bell wire stapled to the picture molding of your room, or just lain along the floor, for that matter, if your receiver is sensitive enough. Even the finest receiver, however, works best with a good outdoor antenna. This will still be a simple wire, compared with the plumber's art abstractions that are TV antennas.

A "long wire" antenna may be anything from thirty to a hundred feet along its flat top, for short-wave work. The vertical "lead-in" coming down from the antenna, through your wall or window, and to your receiver, will add a few more yards. "Plenty of antenna, high and in the clear," is the rule of

For the do-it-yourselfer who wants to listen wherever he goes, here is a portable communications receiver kit. It has all the standard features including BFO, noise limiter, bandspread, etc., and is powered by battery or AC.



DIPOLE DIRECTIONALITY

A dipole is directional broadside to its length, with very little pickup from the ends. Arrow length indicates sensitivity in given direction.

thumb here. The longer, higher, and less obstructed the antenna, the more signal energy it will pick up and deliver to your set. This helps the signal-to-local-noise ratio, too.

However, antennas that are longer than a half-wavelength may have very tricky directional characteristics, and the 30-100 foot length is best all around on the short waves.

The antenna should be insulated from its supports at both ends, with glass or porcelain insulators. The lead-in should be held away from the house—TV type standoff insulators will do for that: they just screw into the siding or shingles.

Longwires work best against *ground*. Run as short and heavy a wire as you can from the receiver to the nearest ground—a cold water pipe, a metal grounding rod driven into the earth beneath your window, or the mounting screw of the brass faceplate of the electrical outlet that powers your gear.

Install a lightning arrester, too. You can pick up one of the several types cheaply at any parts store. Install it outside the house. Attach the antenna to the arrester as well as to the receiver, and ground the arrester directly, outside the building. If a lightning stroke hits your antenna, it has a "short" path to ground rather than through your house and your receiver! A well-installed, arrester-equipped antenna can be a lightning *protection* device for your house. Without the arrester, it is a lightning hazard at least to itself.

If you want to concentrate on certain bands, and have some directional characteristics to your antenna system, you can erect half-wave *dipole* antennas for these purposes. They are very efficient.

A dipole is directional *broadside* to its length. You can make one of ordinary antenna wire—it's just a half-wave antenna cut in the middle, and "fed" there, but dipoles tend to be very "sharp-tuning" and do not work well very far from their naturally resonant frequency!

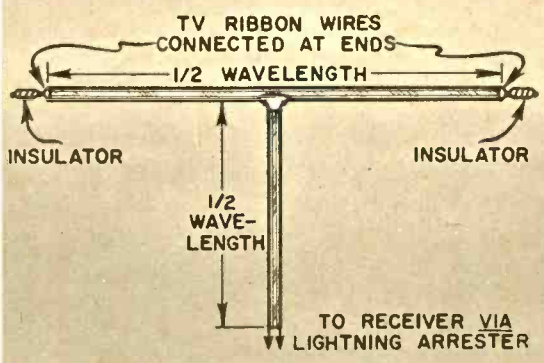
There is a way out: if you use television "twinlead" for the flat top, you can make a *broadband* folded dipole that will work over an entire international broadcast or utility band.

For dipole dimensions and designs, consult the books listed toward the end of this article.

Accessories

Whether you spend sixty dollars for a basic receiver, a hundred fifty for one with an RF stage and more to its IF, three hundred for one with a crystal filter and double conversion (a highly desirable feature), or more, there are a few aids not found on most receivers.

Crystal calibrator: A crystal-controlled oscillator operating at 100 kc, with an output rich in harmonics. It feeds the receiver accurate marker signals every 100 kc. Getting the hang of identifying which 100-kc marker you



A "FOLDED" DIPOLE

A folded dipole works over a broad band of frequencies for primary band and harmonics. A tuner is helpful. See text.

have tuned in is easy. This helps you set your main tuning dial correctly for using the bandspread, and helps you interpret the bandspread calibration markings on any frequency range. Calibrators can be had, ready made or as kits, for under twenty dollars.

Antenna tuner: While the antenna tuning capacitor found in many receivers does well with simple longwire antennas, a *tuner* helps match any antenna, any feedline, to a receiver. A tuner usually has *input* and *output* tuning capacitors, and a tapped coil, with a switch for selecting the taps.

A tuner arranges for proper matching of the antenna to the receiver at all frequencies, and for maximum transfer of energy between them.

You will search the catalogs in vain for tuners, unless you want to buy a transmitting tuner and hook it up "backwards." The various handbooks, antenna manuals, etc., have designs for simple, inexpensive tuners. *Electronics Illustrated* ran such a design in its February, 1960 issue, and we reprint the circuit diagram and parts list in this section.

Q Multiplier: Many receivers have these built in, but the smaller ones have none. Kits may be had for as little as ten dollars. Their function was described in the section on receivers.

How To Find Them

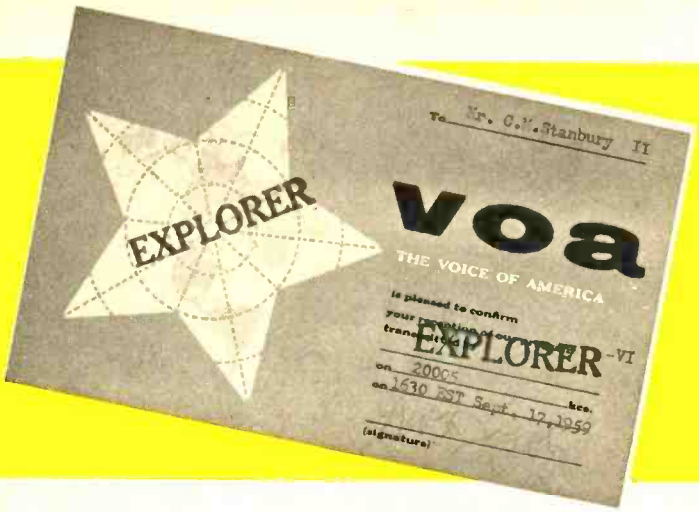
At first, you will tune your receiver in a random way, all over its range. Then you will become systematic, settling down in various parts of the spectrum where you think the fishing is good. You will also choose definite kinds of fishing: international broadcast, amateurs, utilities, even particular kinds of utilities. Some day you may want to go back to the medium-wave, standard broadcast band, where signals do not travel long distances easily. Your communications receiver will still be highly useful there: especially for pulling foreign stations out of the pileup of North American signals.

International Broadcasting centers at 6, 10, 15 and 20 megacycles, with some stragglers in between. The segments are often referred to as the 49, 31, 19 and 15-meter bands, respectively. Transmitters of all powers are on them at some time of the day or night.

Six mc, or "49 meters" is generally a night band, though at some times of the year, and in the right parts of the sunspot cycle, it is good at almost any time. A 3000-4000 mile range is common.

The 31 meter band is "in" or "out" depending on time of day, year, or sunspot cycle, and is always worth trying. A 5000-8000 mile range is common.

Radio Andorra uses an ancient castle which is a tourist landmark for its transmitter site. Photo is on back of QSL.



Even a space probe can be verified. Explorer I was first American shot to use 20-mc frequency, found on SW receivers.

The 19 and 15 meter bands are generally considered "daylight" and "summer" bands, but check them always. When they are "in," they cover greater distances than the others—completely around the globe.

Amateur assignments are at 3.5-4.0, 7, 14, 21, and 28 mc. In the U. S., 7 mc (or "40 meters") is exclusively an amateur band, but in Europe and Asia it is shared with broadcasting, and you will find Russian 50-kilowatters throughout the 'phone segment. The propagation characteristics follow those for broadcasting: 3.5-4.0 mc, the 80 (code) and 75 (phone) meter bands, are most reliable at night and in winter, but are used all year, and you may find many signals any time. 7 mc, or 40 meters, is good almost any time. 20, 15, and 10 meters are critically subject to the sunspots and to seasonal effects, but on those, 12,000-mile "hauls," even with low-power transmitters, are often the rule.

Ship frequencies are assigned in blocks at 4, 8, 12, and 16 mc. They use code almost exclusively. If you read code some of the traffic you pick up is fascinating. (See the article, "Learn Code the Easy Way," in *Electronics Illustrated* for November, 1960.)

Remember one thing if you listen to utilities like ships, on phone or code: there is a *radio secrecy law*. You may *listen* to anything you please, but you may not divulge the contents of a message to anyone but the addressee. (The secrecy law does not apply to *broadcasts*, of course: the broadcaster, whether for the sake of propaganda or advertising, wants his message to reach as many people as possible.) The penalties for revealing the contents of any message not addressed to you are stiff.

The other utilities are sandwiched in all over the place. You will stumble across some highly useful ones. For coastal DXers, pickup of the Overseas airlanes channel at 3 mc will give you constantly revised, up-to-the-minute weather reports and forecasts, in voice, every half hour.

Stumbling Blocks

DXing isn't all beer and skittles. You have man and nature to contend with, and both are perverse. Sometimes you will patiently spin your tuning dials and turn your bandswitching knob and pick up practically nothing—except perhaps some noise.

Noise is always with us. There is the receiver's own noise, explained earlier. There are electrical noises coming from appliances, tools, factories, and leakages in the electrical power system itself. There is auto ignition noise on the higher frequencies, though the newer-model cars tend to be fairly quiet. You may have a "noisy" location, but it is seldom that noise spoils *all* the fun.

There is atmospheric noise: the "static" from lightning in nearby or distant thunderstorms.

Above 15 mc, atmospheric noise tapers off: at 30 mc lightning static isn't even heard unless the storm is overhead. However, at these frequencies

auto ignition noise appears and gets worse the farther up you go.

The short waves are full of "noises" from non-voice utilities: code and teletype stations, telemetering, facsimile picture transmission, and Soviet jammers—"the 25-kiloton washing machine." Your set's selectivity helps here.

Fading

Short-wave signals do not come to you directly. They "bounce" off reflective layers in the upper atmosphere. The signal may come to you from more than one path. At lower frequencies, you may be getting direct "groundwave" propagation and reflected "skywave" energy at the same time.

Momentary changes in the height, thickness, or conductivity of the reflective layers, or in the *phase relationship* of the direct and reflected signals, or between two reflections of the same signal, will cause its apparent strength to rise and fall. This is *fading,* and it can be very troublesome. Sometimes, part of the signal will fade differently from another part—*selective sideband* fading—and the sound is very distorted.

Your receiver's AVC will help deal with fading because it tends to keep the volume level constant whether a weak or strong signal comes down the antenna. Switching antennas could help.

Sometimes fading just isn't there. Under the very best conditions, signals come from across the world and sound like "locals." They are rock-steady and strong.

Ionosphere

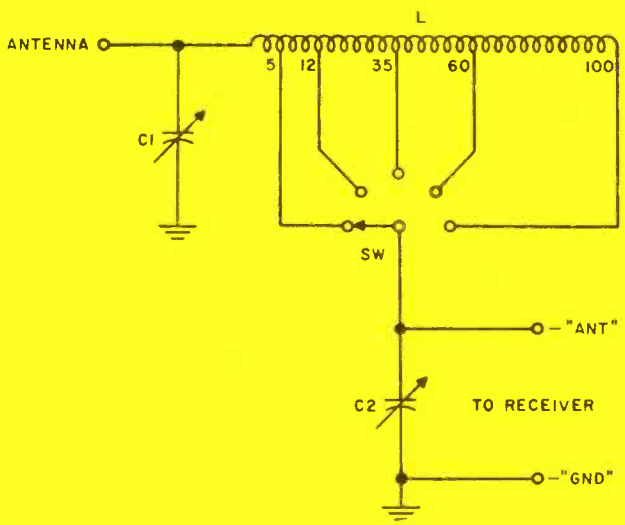
The reflective layers of the "ionosphere" are made by electrical particles from the Sun, which strike the outer reaches of the atmosphere and make them conductive. The "F" layers are all but permanent: sometimes a *magnetic storm* will wipe them out. The layers themselves are most effective during years of high sunspot activity.

In daylight, there are two "F" layers, the lower one designated "F_1" and the higher "F_2." Their "virtual heights"—the height where the layers can be considered as containing "mirrors," are about 150 and 200 miles, respectively.

At night, the F layers merge at about 175 miles.

At certain times, during high sunspot activity, there is a temporary "E" layer, about sixty miles up. This is a daylight layer only.

Now, up to about 30 mc, signals will be effectively bounced off the F_1 or merged F layers. Beyond 30 mc, they tend to be absorbed by the F layers, or



An antenna tuner matches any length antenna and feedline to receiver at any frequency in 3-30 mc range. C1 and C2 are 140-mmf midget variable capacitors; SW is a 5-position, single pole rotary switch. Coil L is 100 turns No. 26 enamel wire, closewound, tapped at 5, 12, 36 and 60 turns, on 1¼" diameter 3-inch plastic or Bakelite form. Experience quickly shows which tap is best for a given frequency band and given antenna.

even to penetrate them. On the other hand, the occasional E layer absorbs lower-frequency waves, and reflects waves above 30 mc.

The E layer never exists at night, but in the daytime there may be both an E and an F layer to contend with. This may work "for" or "against" you. Notice, in the diagram, the signal from the station on the right passing from a nighttime region to a daylight one. Both night and day conditions can affect it.

Keep in mind that none of these layers is a uniform shell covering all the Earth, or the sunlit and dark halves, at once. Depending on what kinds of layers are overhead and their relative intensity, at both ends of the signal path, the signal may be helped or hindered on its way to you. Because short wave signals go long distances by being reflected off the ionosphere, there is a region between the transmitter and receiver sites where no signal is heard on the ground. This is called the *skip zone*. Within a few or a few dozen miles of the transmitter, there will be a *ground-wave zone* of direct pickup.

Signals are not reflected from ionosphere layers in exactly the way light is reflected by a mirror. They actually penetrate the layer, and are *refracted*, or bent, until they are "aimed" back at the Earth again. At times, the bending is so gradual that "reflection" does not take place. There is no skip, and the signal never reaches you. It was *absorbed*.

And now, gentlemen, it is time to mention the occasional "D" layer, a daytime thing strongest about local noon. It tends simply to absorb energy, especially at the lower frequencies. When you have a strong D layer you just play your hi-fi and read your magazines.

Sunspot Cycle

The condition of those helpful-hindering layers is tied to sunspot activity. Sunspots are giant "storms" on the Sun, and in telescope pictures they have the "whirl" shape of cyclonic true storms here on Earth. When there are sunspots, great streams of ionizing particles from the sun reach the Earth and affect the atmosphere and therefore, radio propagation.

There are minor cycles of 28 days (the Sun's rotation period) and major cycles of eleven years in sunspot activity. Unfortunately we are now near the low spot of an 11-year cycle, but DXing is still rather good. It will get better and better, and by 1968, sensationally good —too good, in fact, for some purposes. When every signal is being propagated superbly, there is an interference problem with a vengeance!

Verification

Through these pages you have seen examples of the verification cards issued by DX stations. Most "veries" or QSL's seen in short wave listeners' dens (or "shacks") are from international broadcast stations, but many radio hams have QSL cards, and in many cases both hams and utilities will verify a good report.

How to get them? Send a report, a *good* report, of reception to the station. This should include the date, time, frequency and as much of a description of program material as you can manage. After all, without the program description, the station may assume you merely looked up its schedule in a publication, and did not even bother to tune in.

Besides your proof of actual reception, you should give a *signal report*. The station's engineers are interested in how their signal is getting through. How strong was it? How "readable?" Was it fading? Was there interference—from natural causes, man-made, or other stations?

The colorful card is a public-relations gesture. It encourages listeners to send in reports. This enables the station to estimate the size and composition of its listenership, and the effectiveness of its signal.

For the bigger stations (like Voice of America) cards and postage are easily taken as parts of the normal operating budget. For smaller stations, especially in the poorer countries, postage can be a crushing expense. To insure a response, enclose an *International Reply Coupon*, available at your post office for 15 or 25 cents (tell the clerk where your reply will be coming from). This prepays the postage.

Not all hams print up QSL's, and of those who do, not all will respond to listener reports. However, if you make it a good report, and give even a domestic ham the courtesy of a return stamp and self-addressed envelope, your luck will probably be good.

With utilities—be they fishing boats, truck fleets, aircraft—you may have to go a step further and even "pre-print" the card. You can do this with a little typewriter artistry, or use stick-on letters from the stationery store, or anything your imagination suggests. But remember the radio secrecy law—don't discuss message contents in your report.

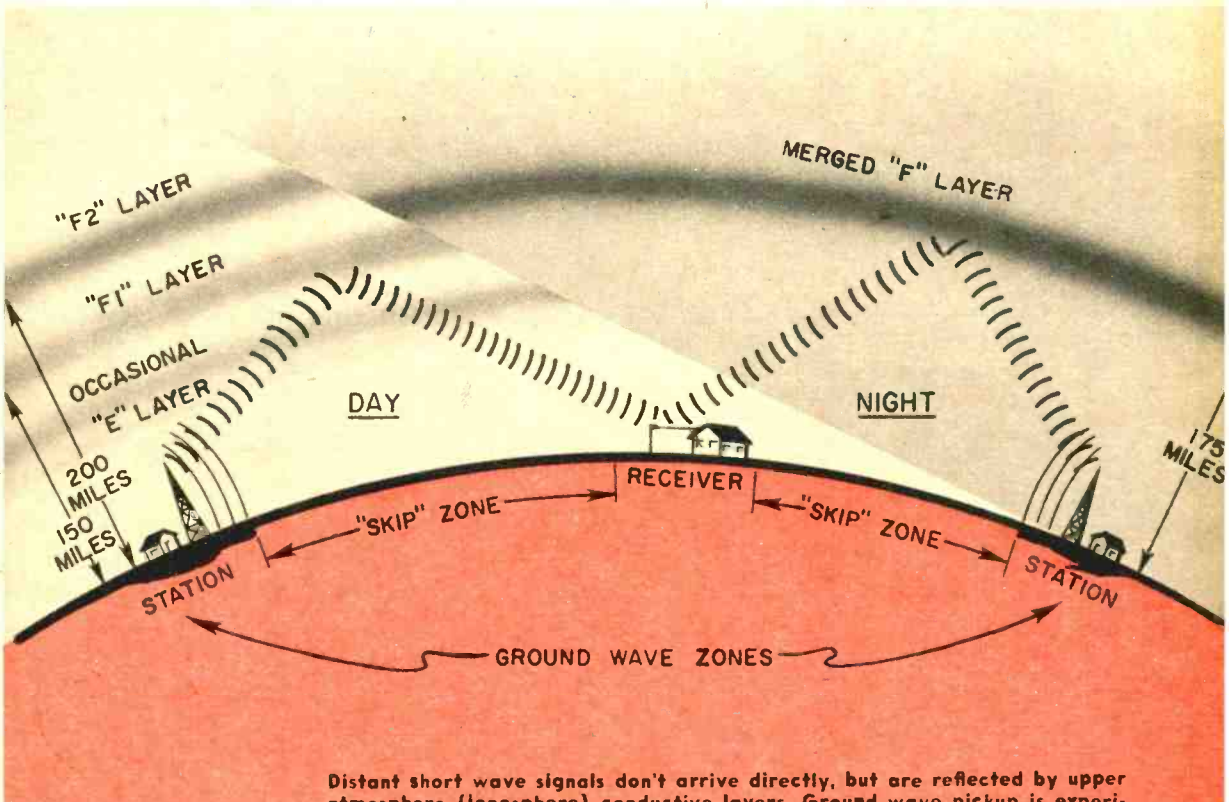
See "DX from the Real Treasure Island," *EI*, October, 1960; "Underwater DX," *EI*, November, 1960 ;"How To Get That QSL," *EI*, December, 1960, for tips on getting QSL's from utilities or from any station. It is an art in itself.

Give the station a little "local color." Tell what kind of equipment you are using, what kind of antenna, and what kind of location. Hilltop? City apartment? Next door to the neon sign factory?

Clubs

There are many clubs, local, national, and international, for the DXer. Through these you will make many friendships, at least by mail, though there will be get-togethers, too, like the National Radio Club conventions. Most put out bulletins, and these give you all kinds of tips: new stations, new schedules, station reactions to reports, etc.

American's largest all-band radio organization is the *Newark News Radio Club*, 215 Market Street, Newark 1,



Distant short wave signals don't arrive directly, but are reflected by upper atmosphere (ionosphere) conductive layers. Ground wave pickup is experienced fairly near transmitter. "Skip" zone, where no signal is heard, exists between ground wave and receiver zones. Day, night conditions vary because of difference in dark/light ionosphere conditions. A signal (right) could be subject to both as it crosses world. Layers are affected by sunspots (see text).

New Jersey. A sample copy of their bulletin can be had for 25¢. The *Universal Radio DX Club,* 109 Mesa Street, Vallejo, California, specializes in short wave and space reception. The *National Radio Club,* Box 63, Kensington Station, Buffalo 15, New York is mostly concerned with broadcast band DX, and a sample of its bulletin, DX News, costs 10¢.

Aids

There are a number of books and booklets that you will find useful and even essential. The *World Radio Handbook,* an annual, lists 99% of the world's short wave broadcast stations as well as many standard broadcast transmitters. $2.50 from Gilfer Associates, P. O. Box 239, Grand Central Station, New York, New York. *Broadcasting Stations of the World,* published every two years by the United Stations Information Agency, lists stations alphabetically by slogan and call letters. $1.50 from the Superintendent of Documents, Washington 25, D. C. (Ask for Part III). *White's Radio Log,* an old and famous listing of U. S. and Canadian broadcast stations, is now contained in *Radio-TV Experimenter,* found on the newsstands every March and September. All list station call letters, locations, frequencies, schedules, and other useful information.

For utilities, the Communication Engineering Book Company, Monterey, Massachusetts, publishes "call books" of police, power company, forest patrol, aviation, etc., communications systems. Query the publisher.

Radio Amateur Call Book Magazine, known universally as "Callbook," published quarterly, lists every radio amateur alphabetically by call, giving name and address. U. S. and Foreign stations in separate volumes. Each volume, $5.00. Radio Call Book, Inc., Chicago 39, Illinois.

The American Radio Relay League, West Hartford 7, Connecticut, publishes the famous *Radio Amateur's Handbook,* $3.50, and the *ARRL Antenna Book,* $2.00, both of which carry valuable technical information for DXers.

"Callbook" and ARRL publications are available at most parts distributors.

Central Radio Propagation Laboratory Bulletin: by U. S. Bureau of Standards. Monthly. Propagation predictions, expected maximum usable frequency, in advance. $1.00 a year from the Superintendent of Documents, Washington 25, D. C.

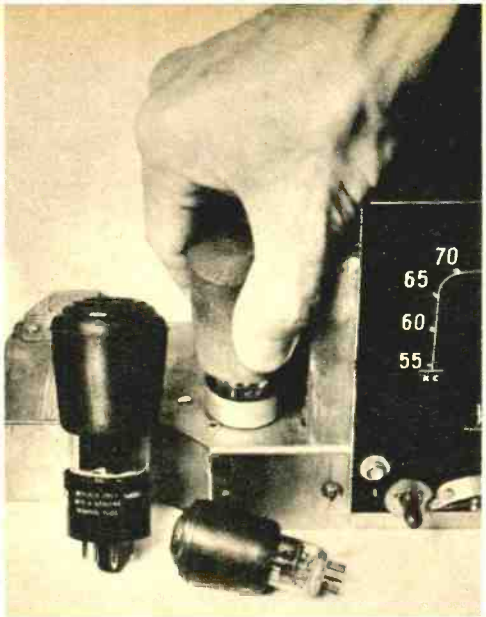
By reading the DXing articles that regularly appear in *Electronics Illustrated,* you will learn more about unusual DXing targets, new sources of station lists, new methods of signal reporting, etc., and "technical" explanations of how and why the short waves, or radio waves in general, behave the way they do.

Jargon

We have written this article in English, but the temptation to lapse into what might seem like pure gobbledegook was ever-present. All hobbies develop an esoteric language, and radio's is downright exquisite. You will recall that verification cards, for instance, are called "QSL's." This name is from the international radiotelegraph "Q" code, and the abbreviations are so handy that they are often used in voice transmissions (especially by hams, often by utilities) and in writing on DXing or on amateur radio. Other commonly used Q signals are *QRM* for interference from other stations, *QRN* for atmospheric or other "static," *QTH* for station location (and *QRA* for address, by SWL's), and *QRX* for "wait." Then there are numbers, like *73* for "best wishes," and the coy *88* for "love and kisses." A whole long article could be written on radio jargon alone, and in fact, one will appear in an early issue of *Electronics Illustrated.*

-73-

If radio waves could be seen, the Earth at this moment would be glowing with patches and smears and beams of energy, thousands of them overlapping and scintillating right where you are. The world's music and politics, entertainment and earnest messages, are right in the room with you. All you have to do now is reach out and turn that knob—and you can tune in the world.



Try These

By Art Trauffer

Pulling Hot Tubes

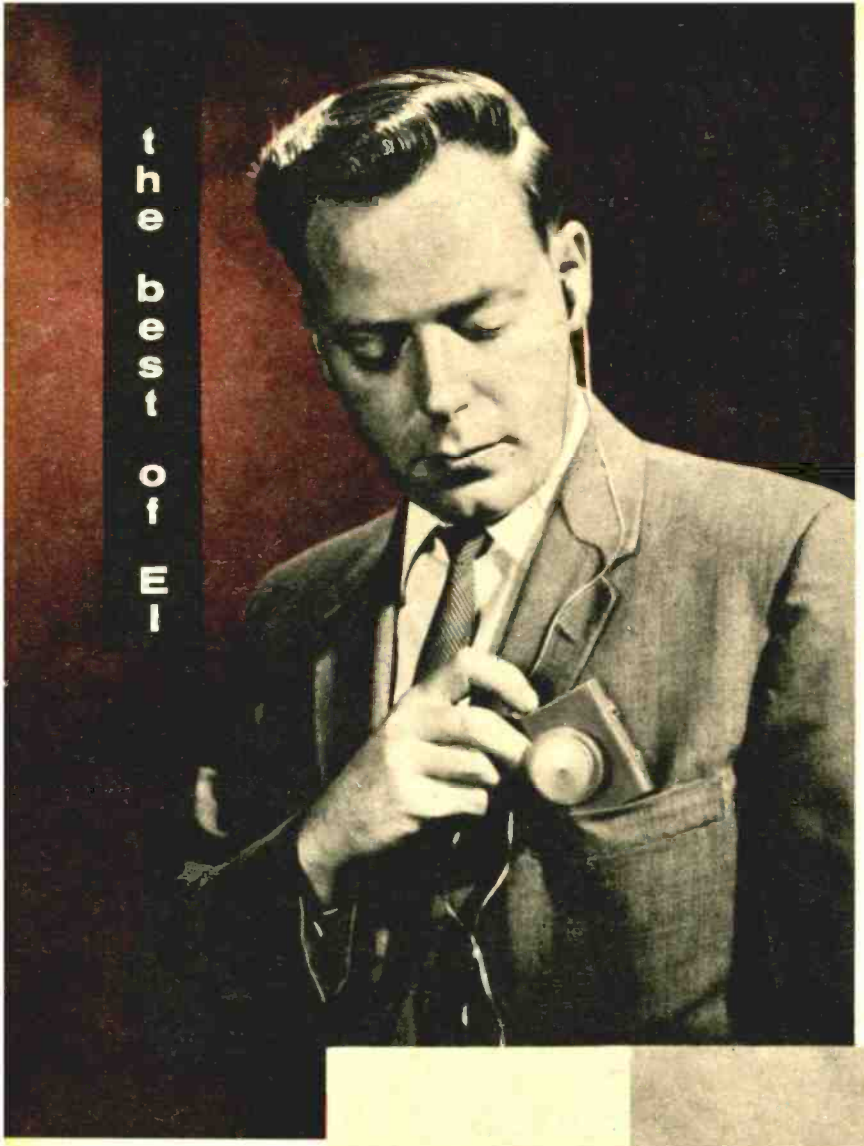
Tired of burning your fingers? Try a few rubber "crutch tips" as tube pullers. Different sizes of tips will fit various tube types. If the rubber tips fit too tightly, simply take a razor blade and cut a few lengthwise slits in the rubber to enable them to slip on and off easier.

Power Cord Lock

If you have inquisitive small fry around the house, a few small locks and a slight alteration on your plugs will give you peace of mind while you are away from your equipment. Enlarge the holes in the plug prongs slightly with a small rat-tail file to pass the yoke of a small lock. If necessary, the prongs can be shortened a bit so they could not be inserted into the outlet and cause a short while the lock is on the plug.

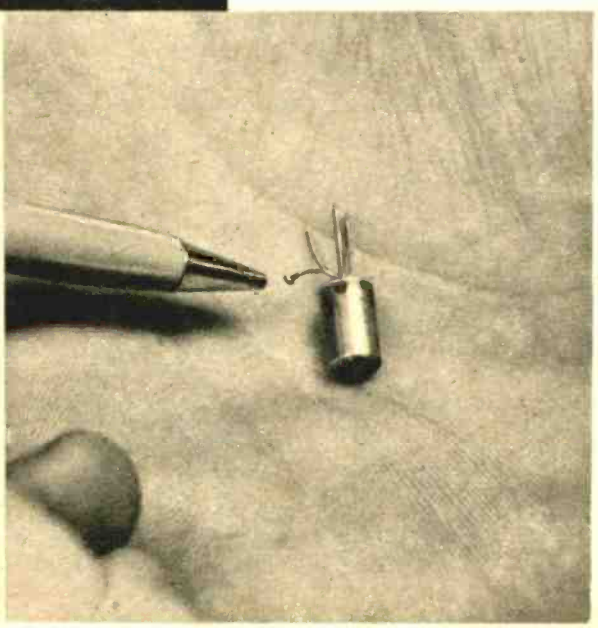
Aluminum Cup Coil Shields

Aluminum drinking and measuring cups make excellent shields for RF coils, etc. The cup handles are easily removed by filing the aluminum rivets flush with the handles and then pushing out the rivets. You can mount the cups as shown, by flattening the rim at two or three places and drilling a small hole through each flat for small mounting screws. The cup shown in the photo measures approximately 3" by 3".



The extra large knob seen on the receiver case provides a gear reduction for tuning.

Bent wire on transistor is the internal shield lead (not used), kept clear of other wires.



1-Transistor FM Receiver

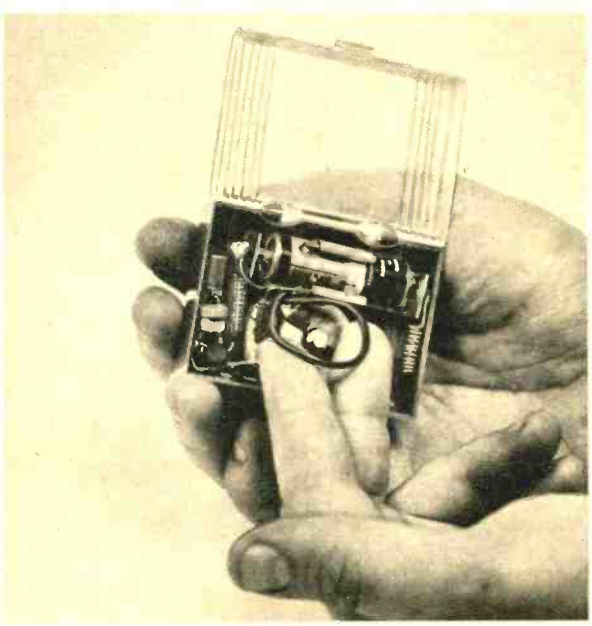
By Herb Cohen

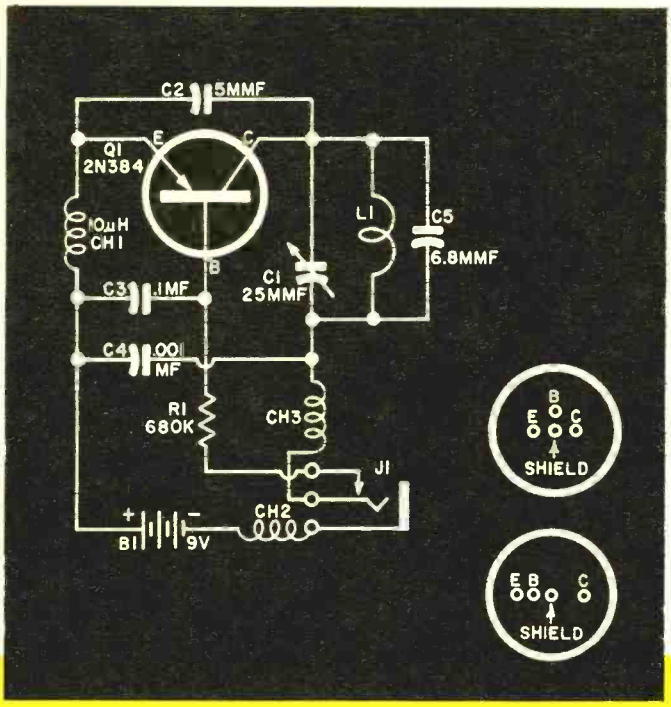
The first complete FM receiver using one low cost transistor may be built into a pocket size case.

FOR less than $10 you can build an FM receiver that is about half the size of a pack of cigarettes. It needs no external antenna and draws only a tiny amount of current from its single battery. This unit was made possible by the availability of transistors that will operate in the high frequency range of the FM band at a cost within the reach of the home builder. Add the old principle of superregeneration and you have a 1-transistor circuit that will tune, amplify, and provide audio output to drive an earphone.

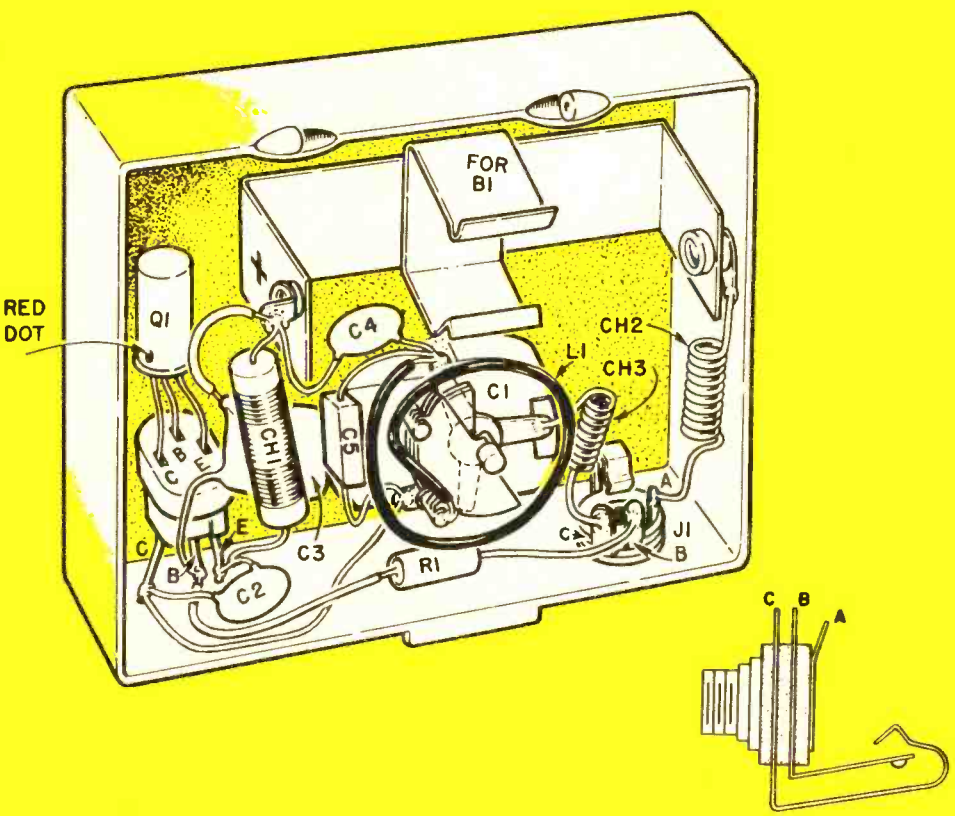
The sound quality is not in the hi-fi category but certainly suffices. High sensitivity makes it possible to receive stations in suburban areas *without* an antenna. Its ability to separate signals is also good. A brief word of caution before embarking on this project. This is not the kind of portable you can stroll down the street with, whistling to the music coming over the earphone. The extraordinary simplicity of the circuit imposes some limitations. After a station is tuned in, the case must be held in a fairly

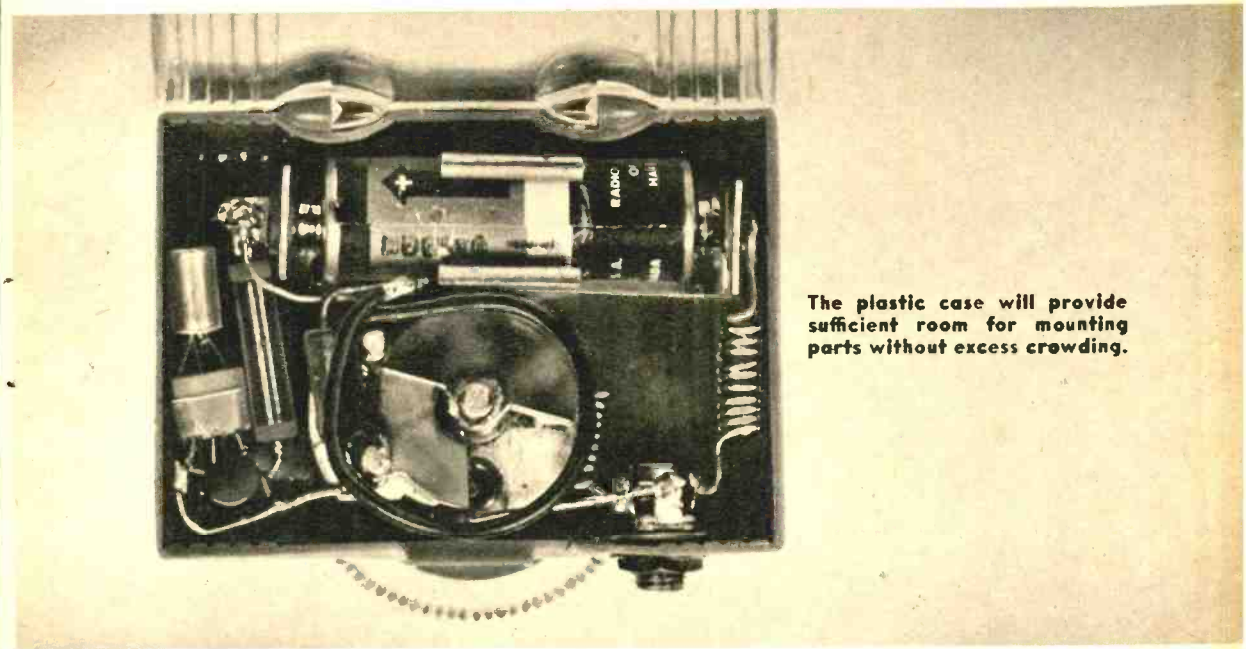
Lower left points out coil L1. This loop is formed of solid, insulated wire and pushed down parallel to the tuning capacitor. Other photo shows earphone jack on side of case. After modification, it is also an on-off switch.





On wiring guide below, note plus side of battery holder. Red dot on Q1 indicates collector (of 2N384). If a different type of earphone jack is supplied than that shown, bend the contacts to suit. Base diagrams are shown for the RCA 2N384 (top) and the Amperex OC171 (bottom) transistors.





The plastic case will provide sufficient room for mounting parts without excess crowding.

fixed position. Otherwise changing body capacity will detune it.

A novel feature in the construction is that the complete receiver is built into the case that the earphone is packed in. Of course if you already have an earphone of 3000 ohms, any plastic case of the approximate dimensions will do. Don't use a metal one or the signal pickup will be cut down.

Tuning capacitor C1 is mounted first. The holes for its screws may easily be made with the tip of a warm soldering iron. This is a much safer process than attempting to drill it.

Make the one hole for J1 in a similar manner. Before mounting the jack, modify it according to the diagram included on page 84. Once this is done, the receiver will automatically go on when the earphone is plugged in, obviating the need for a separate on-off switch.

The battery holder is glued into place with Duco or any similar household cement. Mark one end of it to indicate the plus side, as incorrect battery polarity can prove disastrous to the transistor. The same precaution applies to inserting the transistor into its socket.

If when C1 and J1 are mounted, the lid of the plastic case will not close completely, clip the projecting lugs of the capacitor.

The rest of the construction is straightforward. If there is danger of any bare component leads touching, use spaghetti sleeving. Do all the wiring except for the resistor (R1). The recommended value of 680,000 ohms will work but the circuit may be refined even further. If you have a milliammeter, adjust the resistance by a 1 megohm potentiometer wired in temporarily. The meter should read *under* two milliamperes when the potentiometer is set for a high pitched [*Continued on page* 106]

PARTS LIST

R1—680,000 ohms, ½ watt resistor
C1—variable capacitor, 25 mmf maximum capacity (Hammarlund APC-25B)
C2—5 mmf, low-voltage disc capacitor
C3—.1 mf low-voltage disc capacitor
C4—.001 mf low-voltage disc capacitor
C5—6.8 mmf mica or low-voltage disc capacitor
Q1—2N384 or OC 171 (Amperex) transistor
L1—tuning coil, 1¼ turns #20 enameled wire
CH1—10 microhenry choke
CH2,CH3—10 turns #20 enameled wire
B1—9-volt transistor battery (RCA VS 309 or equiv.)
Earphone—3000 ohm dynamic (Lafayette AR-51 or equiv.)
J1—jack, supplied with earphone (modified as shown)
Misc.—Transistor socket, plastic knob, screws for mounting C1

INTERCOMS (C)

KITS AND KIT REVIEWS

MEDICAL ELECTRONICS (F)

MILITARY ELECTRONICS (F)

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[*Continued on page 94*]

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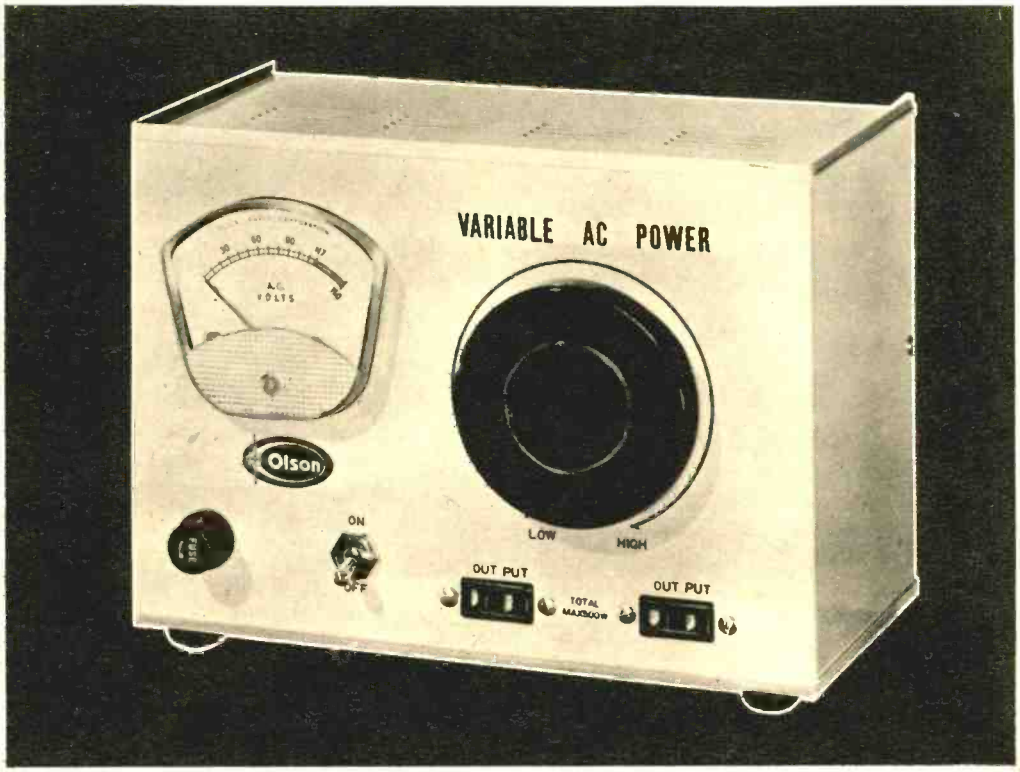
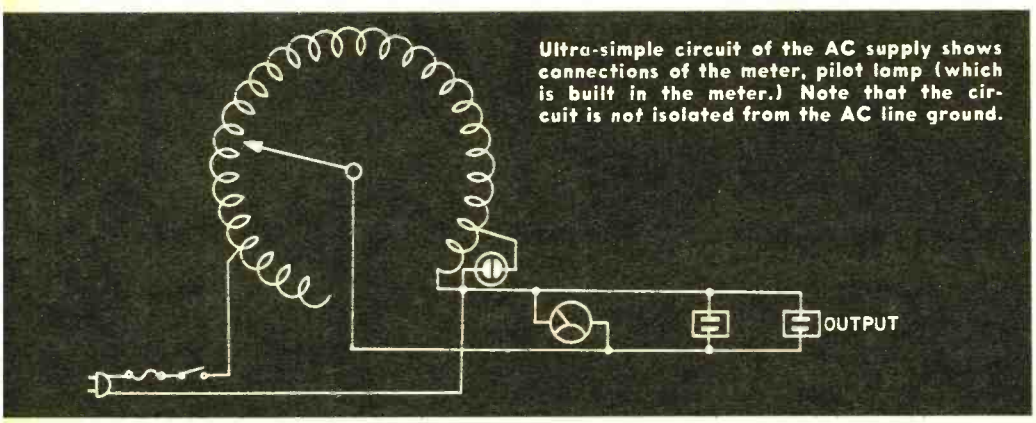


El builds a

Variable AC Supply

Easy-to-build kit should find a welcome niche on the experimenter's and engineer's test bench.



Ultra-simple circuit of the AC supply shows connections of the meter, pilot lamp (which is built in the meter.) Note that the circuit is *not* isolated from the AC line ground.

PROBABLY one of the handiest items on the experimenter's test bench is a variable AC power supply. At one time these devices were far beyond the budget of the average basement laboratory, but now, with kits available, everyone should be able to find a place for one of these instruments.

One of the latest units available, the Olson Model T-281 has a voltage output adjustable from 0 to 140 volts at a high 500-watt rating. A panel meter monitors the output and all controls, outlets, switches and fuses are front panel mounted. The unit can be placed flush side by side with your other test equipment with no interfering connections.

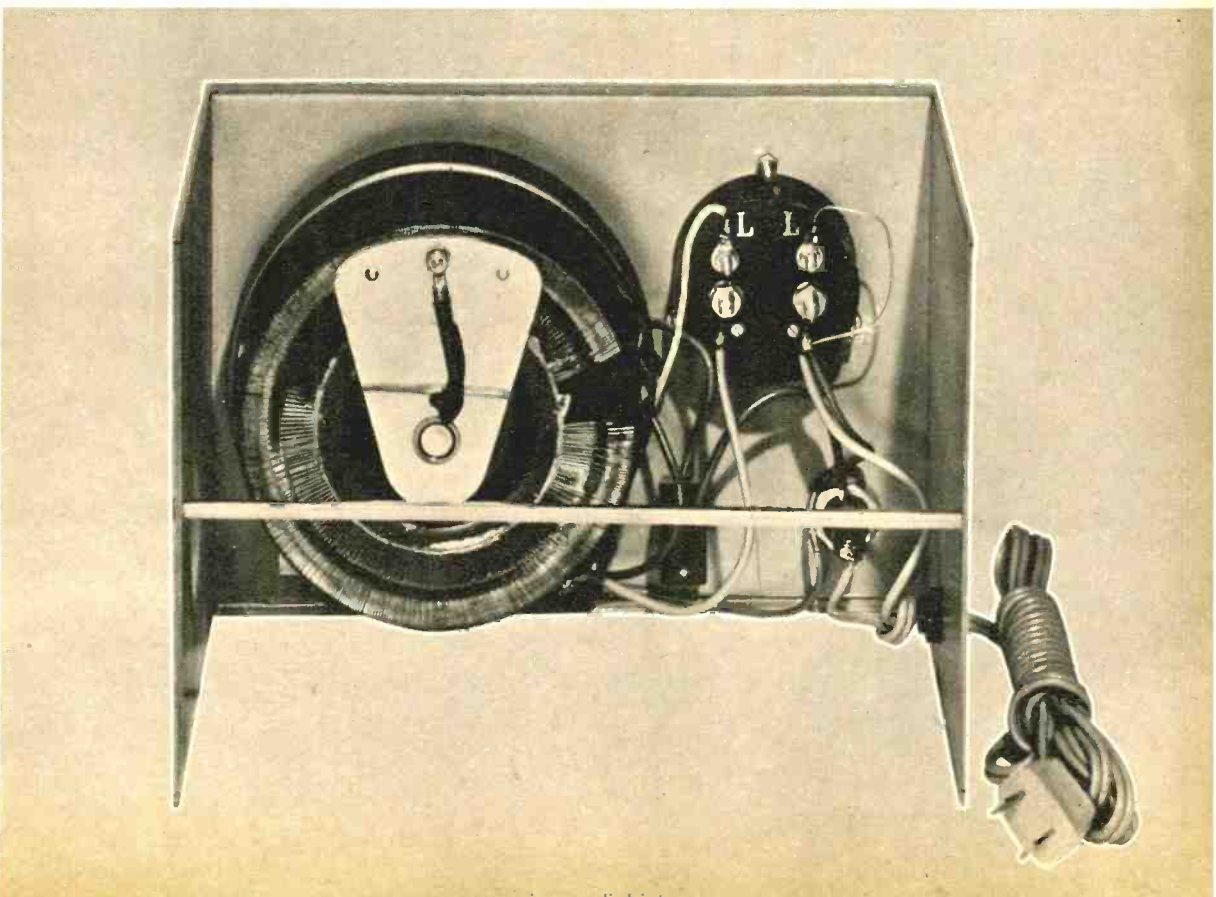
The operating principle of the supply is simple; it incorporates a heavy-duty variable transformer (actually an autotransformer of toroidal core design) with a sliding brush for adjustable output voltage. It not only can check out intermittent components and tubes in radio and TV sets by providing actual varying line voltage conditions, but can provide the voltages needed for checking silicon, selenium and other rectifiers.

During troubleshooting or on the first tryout of a newly completed project, gradual application of the AC line voltage through the Olson unit will save fuses and gently form the filter capacitors.

Although Olson's instructions leave something to be desired, the kit is basically so simple (there's only about half dozen solder connections to be made) that no problems should be experienced. For a total assembly time of about 1 hour and you have a unit capable of supplying AC from 0-140 volts and (if you add a rectifier and filter network) DC up to about 175 volts.

At its modest price, the Olson T-281 is very definitely *a Good Buy.*

Interior view of completed assembly. Rear cover is slid into grooves on the front panel sides. Cross rod when tightened in place locks the cover.



NEW! LAFAYETTE HE-15A
2-WAY SUPERHET CITIZENS BAND TRANSCEIVER

57.50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Boating — Ship to Shore

- **5 Crystal Controlled Transmit Positions:** Operates at maximum FCC power input of 5 watts fully modulated.
- **Superhet Tuneable Receiver over Full 23 Channel Band:** RF stage in transmitter and receiver, 3 watts audio output plus 4" speaker.
- **Complete with Channel 9 Transmitting Crystal.**
- **4 Dual Function Tubes, 2 Single Function Tubes, plus 2 Rectifiers for 12 Tube Performance:** Coverage up to 20 or more miles depending upon antenna height and terrain.
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- **High Output Crystal Microphone:** 2 position push-to-talk switch plus 5-prong microphone jack for easy conversion to push-to-talk relay.
- **Adapts for Use Everywhere:** Compact styling. Brackets supplied for easy mounting in auto, truck or boat. Addition of 6 or 12 volt power supply (separately supplied) adapts transceiver for mobile use. Only 10¾Wx6⅞Dx5⅞"H. Shpg. wt., 11 lbs.
- **Anyone Can Operate:** No exams—no technical knowledge. Any. citizen 18 yrs. or older is eligible for a license. Simply fill out FCC application supplied with HE-15A.

HE-15A		5.00 Down	Net 57.50
HE-16	Power Supply for 12 volts		Net 10.95
HE-18	Power Supply for 6 volts		Net 10.95
HE-830	Transmit Crystal (specify channel)		Net 1.95

LAFAYETTE "EXPLOR-AIR" 4-BAND RECEIVER KIT

- **Complete 4-Band Coverage**
- **Built-in 4" PM Loudspeaker**

19.95

Complete 4-band coverage of broadcast stations, international broadcast bands, amateur, maritime, fire and police services . . . even satellites! One front panel knob does all the band-switching. Complete with all parts, instruction book, etc. 10x7x5". Shpg. wt., 5 lbs.

KT-135	Less cabinet	Net 19.95
ML-150	Leatherette covered wood cabinet	Net 2.75

LAFAYETTE 20-IN-1 TRANSISTOR EXPERIMENTERS KIT

- **20 Projects — Rain Alarm, Burglar Alarm, Timer, Solar Radio. Metronome, etc.**

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Easy to build—each project with instructions, pictorials and schematics. Kit complete with perforated mounting board, transistors, diode, earphone, etc. plus 28-page booklet. Less batteries and tools. Shpg. wt., 6 lbs.

KT-173	Kit	Net 18.95
BA-155	"Z" cell battery for projects	Net .13
BA-270	22½ V battery for projects	Net 1.61

LAFAYETTE 4-TRANSISTOR TELEPHONE PICK-UP AMPLIFIER KIT

- **For Family and Business Group Listening**

14.95

Transformer coupling for optimum performance. Complete with 4 transistors, 3 transistor audio transformers, speaker, volume control, cabinet, pre-cut chassis, wire, solder, instructions. Less batteries and pick-up coil. 4½x4¼x4¼". Shpg. wt., 3 lbs.

KT-131A	Kit	Net 14.95
BA-180	9-Volt battery (5 oz.)	Net 1.30
MS-16	Telephone Pickup Coil (4 oz.)	Net 1.95

NEW! LAFAYETTE TELESCOPIC CITIZENS BAND WHIP ANTENNA

- **Chrome Plated**
- **Telescopes From 16½" to 40"**
- **Mounts Vertically or Right Angle**

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An outstanding antenna value. This high quality three section telescoping antenna is designed for attachment directly to your citizens band transceiver. Ideal for point to point service over short distances. Molded base loading coil has a threaded stud with a PL-259 plug—connector for vertical or right angle mounting. Shpg. wt. 1 lb.

HE-19		Net 3.95

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- **Extra Large 3½" Meter Face**
- **Completely Wired and Tested**
- **All Accessories Included**

Convenient pocket size with single range selector switch. First capacity range requires 120V AC, second range requires 6V AC. Durable Bakelite case and panel. Complete with leads and battery. 4½x3½x1⅛". Shpg. wt., 1½ lbs.

TE-10		Net 9.95
TE-14	Pigskin Carrying Case, Shpg. wt., 8 oz.	Net 1.95

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SHORTWAVE LISTENING

Continued next month

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HT-40 TRANSMITTER, $79.95

A perfect match for the handsome SX-140, both in quality and appearance. Hallicrafters' transmitter leadership is evident in every precision-engineered feature of this crystal-controlled 75-watt beauty—features as important to old-timers as they are to novices.

- **FEATURES:** You get excellent CW performance as well as AM. Full band switching, 80 through 6 meters. Enjoy easy tune-up and crisp, clean styling that has efficient operation as well as appearance in mind. Unit is fully metered, TVI filtered.
- **SPECIFICATIONS:** Maximum D.C. power input: 75 watts. Power output in excess of 35 watts CW, 30 watts peak AM phone. (Slightly less on 6 meters.) Frequency bands: 80, 40, 20, 15, 10 and 6 meters.
- **TUBES AND FUNCTIONS:** 6DQ5 power output; 6CX8 crystal oscillator and driver; 12AX7 speech amplifier; 6DE7 modulator; silicon high voltage rectifiers.
- **FRONT PANEL:** Function (AC off, tune, standby, AM, CW); Band Selector (80, 40, 20, 15, 10, 6); Drive control; Plate tuning, plate loading, Crystal-V.F.O.; Grid Current; Meter; AC indicator light; RF output.
- **REAR CHASSIS:** Microphone gain; antenna co-ax connector; remote control terminals; AC power cord.

SX-140 RECEIVER, $94.95

Doesn't it make sense to team up your skill with the experience of a company who has designed and built more high-performance receivers than any other in the world? Especially when the result is the *lowest-priced amateur band receiver available?*

- **FEATURES:** You get complete coverage of all amateur bands 80 through 6 meters, with extremely high sensitivity and sharp selectivity. Unit has RF stage; S-meter; antenna trimmer; and XTAL calibrator. Tuning ratio is 25 to 1.
- **CONTROLS:** Tuning; Antenna Trimmer; Cal. Reset; Function (AC off, standby, AM, CW-SSB); Band Selector; Cal. on/off; RF Gain; Auto. Noise Limiter on/off; Selectivity /BFO; Audio Gain; phone jack; S-meter Adj.
- **TUBES AND FUNCTIONS:** 6AZ8 tuned RF amplifier and crystal calibrator; 6U8 oscillator and mixer; 6BA6 1650 kc. IF amplifier and BFO; 6T8A 2nd detector, A.V.C., ANL and 1st audio; 6AW8A audio power amplifier and S-meter amplifier; (2) silicon high voltage rectifiers.

P.S. *Both units are available fully wired, and tested. SX-140, $109.95. HT-40, $99.95.*

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AD-10 $33.95

STEREO RECORD PLAYER KIT (AD-10)

Made by famous Garrard of England to superb specifications. "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 styli. Assembles in minutes; mechanism and vinyl covered mounting base preassembled, arm pre-wired. With 12" record on table, requires approximately 15" W. x 13" D. x 6" H. Color styled in cocoa brown and beige. 10 lbs.

Mechanism Only: Less cartridge, base and cables. Model AD-30, 8 lbs., ... **$22.95**

AA-50 $79.95

HI-FI RATED 25/25 WATT STEREO AMPLIFIER-PREAMPLIFIER KIT (AA-50)

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 two circuit boards, simplifying assembly and minimizing possibility of wiring errors. Handsome cabinet features new "visor" effect, with vinyl-clad steel cover in black leather-like texture with gold design. 30 lbs.

AA-20
$34.95

AA-30 $45.95

ECONOMY PREAMPLIFIER KIT (AA-20)

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 (RIAA "mag" phono, "xtal" phono, and two auxiliary inputs). A 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". Self-powered. (AA-20) 8 lbs.

HI-FI RATED 14/14 WATT BASIC STEREO AMPLIFIER KIT (AA-30)

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 channel gain controls, speaker phase reversal switch and convenient pilot light. Output accommodates 4, 8 and 16 ohm speakers. Handsome satin black expanded-metal cover, gold colored chassis. (AA-30) 21 lbs.

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Procedures for checking home appliances and automobile circuits are 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. 4 lbs.

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XR-2L
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6-TRANSISTOR PORTABLE RADIO KIT (XR-2 series)

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 grille in sun tan color Sur-o-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 provides "big set" richness of tone. Ready to play after simple assembly—transformers prealigned. Six flashlight batteries used for power (500-1000 hrs.) (batteries not included).

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HW-29 (6 meter)
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Vibrator Power Supplies: VP-1-6 (6v.), VP-1-12 (12v.). 4 lbs. kit; **$8.95** ea., Wired; **$12.95** ea.

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A Professional's Theremin

Continued from page 59

tenna a low frequency tone is produced. When the hand is moved in toward the antenna, the pitch should rise. Note that on one side of the null the tone rises as the hand is moved closer to the antenna and on the other side of the null the sound lowers in pitch. Careful adjustment of L1 will yield the desired range of about 6 or 7 octaves.

Volume Antenna. 1) With the left hand close to the tone antenna, slowly turn L3 until a null is produced. 2) Adjust L3 so that the right hand turns the sound on only when held about 2 inches away from the volume antenna (and the left hand is close to the tone antenna).

Playing The Theremin

Initially the beginning thereminist discovers the variety of strange noises that can be made. Low range grunts and growls can be produced by means of quick sweeping motion of the hands. Similarly, in the high range, wails and squeaks result. The midrange, however, has the best musical tone.

The theremin may be used to play individual notes, or can slide from note to note. Generally a combination of both techniques will be useful. To play individual notes, place the left hand in position near the tone antenna to "select" the desired note and then move the right hand briefly near the volume antenna to sound a note. The procedure is repeated for each successive note. With practice you can play scales. A slight wavering of the hand or fingers give the one a vibrato which lends more color to the tone.

How The Theremin Works

The circuit produces an audio tone by combining the outputs of two RF Hartley oscillators V1 and V2. Pentodes are used because they yield a larger output than triodes and they are more stable under a varying load. V2 also serves as a mixer for the outputs of the two oscillators to obtain the difference frequency which is the audio tone. When a hand is brought near the tone antenna, V1's oscillation frequency changes because the hand adds capacity across tank coil L1.

The audio tone appears at the plate of mixer V2 and is coupled to the grid (pin 2) of V3 through volume control R7. Any RF in the signal is bypassed to ground by capacitor C9 and by the input capacitance of V3. V3 is wired as two cathode followers, the output of one feeding the other, with the grid bias (and hence gain) of both controlled by V4A.

The output of V3's second cathode follower is applied to output phono jack J1. Diode CD1 is connected across J1 to "distort" the waveform for a more musical sound.

The pentode portion of the 6AN8 (V4B) is a Hartley oscillator operating close to 500 kc. The output of V4B is coupled to the crystal which is in series with R15. At its resonant frequency, the crystal has minimum impedance and therefore the maximum signal voltage appears across R15. This is applied to the grid of V4A.

The cathode follower output of V4A is rectified by diode CD2 to produce a negative bias voltage which serves to cut off V3. When V4's frequency of oscillation is varied by hand capacitance near the volume antenna the oscillator frequency shifts from the resonant frequency of the crystal. Since the crystal will not pass this new frequency, there's less signal applied to the grid of V4A and the lower negative bias developed permits the audio signal to get through V3.

The power supply circuits are conventional. A full wave rectifier (V5) is employed with additional filtering to prevent the oscillators from interacting through the power supply.

VOLTAGE (DC unless otherwise indicated measured to chassis ground)

PIN #	1	2	3	4	5	6	7	8	9
V1	−4 to −6	1.4 AC	0	6.3 AC	150-200	60-70	0	X	X
V2	−4 to −6	1.4 AC	6.3 AC	0	150-200	60-70	−3.5	X	X
V3	310	−15	8.5	0	0	310	−15	8.5	6.3 AC
V4	300	approx. 4 AC	26	6.3 AC	0	95	40	−1.4	.4 AC
V5	240-250 AC	0	0	6.3 AC	0	240-250 AC	330 AC	X	X

RESISTANCE (measured to chassis ground)

PIN #	1	2	3	4	5	6	7	8	9
V1	22K	0	0	near 0	high	high	0	X	X
V2	22K	0	near 0	0	high	high	100K	X	X
V3	high	approx. 900K	56K	0	0	high	approx. 900K	56K	near 0
V4	high	120K	47K	near 0	0	high	high	22K	0

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	0Z4M	.79		4BQ7	.96		6AR5	.55		6CG7	.60		6SA7GT	.76		8EB8	.94		12B4	.63		12EL6	.50		19BG6	1.39
	1AX2	.62		4BS8	.98		6AS5	.60		6CG8	.77		6SK7	.74		100A7	.71		12BA6	.50		12EG6	.54		19T8	.80
	1B3GT	.79		4BU8	.71		6AT6	.43		6CM7	.66		6SL7	.80		11CY7	.75		12BD6	.50		12EZ6	.53		21EX6	1.49
	1DN5	.55		4BZ6	.58		6AT8	.79		6CN7	.65		6SN7	.65		12A4	.60		12BE6	.53		12F5	.66		25B06	1.11
	1G3	.73		4BZ7	.96		6AU4	.82		6CR6	.51		6SQ7	.73		12AB5	.55		12BF6	.44		12F8	.66		25C5	.53
	1J3	.73		4CS6	.61		6AU6	.50		6CS6	.57		6T4	.99		12AC6	.49		12BH7	.73		12FM6	.45		25CA5	.59
	1K3	.73		40E6	.62		6AU7	.61		6CU5	.58		6U8	.78		12AD6	.57		12BL6	.56		12K5	.65		25CD6	1.44
	1L6	1.05		40K6	.60		6AU8	.87		6CU6	1.08		6V6GT	.54		12AE6	.43		12BQ6	1.06		12SA7M	.86		25CU6	1.11
	1LN5	.59		40T6	.55		6AV6	.40		6CY5	.70		6W4	.75		12AF3	.73		12BY7	.74		12SK7GT	.74		25DN6	1.42
	1R5	.62		5AM8	.79		6AW8	.89		6CY7	.71		6W6	.69		12AF6	.49		12BZ7	.75		12SN7	.67		25EH5	.55
	1S5	.51		5AN8	.86		6AX4	.65		6DA4	.68		6X4	.39		12AJ6	.46		12C5	.56		12SQ7M	.73		25L6	.57
	1T4	.58		5AQ5	.52		6AX7	.64		6DB5	.69		6X5GT	.53		12AL5	.45		12CA5	.59		12U7	.62		25W4	.68
	1U4	.57		5AT8	.80		6BA6	.49		6DE6	.58		6X8	.77		12AL8	.95		12CN5	.56		12V6GT	.53		25Z6	.66
	1U5	.50		5BK7A	.82		6BC5	.54		6DG6	.59		7AU7	.61		12AQ5	.52		12CR6	.54		12W6	.69		35C5	.51
	1X2B	.82		5BQ7	.97		6BC7	.94		6DQ6	1.10		7A8	.68		12AT6	.43		12CU5	.58		12X4	.38		35L6	.57
	2AF4	.96		5BR8	.79		6BC8	.97		6DT5	.76		7B6	.69		12AT7	.76		12CU6	1.06		17AX4	.67		35W4	.52
	3AL5	.42		5CG8	.76		6BD6	.51		6DT6	.53		7Y4	.69		12AU6	.50		12CX6	.54		17BQ6	1.09		35Z5GT	.60
	3AU6	.51		5CL8	.76		6BE6	.55		6EU8	.79		8AU8	.83		12AU7	.60		12D85	.69		17C5	.58		50B5	.60
	3AV6	.41		5EA8	.80		6BF6	.44		6EA8	.79		8AW8	.93		12AV5	.97		12DE8	.75		17CA5	.62		50C5	.53
	3BA6	.51		5EU8	.80		6BG6	1.66		6H6GT	.58		8BQ5	.60		12AV6	.41		12DL8	.85		1704	.69		500C4	.37
	3BC5	.54		5J6	.68		6F 16	.65		6J5GT	.51		8CG7	.62		12AV7	.75		12DM7	.67		17DQ6	1.06		50EH5	.55
	3BE6	.52		5T8	.81		6&H8	.87		6J6	.67		8CM7	.68		12AX4	.67		12DQ6	1.04		17L6	.58		50L6	.61
	3BN6	.76		5U4	.60		6BJ6	.62		6K6	.79		8CN7	.97		12AX7	.63		12DS7	.79		17W6	.70		117Z3	.61
	3BU8	.78		5U8	.81		6BK7	.85		6S4	.48		8CX8	.93		12AZ7	.86		12DZ6	.56		19AU4	.83			
	3BY6	.55		5V6	.56		6BL7	1.00																		
	3BZ6	.55		5X8	.78		6BN4	.57																		
	3C86	.54		5Y3	.46		6BN6	.74																		
	3CF6	.60		6AB4	.46		6BQ5	.65																		
	3CS6	.52		6AC7	.96		6BQ6GT	1.05																		
	3CY5	.71		6AF3	.73		6BQ7	.95																		
	30K6	.60		6AF4	.97		6BR8	.78																		
	30T6	.50		6AG5	.65		6BU8	.70																		
	3Q5	.80		6AH6	.99		6BY6	.54																		
	3S4	.61		6AK5	.95		6BZ6	.54																		
	3V4	.58		6AL5	.47		6BZ7	.97																		
	4BC5	.56		6AM8	.78		6C4	.43																		
	4BC8	.96		6AN4	.95		6C86	.54																		
	48N6	.75		6AN8	.85		6CD6	1.42																		
				6AQ5	.50		6CF6	.64																		

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Superior's New Model 77

VACUUM TUBE VOLTMETER

WITH NEW 6" FULL-VIEW METER

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Model 77—VACUUM TUBE VOLTMETER . . . Total Price $42.50 — Terms: $12.50 after 10 day trial, then $6.00 monthly for 5 months.

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- Model 77 employs a sensitive six inch meter. Extra large meter scale enables us to print all calibrations in large easy-to-read type.
- Model 77 uses new improved SICO printed circuitry.
- Model 77 employs a 12AU7 as D.C. amplifier and two 9006's as peak-to-peak voltage rectifiers to assure maximum stability.
- Model 77 uses a selenium-rectified power supply resulting in less heat and thus reducing possibility of damage or value changes of delicate components.
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- Model 77 uses selected 1% zero temperature coefficient resistors as multipliers. This assures unchanging accurate readings on all ranges.

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Model 88—Transistor Radio Tester and Dynamic Transistor Tester. Total Price $38.50

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The Model 88 is perhaps as important a development as was the invention of the transistor itself, for during the past 5 years, millions of transistor radios and other transistor operated devices have been imported and produced in this country with no adequate provision for servicing this ever increasing output.

Designed specifically to test all transistors, transistor radios, transistor recorders, and other transistor devices under dynamic conditions.

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The Model 88 will test all transistors including NPN and PNP, silicon, germanium and the new gallium arsinide types, **without referring to characteristic data sheets.** The time-saving advantage of this technique is self evident. A further benefit of this service is that it will enable you to test new transistors as they are released!

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AS A TRANSISTOR RADIO TESTER:

The Model 88 provides a new simplified rapid procedure—a technique developed specifically for transistor radios and other transistor devices.

An R.F. Signal source, modulated by an audio tone is injected into the transistor receiver from the antenna through the R.F. stage, past the mixer into the I.F. Amplifier and detector stages and on to the audio amplifier. This injected signal is then followed and traced through the receiver by means of a built-in High Gain Transistorized Signal Tracer until the cause of trouble whether it be a transistor, some other component or even a break in the printed circuit is located and pin-pointed.

Model 88 comes housed in a handsome portable case. Complete with a set of Clip-On Cables for Transistor Testing, an R.F. Diode Probe for R.F. and I.F. tracing; an Audio Probe for Amplifier Tracing and a Signal Injector Cable. Complete—nothing else to buy!

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Model TW-11 — TUBE TESTER . . . Total Price $47.50—Terms: $11.50 after 10 day trial then $6.00 per month for 6 months.

- Tests all tubes, including 4, 5, 6, 7, Octal, Lock-in, Hearing Aid, Thyratron, Miniatures, Sub-miniatures, Novals, Sub-minars, Proximity fuse types, etc.
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- Free-moving built-in roll chart provides complete data for all tubes. All tube listings printed in large easy-to-read type.
- NOISE TEST: Phono-jack on front panel for plugging in either phones or external amplifier will detect microphonic tubes or noise due to faulty elements and loose internal connections.

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.

The Model TW-11 operates on 105-130 Volt 60 Cycle A.C. Comes housed in a beautiful hand-rubbed cabinet complete with portable cover.

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

Continued from page 55

you took the license exam. Your transmitter has probably been built while you waited for the license. Now, in one Saturday afternoon you can have everything ready to go—smoothly and snappily—once your "ticket" arrives.

The antenna changeover relay can do only "that," or it can have extra contacts for receiver silencing or "disabling." The coaxial relay shown in our first illustration flips the antenna over to the transmitter and short-circuits the receiver input to ground. Auxiliary contacts also open the receiver's B-plus lead. When the relay is released, the antenna is switched back to the receiver, the receiver input is "ungrounded," and the B-plus circuit closed.

Most of the newer transmitters have accessory sockets that supply, among other things, energizing voltage for a changeover relay. This is usually ordinary line voltage, 117 volts AC. Extra contacts on the "transmit" switch take this voltage from the power-transformer primary and put it on the socket terminals.

Coaxial relays are fairly expensive, and the job can be done with cheaper relays. Even a twin-lead type can be used with little or no RF loss in an all-coaxial circuit, if leads inside the relay box (see below) are short and direct. A twin-lead relay is of course a double-pole, double-throw type, and one set of contacts can be used for antenna switching, the other for receiver muting. Also, a second relay, of as many poles and contacts as needed, can cut receiver B-plus, actuate a modulator, etc. The second relay's coil is simply wired in parallel with the first relay's coil.

A relay also can be actuated by connecting the relay coil and a single-pole, single-throw switch in series with the regular 117-volt AC wall outlet power. If you don't wish to handle this higher voltage, a small 6.3-volt step-down transformer can still do the job perfectly and safely. You must then use a relay coil designed for 6.3-volt operation.

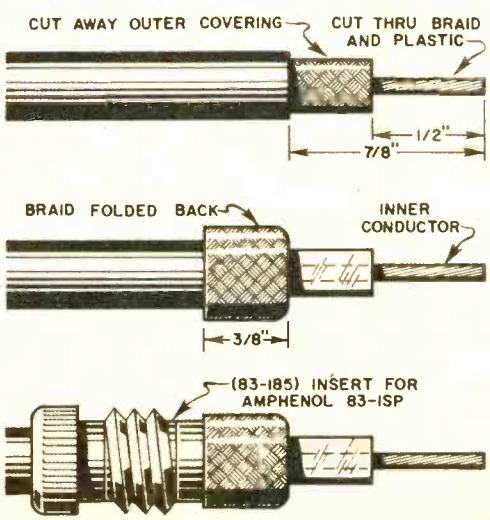
The relay should be housed in an aluminum or steel utility box. The size is unimportant as long as everything fits inside. Female coaxial connectors should be used to bring the leads through the box. Amphenol type 83-1R is one popular type. Use a two-connection insulated terminal strip for attaching the antenna line to a receiver having no coax input connector.

The standard coax connectors, like the Amphenol 83-1SP (male) are designed for half-inch diameter cable such as RG/8U, which is too stiff and heavy for short indoor runs. RG/59U cable (electrically similar to its big brother) has half the diameter and is much more flexible. To use the "little" cable with the "big" male connectors, *inserts* are needed. These effectively "swell" the cable ends to fit the connector and guarantee good electrical contact. The diagram shows the treatment of the cable for the insert.

Care must be taken when cutting through the cable's outer covering not to cut the braid, and when cutting through the braid and plastic insulation, not to slice the inner conductor. A mistake only means starting all over and making the cable ¾" shorter. Use a sharp knife (like an "Exacto") or a good razor blade and do a neat clean job. First step, remember to slide on the coupling ring and insert. They can't be put on after the connector plug is soldered in place. Prepare the cable as shown in the drawing and bend the braid back over the end of the insert. The connector plug and insert are now screwed together with the inner conductor of the coax sticking through the connector. Now solder the inner conductor to the tip. It is not absolutely necessary to solder the braid to the plug through the connector's little holes.

Lengths of coax and end fittings can now

How to prepare small-diameter coaxial cable for adapter to standard fittings. Adapter or "insert" is "waiting" on the wire while cuts are made, then slides forward to fill "cuff" made of folded-back braid. The rest is easy.



be prepared to connect the transmitter to the control box and the box to the receiver. Exact length is not important. Don't forget to prepare the end of the coax cable coming from your antenna.

If you are using a simple dipole, use RG/58U cable (75-ohm nominal impedance) throughout, including the feeder to the antenna. It has its own type of insert.

For multi-band antennas using twin-lead or ladder-line feed, your "antenna" cable from the relay box will feed either an antenna tuner or a "balun" coil to provide proper matching.

Lightning protection should be provided for either 300-ohm antenna lead-in wire or coax cable. Commercial inexpensive arresters should be attached at some convenient point in your transmission line, say at the point where it enters the shack. The arresters must be connected to a suitable ground point such as a water pipe, electrical conduit or an actual ground rod driven into the earth near your ham setup.

All your equipment should be connected to a common ground. Short lengths of braid with soldering or spade lugs should be prepared and connected from relay box, receiver, and transmitter, to a common ground "bus" (braid or solid bus wire) and then to the electrical system ground. Braid connections can be made under rear cabinet chassis and wall outlet plate screws.

In order to comply with FCC rules it is necessary to monitor a regular AM radio, FM or TV receiver to tell when a *Conelrad* alert is in progress. During an alert all hams must leave the air at once. If a station that should be "on" goes off, you had better investigate. This can also be done by an automatic alarm receiver such as the Regency Model CD-2 or Ameco Model CD-1 which will sound a warning audio tone for an alert.

After building the relay box, preparing cables and fittings, and connecting your equipment to the relay box you are ready to go "on the air" with no fuss once you are "on." Follow the individual manufacturers transmitter tune up procedures and be ready to "work the world."

The "Reverb"

Continued from page 33

to the two springs. At the output end, the resulting mechanical motion of the springs is picked up by the output transducers and reconverted into equivalent electrical energy. Because of the time required for the mechanical vibration to run the length of the springs, the output signal is a faithful but delayed replica of the input.

The transducer action is quite simple. The signal is applied to a coil wound around a U-shaped, laminated core. Suspended within the core are two magnetically polarized, cylindrical *armatures* which are free to rotate in both directions. As the signal is applied, the coil-core becomes magnetized, with the magnetic polarity changing in accordance with the polarity of the electrical signal. The armatures, therefore, rotate first in one direction and then in the other, as they try to align themselves with the changing North and South poles induced in the core poles by the signal. The springs, being connected to the armatures, transmit this rotary motion to the armatures of the output transducer.

The operation of the output transducer is the reverse of that of the input. Here, the armatures induce a magnetic field in the core of the output coil. This field varies as the armatures are rotated by the springs. This, in turn, causes an output voltage to appear across the coil terminals.

The principle is really the same as in the "*EI* Echo Chamber" (*EI*, August, 1960) except there, a small speaker was used as an input transducer and a crystal phono cartridge for the output.

The two springs used in the reverberation unit have intrinsic delay characteristics of 37 and 29 milliseconds respectively. While reverberation could be obtained with a single spring, it takes at least two for a really effective job. The mechanical signal actually traverses each spring a number of times before decaying entirely. Each time the delayed wave arrives at the output transducer, some of its mechanical energy is converted into electrical energy while the remainder is reflected back toward the input. At certain critical frequencies, these reflected waves reach the input in phase-opposition to the applied signal. This causes partial cancellation of the applied signal, leaving gaps in the frequency response of the system. Working in unison, two springs with different delay characteristics flatten out the response so that individual cancellation effects are no longer objectionable.

Being loosely suspended between their two armatures, the two springs are subject to interference problems created by vibrations other than those caused by the electrical signal. To combat this, each spring is divided into two parts, mechanically coupled in the center. The two halves of each spring are wound in opposite directions so that the interference generated in one section tends to cancel that of the other.

While the actual Reverberation Units employed in all of the current systems are identical, the associated circuits vary considerably. In most, the delayed reverb signal is electronically mixed with the main signal and is amplified and reproduced by the same components. In the Motorola system described here, the reverb signal is isolated from the main sound information, even to the point of being reproduced through its own loudspeaker. This, Motorola engineers claim, eliminates the possibility of cross-talk and intermodulation distortion which could occur with electronic mixing.

For stereo, the signal applied to a single Reverb Unit must be a monophonic blend of the two separate stereo channels. Motorola, which uses three separate amplifiers in its stereo system, obtains a monophonic signal by employing a center-tapped coil for the input transducer of the Reverb Unit. With the centertap grounded and the opposite ends of the coil connected to the "hot" side of the stereo speakers, the coil is energized by a composite of the two stereo signals. It lacks the bass frequencies, below 200 cycles, but since the very low frequencies contribute nothing to the reverberation effect (just as they do not help the directional effect of stereo) their absence from the reverb signal does no harm.

Using Reverberation

A reverberation control is mounted on the main control panel. Like all other operational controls, this must be carefully adjusted by the critical listener. Too much reverberation volume, particularly on speech and solo vocals, creates the illusion that the artist is performing in an empty auditorium. This permits some startling "special effects," but it could hardly be called high fidelity.

Proper adjustment depends upon the type of program material, the size of the living room, the amount of reverberation already present in the program source, and just plain personal preference.

The Electronic Level

Continued from page 31

mounted above the ordinary bubble in a standard leveling tube. When the bulb is on, light shines through the bubble, which acts much as a camera lens and focuses light on two photo electric cells directly underneath it. Light must register equally on both cells, or the device will not read "level." For ordinary use, readings are taken off a meter. For the blind person, the amplifier emits a signal which can be heard.

The electronic level or the principle behind it can be applied in any precision leveling operation requiring rapid and economical results such as surveying or wheel balancing. It might take over some of the functions of the gyro in an airplane. It could be used on precision counter balancing scales, or for laying foundations and key points of any structure, or for remote reading or permanent log of deviation from vertical in an oil well.

The level is made by the Surber Electronics Corporation, Inc., of which Surber is president.

Phototape

Continued from page 45

nal off these strips on the moving film, using much the same principle as the third rail on an electric train.

The operating principle is fairly simple. The "capacitor" formed by the polystyrene layer and the photoconductor beneath, plus the resistance of the photoconductor, make up an effective *series R-C* (Resistance-Capacitance) circuit. Like every such circuit, this combination has a "time constant." This is the time required for the capacitor to discharge once the charging voltage is removed and a short-circuit is connected across the pair. Now, since the resistance of *R* in our *R-C* circuit varies with the amount of light striking the photoconductor layer, the time constant, or discharge time, varies too.

To prepare the tape for recording, it is "erased" by flooding its surface with electrons from the electron gun, charging it uniformly. For this, the tape may be kept in either complete darkness or in uniform light.

In the recording process, parts of the

charge are *removed* in accordance with the light pattern striking the film's photoconductive surface. Wherever light has struck it, the photoconductor will have a rapid discharge time, as its resistance will be lower, and the discharge time is the product of R times C in an R-C circuit. The dark parts of the film will have a longer discharge time. Thus a pattern of charges corresponding to the optical image on the film will be built up.

Playing back is similar to the erase process: it consists of raising all parts of the tape back to the fully charged condition, by means of a finely-focused electron beam (instead of a flooding one) which scans the electrostatic "picture." Each point on the "picture" will have its charge boosted back up, from a lower "record" value to the full "erase" value.

The amount of recharging at any point will depend exactly on the amount of discharging during the recording process. In any case, electrons will flow in the camera circuit. Our film "capacitor" is part of that circuit, and fluctuations in the electron flow will be "video information" to the camera.

The Phototape system is a one-shot process, with what the engineers call "destructive readout." When the tape is played back, it is practically erased at the same time. Actually, a recognizable picture can be obtained for two or three more plays, but the system wasn't intended to be used for repeat performances. It is to record on each trip around the world, play back quickly to its control station, and then start recording again.

The first assignment for Phototape will be the preparation of reports on weather conditions around the world, which it must transmit to earth during the few minutes it is passing over its control station. For low-altitude orbits (about 300 miles above the earth), the time required for one trip around the world is about an hour and a half. Of this time, the satellite is above the horizon at a given point for only about 10 minutes.

Hence the satellite will have about 80 minutes to gather information, and about 10 minutes to radio it back to earth. If it transmits all the information it receives, it must play back its recordings at least eight times as fast as it makes them.

The recorder can store a continuous strip of pictures, showing cloud formations completely around the earth, on only 180 feet of tape. This means that its operating speed would be less than half an inch per second, slower even than the lowest fidelity audio tape recorders.

Although the satellite will be commanded to reveal its findings every 90 minutes, for some applications it may be desirable to retain the stored pictures for a longer period. The time which an electrostatic charge image can be stored is determined by the dielectric quality of the insulator layer on the tape. With presently available materials, it is thought that pictures can be stored for three months or more, and in laboratory tests images have been stored on tape for several weeks without noticeable deterioration.

Be watching for *NIMBUS* when it flashes through the night sky this spring. When you see it, you will know it carries the very latest thing in video tape recording.

1-Transistor FM Radio

Continued from page 85

squeal in the earphone. If this condition is not present, recheck your wiring. When the circuit is operating properly, measure the resistance of the potentiometer and substitute a fixed resistor.

The circuit gets its sensitivity from the superregenerative detector principle. C1 and L1 select the station and it is amplified. C2 feeds back some of the signal for reamplification.

Battery life should be extremely good. The original unit used in the model pictured here has been going strong for 100 hours and shows no signs of wearing out. Don't install the battery into its holder with the transistor in its socket to avoid damaging surge currents. In fact, the *last* step in construction, after all soldering has been completed, should be to insert the 2N384 in its socket.

Several steps were taken to reduce the critical tuning of the receiver. Don't attempt any of them until you are sure the circuit is working properly.

First, take a pair of needlenose pliers and gently twist off one of the rotors (moving plates) of the tuning capacitor. Rotate the plates to an open or unmeshed position before doing this to prevent damage to the stationary ones. The remaining two rotor plates will "bandspread" the tuning.

Another modification is to add an extra turn on coil L1. This is easily done after the receiver construction is complete. Instead of starting with 1¼ turns, try another complete loop for a total of two turns. Cut and try different lengths until an improvement in tuning is noted.

A Stereo Recording Session

Continued from page 30

or the conductor a lack of the particular sound he wants, the whole thing grinds to a halt. They discuss the problem, decide how to overcome it, and they're off again.

A session is generally planned to last about three hours and often runs longer. As soon as the producer is convinced that he has enough material for an error-free tape, the session ends, with all hands usually waiting around for one last playback.

Then the editing begins. In an editing room very much like the control room at the studio, the producer and an editor play back every inch of the recorded tapes, cutting out the "clams," and selecting the best takes for their musical and technical qualities. These are spliced together into a single spliced original, a composite image of the best work of these highly skilled musicians and technicians.

Another problem is how to connect the edited portions, allowing tape for the lead-in and the separation between the bands. Blank tape won't do, because the absolute silence would jar. So the engineers record silence in the same studio as the session and splice in "room noise" as needed.

Now comes the transfer from the half-inch tape to the quarter-inch master carrying only two channels. Here the tape editor and the producer work small miracles, emphasizing the sound from one channel, cutting the volume on the other, blending into either right or left some of the center to fill out the sound qualities of the master tape. Though this is a frequently discussed process, there is a generally held but mistaken idea that the editor is an expert who takes an orchestral background from one tape, a solo from another and a run of sixteenth notes from a third to put together a performance that never really existed. This is anything but the truth, even though it could be done. Editing in the hands of a conscientious producer is used only to further the musical integrity of the performance. It is used as an aid, not as a crutch, to carry forward the goals of the composer and the conductor. There are times when a few notes will be spliced in, or effects superimposed on the background, but in general the practice is a lot closer to depending on a good, clean performance than the public realizes. The complete, edited tape is now ready for transfer to the master disc.

This process will be described in an early issue of *EI*.

Light-Amplifier Breakthrough

Continued from page 43

process would also be much simpler.

The applications of the light maser are a lot closer to home, and closer in time, than any proposed expedition to Mars or the Moon. Communications systems here on Earth are already urgently in need of more, and wider, channels. The need for the new channels and new uses is already upon us, and by the present rate of growth in communications, 1970 is the deadline date. By then, there won't be a channel to spare, anywhere in the world, and there will be communications bottlenecks because more channels will be needed.

In the last few years the working radio spectrum has zoomed to 30,000 mc, and laboratory devices are straining to get useful outputs at 50,000 mc. Now, the new ruby masers operate at about 500,000,000 mc—a jump of 10,000 times.

All radio signals require some channel width. Even a code signal, considered a "point" on the dial, needs a kilocycle or so to deliver an audio tone. An AM broadcast signal needs 10 kc for its sidebands; an FM signal, 300 kc; and a television signal has a channel six megacycles wide. Worldwide satellite communications systems, planned by Bell Labs and others, call for channels *thousands* of megacycles wide. Common sense quickly demonstrates that no radio channel can be wider than its highest frequency.

How It Works

The light maser is a synthetic ruby rod, five inches long and a fifth of an inch in diameter. *Ruby* is crystalline aluminum oxide, with an "impurity" consisting of chromium atoms.

Like many materials, ruby will undergo *fluorescence* and emit light when stimulated by light of a higher frequency. We have all seen fluorescent materials that glow with visible colors when stimulated by ultraviolet light. Under the attack of green light, the ruby will glow faintly *red*. The red is *below* the visible red of the red of the white light spectrum.

One more step, and you will understand the light maser. In fluorescence, the atoms of the substance under attack jump to higher energy levels because they absorb energy from the incoming "exciter" light. Spontaneously, they drop eventually to their original energy level, getting rid of their excess energy by sending off light particles of a particular wavelength.

In the maser, this "relaxation" to a low energy level is *stimulated*. If the atom is struck by a light photon of its characteristic frequency, it will release its excess energy then and there.

The maser's ruby is in the shape of a long rod. The ends of the rod are polished optically flat, and then coated with enough silver to make them opaque. When the exciter lamp surrounding the ruby rod is turned on, chromium atoms in the ruby absorb light, make two "upward" energy "jumps" to a higher level, and fall back to an intermediate level, where they emit no light. A few fall back to the original level, giving off red light as they do so.

This red light is *random*—photons from different atoms fly off in different directions. Most escape out the sides of the rod as ordinary fluorescence.

Those that happen to be traveling along the rod's long axis, however, reach one of the silver reflectors at the ends, and are reflected back. As they go, they strike "intermediate state" atoms and cause them to let go of their excess energy. Now a "chain reaction" builds up, and the number of photons flying back and forth along the main axis, being reflected by the silver "mirrors" at each end, increases rapidly. The long axis becomes the *favored direction* for new photons escaping from the atoms, which follow the "triggering" photons immediately. Now waves of red light are racing back and forth, picking up more and more energy from "intermediate state" atoms as they do so.

Finally, in about a millionth of a second, the amount of light energy built up is so enormous it *breaks through* the opaque silver coatings at the ends. It emerges as a powerful, thin beam.

It is easy to narrow the beam further by means of lenses, because it is made up of *monochromatic* light. Focusing white light is always a problem, because it is made of light of so many wavelengths. Lenses and reflectors tend to bend or direct the light of different wavelengths at different angles.

At present, the best way to communicate with a maser is by keying it—which seems to bring us back to the old blinker light. But it can be so much more effective than a blinker. The narrow beam insures secrecy, and freedom from interference, as two or more beams of the same frequency can ride side by side, or cross. Also, a maser beam can ride a narrow, closed pipe —a "waveguide."

Light masers under development will use other types of crystals, and also gas molecules. The original idea of a ruby maser,

suggested by Bell Labs' Dr. A. L. Schawlow and Columbia University's Dr. C. H. Townes, would have used a paired-atom technique that would require the maser to be operated at very low temperatures. Dr. T. H. Maiman of the Hughes Aircraft Company's research laboratories devised the first working light-maser described here.

"Maser" is from the initial letters of "Microwave Amplification by Stimulated Emission of Radiation." Dr. Maiman calls his design a "laser," for "light amplification," etc., and this name will probably stick.

The illustrations and the text say that the laser's beam is in the *invisible* portion of the spectrum, and more than hint that we *saw* it. Our drawing shows an eye looking at the spectrum from a white light, and also the laser's "red" flash which is *off the end of the visible spectrum.* This means it is off the eye's normal low-frequency response curve, but being so powerful, it registers on the retina. The eye reports "red flash" to the brain, since that is the closest "normal" report it can make. It is a "spurious response," just as your radio receiver may respond to a powerful nearby signal on a frequency not even covered by its dial.

The light maser, or laser, pulses at such a high rate it may also find use as a *switching* device for computers and control systems, as transistors are used now.

The small size and simplicity of the equipment make it economical, except for the cost of the ruby element. No doubt gas-molecule lasers (watch *EI* for developments) may make for further economy. This will be very important as the world's need for communications and telemetering expands in the near future.

A True Electronic Watch

Continued from page 47

turns the gear train connected to the hands. This results in a smooth sweeping movement of the second hand instead of the normal jerky motion of escapement timepieces. Bulova says it can be accurate to a gain or loss of *one minute per month.*

This extremely simple mechanism is downright astounding when the size of the components is considered. The magnetic assembly at the tip of each tine consists of a cup-like piece of magnetic iron. Within the two cups are conically shaped electromagnets, each with a coil, one made up of 8000 turns, the other of 6000 turns, of 0.0006" insulated wire (that's about *one*

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fifth the diameter of human hair!). These coils, 0.15 inches long and 0.18 inches in diameter, each with about 300 feet of the tiny wire in it, drive the tuning fork. Their pulses of electric current become pulses of mechanical energy in the fork tines. A third, smaller coil inside one of the other two acts as a "feedback" coil for the transistor, which works essentially as an oscillator to supply the 360-cycle driving current. The circuit requires 0.000008 watts of operating power.

If anything in this description sounds familiar, just remember the crystal oscillator used in radio transmitters and in frequency standards. The crystal has a natural resonant frequency, just like the tuning fork in the watch, and the coils are designed to operate electrically at that frequency. The crystal actually vibrates. In both cases, mechanical and electrical elements give each other "nudges" to keep them operating on time, on frequency.

Although the face of the watch is not unusual, the back is. The time-setting wheel and replaceable mercury battery ($1.50) are located here.

To assure the wearer that it is calmly, smoothly, accurately keeping time, the electronic watch doesn't tick—it purrs.

——*Elaine E. Sapoff*

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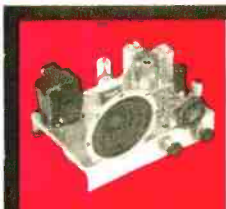

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