Voice communications on every front...

Whether by radio or land wire telephone, a voice command gets the job done with clarity and speed.

UNIVERSAL microphones are playing a vital part in voice communications of all the Armed Forces... being the first instrument through which a command is given. Care must be taken that the electronic patterns of the voice are held true for the many electrical circuits through which they must later pass. UNIVERSAL microphones with their precise workmanship are carrying the message through in all forms of voice communication whether from a tank, ship or aeroplane. UNIVERSAL products meet all U.S. Army Signal Corps Laboratory tests. Standardization of parts, inspection, and workmanship of high order combined with the best of material, make UNIVERSAL'S microphones and accessories outstanding in every application.

U.S. Army Signal Corps and U.S. Navy plugs and jacks are offered as voice communication components to manufacturers of transmitters and sound equipment for the Armed Forces. Catalog No. 830 contains complete details.
# 1943-1944 Radio-Electronic Reference Annual

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WHAT YOU SHOULD KNOW ABOUT ELECTRONICS

By W. C. WHITE*

ELECTRONICS is defined as "the science which deals with the behavior of electrons." Like many definitions, this one is not very helpful and one must go a step further. Recently I saw a definition which I rather liked and which read "electricity freed from the bondage of wires." That, I think, is better because it is descriptive and intriguing.

The electron is the basic unit of electricity. Just as a drop of water can be considered a sort of basic unit in measuring amounts of water, so the electron is the unit by which we could measure the quantity of electricity. I say "could" because it is not a convenient measure. Again using the drop of water analogy, if we are talking about small amounts of liquids, such as a teaspoonful, it is logical to express the amount by the number of drops. However, when speaking of large amounts of water, such as go over Niagara Falls per hour, it would be absurd to express them by the number of drops.

The same thing is true of electrons. Even the number of electrons that make up the small current used in the filament of a household incandescent lamp is so huge and, therefore, runs into so many significant figures that we don't talk about the electric current offers possibilities of currents in ways that are totally impossible in an ordinary conductor like a piece of wire. This possibility arises from the fact that these electrons may be started, stopped, and deflected very easily. This is done by putting additional electrodes in the tube and operating them at a certain combination of voltages which determines how many of these electrons travel across the space and at what speed and how often they are started and stopped.

Here again, it is well to remember those two separate steps in this process of electrons moving through a vacuum. The first is the free end of the cut wire, the negative one, is connected to the hot-cathode terminal of the tube and the other, the positive, is connected to the cold anode plate.

That in its simplest form is an electron tube in an electrical circuit. During the split second when the electric current in this circuit is in the form of a stream of free electrons leaping across the gap through the vacuum of the tube, you can control this current with great speed and accuracy. The control element in the tube is usually like a screen or grid which is placed directly across the stream of electrons.

If to this grid or control electrode a proper voltage is applied, the current through the tube, and thus the current in the circuit, may be varied. The kind of tube used depends on the magnitude of the currents and voltages involved and how fast the control has to be, and it can easily be up to a billion times a second.

It is natural to ask why, year after year, we continue to use electron tubes both in our radio receivers and radio transmitters. Is it not possible to substitute for them other devices that will do the job as well or better? The answer is "yes" and will probably continue to be "no" in radio for a very long time to come because electron tubes can do certain things that just cannot be done in any other way.

There are several reasons why electron tubes are the heart of radio equipment. The first of these results from their almost complete independence of electrical frequency. As you well know, many electrical devices are suitable only for use on direct current or only on the one frequency of 60-cycle alternating current. However, as we have seen, an electron tube can function at millions of cycles a second just as well as at 60 cycles. It can do this because the myriads of electrons in the evacuated space inside the bulb can move at such enormous speeds that the frequency range mentioned above is
SINCE Lee De Forest first put the famous "Edison Effect" to work in the electronic vacuum tube that made radio possible, many similar tubes have been developed in the nation's engineering laboratories. There are many electronic tubes which can do jobs that have to be done in a hurry—and in most cases do them better.

Many of them are well known, but with few exceptions these tubes have been ignored by the men whose job it should be to install them. Possibly some radio men have been frightened away by such names as Sterilamp, Thyatron, Grid-Gate, Supervisor Protector, Ignitron, Leonard Ray and Phanatron. Perhaps others felt that circuits involving these vacuum tubes require an engineer for installation. Herefore this latitudinal was merely unsound business practice; today it's wasteful neglect of developments vital to the unified war effort.

It takes no engineering skill to install these tubes. Any man with a radio background and a knowledge of the fundamentals of electronics can do the job quickly and simply. Briefly this is a summary of the most widely adaptable of the electronic tubes; what they have done, what they can do, and how they can be of most value.

THE STERILAMP

This baby is the snappiest little microbe killer of them all. This tube has just begun to emerge from obscurity, and has a thousand-and-one uses. This tube radiates ultra-violet rays which mean instant death to bacteria, fungi, and mold.

Sterilamp has licked the spoilage problem for the meat industry. Previously the only way to store meat for any period and keep it germ-free was sharp freezing and chilling. But this process robbed the meat of its juices and vitamins, shrunk it, and discolored it. Recently several of the more progressive storage houses have installed Sterilamp. They have found this electronic tube an economical and highly efficient answer to the key problem of storage as the meat moves along the line from slaughterhouse to the modern streamlined meat counter. Sterilamp, operating at normal temperature of about 70 degrees Fahrenheit, does the job of high-cost extreme refrigeration, without shrinking, or discoloration, or waste of important food value. This means better, richer, meat for the consumer and less complaints for the butcher.

Other uses of the Sterilamp are manifold. Think of any situation where antiseptic cleanliness is imperative to human health and ten chances to one you can use Sterilamp. For example, the commercial baker has to deliver his bread, cake and rolls to the consumer's table fresh and mold-free. Mold spores, which are always present in the air, attack these important foods as soon as they come out of the oven. A Sterilamp would kill these molds even if they get on these foods.

Similarly this ultra-violet-ray emitter could be used in restaurants, soda fountains and hotels to protect drinking glasses and silverware.

Every barber shop, every beauty parlor, could use a Sterilamp hook-up to replace complicated and ineffective steam methods of sanitizing the much-used instruments.

Sterilamp's life-saving potentialities make it A1 material for active military service. Install it in barely equipped combat hospitals, and slice the startling mortality from infection of the last war, to a minimum.

On the farm, Sterilamp has countless possible uses. The sanitation of the storage and delivery of milk and milk products would protect the most vital source of the nation's food supply. Beneficial installations could also be made in poultry houses and incubators, to protect the extremely susceptible hens and chicks. One company has even put Sterilamp on duty guarding the humble but so important toilet seat. The limits of the use of Sterilamp are only those of the radio-man's ingenuity. Economical to operate, easy to connect to an A.C. transformer as shown in Fig. 1, and possessing an exceptionally long life (4000 hours under normal operating conditions), Sterilamp has endless practical applications.

THE LEONARD RAY TUBE

This is a small-scale death-ray that foretells a diseaseless future for mankind. The tube is constructed with a special glass window which allows the passage of high-speed electrons.

The electrons are concentrated into beams which are so powerful that they not only destroy microscopic bacteria, as with the Sterilamp, but also insects as well. Roaches, fruit flies, locusts and house-flies can be electrocuted instantly when they pass through the beams from this tube. The radio-man can commercialize the Leonard Ray with installations in hot-houses, food-markets and other places where disease-carrying insects are likely to do considerable damage.

Leonard-Ray tube installation and operation is as simple and economical as with the Sterilamp.

THE SUPERVISORY PROTECTOR TUBE

Here is the ideal inexpensive replacement for costly cumbersome relay systems used in many control applications. Constructed with three graphite electrodes enclosed in a gaseous atmosphere, the supervisory protector can handle virtually any control job where surges of voltage occur. Two of the electrodes are connected with the circuit to be protected, while the third is grounded as shown in Fig. 2.

Sudden voltage rise causes the third electrode to become conductive and drain off the excess to the ground. One drawback of this tube is that extremely high voltage will destroy it. However, even when the tube is ruined the flow to the ground is maintained and the circuit saved regardless of the voltage quantity.

A Supervisory protector system is believed by many engineers to be more (Continued on page 36)
THE ELECTRONIC "SOLOVOX"

New Radio-Musical Adjunct to the Piano

THE Solovox is a new 14-tube instrument— invented by Laurens Hammond, creator of the Hammond Organ and the Novachord, and expressly designed as a musical supplement to the piano—that even a child can play perfectly. Operated entirely by electricity, the Solovox is a 3-octave keyboard which is attached to the piano so that the fingers of one hand can easily span the 2 keyboards. A total of 12 control tablets give the Solovox a 6-octave range as well as an indefinite variety of tone colors, and being smooth, sustained and capable of "swell," its tone colors make an effective contrast to the percussive brilliance of the piano. A knee lever controls the volume. A slim tone cabinet containing the electrical equipment, including the loudspeaker, is set alongside a vertical piano or underneath a grand piano.

This instrument represents a new source of income for Servicemen and Servicemen-dealers.

MODUS OPERANDI

All the notes of the Solovox are controlled by a single radio vacuum tube master oscillator (see diagram) operating at one of the 12 audio frequencies in the highest octave of the instrument (2,093 to 3,951 cycles). Each time a key is depressed, a switch under it tunes this oscillator to the pitch associated with the key in this highest-octave range. This occurs regardless of whereabouts on the keyboard the playing key is depressed. Thus, whenever any one of the "C" keys is depressed, this oscillator is tuned to 2,093 cycles, which is its lowest frequency. If any "B" key is depressed, its frequency will be 3,951 cycles, which is its highest frequency.

The output of this master oscillator controls the frequency of another oscillator called the buffer oscillator which operates at the same frequency as the master oscillator. The output of this first controlled (buffer) oscillator in turn controls the frequency of a second controlled oscillator, so interconnected with the first as to oscillate at one-half the frequency of the first oscillator. This new frequency corresponds to a note of pitch one octave lower than the first controlled oscillator.

Similar succesive oscillators provide pitches of 2, 3, 4 and 5 octaves below that of the master oscillator. In this way, each time the master oscillator is tuned to some one of its 12 audio frequencies (for each note of the scale), each of these 6 controlled oscillators immediately follows it to produce outputs which are the lower octaves of this pitch, to form a series of 6 frequencies in exact octave relationships. Now the particular oscillator outputs desired for passing through the amplifier and speaker, depend upon the particular playing key depressed (for instance on which one of the 3 "C" keys) and also upon which of the "BASS-TE♥OR-CONTRALTO-SOLOPRANO" controls are used. The selection of the desired oscillator occurs when a second contact under each key closes. This second contact operates an electrical relay having contacts to make the desired oscillator selection. It is to be noted that there are 3 relays, one of which is common to each of the 3 octave groups of keys. Thus, we see that a playing key functions in 2 ways—first, it tunes all of the oscillators to the pitch of the key being depressed, and then selects the output of the particular sub-octave frequency controlled oscillator desired.

A further function of the second key contact is to transmit the signal to the speakers with a controlled rate of attack, so as not to be musically abrupt. Tuned electrical circuits and tone controls follow, which control the quality of tone over a very wide range.

The effect of the "MUTE" is produced by passing the signal through a vacuum tube operated non-linearly so as to suppress the sharp curvature of its input wave, and thus render the tone more mellow.

PERMEABILITY TUNED

The "VIBRATO" effect is produced by a vibrating reed (which is put into motion when the volume control lever is brought forward in starting the instrument) which intermittently changes the pitch of the master-oscillator by varying the inductance of a small coil (L1 in diagram) connected across it.

The volume of sound from the speaker is controlled by a knee-operated rheostat which acts to control the amount of amplification.

The Solovox will remain in tune indefinitely. However, as the pitch of the piano with which it is to be played will vary considerably, a tuning adjustment knob at the top of the tone cabinet has been provided with which the instrument may be easily tuned by the pianist in 10 seconds' time, to the piano. It is not necessary to tune each note—the single tuning knob provided simultaneously tunes them all by varying the inductance (L2 in diagram) that resonates the master-oscillator circuit.

USES

The Solovox, which can be played by even the self-made pianist without any special instruction, adds singing voices like orchestral instruments to the tones of the piano. The player carries the melody on the Solovox with the right hand and the left hand accompanies on the piano. The right hand can easily encompass notes on the Solovox and piano keyboards simultaneously, considerably enlarging the pianist's scope. On the front of the Solovox are the previously-mentioned, tablet-shaped tone selectors and all that the player must do is to push them in various combinations to extend the range of the instrument to 6 octaves and create hundreds of exciting new tone-colors. Some of these tones resemble flutes, strings, brasses or woodwinds, while others have never been heard before!

The exceptional versatility of the Solovox makes it a flexible addition to the studio equipment of any radio station. With the Solovox attached to the piano, ensembles are heightened and dramatized by its smooth attack. The rich variety of its tones ranging from a brilliant, string-like effect to a deep and penetratingly organ-like quality make it a new and different instrument for music lovers to hear and enjoy.

(Continued on page 57)
Diagram, model J Solovar. Following are circuit notations. Including omissions, not located in time for inclusion. In the diagram, Tube V9 (780); consider the grids, connected to the cathode, an idio plates. A movable iron core tunes L2.

Missing component values: V3 plate R.F. load resistor, shunted by 0.05-mf. condenser, 4,000 ohms; V5 plate D.C. load resistor, 64-meg.; V10 10.5-ohm resistor, 0.5-meg.; connected to center-tap of "A.F. trans." is a 0.72-meg. unit shunted by 0.15-mf.; V12-V14 coupling unit, 0.005-mf. Note that contacts shown normally open, nearest to "Highest." Middle- and Lowest-Octave relay magnets, should be shown closed; alike, the 3 pairs of contacts, at top, contacting the +10 V. bus.
PHILCO’S LIGHT-BEAM PICKUP

The basic principle of the “mirror galvanometer,” in which a weightless lightbeam-magnifies small motions by being reflected to a distance, receives its newest application in Philco’s new phono pickup unit. The result is a Photoelectric Phonograph. A number of important advantages are claimed, including higher fidelity, less needle scratch, and lengthened record life.

The Photoelectric Pickup. It is said to be 40% to 60% more sensitive than preceding types. The light from a high-intensity argon-filled filament-type exciter lamp led by a radio-frequency current is reflected from a mirror, about 1/2 x 1/2 in. high, and paper-thin to a selenium “electric eye.”

The Photoelectric Phonograph. A number of important advantages are claimed, including higher fidelity, less needle scratch, and lengthened record life. These advantages are the following: (1) greater volume and tonal range with the old-fashioned steel needle; (2) record life increase of at least 10 times; (3) greater reproduction fidelity, especially in respect to cleaner bass notes and clearer high notes; (4) greater volume and tonal range with apparently less record scratch and noise; (5) safeguarding against accidentally scratching the record, or breaking the needle as is so readily possible in ordinary phonographs (as by accidentally allowing the pickup head to drop on the record).

Philco Radio Corp. engineers have found that the way to obtain these results was to “do it with mirrors.”

THE TRIGGER ACTION

It was apparent that little force would be required to move a tiny mirror mounted on the rotating axis on which the mirror would swing as the floating jewel (which replaced the old-fashioned steel needle) followed the curving record groove. Thus, by directing a beam of light into this mirror, at an angle which reflects it on the photoelectric cell, it was possible to set up a controlling source of energy without making the record do the work.

As the floating jewel (sapphire) moved along the curve of the record groove, the mirror swung from side to side on its axis, flashing the beam of light on and off the photoelectric cell. Since the photoelectric cell translates light into electrical energy—such being the peculiar property of certain materials—the flow of current generated by the photoelectric cell varies in proportion to the amount of light flashed in the cell as the mirror is swung by the jewel.

There are 4 definite stages, then, in the process of taking the music off the record and transmitting it to the ear. First, the photoelectric phonograph employs mechanical vibration as the jewel pulses in the groove of the record. Second, light vibrations are brought into play when reflections of the light beam shining on the mirror play on the photoelectric cell. Third, electrical vibrations generated by the photoelectric cell are transmitted to, and operate, the loudspeaker. Fourth, acoustic vibrations carry the sound waves to the ear and complete the process.

Such, in brief, is the fundamental operating principle of the new photoelectric pickup built into the latest Philco radio-phonograph combinations. However, in order to make it work properly and practically, a number of other refinements and innovations were necessary.

STRUCTURAL DETAILS

One of these contributing features is represented by the mirror itself. To minimize the amount of energy required for the jewel to swing the mirror, it was necessary to utilize a paper-thin mirror specially designed for use in galvanometers. This is slivered with a vaporized aluminum and mounted on a tiny block which swings on an axis which floats on 2 flexible bearings.

The solution of another problem involved the design of a tiny bulb to supply the light beam directed against the mirror and reflected on the photoelectric cell. To meet technical requirements as to size and weight a tiny bulb filled with argon gas is inserted in the axis. The filament is designed—lengthened by the photoelectric phonograph employs mechanisms of the light beam shining on the mirror to the ear. First, the beam of light is reflected from the mirror and transmitted to the ear. Second, light vibrations are brought into play when reflected from the mirror and transmitted to the ear. Third, electrical vibrations generated by the photoelectric cell are transmitted to, and operate, the loudspeaker. Fourth, acoustic vibrations carry the sound waves to the ear and complete the process.

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It is difficult to understand why servicemen generally permit such a lucrative field as the hearing-aid business to be monopolized by a few large concerns, unless they are perhaps dazzled by the high-pressure (pseudo?) medical advertising in which some of these concerns excel.

Servicemen's standards of tone quality are generally rather high, and they have difficulty adjusting themselves to the limitations of response set by the size and power of devices. The usual customer can be discouraged if a customer doesn't immediately be satisfied with any hearing aid, whether it is of the utmost importance! That is intelligibility. A hearing aid with indistinct and ragged response is a sure business loser and must be avoided. Poor results are almost always due to undesired circuit feedback, or, to a poor quality or poorly fitting receiver. Intelligibility is not achieved by cutting the lows, but by careful workmanship and perfect tube and circuit performance.

The pocket type hearing-aid, described here, is recommended to the serviceman as being particularly suited to his requirements for easily available, standard parts and tubes; and, has power and quality equal to any such device sold.

The container is a common, smoking tobacco tin (or its equivalent), which is given a coat of crystallizing lacquer, or flock, when completed. It measures 3 1/4 thick x 3 1/8 wide x 4 1/2 long, approximately; a convenient size for personal wear.

The bottom is fastened in by a convenient size for personal wear. The bottom is fastened in by a fold of the metal over the end. This is fitted through and the bottom (Fig. 1) is pushed out and is hereafter called the top. The hinged top of the tin is to be the bottom of the hearing aid, and is convenient for inspecting and replacing the tubes, without the necessity of opening the entire instrument.

The top will be replaced in the tin—up-side down—to make a smoothly rounded top of the instrument (Fig. 2). Inside the top, solder two 7/16" standard machine washers, as shown in Fig. 3, and punch and file the holes. The hole for the switch is 3/4 x 3/4. At one end the volume control is placed. The cords for the microphone, batteries, and receiver are threaded through the other end hole, and the D. P. S. T. slide switch is soldered in place in the central hole. This switch is too large, and must be trimmed down, as shown, in order to fit into the space allowed. (Fig. 4.)

Take the wafer sockets and remove the excess material as shown in Fig. 6. The sockets are mounted by soldering their filament minus prong tab directly to the chassis. Two and one half inches from top of tin to bottom of glass base of tube.

Mount the insulated binding strip, one inch from the side as shown in Fig. 7.

The exact position of each item may be determined from Fig. 7. Keep grid and plate leads separated as far as possible—particularly, those belonging to separate tubes. Use spaghetti tubing and thin fibre insulation in tight spots.

The output transformer or choke should be mounted with the iron core parallel to the base plate. The transformer shown, is I bought to match a miniature receiver,
Several views of the "home-type" short-wave diathermy apparatus here described are illustrated above, some showing the apparatus in use.

**ELECTRON-TUBE DIATHERMY**

THE short wave diathermy machine has come to be an accepted part of the equipment in the progressive doctor's office. In the short space of ten years (since its introduction into this country) it has convinced most of the skeptics and conservatives in the medical profession that it is not "quackery." The heating produced deep down in the tissue by the high frequency currents induced into the patient stimulate the capillaries, we are told, and assist nature in its work of clearing the waste products out of the tissues.

The machine described in this article was designed and built for home use. More and more, since diathermy treatments have become an accepted aid in certain cases, patients have been purchasing these machines for home use. This saves the time, trouble and expense of frequent trips to the doctor's office. The authors built this one for use by a patient having sciatica who had been making numerous visits for treatment.

The machine was constructed on a shelf. It is expected to mount it in a radio-type cabinet. No meters are used on the machine because experience has shown that once the proper adjustments have been made to the grid bias, feed-back tap, etc., a neon bulb held near the treatment "pad" during "tuning" in of the patient serves as a perfect indicator of resonance. The total cost for parts was $13.32, exclusive of the tube. The tube, a 203-A, was bought second-hand for $2.00 from an amateur friend.

The machine consists of a self-excited oscillator with A.C. plate and filament voltage supply, and a patient coupling circuit. The plate voltage is obtained from an amateur type 1,200 volt 200 mil c.t. (center-tap) transformer with a 6.3 volt winding (used for pilot) which cost $2.95. The filament voltage is obtained from a separate filament transformer delivering 10 volts, 4 amps., and suitably insulated. Using the tube in question it was found that the best operation was obtained with no bias on the grid. However, a grid-leak and condenser is shown in the circuit because some tubes will operate better when biased. The feedback adjusting tap should be set for maximum output of the machine as described later. Fractions of a turn are important in making this adjustment. Ours was best 5½ turns from the plate end of the coil.

The Patient Circuit: This circuit must provide means of coupling the output of the oscillator to the patient efficiently and safely. It will be noted in the sketch that the patient coil is mounted inside the oscillator "tank" coil. This was found to yield maximum output. A glass pickle jar was put around the patient coil to assure the safety of the patient; it prevents the patient coil from touching the "tank" coil which has high voltage on it (enough to KILL you instantly).

A tuning condenser is provided which is adjusted until the patient is in resonance. This is indicated by a neon bulb held near the pad. Connection is made to the patient by means of insulated electrodes. These act as the plates of a condenser—the patient "sandwiched" between them acts as the dielectric. Heating of the patient is partly by induced current and partly by dielectric hysteresis.

In setting the feedback tap previously referred to, in order to obtain maximum output—an incandescent lamp is coupled to the pads, by attaching small metal plates to

(Continued on page 17)
Experimental PHOTO-CELL RELAY

RELAYS operated by photo-cells are today becoming increasingly common in industry, and are even spreading into the home, as kitchen door-openers and burglary alarms, for example. The experimenter will find the unit described here reasonably simple to build, yet dependable and sensitive in operation.

We present here a little unit that can be built easily and that will work efficiently. It can be used for almost any number of applications such as counting, announcing, grading, safety control, smoke control, lighting control and as a burglar alarm.

As shown in photo A, the unit is built into a small metal box measuring only 5"x4"x2". The box need not necessarily be made of metal or built that small. The photo-cell is mounted under the chassis in a position so that light reaches it through the 1/4" round hole in the front apron. This is a simple way of keeping extension light from falling on the photo-cell.

The parts are mounted according to wiring convenience and your choice as to location of terminal connections. In this model, the sensitivity control was located on the rear apron of the chassis. It need not be in a convenient location, as it is adjusted only once. The parts are available at radio mail order companies and are inexpensive.

Notice the simplicity of the circuit diagram (Fig.1). Anyone who can wire a simple one tube receiver, can wire this unit. The usual precautions, such as careful soldering, short connections, etc., apply. Be sure to observe the proper polarity of the electrolytic condenser. Connect minus to the plate (No. 3 contact) and plus to the screen (No. 4 contact) of the 50L6GT tube socket. The filament voltages dropping resistor should not be mounted too close to the electrolytic condenser or it may melt the wax out of the condenser.

HOW TO ADJUST UNIT

Adjustment of the completed unit is simple. Plug it into any 110-120 volt A.C. or D.C. supply. Allow a minute for the tube to warm up. Adjust the sensitivity control so that the relay armature just opens. This is a condition of near zero bias on the tube and consequently very little plate current—not quite enough to close the relay. When light falls on the photo-cell, D.C. current gets through the cell and a D.C. voltage appears at the grid, causing the tube plate current to increase, closing the relay.

Using a single-pole, double-throw relay such as we do, there is a wide choice of operations to choose from. The relay contacts may be connected to close a circuit or open a circuit when light falls on the photo-cell. Also, a beam can be permanently fixed to fall on the photo-cell and the contacts hooked up to either open or close a circuit when the beam is interrupted.

The light source should be of a concentrated type. The bulb should have a small filament. A 32 candlepower headlight is a good source. There are several 110 V. bulbs on the market that are made for projection machines that will do nicely. A lens is used in front of the bulb to concentrate the light into a beam.

Now that we have a photo-cell operated relay going, let's see what we can do with it.

COUNTING

This unit may be used to count packages on a factory belt, people entering a doorway, etc. The beam of light is set up with the photo-cell unit opposite so that package interrupts the beam as it passes down the line. The relay contacts are hooked up as in Fig. 2. Each time the beam is interrupted, the counter is actuated.

ANNOUNCING

The unit is especially useful for announcing the entrance of a customer in a store. It is installed so that the beam of light crosses the doorway. The circuit is the same as for the counter except that a chime or bell is used in place of the counter and the voltage supply is 6 or 8 volt. A.C.

GRADING

For grading the color of paper, cloth, paint, etc., the unit is set up as in Fig. 3. The beam is thrown down at the material and the relay unit set to receive some of the reflected light. The relay is replaced by a 0-10 ma. meter and the sensitivity control set for a reading of 5 ma. with everything operating. If the material passing under the beam of light is all of the same color, the meter will remain at the 5 ma. reading. If the color becomes lighter, the meter will read higher; if darker, meter reads lower.

SAFETY CONTROL

Here is an important application, yet it is simple to accomplish. The unit is used on power stamping machines to prevent the application of power if the hand is in the press. Install the light horizontally just in front of the point of entrance of the metal being fed the machine. Use circuit Fig. 4. It involves the use of a second relay, having contact points capable of carrying the current required to operate the machine.

SMOKE CONTROL

The photo-cell, installed as in Fig. 5 and

(Continued on page 164)
FREQUENCY MODULATED PICKUP

HARD on the heels of Frequency Modulation broadcasting comes this ingenious development of a Bridgeport, Conn., radio man. Here for the first time in any radio magazine are the complete details for the home construction of this "wires" F.M. Phono Pickup, a unit which bids fair to replace in time all other types of pickups. Patent applications have been made by its inventor.

FIDELITY

The most amazing thing about this Frequency Modulation Pickup, developed by Leslie A. Gould, is its extreme simplicity. If this were its only achievement the new instrument would be outstanding; but it goes much further! Its fidelity range—the band of audio frequencies which it is able to transmit—is said to go considerably beyond that of the ordinary crystal and magnetic types. Being a Frequency-Modulated device, its inherent range of frequencies is limited primarily by the mechanical seriations in its record groove.

What is the frequency range? It must be remembered that this is an experimental pickup. More highly engineered commercial models would undoubtedly exhibit better performance. Therefore it is especially interesting to note that nearly as one can judge the frequency response of the model here illustrated is approximately 16 to 8,000 cycles. It is expected that with an improved stylus holder it could be quite possible to reproduce up to 15,000 cycles. The latter frequency "top" of course presupposes that the recording extends out to this high frequency.

However the bottleneck in present-day phono record reproduction is not in the recording but in playback. How does the output voltage compare with crystal and magnetic units? With present models, approximately the same. Whereas formerly, the various types of pickups were used as a means for modulating a carrier frequency generated by any other instrument such as an oscillating tube this unit performs the functions of both. The R.F.-carrier frequency generated by a built-in vacuum tube is shifted back and forth in frequency, a process which in itself is a form of modulation.

A much better picture of the extreme simplicity of this device may be had by referring to the circuit shown in Fig. 3. Here a type 6CS is used as an oscillator tube in the simplest type of oscillatory circuit imaginable. To get down to the Frequency Modulation band an oscillator coil consisting of 9 turns of No. 20 enameled wire wound on a ¼ in. lucite form is used. This coil is mounted at the forward end of the pickup.

Like any other oscillatory circuit, any metal placed in the vicinity of this oscillating coil will change the frequency of the circuit. Capitalizing on this phenomenon, Mr. Gould mounts a small metal ring adjacent to this oscillating coil, and since the ring is mechanically fixed to the needle-bearing stylus arm, any vibration of the needle is translated into the mechanical motion of the metal ring which in turn shifts the frequency of the circuit back and forth over the definite range determined by the recording.

That is the entire unit. Few resonance points, no expensive parts, no complicated electromechanical systems requiring delicate armatures, and crystals or permanent-magnets.

CONSTRUCTION

Details for the construction of this pickup may be obtained from the various illustrations which accompany this article. These are explanatory and complete in themselves.

The body of the pickup was made from an old, cast-off crystal pickup. The oscillator tube for shortest possible leads is mounted directly on the pickup arm. The reader may wish to improve upon the method of mounting the stylus and can usually do so. The method shown in the drawings is simple and very effective. However, there is no question but what better methods can be found and employed. It is merely necessary to say that the minimum amount of friction or damping should be used in the mechanical attachment of this stylus to the arm, since the frequency range of the unit is limited mainly by its mechanical system.

The ¼-in. ring used in this pickup can be an ordinary brass curtain ring found in most 6×-and-10× stores. These rings, being hollow, and very light and stiff, are ideal for the purpose. When soldering the ring to the stylus shaft use as little solder as possible thereby keeping the stylus as light in weight as possible which will give the best results on the high-frequency portion of audio reproduction.

"WIRELESS" PHONO-OSCILLATOR

No antenna is necessary. The pickup transmits a Frequency-Modulated wave directly to your F.M. radio receiver up to 50 ft. or above, under usual conditions. If an antenna is desired, a short piece of insulated wire about 6 ins. long can be connected to the cathode terminal of the radio tube socket and allowed to extend through the rear end of the tone arm.

The F.M. signal from this pickup can also be received on a superregenerative type of receiver. It may be necessary in some locations that are noisy to disconnect the regular antenna of your F.M. Receiver and connect in its place a short, 1-wire antenna about 3 to 6 ft. long when tuning-in on this pickup.
A MIDGET CODE OSCILLATOR
A useful aid to the radio-telegraphy student

Code oscillators have long been victims of raw beginners on their first construction job. That is why it comes almost as a surprise to see one which is a thing of beauty and an object of good engineering. Mr. Gnessin proves that care and workmanship pay the best dividends on the simplest projects. A single loktal tube makes a very efficient little combination oscillator and power supply.

Although there are many uses for an audio oscillator, e.g., signal-generator, tuning pitch, attention signal, etc., probably its most popular use today is that of code oscillator for telegraph sending and receiving practice. The unit described here is designed for just such use.

It is readily portable, weighing little over one pound complete, and is just over three inches square. The power cord is wound around the box when not in use. In this manner, with the tube removed from the socket the entire unit may be carried in the overcoat pocket.

At the end of the construction article the theory of operation will be summarized. The oscillator is constructed on a chassis made of an old wooden 2 or 5 pound cheese box. After estimating the size required by temporarily placing the transformers and filter condenser in one end of the box, the box is shortened to where it can just accommodate all components comfortably. Then take the end from the sawed-off part and join it to the chassis end. This should make a box just over three inches in each dimension.

Mark off a circle in the center of the top of the chassis to permit the loktal tube base to show through. Then drill small holes around the periphery of the circle. Cut out and sandpaper the hole. A broomstick wrapped with sandpaper makes a fine finishing tool. Mark and drill socket mounting holes.

Without mounting the two transformers and filter condenser, move them around like chessmen until you find the most convenient placement for each part. Mark and drill the mounting holes for them. Then drill a hole for the power cord, then two pairs of holes for the phones and key jacks. Then sandpaper the chassis smooth and paint. You'll probably be impatient to build the oscillator; but it will pay to paint the chassis first because painting the finished oscillator is messy. After permitting the first coat to dry hard, finish with black enamel or crackle finish.

After the chassis dries out completely, mount the loktal socket. Check again to make certain where each component goes. Then, don't mount them! Leave the transformers and condenser outside and connect long leads to them. This is necessary because it is impossible to build, solder and test the oscillator in the confined space when the components are already mounted.

Wire the socket, connecting the other elements, using the base diagram shown. The cathode resistor may be bolted to the side of the box, if desired. This will avoid vibrating and shorting wires.

After all connections are made, check carefully. Test for continuity and correct terminal connections with an ohmmeter, if one is available. Then plug in the 7F7 tube, plug in to A.C. hook up phones and key and test. The phone and key terminals may be reversed without damage. There may be a difference in tone in that case. A small lettered paper name plate may be pasted above the jacks. A piece of Scotch tape over the name plate will protect it.

If there is no clear oscillating note when the key is depressed, reverse the primary leads in the audio transformer. This will give a musical note. To change pitch, vary the resistance of the cathode resistor.

One outstanding feature of this oscillator is that of code oscillator for telegraph sending and receiving practice. The unit described here is designed for just such use. Consider the left hand triode, shown, as in the schematic diagram. The filament transformer (this should be as small as possible; an output transformer giving 6 volts out of the smaller winding is satisfactory) is connected from power cord to the tube filament. No "on-off" switch is shown, although one may easily be incorporated if desired. The same six volts output provides the D.C. high-voltage supply. (Yes; in this case the "high-voltage") is 6 volts D.C.

The output of the filament transformer goes to the plate and grid connected together, forming a diode half-wave rectifier. The direct current is taken off the rectifier cathode. This is filtered by the 25 mfd. condenser. This is a competent filter. The plate goes through the headphones to the primary of the audio transformer.

Now, consider the right hand triode in the diagram. The grid winding of the audio transformer constitutes the tuned grid circuit. The feed-back from the plate circuit causes oscillation. Varying the cathode resistor varies grid bias, changing the oscillating frequency. The audio transformer should be as small as possible. A small output transformer with the secondary replaced by as many turns of fine wire as it will hold will prove an efficient substitute.

The 6 volts of D.C. provides a good clear signal in a pair of headphones. Two pairs of phones in series will permit two persons to hear simultaneously. Some phones will give greater response when connected in parallel. Two pairs of phone jacks may be built in to the oscillator if desired. If they are hooked up in parallel, one or both pairs may be used.

If loudspeaker volume is needed, a choke may be substituted for the phones, and the output taken off through a condenser to an amplifier or the phone input of a radio receiver.

One outstanding feature of this oscillator is its safety feature. The only exposed terminals have 6 volts at low current. The entire oscillator is isolated from the A.C. power line by the filament transformer. Thus it is impossible to receive a shock even if the oscillator is connected to ground. Those who have been "hit" when using AC-D.C. oscillators will appreciate this feature.

X — Filament transformer (6.3 v.)
X — Audio transformer (any ratio)
Sw — Telegraph key
R — 2000 ohm (1 watt) resistor
C — 25 mfd. 25 volt condenser
P — 4 phone pin jacks
7F7 — Vacuum tube
1 loktal socket
9 small bolts and nuts
1 AC power plug
Wire, solder, etc.
Radio headphones, 1 pair (or 2)
Cheese-box chassis

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A Home Made

STRING MUSIC PICKUP

Want to play that guitar (mandolin, etc.) so sweet and low no one else can hear you? Then build this simple magnetic pickup, connect it to an amplifier, and listen to your playing through headphones. Or rattle the window panes, at that dance next month, by using a loudspeaker!

ONE of the novel and interesting developments of sound amplification is an electro pickup that increases the volume of metal-stringed musical instruments tremendously. When used with a guitar and a suitable amplifier it is possible for a performer to fill with music, an auditorium seating several thousand people.

Hence, the cost of reproducing an electro pickup was almost prohibitive but now one may be built solely from salvaged material that will amaze the listener with its purity of tone. The only materials required are some old hacksaw blades, a discarded ignition coil, an old radio panel, a few machine screws, and some pieces of cardboard.

Break the hacksaw blades into pieces about 4 inches long, grind off the teeth and shape as shown at Fig. 1A. A hole should be drilled through the center of each piece but before drilling it will be necessary to "anneal" (soften) the spot to be drilled.

ANNEALING

This may be done by a small acetylene flame, or if that is not available, a heating gas flame and a small metal or glass tube to serve as a blowpipe will do the job. Most garages have acetylene gas on hand for welding purposes and since the job of heating the pieces will take just a few seconds, the cost should be trivial.

Heat the spot to be drilled to a red heat and allow it to cool slowly; try to keep the heated areas as small as possible.

Drill a hole in each piece where indicated, and tape together, as shown at Fig. 1B. Before taping together it will be advisable to join the pieces together with a small bolt to line them up. After the pieces are taped together they should be "dressed down" (filed to shape) with a file or emery wheel until all pieces are even at the ends. The taped pieces are to serve as the core and there will be 2 required for the pickup. The holes to be drilled in the core pieces are indicated as 3/16-in., but may be varied if the builder desires to use a different size of rod for the crank on the winding form.

MAGNETIZING

After the core sections are completed, they should be magnetized by wrapping each section with about 50 turns of magnet wire, size No. 18 to 22. Connect this "electromagnet" to a storage battery, as shown at Fig. 1C. Since it is important to know the polarity of the cores when connecting the coils of the pickup, each end should be marked when it is being magnetized. A small magnetic compass will assist in determining the polarity of the magnetized end, but if one is not available, polarity may be determined by winding the coil and connecting it to the battery as shown at Fig. 1C. Assuming that the current flows from the positive pole of the battery in a clockwise direction around the core, the end toward the observer will be the South pole of the core.

Changing or reversing the connections at the battery will cause the current to circulate in an opposite direction and make the observed end the North pole of the core.

If the larger sizes of wire are used for magnetizing the core, the coil may heat up rather quickly, but that may be reduced by connecting the coil so that it gets only 4 volts instead of 6, or across 2 cells of the battery instead of 3. At the most it should not be necessary to leave the coil connected to the battery longer than 1 minute. The magnetized cores should have sufficient strength to support their own weight, without the windings, when the North pole of...
One is suspended from the South pole of the other.

CORE STEELS

The experimenter may wish to try other types of core material than hacksaw blades. The steel should be hard and of good magnetic quality, that is of such nature that it will retain magnetism over a long period of time. It is easy to try pieces of different steel by magnetizing them as described above and testing to see if they retain their magnetism.

When working hard steel it will be necessary to first anneal it by heating to a cherry red and cooling it with charcoal or ashes so that it will cool very slowly. After the pieces have been cut to the desired shape, they may be re-hardened by heating to a dull red and plunging quickly in water. The author has found that flat tool steel makes excellent core material but it is not so readily obtainable as are old hacksaw blades.

It is well to note here that some hacksaw blades have tempered teeth and soft backs, if hard blades are not obtainable it is not so readily obtainable as are old hacksaw blades.

WINDING JIG

The details of the winding form (or jig) are shown at Figs. 1D and 1E. Cut 2 pieces of sheet metal, No. 14 to 20 gauge, to the size, and shape shown at Fig. 1D. Drill a hole through the center of each piece to allow winding crank to slip through. Since the wire used in winding the coils is very small and easily broken, it is advisable to bend the corners of the metal sides outward to avoid the wire catching at those points. Now bend a short piece of round metal rod, 3/16-in. in diameter to the shape shown at Fig. 1E, and thread one end. Place the core in the form so that it is parallel with the long side of the metal plate, with a piece of waxed paper in between the core and each metal plate, and bolt the whole tightly together, as shown at Fig. 1E. Wrap a strip of thin cardboard around the core and fill the corners between the sides of the form and the cardboard with paraffin so that there will be no possibility of the sides of the coil touching the core and the side of the form. Fold the edges of the waxed paper over the outside of the form and hold it in place with pieces of gummed paper.

For the coil windings approximately 1 ounce of No. 36 or 38 enamelled wire will be required for each coil. This wire may be obtained from the secondary of an old ignition coil. (Remove the primary and all of the insulation compound from the secondary, also layers of insulating paper over the secondary coil so that the wire will unwind freely.)

Place the threaded end of the winding form in a small piece of pipe held in a vise, the long side of the metal plate, with the cable wheel turned freely. Wrap several turns of the ignition-coil secondary wire around the form, bring the end of the wire over the form and secure it to the winding crank. Place a round rod through the secondary coil and begin the winding by turning the crank slowly.

Do not attempt to hurry the winding job and you will be repaid by having the coil in good shape. Since the wire is extremely soft, any unusual strain on the wire will cause it to break. When approaching the end of each layer of wire on the ignition-coil secondary, it is advisable to stop winding and remove the strip of paper at the end of each layer. If a break occurs in the wire, the ends of the wire should be carefully scraped with fine sandpaper, then twisted together and soldered, using rosin (only, no acid) as a flux.

In winding the coil there will be tendency for the wire to pack tightly at the ends of the coil and wind loosely between the ends or along the sides of the coil, which if not corrected would cause the coil to cut out of shape and prevent the proper amount of wire from going on the core. If during the winding operations the wire on the sides of the coil is pushed around the core and the wire to pack tightly, the proper depth will be reached.

When the winding is completed, melted paraffin should be poured over the winding. When the coil has cooled, trim the waxed paper, even with edges of the winding form and remove the coil by taking the sides of the form apart. The waxed paper may now be trimmed even with the coil, taking care not to cut the coil ends. Two coils will be required and each should be wound in the same direction.

COIL FRAME

The frame for the coil case is made from a section of an old radio panel, either hard rubber or bakelite, 8/16- or 1/4-in. thick. The holes are drilled in the sides to receive the wire. A flexible cord should be connected between the pickup terminals and the input jack of the amplifier. The pickup may be permanently secured to the frame or plate to the frame (with No. 4-40 flat-head screws) and to place the coils in the case. A North and a South pole of the core must be on opposite sides, and the windings must be in opposite directions, as shown at Fig. 1F.

Before making permanent connections it is advisable to try out the pickup for maximum response by connecting it to an amplifier. If the coils have been connected improperly it will be a simple matter to change the coil connections. Once this matter has been settled, you are ready to make permanent soldered connections between the coils, and solder the remaining ends to the terminal screws.

Melt the insulating compound that was salvaged from the ignition coil and pour it around the pickup coils. If the compound is alloyed to flow around the coils and not over them, it will be a simple matter to remove the core, if it ever becomes necessary to remagnetize it. By carefully cutting through the waxed paper and lifting the core out.

HOW TO USE

To operate the pickup, it should be placed under the strings of the musical instrument at a distance of 1/16-in. from the strings. A flexible cord should be connected between the pickup terminals and the input jack of the amplifier. The pickup may be permanently secured to the frame or plate to the frame (with No. 4-40 flat-head screws) and to place the coils in the case. A North and a South pole of the core must be on opposite sides, and the windings must be in opposite directions, as shown at Fig. 1F. The vacuum cups are made to hold various items on automobile windshields and may be obtained from most stores dealing in automobile supplies.

This pickup will work only with steel-stringed instruments having a steel center but which have a wrapping of brass wire on the outside, also will operate the pickup.

The pickup operates on the principle that the metal strings vibrating across the magnetic field will cause changes in the lines of force cutting through the coils and set up a measurable current in the coil windings. Since the current generated is very low, the amplifier used with the pickup should have a high gain and sufficient power output to cover the location in which it is to be used.

Experimenters who desire to build their own amplifier will find the one described later admirably suited not only to the electronic pickup, but to many other applications of public address work as well. Although the size of the chassis and the number of parts required have been kept to a minimum, the amplifier has a normal high quality output of 15 watts and a peak output of 22 watts, which is sufficient to cover an indoor gathering of 2,000 to 3,000 people. It has a gain of about 100 decibels, which in non-technical language means that it is capable of amplifying, without the use of preamplifiers, a very weak signal such as put out by a crystal microphone. It may be used to amplify phonograph records simply by plugging in a high impedance magnetic or crystal phonograph.
The amplifier at the left uses a double triode as inverter, to make an amplifier without a driver transformer. A second double triode is used to permit two inputs, low-gain for phonograph, and high-gain, from a pre-amplifier stage, for use with a low-level microphone. The combination makes for both simplicity and fidelity. The three controls are: Microphone, phonograph and tone.

A HIGH-FIDELITY AMPLIFIER
For Phonograph, Public Address or Radio

THE "HF-20" amplifier answers the need for an extremely compact audio system capable of considerable power output with high fidelity. Giving a full undistorted output of 20 watts this amplifier is excellent for phonograph or radio amplification, or for general public address work. It may also be used as an inexpensive plate modulator for the amateur transmitter, running an input of 60 watts or less; or a cathode modulator for the "rig" running 200 watts or less input to the final. For modulator application it is, of course, necessary to use the proper type plate or cathode modulation transformer in place of the output transformer shown in Fig. 1.

The tube lineup consists of a 6SJ7 input voltage amplifier, a 6SC7G intermediate amplifier and electronic phonograph mixer, a 6SC7G phase inverter and a pair of 6L6Gs in the push-pull class A output. Current requirements for these tubes fall within the power capability of a single 5X4G rectifier. The 6SJ7 tube has its control grid conveniently located at the bottom, eliminating a long grid lead to the top of the tube as necessitated by the older type 6J7.

Two input circuits are provided. One is a high impedance, low-level input for dynamic, velocity or crystal microphones; the other is a high impedance high-level input for phonograph pickups. The frequency response is practically flat (within \(\pm 2\) db.) from 60 to 15,000 cycles per second. If an extremely high-level microphone is used, such as the Brush "HL" and similar types.
Considering the number of condensers used in isolating circuits from each other, the underchassis wiring is clear and uncomplicated. Resistance-capacity networks are inserted not only in the pre-amplifier plate circuit, but also in the high-voltage lead to the inverter stage. These working in conjunction with the "balanced" inverter circuit, produce an amplifier with remarkable stability.

One or more speakers may be connected to the output of the amplifier, as long as the combined voice coil impedances conform closely to those offered by the output transformer. For instance, two 8 ohm speakers of the permanent magnet type may be connected in parallel across the 8 ohm output. On the other hand, if desired, two 4 ohm speakers may be connected in series across the 8 ohm output, or two 8 ohm speakers may be placed in a series connection with the 15 ohm output. Any single speaker of 4, 8 or 15 ohms may be connected directly to these respective impedances offered by the output of the amplifier.

Regardless of the particular service for which this amplifier is used, use only the best quality parts throughout. This is especially true of the output transformer and the associated speaker. The author used a type PM15B Jensen for phonograph record reproduction although almost any good make of 10 to 18 inch permanent magnet dynamic speaker will be satisfactory. The auxiliary speaker shown in the photograph is small 8 inch type designed to handle about 8 watts.

Another place where the use of excellent parts is well worth while is in the selection of blocking condensers. It used to be the practice to use only mica condensers for this work, but paper condensers of 600 or more volts rating are commonly used today. High voltage ratings in the electrolytic filter condensers are also advisable, as a breakdown may expose other parts, such as the rectifier tube or even the transformer, to damage, and at best causes delay and extra work.
A New and Improved

EXPANDER-COMPRESSOR

The home-made units here described provide both "expansion" and "compression," either one or the other in varying degrees, with but a single control. There are no critical bias adjustments to make—all tubes are standard receiving type tubes.

By this time the terms "volume expansion" and "volume compression" are pretty well known to everyone. Volume expansion restores the original dynamic range in recorded music. It also increases the dynamic range, or difference between light and soft passages in radio broadcast music, adding a fullness and brilliance to the music that is thrilling to listen to. Volume compression does to public address amplifiers what automatic volume compression does to a radio. It levels out the difference between high and low passages, resulting in a constant speaker output. It is especially helpful where the speaker standing before the microphone has a tendency to turn from side to side as he talks. With volume compression the output would be held fairly constant.

The units described here provide both expansion and compression, either one or the other in varying degrees, with but a single control. Here is a circuit that is entirely new—it eliminates the use of the tricky 6L7 tube. There are no critical bias adjustments to make—all tubes are standard inexpensive receiving-type tubes.

The principle of operation makes use of the remote control grid of a super-control R.F. tube. This is the 6SK7. As you know, this type of tube has been used in the R.F. and I.F. stages of receivers. In that application a D.C. voltage is developed in the diode load circuit of the second detector in superhet. This D.C. voltage from the second detector is added to the fixed bias voltage of the R.F. and I.F. tubes, decreasing the amplification of the tube. There is no reason why the same thing cannot be done with audio voltages, and that is exactly what we do in this "expander-compressor."

Referring to the schematic diagram, an audio voltage is fed to the grid of both the 6SK7 and 6SJ7 tubes. The 6SK7 tube amplifies this voltage and carries it on to the 6H6, where it is rectified. A rectified D.C. voltage in the one-megohm center-tapped potentiometer will vary according to the audio voltage reaching the grid of the 6SK7. The center tap of the one-megohm potentiometer is grounded. The circuit is so arranged that the two ends of the potentiometer are of opposite polarity. Looking at the diagram, the left end of the control will have a positive potential, and the right end will have a negative potential. With the control arm to the left of the potentiometer resistance, positive voltage will be added to the 6SK7 bias, which varies according to the amount of audio voltage at the input. This positive voltage at the 6SK7 grid is added to the fixed bias on it, increasing its amplification. The result is volume-expansion. With the control arm to the right of the one-megohm potentiometer, a negative voltage is added to the fixed bias of the 6SK7 tube, causing a decrease in amplification which decreases the audio output. This results in volume-compression.

Assembly is simple. Since high-level audio voltages are used, exact placement of parts is not critical. It is best, of course, to use a little logic in the layout so that the leads will not be excessively long.

Wiring should be done carefully with a hot, well-tinned soldering iron. As there are quite a few fixed resistors and condensers in this circuit, you must be careful to do your work slowly, checking against the diagram frequently as you go along. Use as many wiring tie-points as you think necessary.

One point to keep in mind during the operation of this unit is that the input voltage must be of high level. By "high level" we mean approximately the equivalent of an average crystal pickup output—about two or three volts of audio. A microphone cannot be connected directly to the expander-compressor.

For phonograph reproduction the crystal pickup should be connected directly to the input of the unit, and the output of the unit to the amplifier where the phonograph pickup was previously connected.

The large binding post shown at the extreme left in the photograph is a common ground for both input and output. In place of an amplifier the phonograph input of any radio may also be used.

Where it is desired to expand or compress radio music, it is necessary to break the coupling condenser lead between the first and second audio stages. For this, run two shielded leads from the expander-compressor in through the radio set chassis. Connect the input lead to the coupling condenser which has been disconnected from the grid of the second tube. Connect the output lead to the grid of the second tube where the coupling condenser was formerly connected.

The connection, as described above, applies to public address amplifiers also. In high-gain amplifiers break the coupling between the grid of the driver stage and the plate of the previous stage.

Try the unit first with the expander-compressor control in the center. In this position there is no expansion or compression. Adjust the volume setting so that it is approximately what it was before the unit was connected to the circuit. Now, as you play a record, or have someone speak into the microphone, turn the expander-compressor control either to the left or to the right (depending upon whether you want compression or expansion) slowly until the desired amount of expansion or compression is obtained. At the extreme...
HOME recording as a hobby has developed greatly in the past few years. Many people have come to realize the amount of fun to be had with a simple homeworker system or the pleasure to be derived in building and operating a recorder of the semi-professional type.

Let us attack the problem of a suitable recording amplifier first. A recording amplifier should have a maximum undistorted power output of at least ten watts. The reason for this is that the impedance of the cutting head may match that of the output transformer, while the output of at least ten watts is used for operating a monitor speaker, or at another frequency, it may not. If an amplifier is used which has more power than is actually needed, and this extra power is used for operating a monitor speaker, or simply dissipated in an equalizing circuit, distortion in the final recordings will be minimized.

For instance, if a crystal cutter is used, an inductance can be added which would tend to make the overall impedance have a flatter characteristic throughout the audio frequency range. The amplifier to be described makes use of a monitor speaker to use some of the extra audio power. After these adjustments are made, the amplifier is flat within 1 db. from 50 to 11,000 cycles. Driven by a good broadcast tuner, or F-M converter, the amplifier is capable of turning out some first-class recordings.

It is not within the scope of this article to enter upon a complete discussion of the relative merits of constant-amplitude vs. constant-frequency recordings. But, to assist the uninitiated, it might be explained that a constant amplitude recording is one where the distance of the cutting head varies inversely with the frequency affecting the cutting head. Because low-frequency signals would cause a large movement of the stylus (and possibly cross-cutting of adjacent grooves), some form of constant amplitude response is always used below a frequency of 500 cycles. Therefore, the term "constant velocity" applies only to frequencies above 500 cycles.

Looking at the amplifier, Fig. 1, from left to right, the controls are, amplifier powerswitch, record-speaker switch, tone control, low-gain channel volume control, and switch for magnetic pickup or microphone. On the far left is a jack for the speaker or earphones, and on the extreme right are the low gain channel jack, and the microphone connector. In the center is to be seen the Volume Level meter, to indicate the proper sound level. The meter will register on Record only—not on playback. On top of the chassis, near the mike connector, is a small jack for the magnetic pickup. The output transformer, filter condensers, and fuse, are mounted on top of the chassis. Underneath the chassis, in the lower left-hand corner is a shield for the microphone connector. The choke is mounted beneath the chassis near the power transformer.

The cutting head should be of the magnetic type, of proper impedance to match the secondary of the output transformer (in this case 500 ohms). There are several types of mountings for the cutting head. The best type is the lathe type mounting, which is usually very expensive. An excellent compromise is found in the overhead-feed mounting, Fig. 2, which is sweated to the center of the turntable when recording. It is advisable to buy the type of cutter which is so constructed that the angle of the cutting stylus can be adjusted. However, it is essential that the weight of the cutting head be changeable.

The motor should have enough power to turn the turntable at an even speed. This can be tested by actually cutting a record with an audio tone being recorded. (Station KWKV is good for this purpose). If the motor is too weak, "wows" will result. Wows are usually indicated by a wavering reproduction, when the recording is played back and are most troublesome when musical recordings are being made.

The turntable should have a drive-pin one inch from the center shaft, to prevent the recording disc from slipping on the turntable. The motor and turntable should be mounted on a heavy stand, or in the top of a heavy table, to prevent vibrations from being carried into the recording. It is well to mount the motor with rubber washers and padding to insulate it mechanically from the stand.

STYLI AND NEEDLES

Now for the needles: Steel cutting styli are the least expensive on a first cost basis, and are to be preferred when there is danger of the stylus being damaged. Steel styli cost 15c to 75c each, and have a useful life of about thirty minutes. For the first minutes of cutting are virtually as quiet as a sapphire, but after repeated cuts they get more and more noisy. They must be discarded after thirty minutes. The cutting angle should always be at right angles to the record. Careful tests made by recording experts over a long period of time, show that trick cutting-angles are of use only when some defect is present in the cutting head, or in the stylus itself.

BLANKS AND DISCS

The quality of the blank disc will have an important bearing on the fidelity of the recording. If the surface of the blank is too hard, the thread will be powdery and tend to roughen up the groove as it is cut. If a paper-base disc is used, the high-frequency response will drop off above 4000 cycles. Although these are not as satisfactory as the glass, aluminum, and steel base discs, the bond-base discs are good for speech recordings and incidental recordings. The best type of lacquer coating is the nitrate of cellulose ("acetate") coating. The -slow-burning coatings, blanks are usually too soft, and not at all suited to good recordings. A good blank will be perfectly flat, and have a smooth, uniform coating that is not mottled with "orange peel." Any bumpy or visible imperfections in the coating indicate that the blank is not of the highest quality. Most manufacturers endeavor to keep the characteristics of a certain brand of blank, as uniform as possible, so by using as few types as practicable, the number of necessary changes to be made in the depths of cut can be minimized. During recording, the shavings from the groove should be about the thickness of a cow's hair, (when the cutting depth is about 0.003 inch).

When recording at 33 1/3 r. p. m., care must be taken not to cut too near the center of the blank, as a loss in the "highs" results.

Figure 3 shows the maximum recording times for different diameter blanks. They allow for keeping safely away from the center of the disc.

<table>
<thead>
<tr>
<th>Turntable Speed 78 r.p.m.</th>
<th>PLAYING TIME</th>
</tr>
</thead>
<tbody>
<tr>
<td>Disc Dia.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>([96 lines per inch])</td>
</tr>
<tr>
<td>6&quot;</td>
<td>1'/5 min.</td>
</tr>
<tr>
<td>71/4&quot;</td>
<td>2 min.</td>
</tr>
<tr>
<td>9&quot;</td>
<td>2'/3 min.</td>
</tr>
<tr>
<td>10&quot;</td>
<td>3'/5 min.</td>
</tr>
<tr>
<td>12&quot;</td>
<td>5 min.</td>
</tr>
</tbody>
</table>

Turntable Speed 33 1/3 r.p.m.

<table>
<thead>
<tr>
<th>Turntable Speed 33 1/3 r.p.m.</th>
<th>PLAYING TIME</th>
</tr>
</thead>
<tbody>
<tr>
<td>Disc Dia.</td>
<td></td>
</tr>
<tr>
<td>13&quot;</td>
<td>7'/6 min.</td>
</tr>
<tr>
<td>13 1/4&quot;</td>
<td>9 min.</td>
</tr>
<tr>
<td>16&quot;</td>
<td>12 min.</td>
</tr>
</tbody>
</table>
A NY speaker sounds good if you put it in a big enough box. We were respectfulful—being young and inexperienced in radio—and so believed him implicitly. So we bought the speaker, built a nice big box and—surprisingly—thought it sounded pretty good. We heard something better. Our ear was dull in those days.

Then by and by permanent magnet speakers came in and the idea fascinated us. Imagine not having to have a field supply! So we saved our dough and paid $36.00 (net price) for a fine PM. We had by that time learned not to believe these "practical radio men" and went to considerable time and trouble to build a tuned baffle box.

We had learned that the waves from the front and the back of the speaker are 180 degrees out of phase, and thought the idea of a slot for the bass notes to escape from the back of the box, to reinforce the front wave, was a fine idea. We conquered an impulse to slap some plywood together into a box and decided to go about it in a more scientific manner. We fed an audio oscillator (borrowed) into the outlet and placed a mike 10 feet from the speaker. Then we decided we'd experiment a bit with a horn. So we bought the speaker, built a nice big exponential type way ahead of the other permanent magnet type and a horn whose area doubled every 12 inches would have a cut-off of 128 cycles. To get a figure for doubling the area of our horn with the 50-cycle cut-off we worked out a simple problem in proportion:

\[ D \] came out equal to 15.36 inches. In other words, our horn had to double its area every 15.36 inches to have a cut-off at 50 cycles.

The throat of our horn had to fit our 13-inch speaker, so the value of \( S_t \) would equal \( 13 \times 13 \) or 169 square inches, and the area at 15.36 inches would be \( 2 \times 169 \) or 338 square inches. This meant that we could find the value of "m" in the horn formula, by substituting 15.36 for "x" and 338 for \( S_t \): \( 238 = 169 \times 2.72^{15.36} \).

The value of "m", came out equal to 0.045. So we now had a formula for a horn with response down to 50 cycles: \( S_x = S_t e^{0.045x} \) and in our case with \( S_t \) fixed at 169 square inches, \( S_x = 169 \times 2.72^{0.045x} \). From that relationship, we were able to calculate the exact measurements of the horn.

The building of it took some pains as we were not carpenters, but we did manage to bend some 1/4 inch plywood to the dimensions shown, and by judicious bracing, we were reasonably sure it would stay that way.

The thing was a whisker over 80 inches long (6 feet 8 inches if you prefer) and the mouth size (80x80) still left a little room around the sides of the single car garage so we finished up the plywood by walling up that opening and let the horn in the back of the garage to get in and out.

The big day came and we carried out the good amplifier and a turntable unit to the garage. The XYL and a few friends gathered the drive way along with some curious neighbors to hear the nice concert. I screwed the speaker onto the throat of the horn and latched everything up—put a record on the turntable and let her go. I don't know what made me pick out that bagpipe record except that that seemed like an outdoor music—sort of.

The amplifier in question had a pair of...
A CALIBRATED U.H.F. OSCILLATOR

The increasing use of wavelengths in the order of a few meters demand test equipment adapted to high frequency. This high-frequency oscillator is so constructed as to hold calibration better the laboratory devices commonly used at such frequencies. Thus it becomes useful as the U.H.F. equivalent of the Serviceman's signal generator.

THE most important point to know when operating at ultra-high frequencies is the wavelength at which the oscillator is operating. Many experimenters wish to know the wavelength of operation and they have no calibrated wavemeter. A calibrated receiver is also often useless because it will not pick up unmodulated waves such as those produced by simple oscillators. In fact, there are very few people indeed that have any kind of receiver, let along a calibrated one, that will pick up oscillations at a wavelength of 10 meters and lower.

I have perfected a new type of wave-meter that generates an ultra-short-wave and does not have to be calibrated but the wavelengths can be found by simply measuring the lengths of the leads in the oscillating circuit. This is a new idea; it is known that coil specifications can be given, but it is also true that it is very easy to slip up in these specifications and so change the frequency materially. The present wavemeter is perhaps the most perfect in this respect of any, because its oscillating circuit consists only of two straight wires, the lengths of which can be very exactly determined. It is possible (if a 955 tube is used) to build an oscillator to specifications that will oscillate within any desired frequency. To find the frequency of operation, simply measure the wires and take the wavelength of operation from a prepared graph which is shown later on in this article.

A common method for measuring frequencies is the use of two parallel wires and a shorting bridge, but these wires have to be made rather long and they have to be strung tightly which requires troublesome and perhaps undesirable fixed supports of some kind. The 955 tube makes it possible to construct an oscillator and measure the length of the oscillating circuit to find the frequency of operation.

In Fig. 1, a complete diagram of connections for the wavemeter is shown. A 955 tube has its cathode supplied from a filament transformer. Two chokes are used in the filament transformer leads. If headphones are to be used to listen for beat notes with other oscillators or regenerative receiver, connect as shown. If headphones are not used, only one phone and close the lead. If you use a gridmeter as shown, and it is 0.1 milliamperc D.C. maximum scale, shunt it with a resistor so it reads 1/5 milliamperc when 1 milliamperc is passing through it; then its maximum range will be 5 milliamperes which is the required maximum scale-reading when 250 volts is used on the plate of the 955 tube.

The chokes are all made as described in Fig. 1. Drill the dowel rods at the ends and tie a heavier wire around the rod, soldering the choke wire lead to the heavier wires which are used as leads. Bolt the rods in hot paraffin before you wind the wire on. A 15,000-ohm 1-watt grid resistor is the correct value to use.

The oscillating circuit of the oscillator consists of a pair of parallel wires and the correct lengths to use will not vary very much with different 955 tubes. Hence, if you tell me how long to make the oscillating circuit wires AB and CD (Fig. 1), your oscillator will operate close to the frequency of the oscillator I have constructed and calibrated. The lengths of wires AB and CD maintaining each at the same length, were varied and for each length of oscillating circuit the frequency of operation was measured. The results, given later, will enable you to tell quite closely where your oscillator will operate (C is plate terminal).

Checking the Results

Say you built the oscillator and measured the wires as will be clear later, so that your oscillator was operating on say 5 meters exactly. We don't care whether it is 5.05 or 4.95 meters for the time being, because we can check it up and find out more exactly later on. We thus can come fairly near a correct value and not be far off.

Using a simple regenerative receiving set (one tube), near the oscillator, tune in a short-wave station around 30 meters the wavelength of which you know or can easily find. Say, it was a 30-meter station, and the wavelength was exactly 30 meters. Tune in this station exactly. Now listen in the headphones of the oscillator of Fig. 1. It should be the sixth harmonic of the regenerative receiver, but it would be only luck if you heard it in the phones without any adjustments at all. If you don't hear the sixth harmonic, move the regenerative receiver dial, keeping the tube oscillating, until you do hear it in the headphones. Be sure the coupling between the oscillating circuit and the regenerative receiver is very close. For example run the parallel wires of the oscillator near the top of the coil in the receiving set. You could adjust the lengths of the wires AB and CD in Fig. 1 until you do hear the sixth harmonic of the 30-meter frequency, but this would not be easy. It is better to tune the receiver around until you can pick up the harmonic on the short-wave oscillator headphones. Then you can gradually adjust the oscillating circuit wires until you hear the sixth harmonic of the 30-meter wave. You could first calibrate the receiver dial from known stations and then it would not be necessary to adjust the lengths of the oscillating circuit wires.

It will be seen at once that you can calibrate your oscillator for different lengths of wires by first calibrating the dial of your regenerative receiver. This receiver need have only one tube. A simple '30 tube regenerative detector can be used if desired.

If you do not wish to calibrate your oscillator (as in Fig. 1), transfer the wavelength measurements from its tuned circuit to a wavemeter circuit having a good sensitivity.
HERE is a combination signal tracer and test unit which I built and found to be very useful. It is inexpensive to build and simple to operate. There are no dials to set nor any complicated circuits to adjust, yet the rig will pick up and convert the signal anywhere from the aerial and provided no R.F. gain, and an experimental set-up of the other did not provide enough R.F. gain. I experimented further and worked out circuits with tubes I favored and obtained a very satisfactory unit. I wish to express my thanks to the authors of the articles concerned.

All circuits are made quickly available through the use of insulated phone tip jacks. The power pack is also brought out to these terminals so that voltages are readily available for substitution or experimental purposes.

USES 6E5

A 6E5 tuning indicator tube is provided for handy connection to the receiver under test for alignment purposes and measurement of A.C.V. voltages. This is a very simple arrangement of a 1-megohm variable resistor between target and plate with a calibrated scale. When the shadow angle is adjusted to zero by moving the resistor control, the A.C.V. voltage is indicated on the scale by the pointer on the resistor. The 6E5 gives a range of 0 to -8 volts. If the builder desires a greater range than this, a tube with a somewhat more extended cutoff may be used, such as the 6U5/6G5, which will give a reading up to -22 volts. To calibrate, a separate voltage source must be used so that the negative terminal may be connected to the grid. Use a 2000-ohm wire-wound potentiometer with a sensitive voltmeter and mark off the voltages on the scale when the shadow angle has been adjusted to zero.

A Handy and Reliable SIGNAL TRACER

Neat attractive appearance of the tester and signal tracer.

coil, or input to the first R.F. stage, or first detector, right through to the loudspeaker from point to point, and at the same time furnish an estimate of gain per stage. If a signal generator and output meter are used with this instrument fairly accurate gain per stage measurements may be made.

I wanted a test instrument of this kind for some time and saw two articles in Radio-Craft, July and August 1940 issues, which gave me the idea. One used batteries

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NEON TESTER

The neon tube is useful for rough voltage and polarity indication and will save wear and tear on your voltmeter. As D.C. and A.C. voltages are readily available at tip jack terminals the neon tube may be used for continuity tests and checking condenser leakage. A.C. voltage for continuity tests is taken from the 117-volt line through two 0.1 mfd. condensers as shown which eliminates the danger of accidental shorts, yet allows more than ample current to excite the 3/4-watt 117-volt neon bulb. The 0.5 meg variable control in series with the neon lamp will furnish full protection for the neon lamp for voltages up to 300-volts, at about half scale. This resistor may easily be provided with a calibrated scale and found useful for rough voltage indication. Sufficient resistance should always be included when determining unknown voltages. The lamp will glow on approximately 65 volts. For 117-volt operation, all of the resistance should be cut out.

R.F. SECTION

There is nothing very difficult or complicated about the R.F. section of the tracer unit itself. Ordinary receiving circuit practice is all that is required in construction. If the builder follows the layout shown, crowding may be avoided, and at the same time a small chassis used. The chassis measures 6 x 10 x 2 inches, and the panel 8 x 10 inches. There is room on the panel for the addition of a small loudspeaker if the builder so desires, or other units which he may wish. There is also room on the chassis for other additions. Two handy ground connections are made by means of two tip jacks, one in the center of the R.F.-A.F. group on the left hand side of the panel, and the other in the center of the voltage terminal group on the right hand side. The holes for these jacks should be drilled first, and be a good snug fit so as to hold the panel firmly to the chassis.

PILOT LAMPS

Two pilot lamps are provided, one red which shows when the power pack is "on".

(Continued on page 4)
SIGNAL GENERATOR FROM OLD PARTS

Test equipment sufficiently accurate for the Serviceman’s needs can readily be constructed from receiver parts already around the shop. Common sense and the ability to revise standard plans to fit available material, plus care in construction and extreme care in calibration, are the requirements. The Signal Generator below can be made with almost any pair of triode tubes, and with a variety of rectifiers ranging from the 25Z5 to the standard 80.

I HAVE found that it is becoming more difficult to buy new equipment, and as I have been wanting a signal generator, I decided to build one out of old radio parts.

Looking through the junk box I found that I had nearly enough material to build the signal generator. For the radio-frequency portion of the unit I used a Hartley circuit, modulating it with an audio signal of about 400 cycles.

I found that the most difficult thing to get was a cabinet to hold the signal generator. I finally got an old cash box which had been put out-of-commission by a faulty lock; it not only solved the problem, but made a compact and neat appearing unit. To make a finished appearance, the box was painted with black crackle varnish. A panel was from three-ply bristol board.

Scales and the controls’ uses were lettered on. I found that I had a chassis of an old midget radio which, when sawed in half, made a good fit in the box. I decided to use type 27 tubes because I had a pair of 27s and a Thordarson 2.5-volt filament transformer.

As the filament transformer had only the 2.5-volt winding it becomes necessary to use a 117Z6 tube. It has a 117-volt filament and gives well over 110-volts of rectified voltage.

In wiring the 117Z6, it is necessary to connect one side of the A-C. line to the B return or you will have no voltage in the signal generator. I first grounded one side of the A-C. line to the chassis of the unit but found that it was unsatisfactory. The best method is to fasten a piece of bus wire to tie-points and by-pass it to the chassis through an .01 mfd condenser. The 500-ohm resistor leaving two cathodes of the 117Z6 is a 1-watt carbon type.

The D.C. voltage is about 100 volts at the plate of the modulator tube, but at the plate of the oscillator and on both the stator and rotor plates of the tuning condenser it is about 37 volts. It is necessary to insulate the tuning condenser from the chassis.

An old (Pilot) audio input transformer was used to give modulation and an audio signal of about 400 cycles. In connecting the audio transformer into the circuit, I found it necessary to use the connections in the following manner:

The B+ lead of the transformer goes to the grid of the modulator tube, the plate lead goes to the B return; the grid lead goes to B+ and the R— or ground lead goes to B+ and the R— or ground lead goes to the plate of the modulator tube. I found this to be the only way I could get a pleasing audio tone; all other connections gave a deep tone which sounded very much the same as a 60-cycle hum.

I wound the coils for the oscillator with enamel-covered magnet wire, except for the 75 to 220 kilocycle intermediate frequency band; that was wound with double cotton covered wire. The coils were wound on a wooden dowell 1/2 in diameter and the windings were jumble or scatter wound. The coil table below note that the coils are not to be over 1/2" to 3/4" long and that all coils are center-tapped. When the coils are finished (I wound three of my coils on a half inch dowell five inches long) paint them with coil dope or acetone cement. Such doping not only causes the coils to hold their form, but also helps to keep moisture out of them.

When the coils are wound, solder the center-taps to a lead and check the coils for continuity with an ohmmeter. A two-gang three-position switch is needed to switch the coils in or out of the circuit as required. An old single-gang .00035-mf broadcast-type condenser is used for tuning the signal wanted.

This unit gives the intermediate and standard broadcast frequencies. I did not add any short-wave bands as they are hardly ever needed. Fairly accurate aligning of short-wave bands can be done by using harmonics of the standard broadcast range.

I calibrated my instrument by beating its frequency against standard broadcast stations on a T.R.F. receiver. I aligned the I.F. bands by beating their harmonics with known frequencies. If you can obtain a signal generator for several hours, it will simplify matters quite a bit.

Modulation is obtained by leaving the switch S2 in the open or off position; when the switch is closed, you will receive an unmodulated signal.

This unit must be built in a metal can or it will not only cause much interference on the radios in the neighborhood, but will make it impossible to regulate the intensity of the signal coming from the signal generator. Since metal is so hard to get, if you place the unit in a wooden or Masonite box which has been lined with window

COIL TABLE

<table>
<thead>
<tr>
<th>Range</th>
<th>Turns</th>
<th>Wire</th>
<th>Coil Form</th>
</tr>
</thead>
<tbody>
<tr>
<td>L1 75 75 220 120 Kc</td>
<td>1100 No. 84 D. 2 C. 9% 3/8&quot; dia.</td>
<td>22 90-500 Kc</td>
<td>140 No. 38 Enamel 9% 1/4&quot; dia.</td>
</tr>
<tr>
<td>L2 500-1500 Kc</td>
<td>175 No. 22 Enamel 9% 1/4&quot; dia.</td>
<td>3/4&quot; dia.</td>
<td></td>
</tr>
</tbody>
</table>

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A Versatile MULTITESTER

This handy portable unit makes 18 tests on A.C., D.C. and Ohms, with a two-gang, 11-position switch. The meter used is a 1.5-milliampere type, and by following the instructions given a unit can be built with any meter from .5 Ma. or less up to about 3 milliamperes.

THIS tester is a genuine junk-box job. It was built from what parts were available, and for that reason may be unconventional in spots. It is as good a performer as any meter I have ever used. It may be used to make two two-volt ranges of 7.5, 15, 75, 150 and 750 volts, either A.C. or D.C. Current ranges of 1.5, 15, 75, 150 and 300 milliamperes are provided, and there are three ohmmeter ranges, permitting measurement of resistors from 1 to 300,000 ohms. With the help of a 0.5 condenser, it acts as an output meter and can be used such as in aligning receivers.

The multitester was built around a Ferranti 1.5 ma. meter, a D.P.D.T. toggle switch, a cheap copper-oxide rectifier, and a two-gang switch. This instrument was manufactured by the Asiatic-American (Ya Mei) Radio Company of Shanghai, otherwise known as the Amateurs' Home. Hence the name.

The 1.5 meter was used because it was the best thing for the job I had at the time. Although there is a tendency toward lower and still lower-resistance meters, there have been no difficulties in the use of this instrument. Most readings that cannot be made with it cannot be made satisfactorily with a 1-ma. movement, and require a vacuum tube voltmeter. The important thing is to know what you are measuring and to consider the possible effect of the meter on the measurement. Then you cannot be misled by the readings.

CONSTRUCTION OF TESTER

The first step is to mount the parts on the panel. I would not advise the reader to attempt to make as compact a job as this one, at least not at first try. This was the third tester we had constructed within a few months, and the little case—made for another job—was all too available. Even at that there was plenty of grief on account of the compactness. Some of the disadvantage of too small an instrument remain to this day.

Mount the meter first, then the pin jacks, the variable resistor for ohmmeter, the zero adjustment and gain of the rectifier, and the rectifier. The meter is then connected to the center arms of the D.P.D.T. switch, and the incoming A.C. and D.C. leads are connected to the arms of the gang-switch.

This hook-up makes it possible to get both A.C. and D.C. readings with a two-gang switch, and is one of the reasons why we can get 18 ranges with 11 switch-positions.

It was necessary to provide three sets of pin-jack connections, one for each of the ranges. Those on the left are A.C. voltages. The pair on the right cover D.C. voltage and current, and two ohmmeter ranges; while the two at the top of the meter are used for measuring low-ohms and for the 1.5 ma. scale.

A connection from the A.C. switch arm to the D.C. negative jack makes it possible to use the meter for ohmmeter readings. With the exception of the five A.C. voltage ranges, all readings are D.C. The change from one to the other is made through the toggle switch, the "up" position covering A.C. voltages, and the "down" being used for all other tests.

VOLTAGE RANGES

The next step in the construction of the meter was wiring up the voltage ranges. The voltmeter resistors are calculated, according to Ohm's law, at 667 ohms per volt. The 75 volt range uses a 500,000 ohm resistor, the 150 volt range a 100,000 ohm resistor, etc.

Analysis of current flow is as follows: With the positive D.C. test lead on the positive terminal of the voltmeter source and the negative D.C. lead on the other side, the current course is as follows: To the D.C. switch arm, through the resistor selected by it, and down the common positive lead through the D.P.D.T. switch to the meter, and directly to the negative terminal. (Note well that this is the old-fashioned current that moves from positive to negative, not the new radioamateur's electronic stream, which always goes in the opposite direction.)

A.C. VOLTAGES

The arrangement on the A.C. side is a little different. The resistors are only 50% of the value calculated by Ohm's law. This is because a D.C. meter reads only 90% of the effective value of rectified alternating current. By cutting down on the resistors, we compensate for this, and the meter reads the same on A.C. as on D.C.

Before A.C. readings can be taken, the meter has to be switched across the ohmmeter resistors. The rectifier and out the other A.C. pin jack. Analysis of current flow is as follows: With the switch in the A.C. position ("up"), alternating current enters through one of the A.C. pin jacks to the A.C. switch arm, through the selected resistor, to the rectifier and out the other A.C. pin jack terminal. The rectified component of this current then goes through the meter and completes its circuit back to the rectifier.

CALIBRATION

The set was calibrated over the various ranges by comparing with a standard for one of the ranges—then making the other ranges agree with it. The value chosen for the A.C. ranges was 120 volts. This point can be found readily, either from the local electrician, a laboratory or a trip to the nearest power station. Setting this at 1.2 on the meter, we have a zero to 150-volt scale. It is then possible to adjust the 75-volt scale. A voltage that reads "1.2" on it will read "0.0" on the 150-volt scale. One hundred and fifty volts reads full scale on the range where we have the 120-volt point, and "0.3" on the 750-volt scale.

It is usually easy to get a standard for the D.C. scales, but if no accurate voltmeters are available a rough calibration may be made with two good "B" batteries—assuming the voltage to be 90.

MAKING RESISTORS FIT

The actual adjustment was done chiefly with a file. It was necessary to save as much space as possible, so resistors, of odd values could not be made up of two or three units. If it was necessary to have a 45,000-ohm resistor, a 40,000-ohm carbon resistor was chosen and reduced to the calibrated properly. A few wire-wound Davohms which were left from some ancient resistance-coupled amplifier were used to good advantage, all the low-range resistors being wound from them. It was possible to wind them to the exact resistance without trouble, and they were very compact.

RECTIFIER TROUBLES

The 7.5-ohm resistor on the A.C. side cannot be wound according to calculations, at least not with the rectifier used in this set. The rectifier itself has so much resistance that it is necessary to wind the external resistor experimentally, increasing the resistance from zero till the meter calibrates correctly.

A certain lack of linearity was evident on this range, so the resistor was adjusted to give readings as near correct as possible at 6.3 and 2.5 volts, the other points being let fall where they would. This was the only scale where non-linearity of the A.C. readings gave any trouble. The reason was, no doubt, that most of the resistance in this scale was in the meter, so that small changes of meter resistance caused large percentage differences in the circuit. On the higher ranges practically all the resistance in the circuit is in the external resistor, and errors introduced by the rectifier are negligible.

THE OHMMETER CIRCUIT

The high-ohm range reads to about 2000,000 ohms. Voltage is supplied by three large flashlight cells, which have lasted more than three years without renewal.

The current flow in the ohmmeter circuit is as follows: From the positive terminal (Continued on page 48)
METERS are scarce—good ones are not available at any price—so here is a meterless vacuum-tube voltmeter. I use this constantly and find it better than an ordinary voltmeter. It is not only an A.C. and D.C. instrument, but also better than an ordinary voltmeter. It is useful for a number of known voltages (say a battery, potentiometer, and a good voltmeter), various voltages being applied and the position of $P$, noted. It is an excellent idea to put a long pointer on $P$, and cement a white card to the panel for marking the scales. After the meter is calibrated, the card may be covered with a sheet of celluloid or other transparent plastic.

Note that this will measure D.C. or peak A.C. voltages. To measure A.C. conveniently it is best to have a scale marked out in the standard R.M.S. voltages. This scale may be calculated by multiplying the D.C. or peak voltages by 0.707. A better method is to calibrate the A.C. scale directly with known A.C. voltages.

INCREASING THE RANGE

The range of the meter is limited to the amount of drop across $P$. This should be over 100 volts on the average power supply. For greater range, the usual resistor network may be used at the input. With such a network a certain definite fraction of the voltage to be measured can be applied to the input posts and the voltage measured can be multiplied accordingly. For example, the voltage to be measured may be applied to a 20-megohm resistor consisting of 2 10-meg resistors connected in series. If only one of these resistors is connected across the input posts, only half the voltage to be measured is applied to the meter, and its range is consequently doubled. No diagram of such a network is given, as they are very familiar and to be found on practically all the V.T.V.M. diagrams published in Radio-Craft recently.

The process of measuring a voltage with this meter sounds rather complicated, but actually takes less time than it does to describe it. First, you simply short the input terminals (with $P$, in "top" position) for zero adjustment of the eye. Then adjust $P$ until the eye is just closed. The meter is now ready for use. Apply the voltage to be measured. This will cause the eye to open again. Adjust $P$, till the eye just closes, and read the voltage on the calibrated scale under the pointer of $P$. The accuracy of your readings depends greatly upon the care with which the adjustment of $P$, and $P$, are made, as they must be brought to the point of exact closing, and no further.

A CONDENSER ANALYZER

The simple condenser analyzer shown in the two drawings is as effective as a high-priced commercial instrument, if carefully constructed and calibrated. Power may be obtained from a small power transformer, hooked up in reverse, with the 115-volt winding supplying approximately 60 volts, and half the secondary attached to the line. The principle is that of the Wheatstone Bridge. In this case two of the bridge arms are capacities—the unknown condenser and a standard; and two of the arms are resistors. One of these is a variable. When the ratio of the variable to the fixed resistor is the same as that of the unknown to the fixed condenser, the "eye" of the electron-ray tube—connected in standard fashion—opens, and the capacity can be read from a calibrated dial. The resistor in series with the standard condenser is to indicate the power factor of the condenser under test. Care must be exercised in building the leakage tester. It is built to indicate leakages through many megohms, and so all apparatus used in its construction must be almost perfect insulation, or leakages through the instrument itself will neutralize its action.

The analyzer may be calibrated by checking a number of new condensers. It will be easily seen which are of correct capacity, and the dial can be marked accordingly.
5-7cde Sont-Watle
SUPERHET RECEIVER

This is a real 5-tube communications receiver. It includes a beat-frequency oscillator and band-spread, and efficient operation on the short-wave bands is assured through the use of the reliable plug-in coil system. Double triodes simplify the set and keep down the construction cost.

Above—front and bottom views of the short-wave superhet receiver.

HERE it is! All you radio “bugs” who have been wanting to build yourself a good receiver, but just didn’t have the nerve to start—all you beginners who have been looking for a set that is easy to construct, but will still work like a communications receiver should—here it is.

The author makes no claims of new circuit innovations or of extremely new applications of existing circuits. Rather the only claim to a place on your operating table that this set has is its very compact and efficient application of well known principles. The parts complement has been kept low and standard; easily obtainable parts have been adhered to. The cost of the parts should not be found exhorbitant, but nowhere has quality been sacrificed for cost.

SAVING TUBES

To begin with, the beat frequency oscillator, which usually requires a separate tube, has been combined into the detector circuit through the use of a double triode, the 6C8G. This idea saved an extra tube. It also saved the annoying necessity of external coupling into the second detector circuit, as the inter-electrode capacity of the two triode sections serves the same purpose as the coupling “condenser.” Another example of a similar saving is the choice of the 6K8 as oscillator-converter tube. The use of the internally connected “injection” grid in this tube eliminates an external oscillator coupling condenser, and at the same time cuts down on losses by doing away with the external wiring of this circuit. The one extravagance the author allowed himself was the use of 1500 k.c. I.F. transformers of the iron core variety, rather than the cheaper air core type. It was found a wise choice, too, since the gain of this type of transformer is inherently much higher than the air-core type. The choice of 1500 kc rather than a more conventional lower frequency type was, of course, made necessary by the lack of an R.F. or pre-selector stage. The image rejection ratio was thus kept high enough so as to be unobjectionable.

The second detector is wired in a conventional “power” or grid-bias detector circuit. This was found desirable over a diode circuit as it introduced enough gain into the audio circuit so that a 2-stage audio system was not necessary. Sufficient space has been reserved on the chassis for the addition of another tube, however, thus allowing the constructor to add a diode detector, thus making automatic volume control possible, at some later date. Panel space is also reserved for an “R” meter. If automatic volume control should be added, a point which should appeal to the beginner is the fact that separate oscillator and R.F. variable condensers are used, thus doing away with the difficult and patience-trying problem of tracking the sections of the gang condenser in more conventional circuits. A 140 mmf. condenser tunes the R.F. section, a 150 mmf. “bathtub” type tunes the oscillator and a 30 mmf. midget is used for spreading the amateur or foreign bands over the whole tuning dial.

A dynamic loudspeaker is used, and its field, together with 3 8 mf. condensers and a 30 hy. choke, provide excellent power supply filtering. The phone plug is connected into the grid circuit of the 6F6G, doing away with D.C. in the phones, and also making it possible to use high-impedance crystal phones if desired, without external blocking condensers.

CONSTRUCTION

So much for the design. Now for the construction. The set is constructed on an electricalloy or galvanized chassis base, 7” x 12” x 2”. The panel is 15” x 9”. The band-spread in the original is a 4” airplane type dial, mounted so that the knob extends to the left of the dial, and even with the center. To mount it in this way, the dial must be revamped slightly. The small metal tabs...
that hold the glass in place are bent up carefully, and the glass removed, as well as the gasket below it. The hand is next taken off, and the celluloid dial scale will then fall free. Remove the scale, and turn it 90° to the right, so that the scale will be in position for reading properly when the dial is mounted on its side. Then cut a notch in the dial scale in the right position to engage the pin which serves to hold it in position. Then carefully reassemble the entire mechanism. Some means must be devised for supporting the dial in this position, and just what this will be depends on the type of dial you have chosen. In the model being described, a simple right-angle bracket mounted on the base of the oscillator tuning condenser, which, incidentally, extends through a cutout in the chassis top, was sufficient, together with the support given the dial by the connection to the tuning condenser shaft. The 30 mmf, tuning condenser must also be mounted on a right-angle bracket. No particular data is given for this part of the construction, as all measurements, etc., will depend entirely on the parts used.

**CHASSIS DETAILS**

The chassis must of course be obtained before you can start construction. A word might be said here in regard to the source of supply for this unit. It probably can be obtained from any of the radio mail-order houses, but when this is done, it is usually necessary to punch and drill your own chassis. Considerable equipment is necessary to do this job, and do it neatly, and the beginner is not always so equipped. The author has found that the proprietor of your local tin shop is usually equipped with the proper equipment necessary to do this job, and do it neatly, and with a minimum of trouble. The chassis and panel for only slightly more than the price of the chassis it is more convenient to provide. Almost all sheet-metal shops have a grade of galvanized sheet metal that is excellent for a chassis, and can cut, bend, drill and punch both the chassis and panel for only slightly more than you would pay for the same material, unpunched, from usual sources. It might be helpful in this line. Almost all sheet-metal shops have a grade of galvanized sheet metal that is excellent for a chassis, and can cut, bend, drill and punch both the chassis and panel for only slightly more than you would pay for the same material, unpunched, from usual sources. It might be helpful in this line. Almost all sheet-metal shops have a grade of galvanized sheet metal that is excellent for a chassis, and can cut, bend, drill and punch both the chassis and panel for only slightly more than you would pay for the same material, unpunched, from usual sources. It might be helpful in this line.

After the chassis and panel have been prepared, mount all of the larger parts— that is, the power transformer, tuning condensers, speaker, volume control, switches, b.f.o. transformer, I.F. transformers, choke, "can" type electrolytic condenser, dial, and tube sockets. Also the dial plate which is to serve as a band-set marker on the large oscillator tuning condenser can be mounted on this plate now more conveniently than after the wiring is completed. If the holes have been drilled and punched as given in the specifications, very little trouble should be experienced with this phase of the work. The panel is held to the chassis by the mounting bushings for the two switches, volume control, and R.F. tuning condenser. The speaker is fastened to the panel with four 1/2" stove bolts and the dial escutcheon is held in place with the four small machine screws provided.

Alignment of the set is simple, as the band-spread condenser permits a certain amount of misalignment in the coils can be compensated for. Best results with the band-spread, however, can be obtained only if the coils are so trimmed as to give perfect tracking, and it is suggested that this condenser be set on center position and I.A. adjusted to give loudest signals. This may be done at a point where the "bath-tub" condenser is about two-thirds in. Needless to say, the I.F. section must be perfectly aligned before any attempt is made, to regulate the R.F. end of the receiver.

### CONDENSERS

- One static .1 mf., 200-V. condenser, C11
- One .01 mf., 600-V. condenser, C5
- One Aerovox .0001 mica condenser, C10
- One Aerovox .00025 mica condenser, C6, C7
- Two Aerovox .0005 mica condenser, C12
- One Aerovox .1 mf., 200-V. condenser, C13
- One Aerovox .001 mica condenser, C9
- One Aerovox .0005 mica condenser, C14

### RESISTORS

- One Ohmite 100, 1-W. resistor, R1
- One Ohmite 50, 1-W. resistor, R2
- One Ohmite 50, 1-W. resistor, R3
- One Ohmite 100,000 ohm, 1-W. resistor, R4
- One Ohmite 250,000 ohm, 1-W. resistor, R5
- One Ohmite 1,000 ohm, 1-W. resistor, R6
- One Ohmite 500 ohm, 1-W. resistor, R7
- One Ohmite 250,000 ohm, 1-W. resistor, R8

### TRANSFORMERS

- One S.P.S.T. toggle, Sw2
- One R.F. plug-in coil, L4
- One UTC 30 hy. choke, L2
- One S.P.S.T. toggle, Sw3
- One Allied 150 Kc. iron core I.F. transformer, T4
- One Allied 150 Kc. iron core L.P. transformer, T6

### MISCELLANEOUS

- One 450-ohm speaker field, L1
- One 140 mmf. variable condenser, C14
- Two Aerovox dual .1 mf., upright condenser, C15
- Two Aerovox dual .0001 mica condenser, C16
- One Aerovox dual .0005 mica condenser, C17
- One Aerovox dual .001 mica condenser, C18
- One Aerovox dual .0025 mica condenser, C19
- One Aerovox dual .005 mica condenser, C20
- One Aerovox dual .01 mica condenser, C21
- One Aerovox dual .05 mica condenser, C22
- One Aerovox dual .1 mica condenser, C23
- One Aerovox dual .5 mica condenser, C24
- One Aerovox dual 1 mica condenser, C25

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**1943-1944 Radio-Electronic Reference Annual**

Page 25
The following article on "Wireless" Phono-Oscillators is presented in answer to the insistent demand of Radio-Craft readers for an authoritative article describing the latest development in this type of equipment. Servicemen will find this article exceptionally useful in view of the popularity of these "wireless" phono players which enable any record player to be operated in connection with any radio set.

People say that the musical trend today is "back to the phonograph records." The word "back" is a misnomer. Actually, improved methods of recording and lower prices on records have appealed to the public, making them desirous of forming a permanent library of some of the best musical works as well as popular pieces.

This trend towards phonograph music has brought about the use of phonograph reproducing units in combination with home "radios." In most cases, especially in the case of modern-type superheterodynes, terminal strips are provided on the back of the radio set to which a phonograph pickup can be connected. In the majority of cases the terminals connect to the 2nd-detector.

Schematic circuits of 2 of the Phono-Oscillators described in the accompanying article, and illustrated at top of page pictorially.
RECORD-PLAYING THROUGH ANY RADIO SET

But there are, still, millions of radio sets that do not have the connection strip on the back. Here, then, is a potential market for additional sales which the radio dealer andServiceman should take advantage of.

Most Servicemen know how to connect a phonograph pickup to the average radio receiver. But "radios" that are not of superhet type do not lend themselves well to phone-pickup connection. The midget T.R.F.s, for example, which are so numerous on the market today, are usually designed so that do not have the connection strip on the back. Here, then, is a potential market for additional sales which the radio dealer and Serviceman prefers.

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2-TUBE "6A8" PHONO-OSCILLATOR

Figure 3 represents one of the simplest circuits for a wireless phono-oscillator. In this circuit, as in all of the other circuits, the unit is self-powered in the usual A.C.-D.C. fashion. Since much current is used by the oscillator tube, resistance-capacitance filtering is employed. This type of filtering is economical and entirely adequate.

The grids in a 6A8 tube are not normally used for input and output and are in this case used as an oscillator. The grids normally used as H.F. oscillator in a superhet receiver become the modulation circuit. Modulation voltage is impressed upon grid No. 1, which modulates the electron stream flowing from the cathode. This may be considered "electro-modulation," the modulation volt-

1-TUBE UNIT

Figure 3 is a circuit of a 1-tube phono-oscillator using a 707GT tube. As you know, this tube actually is 2 tubes in 1. The diode section is used for power and the pentode section is used as oscillator.

Notice that 2 loops of wire are coupled to the "hot" end of the grid coil and take the place of separate condensers. The grid coupling condenser and the antenna coupling condenser are thereby eliminated. In this circuit the screen-grid is modulated. A 3-megohm dropping resistor applies a small potential to the screen-grid. In addition, the screen-grid is not bypassed as would be the case in usual oscillator circuits using this tube. In other respects, the oscillator circuit is conventional.

A 0.05-mf., 600-volt condenser, used in one of the pickup connection leads, prevents D.G. from being applied to the crystal pickup.

The unit is pictured in photo C. A small U-shaped chassis is used, making the entire unit small enough to fit within any type of record player.

2-TUBE "6F7" PHONO-OSCILLATOR

A slightly different arrangement is used in Fig. 4. Here we find a somewhat different setup for the use of the 6F7 tube. This tube has a pentode and a triode in one envelope. The triode section of the 6F7 comprises the oscillator, in which we find plate tuning using a compression-type mica trimmer of sufficient capacity to tune the coil into the broadcast band. The adjustment is generally made so that oscillations occur at a quiet spot in the broadcast band. Radiation takes place from a short length of indoor-type antenna which is coupled to the "hot" side of the oscillator coil through a 50-nmf. condenser.

The completed unit is shown in photo A.

D E LUXE "125A7GT" PHONO-OSCILLATOR

Figure 2 represents a de luxe type of phono-oscillator, in which an additional tube is used to provide sufficient gain for microphonic input. The oscillator tube used here is of a newer type and has a bit more stability than the one used in Fig. 1. There is an additional innovation used in this circuit, in which the plate winding of the oscillator coil is the one that is tuned. Electrically this produces better frequency stability in the oscillator circuit. Independent inputs are used for phonograph and talkie, the volume of each control being independently adjusted. The additional amplification of the 12S5GT tube adds sufficient gain to the circuit so that crystal mikes or the popular priced F.M. type microphones may be used on the input.

The finished article of Fig. 2 appears in photo B. A simple chassis, just large enough to accommodate the parts, was used; obviously, any arrangement more suitable to individual needs may be substituted. In any of these circuits the actual, physical layout of parts is not very important.
THE PLASTICETTE RECEIVER

The receiver described below is the orthodox beginner's radio in the most attractive setting we have yet seen. The author used phonograph record material, but a transparent plastic may be used with excellent decorative effect. It is a dependable receiver, too.

This compact little receiver will be of interest not only to the beginner, but also to the experienced builder and experimenter as well. In fact, many of the boys in the service have written in to Radio-Craft asking for a description of a receiver of this type.

It is battery-operated and might be objected to on these grounds, but bear in mind the fact that the chassis can be used for other experiments, and also can be used after the war when batteries are available again. For those who have, or can get batteries, this description will be useful.

GENERAL DESCRIPTION

Basically it is the solid combination of proven worth, a triode in a regenerative circuit. The triode used is the high-mu, 1.4-volt 1H5GT tube. And the regeneration used is the Armstrong or tickler coil type.

A 25,000-ohm volume control is used for controlling the amount of regeneration, and it is of the tiny or midget type, in order to fit into the set-up.

The grid coil is wound first. Then place the grid and tickler coils can be wound as described. Check and double-check, so you won't burn out a tube.

The antenna trimmer condenser, by the way, is not very critical, and can be around 25 to 30 micromicrofarads.

The grid and tickler coils can be wound from an antenna coil, such as are used in small A.C.-D.C. broadcast receivers. The tickler winding consists of 35 turns of No. 28 enameled wire, wrapped around the core and note the many station whistles, hum should be heard. Then place the antenna to the set, repeating the process, and a louder hum should be heard. The receiver is then ready to operate.

Operation

After the chassis has been completely wired up, and ready for operation, the batteries are connected to the correct terminals as described. Check and double-check, so you won't burn out a tube.

It was found best to mark a A-plus, A-minus, B-plus, and B-minus on small strips of adhesive tape, and wrapping them around the three correct wires.

When operating this receiver, it will be found it does not tune-in like the usual broadcast receiver, but tunes very sharply and whirls on every station.

First turn on the switch to the batteries and see if the tube shows any light. It is very difficult to see the filament lit up, so to check further, just place the finger on the control-grid cap of the tube, and a hum should be heard. Then place the antenna to the set, repeating the process, and a louder hum should be heard. The receiver is then ready to operate.

Slowly turn the tuning dial over its range and note the many station whirls, with the regeneration control turned up. If this does not occur, check over the tickler winding and reverse the connection, and try again, until oscillation begins. When a sharp signal is heard, rotate the tuning dial until the signal is as loud as possible. Then lower the regeneration control until the signal turns into a "popping" sound, when the station can be heard.

The constructor will be surprised to find that many stations, hundreds of miles away, can be heard at night, with an antenna 80 to 100 feet long, mounted as high as possible.

The antenna trimmer condenser, by the way, is not very critical, and can be around 25 to 30 micromicrofarads.

PLASTIC CABINET CONSTRUCTION

The builder can now make his own plastic cabinet, out of old phonograph records. Start off with two of the 10-inch size and break them in two at the middle. This can be done if a sharp line is drawn on the record, and the record then broken over a sharp edge, such as a table or desk.

Then lay out the pattern of the side—and cut out as many as possible from each record, using a knife and a straight edge.

When all the sides are fitted together the cracks can easily be filled with small pieces of record. Then cut a few 1/4-inch strips of record and lay in the file furrow, and mold the sides together. The mold will find that the pieces will become very crisp and brittle, and cannot be dropped at this time.

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To mold the front panel place the heated record over the sharpened, pressing down with the fingers or with a pencil. If the first time the record becomes brittle and hardens before the panel is formed, repeat the process. When the front panel is completed, square all the sides measuring 3-inches, heat again and cut off the excess material. To give a smooth finish, iron out all sides with a cold iron.

FITTING TOGETHER

Next file the rough edges and fit all sides together. To melt the sides together, heat a file until the end is red hot and apply to the insides of adjoining pieces. Then cut a few 1/4-inch strips of record and lay in the file furrow, and mold the sides together. (The mold will find that the pieces will become very crisp and brittle, and cannot be dropped at this time.)

When all the sides are fitted together the cracks can easily be filled with small pieces of record. Then cut a few 1/4-inch strips of record and lay in the file furrow, and mold the sides together. The mold will find that the pieces will become very crisp and brittle, and cannot be dropped at this time.

An attractive dial was drawn with India ink, with a ruling pen and a protractor.

The knob was taken from the cap of a fountain pen polish bottle. A 1/4-inch hole was drilled about three-fourths of an inch through the middle of the cap and tapered with 3/16-inch tap.

The wood chassis is 2 1/2 x 3 inches and 1/4-inch thick. The mounting of the parts is shown in the drawing. The mounting of the tube is in an angular position to provide room for other parts.

Parts List

RESISTORS
R1—8 meg.
R2—.2500 mfd.
R3—.00025 mfd., mica
R4—.0006 mfd., mica

CONDENSERS
C1—Antenna trimmer, 0-35 mfd.
C2—.0005 mfd., mica
C3—.0006 mfd., mica

BATTERY
A—1/2-V. penlite cell
B—.5-amp. switch
C1—1H5GT RCA tube

1943-1944 RADIO-ELECTRONIC REFERENCE ANNUAL
The wiring presented no great difficulty, the only necessary precaution having been to keep the terminals relatively short. This meant that most of the condenser and resistor leads had to be shortened.

I found that by changing the coil from the one used by Mr. Dezettel, I could obtain greater selectivity. I made up a tube by rolling up some gummed paper tape into a half-inch coil form, that is, one-half inch in diameter and one-half inch long. About 75 turns of No. 32 enameled wire make a good primary. The secondary consists of 25 turns of the same size wire. The experimenter should make up several coils, varying the number of turns, and select the one best suited for radio reception in his locality. The turns can be random wound, but a space of at least 1/4 inch should be left between primary and secondary windings.

For aerial and ground terminals I used pin jacks to avoid having bulky binding posts on the panel. It was necessary to cut down the excess insulated portion of the two-pin-jack assembly a bit to make it fit between the A battery and the antenna coil. The feature which I believe to be the most novel is the improvised loudspeaker. This was made from a single Trimm earphone and a piece out of celluloid and placed it between the earphone and the back of the panel. This permits free movement of the diaphragm, while holding its outer periphery securely to the panel. A number of holes drilled in the panel exposed a sufficient amount of the diaphragm disc so as not seriously to impede the sound.

The on-and-off switch is a miniature rotary which I happened to pick up somewhere. Only a locking nut and two wires protrude in back of the panel. The tuning condenser is a small Meissner trimmer which varies in capacity from 0 to 0.00001 mf. This trimmer has a ceramic casing and has the usual slotted screw projecting from the top. Although originally I placed the trimmer behind the panel, I found that this caused too much cramping of the parts and therefore I mounted the whole trimmer on the front of the panel, using the lock nut to hold it in place. The wires pass the Bakelite panel through two small holes drilled in the panel. Since the condenser has no knob, I used an old binding post cap, soldering its metal center to the condenser shaft.

The case was assembled from scrap pieces of Bakelite put together by small L angles fastened by screws. Some of these screws had to be removed and replaced by rivets to permit the battery (No. 455 Eveready, 45 volts) to slide into the back of the case. Although some form of aerial was required for reception, I found a ground connection unnecessary.

Precautions should be taken in wiring (continued on page 31).
With batteries unavailable, it becomes necessary to consider the use of a power pack for the small portable. The information given here is therefore doubly welcome. This pack provides "A", "B" and "C" voltages and currents up to 250 milliamperes for the filaments. It is a flexible, light and compact unit, good in appearance and performance.

A Miniature A.C.-D.C. PORTABLE POWER PACK

Due to the war, severe restrictions have been placed on the manufacture and sale of all types of portable batteries. In fact, the small 45 and 67.5 volt "B" batteries for the miniature portable radios cannot be purchased anymore and the "A" batteries, which are ordinary flashlight cells, are becoming difficult to obtain. Unless suitable power packs can be obtained, these radios will have to be put on the shelf for the duration. It is the purpose of this article to describe the author's design of a small light-weight 115-volt A.C.-D.C. type portable power pack for these sets.

The power pack herein described was designed to work on 115-volt A.C. 60-cycle power lines and to furnish "A," "B," and "C" power for a Crosley 45-BV commuter personal portable radio. However, the design is also applicable to other miniature portables. Refer to the July, 1941, issue of Radio-Craft for schematic of the Crosley model 45-BV, and also the Zenith Pocket-radio.

DESIGN CONSIDERATION

In most of these sets the tube complement consists of a 1R5 converter; 1T4 I.F.; 1S5 Det.; and a 1S4 power tube. Series connections of the filaments would result in a simpler power pack but this is not practical, as the 1S4 draws 100 mls. of filament current while the other tubes draw 50 mls. Series connections would also mean rewiring of the set and the use of complicated switching arrangements to change from batteries to A.C. operation.

Since the tubes are connected in parallel, this means that the current supplied must be the sum of the requirements for each tube, or approximately 250 MA at 1.4 volts. The easiest way to obtain this would be to use a transformer and a dry disc-rectifier. However, these parts are difficult to obtain, are bulky and heavy, unless specially designed to do the job. It was decided to use a tube rectifier and a voltage divider to obtain the necessary voltages.

The "B" supply requirements for these sets are approximately 67.5 volts at 10 mls. This is easily obtained. A "C" supply of approximately 5 volts will suffice, as these sets are not noted for high fidelity reception.

Since the "A" and "B" return leads of a tube type power supply must necessarily be common, and the C bias in these receivers is obtained by a 700 or 800 ohm resistor in the B- lead, the A- and B- returns of the power supply cannot be connected together.

The method used by the writer to obtain C bias was to take the "A" and "C" voltages from a voltage-divider as shown in the circuit diagram.

DESCRIPTION OF PRESENT CIRCUIT

Refer to the picture of the power supply plugged into the radio. One of the knobs shown in the photo is the "B" supply adjustment, while the other is the "on-off" power switch.

Since a small light-weight power pack was desired, two 50Y6GT bantam type tubes were chosen for the rectifiers. The filaments are connected in series with a 100-ohm dropping resistor, across the 115-volt line. Two 117Z6GT tubes with parallel filament operation might be used, but the current output rating in these is insufficient according to the manufacturer's rating in the tube manual.

"A" BATTERY SUPPLY

To supply the heavy "A" current both of the cathodes of one tube and one cathode of the other tube were connected together. A 500-ohm voltage divider was used with taps for "A" and "C" power as shown. Since this is a half-wave rectifier, and it was desired to have no heavy choke filtering, rather large values of filter capacity were necessary.

The 20-mfd. condenser was connected at 238 ohms from the B+ side of the voltage divider as hum tests with an oscilloscope showed that this was the point for maximum reduction in hum. In fact, practically no hum is observed with the cathode-ray oscilloscope in either the "A," "B," or "C" circuits.

The remaining cathode of the rectifier tube was used for the "B" supply and is connected in a conventional half-wave circuit using a 5000-ohm resistor in place of the usual choke, and a 16-8 mfd. dual filter condenser. A 5000-ohm variable resistor is included for adjusting the "B" output.

The location of the A- and A+ taps or sliders on the voltage divider will be approximately as shown in the schematic. Their location can be determined before connecting to the receiver by placing a lead resistor equal to the filament load of the receiver 1.4/250=5.6 ohms, across A-. A- is on the voltage divider, and an 800-ohm resistor across A- and B- for a C bias resistor, and adjusting to 1.4 and 4.9 volts respectively. Final adjustments can be made if desired after the power supply has been plugged into the set.

The 500-ohm voltage-divider and rectifier tubes should be located outside the small chassis for proper ventilation. The voltage-divider is on the back of the chassis and does not show in the photograph.

Connections of this power supply to the set are simple and require no switching arrangements whatsoever. The small 4-contact hearing-aid plug is wired to the power supply through the 4-wire cable. There is just enough room in the end of the radio receiver to cut and fit in the 4-contact hearing-aid socket. Connections to this socket are as shown in the schematic drawing. Fig. 1. Only the plate, grid, and filament of the 1S4 output tube in the schematic drawing, as connections are

Schematic of the "Miniature Power Pack." Simplicity and good engineering mark its design.

(Continued on page 451)
Many Service Men do not find it possible to invest in new test instruments, and the author here describes how to modernize an old Supreme "Diagnometer." This instrument, after being rebuilt as here described, permits all of the usual tests being made on sets.

This is the story of how an old Supreme Model 400-B Diagnometer was rebuilt into a modern multi-purpose test set. While thousands of these excellent old test sets must still be extant and waiting to be modernized, it is hoped that several small matters touched upon will be of interest to readers desiring to modernize other test sets, or to construct a test set from odd parts.

The Model 400-B was a rather elaborate set analyzer built around an A.C. Voltmeter, D.C. Voltmeter, and D.C. Milliammeter. Though more expensive to buy, an instrument having several meters is to be preferred to a single, all-purpose meter. The meters are less likely to be damaged in use, and also it is sometimes desirable to measure two or more quantities at once. It was with this in mind that my eyes fell greedily upon the three Weston meters in the panel of the old 400-B. It immediately developed that the D.C. voltmeter did not function on any range. By connecting a galvanometer, which I already possessed, in parallel with it, it was demonstrated that the meter itself indicated current flow properly, and the trouble was soon discovered. One end of the low range resistor was burned or broken loose from its connecting lug, and had to be scraped and resoldered.

The diagnometer, of ancient vintage, was rigidly designed and built for use as a plug-in analyzer of sets using the old four and five prong tubes, and could only be used with difficulty as a general purpose instrument. Study of the extremely involved circuit diagram, and of the instrument itself (the wiring of which was in cable form, and plenty hard to follow), led me to decide I wanted no part of an attempt simply to revamp it. Finally I cut the wires, took every part out, unsoldered all connections, and laid the parts out on a table. The galvanometer previously mentioned was taken out of its case and placed there too; it was desired to use the galvanometer as the balance indicator of a slide-back V.T. Voltmeter, and to build it with the other instruments into the oak case of the 400-B.

Previous experience with multiple purpose instruments had led me to dislike the multi-pole switch as a means of changing ranges, and I determined to place the pin multi-pole switch in which a plug was inserted, in order to throw the various ranges of the instruments into the analyzer plug circuit. Only one of these switch-jacks was retained.

### A.C. Voltmeter

The A.C. voltmeter is of the moving-van type. Although it draws considerable current, it is an excellent and reliable instrument for measuring line and filament voltages, voltages at the various transformer taps, etc. By this time I had long since given up trying to discover the circuits of the various instruments by following the circuit diagram of the 400-B; but a little experimentation with the galvanometer in an ohm-meter circuit revealed which wire-wound resistors were in the circuit of the A.C. voltmeter, and what their approximate value was. The circuit of the A.C. voltmeter is shown in Fig. 1 (the resistance values are only approximate; each one of these meters has its resistors especially calibrated at the factory). I decided to place the voltmeter on the panel with five pin jacks, as shown.

### D.C. Milliammeter

The milliammeter is designed to give full scale deflection with a current of 25 mls. I have found it quite satisfactory; the circuit of the D.C. voltmeter is arranged so that instrument may be used to give full-scale deflection on a current of one mil.

(Continued on page 42)
DYNAMIC TESTING
WITH YOUR SIGNAL GENERATOR

The following article on the use of a standard signal generator in Dynamic Servicing is designed to show Servicemen how to quickly service radio receivers in minimum time and at least cost. Remember: “Time is money.”

MOST Servicemen realize the value of Dynamic Testing, but continue to service as before because they lack the “greenbacks” necessary to get the equipment needed.

To remedy this situation, Radio-Craft and other magazines have published less elaborate outfits that are supposed to do a satisfactory job of Dynamic Testing. Some of these outfits work fairly well, while others are not worth building. If you fellows can lay out enough to build or buy the better instruments, and if your business warrants such an investment, then go to it. On the other hand, you fellows who cannot see your way to add more equipment will doubtless be interested in knowing that your signal generator can be used to do dynamic testing.

PRELIMINARY TESTING

Assuming that we have a receiver to be serviced, our first step would be to check tubes. This would save time if as often is the case, there is an open or shorted tube. Whether tubes are checked or not, the power supply should be checked with a multimeter. This would save time if as often is serviced, our first step would be to check the case, there is an open or shorted tube. This would save time if as often is

AUDIO TESTING

Switching our signal generator to AUDIO OUTPUT, we ground one side of its output to receiver ground. A condenser of about 0.01-mf., rated at 600 working volts, should be inserted in series with the “high” side of the audio output lead from the generator. Note that the capacity of this condenser is not critical and is used only to keep plate voltage out of the generator attenuator circuit. In some generators this attenuator circuit is built into the instrument—if such is the case with your generator, no external condenser is needed.

First we feed a signal into the plate of the power amplifier tube and with the gain of the generator wide open we should hear a signal. If no signal is heard or is distorted it is only necessary that we check speaker, output transformer, and tone bypass condenser for defect.

Assuming signal was heard we now feed the signal into the control-grid of the power amplifier tube. The signal should now be louder. If no signal is heard, or if signal is weak or distorted the tube should be tested or replaced. If signal is still effected a millimeter check of this circuit will quickly disclose the defective part or parts.

If signal is heard the generator is then fed into the next audio plate, the next control-grid, etc., until all stages of audio have been found to be working properly. If signal is effected the tube in the offending circuit should be tested or replaced, if trouble still exists a millimeter check of the offending circuit will quickly disclose the defect.

Having now found our audio section working properly we feed an audio signal into the output of the 2nd-detector (or detector, if set is T.R.F.). If not heard, the coupling system between the 2nd-detector and 1st audio should be checked, also the R.F. bypass condenser.

DETECTOR

To test 2nd-detector we feed into the input circuit of the detector a modulated R.F. signal, tuned to resonance with the detector’s tuned circuit. If no signal is heard the circuit should be checked with a multimeter.

Some generators do not have enough power output to get any audible response when fed into the circuit described above. If your generator does not, try using earphones as an indicator as they require much less driving power. In the case of diode detectors the signal may sound distorted. However, after you become acquainted with this type testing, you will know how the signal should sound, to be OK when the circuit is operating properly.

I.F. AMPLIFIER TESTING

Having found our 2nd-detector and A.F. sections working properly, we are now ready to test the intermediate frequency section of our receiver.

We adjust our generator for a modulated R.F. signal, grounding one side of its output to receiver ground. In the “high” side we insert a condenser in series, if no condenser is included within the instrument itself. With the generator tuned to the I.F., we feed a signal into the plate of the last I.F. amplifier tube, the control-grid, working back through all the stages of I.F. amplification. If the signal becomes distorted, it is only necessary to test the circuit in which the signal is so effected, to determine the cause.

To determine whether the mixer (1st-detector) is passing a signal, a modulated R.F. signal tuned to the I.F. is fed into the input of the 1st-detector. If no signal is...
HE ability to go places faster and do things quicker.

The keynote of a war-crazed world. An absolute necessity in the successful management of a modern competitive business.

And—radio servicing is a modern competitive business!

The need for speed in radio servicing has long been recognized by those who have seen a volume of radio business move through the larger shops. Since the début of the small midgets, a majority of all servicing has been of this type. For years the question has been, "How are we going to make money servicing midgets?" The answer is and always has been—turn out more of them!

HOW?

This statement brings on the natural question—HOW? And, the answer to this one-word inquiry requires careful attention and consideration.

Looking at the rosy side of the picture, there are several things in favor of the midget. First, it is usually brought in by the customer, thereby eliminating the necessity of making a call. Few servicemen realize what it costs them to make calls. Besides the actual time lost, there is the question of automobile expense. It costs money to sit and wait on a red light, and it is your time that is wasted when you stand in the doorway and listen to a customer jabbering on about something that doesn't mean a thing to you. It is almost impossible to charge enough for service calls to break even on them.

Second, since the customer brings the set in, he usually returns for it, and it is a well-known fact that customers pay better when they come to the shop for their sets. The more cash business a serviceman can get, the less time he has to spend in bookkeeping and collecting. And, it might be mentioned that getting the customer into the store or shop affords the alert serviceman an opportunity to show or sell him additional merchandise.

Getting right down to technicalities, the little sets are far easier to service than the big sets—that is, if you know your stuff! All servicemen will agree, I think, that in the majority of cases defective tubes are the cause of midget set failure. In a majority of these cases, it is the power tube. An approximately half of the power tube cases there is filter condenser trouble.

Accordingly a simple routine for servicing midgets is to first check the tubes. Since tube failure is practically always caused by open filaments, if some simple means is used to check filaments without the necessity of placing each tube in a checker and waiting for it to heat, considerable time can be saved. There are several ways to do this, the simplest being to utilize the ohmmeter. If a low scale is used open filaments can usually be detected without removing the tube from the socket. However, occasionally the circuit will afford a round-about reading that is misleading. A simple gadget for checking filaments quickly can be rigged up with the aid of an old tube-checker. A pair of test leads are rigged up with tube prongs on one end so that they can be inserted in the filament positions of one of the sockets on the tube checker (Fig. 1). A pilot lamp of the 2.5 volt variety is wired in series. The proper voltage is fed to the tube-checker through the pilot lamp and to the tube as the test prongs are touched across the filaments. If the filament of the tube being tested is out, the pilot lamp will not burn or will burn very dimly.

"FILTER CONDENSER" TROUBLES

On midget sets, filter condensers are found open more often than shorted! If the power tube is okay but voltage is low or insufficient to read, one or both of the filters are usually open or have lost their capacity. All servicemen are accustomed to placing another filter across the various sections to locate the defective one. This is usually a tedious job, between trying to make connection and keep from getting shocked. However, if a few minutes are given to installing a series of condensers with a switching arrangement in a box which has provisions for plugging in a pair of test leads, not only will this job be speeded up, from the standpoint of locating the proper condenser, but also in determining the proper value to use in the replacement (Fig. 2).

A few precautions are in order here. If one section of the pack only is replaced, the other should be checked thoroughly for both leakage and capacity. The section replaced should always be removed from the circuit as defective low-capacity condensers are low power factor, and cause an unnecessary drain on the circuit, even if they do not become heated and short.

Some servicemen are of the opinion that the only requirement for the replacement of a filter is to get enough capacity. This is not always correct, especially in the case of close cathode rectifiers such as the 25Z6 and 6X5. If too high capacity condensers are used immediately following these types, the condensers can pull enough current on

\[ Continued \ on \ following \ page \]
quick charges such as occurs when the set is turned off and on rapidly or during line interruptions, to completely melt the cathode. This is what happens when a filter shorts and often happens when the serviceman shorts it with a screw-driver to see if he has any voltage. However, it is safe to use 16-20 mf. and if this amount eliminates the hum, no connection should be made unless the proper value is known.

Other common defects with the little "midget" sets are the general run of trouble, shorted bi-passes, output fields and output transformers. However, these troubles are scattered and easily isolated.

ALIGNMENT

Very frequently the serviceman will neglect aligning the "little fellows," because he does not feel justified in wasting the required time to do the job right. Excellent results are obtained in only a few minutes with the following procedure. Connect the oscillator to the antenna and ground connection through a 100,000 ohm resistor or a 25 mf. condenser. Feed in a high voltage and stop the oscillator by placing a finger on the oscillator section of the tuning condenser. This stopping of the oscillation is not necessary but is advisable. Adjust I-F's to reproduce with set volume control "wide open" but oscillator turned down to where the signal is barely audible. If a low signal is used, the hum is not cut out, without hooking up an output meter.

When the I-F's have been aligned, the R.F. oscillator trimmers can be adjusted by switching the signal generator to 1400 kc. or by removing it entirely and tuning in a weak signal in the vicinity of 1400 kc. This set test is preferred.

**Loop Sets:** On sets using loops as both antenna and antenna transformer, coupling is best accomplished by feeding the signal generator into a loop of similar size and number of turns and holding this loop near the one in the set. Such a loop is easily made by winding a few turns of wire on four nails correctly spaced on a piece of plywood, and will serve for testing practically all loop sets.

Nothing slows up service work more than intermittents. And there is no known system that will correct intermittents completely. The busy service man can save himself much trouble and time by proceeding cautiously when he is called to service an intermittent receiver. The first set is cutting out occasionally and if there is nothing that can be done to make it cut out, it can be best left alone. The customer should be told to use the set until it quits for good! Many unprofitable hours can be saved, even though it may seem at the time that business is being lost.

However, the intermittent is fairly consistent and of a definite nature, it is up to the serviceman to find this trouble in the least possible time. The most successful way to do this is to scratch the plate of the defective part. This is done by applying high voltage to the parts suspected of causing the trouble.

The best way to do this is to have a power-supply capable of delivering a flash voltage of 800-1000 volts. This can be probed across condensers, resistors and coils, and while not high enough to break the condensers, it will break a good resistor or winding, will often break down defective parts. In the case of AC-DC sets, the voltage has to be increased accordingly.

High voltage not only breaks down defective parts, but will also show up loose connections and intermittent grounds. Recently the writer had a Philco 610 that had a scraching noise like a defective output or driver transformer. All ordinary checks revealed nothing. The trouble was isolated to the plate circuit of the first audio, but a substitute of parts did not clear it up. However, high voltage touched on the plate with the set off, stopped the noise immediately and although several months have passed it has not returned. No cause for it was ever found.

Another time it was an RCA that tuned in a station on 850 kc. at 600 on the dial and would pick up nothing on the high frequency end. Hours were spent checking. It was found that the oscillator was far off frequency, but no cause could be established. Finally, the high voltage was applied and an arcing was observed under the tuning condenser. It was found that the bond from the tuning condenser to chassis was a cold joint. The high voltage arced across, showing it up.

Sets can be operated on the high voltage by removing the power tube and feeding the external high voltage onto the filament or cathode. When the set becomes good and hot, the intermittent will usually show up. Some intermittents are allergic to low voltages instead of high. A variable line transformer, Fig. 3, which can be bought for a nominal sum, will serve to vary the line voltage and bring the set up to the normal value. Low voltage will cause a weak oscillator to cut out or it will cause distortion and drifting.

When this is checked on high voltage not only raises the D.C. supply, but also increases the filament voltage, causing the tubes to get hotter and thereby breaking down internal shorts, weak filaments and other troubles.

A pack for supplying the high flash voltage is shown in Fig. 4. This is built with the parts that can be found lying around. The gadget will save many hours, and if used to check all sets that go through the shop, the number of kick-backs will be reduced to a minimum. The part lost in the application of the high voltage that might otherwise get by are negligible.

CONSERVING SKILLED LABOR

Not only must the modern serviceman apply every known trick to turn out his work faster, but as more and more men are called into the Government service, a conservation of skilled labor is going to be found necessary. This can be done by diverting the hands of others that part of the service work that does not require technical knowledge. This represents removing sets from service, cleaning, checking tubes, installing parts, etc.

A simple and effective routine is to have the non-skilled man remove the chassis, clean it and check the tubes. He then passes it to the serviceman, who diagnoses the trouble. While the set is being diagnosed, the helper cleans and polishes the cabinet and removes the second chassis. The serviceman passes the diagnosed set back for the installation of the defective part. While the helper installs the part, the serviceman diagnoses set number 2. He then passes set number 2 to the helper for installation of part, and takes set number 1 for final check. No time is lost and maximum efficiency is obtained from both serviceman and helper.

Careful diagnosis of the job from the standpoint of what it will take and how much can be realized for it, will save the busy serviceman much time and trouble. Jobs that are not routine should be avoided whenever possible, they should be left to one time plus material basis. The serviceman must get at least $3.00 per hour for his time and facilities. He should get $5.00, which is the price charged for work at machine shops, sheet metal shops, etc.
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FIRST...
economical on voltage control systems than intricate relay set-ups, even if tubes have to be replaced on occasional blowout.

**CURRENT REGULATOR TUBE**

This is another controller adapted to the purpose of adjusting output when the power source gives fluctuating voltage. The filament of the current regulator tube has a variable resistance which changes in direct proportion to the voltage. That is, as the voltage from the source increases or decreases, the filament responds with decreased or increased resistance, as the case might be. In this way current through the load circuit is always the same. A gaseous atmosphere surrounding the filament safely absorbs the excess heat.

This tube is recommended for the maintenance of constant current in the filaments of radio tubes.

A simple hook-up on A.C. is shown in Fig. 3. The current regulator tube can also maintain power output at a constant level, regardless of variations in potential, when it is placed in series with a power transformer primary. As shown in Fig. 4.

**THE DEMONSTRATION TRIODE**

This triode, introduced by Westinghouse, has its plate coated with willemite, the phosphorescent material. The plate glows spotlighted as the electrons impact upon it, according to the action of the control grid. Thus students can actually see electronic action, just as it is seen on the cathode-ray oscilloscope.

**THE PHANATRON**

Another time-saver is this hot-cathode discharge-tube. It is a rectifier, handling large currents. With vastly increased efficiency, the phanatron can replace the old-type two-tube rectifier combinations.

**OTHER ELECTRONIC TUBES**

There's a type of phototube that responds only to ultra-violet rays. This tube can be hooked-up in a simple circuit as shown in Fig. 5. It does not have to be shielded from light sources other than the ultra-violet. So far this tube has provided the only efficient means of measuring the intensity of ultra-violet ray equipment.

Then there's the thyratron, which is filled with mercury vapor at a low pressure. The thyratron, highly sensitive and efficient, fills violet-ray equipment. This tube can be hooked up to the grid to thefilament of the 6A6 tube should be shielded, with the shield soldered to the chassis. No special precautions need be taken in wiring the amplifier other than to keep the grid and plate leads of the 6B5 tubes separated.

The 8-mf. filter condensers may be either dual or single sections, but if dual sections are used one of the sections should have 2 negative leads, rather than one common negative lead so that one of the leads may be connected to the cathode terminal of the 6A6 tube, instead of being grounded to the chassis as are the other negative leads.

It will be noted from the schematic diagram in Fig. 2 that the speaker field serves as a choke coil for the filter system. The speaker should have a field resistance of 1,000 to 1,500 ohms, and should have sufficient capacity to handle the full output of the amplifier. If it is desired to use a speaker with a lower field supply, a 10-henry choke with a current rating of 150 milliamperes may be substituted for the speaker field. To reduce line noises and hum to a minimum, the speaker frame should be grounded to the chassis of the amplifier.

**THE FLOATING GRID RELAY**

The following experiment is being used in our Radio and Electricity Course to illustrate the functions of the various elements in a radio tube, especially that of the control grid. The tube used had to be as elementary as possible and yet retain most of the features of the modern tube. It would be a waste of time to use one of the multi-purpose tubes, because the average high school pupil would be confused by its very intricacy. Furthermore, the average experiments using volt-meters and ammeters do not clarify the instruction, unless they are combined with some more visual demonstration.

The first tube tested was a No. 30, using a variable resistor on the filament, but it was not as sensitive as desired and would not hold the charge to any extent. Since batteries are scarce, a heater type tube was selected. Experimenting with several types proved that the type 5B best suited the purpose.

In the selection of the light indicator, the two or three watt neon lamp was found to be the most suitable. For this circuit, the two watt was chosen because it demonstrated the rectification function of the tube better than the three watt lamp. The lighted half on top of the two watt was more distinct than the top and bottom elements of the three watt lamp.

The potentiometer needed is at least 10,000 ohms, as it is necessary to drop the voltage on the screen grid to the most sensitive control. By varying the voltage on the screen grid, the neon light will be caused to vary in intensity. This variation will illustrate the use of the screen grid to reduce the space charge and plate-to-grid capacitance.

In demonstrating the control grid, the resistance must be regulated according to the type of charged body, distance, and type of antenna used. The best working voltage on the screen grid is about forty volts at a distance of the foot or less from the antenna. By careful adjustment of the light, the control grid may be tripped up to a distance of twenty feet. At a distance of eight feet or more, it is best to substitute a larger antenna in place of the one shown in this article.

The charged body may be an ordinary fountain pen or rubber bulb, depending on what it will give sufficient charge to trip the grid. For the best results, use a rubber or wax rod about one foot long and half-inch in diameter for building up a negative charge. With the rubber rod, you can hold a negative charge on the control grid for one minute, choking off the flow of current to the neon light. If you adjust the potentiometer so low as to make the neon light glow faintly and bring a positive charged body (such as a piece of glass rod rubbed with silk) near the antenna, the neon light will glow brighter momentarily than when there was no charge on the grid.
PHOTOELECTRIC PICKUP (Continued from page 6)

A view into one of Philco’s phono-radio sets using the new pickup.

mechanical resonance and electrical mum range without transmitting the hissing the high notes to the desirable maximum without any thumping sound and yet reproducing the piano, reproducing the bass notes with the tiny arm which supports the floating jewel in the groove is translated into a varying flow of electric current operating the loudspeaker. Carefully ground to the most exacting dimensions, this floating jewel itself achieves by having the free-floating jewel arm are vibrating with extra intensity in the high-frequency range, consequently an additional motivating force acts on the mirror, causing it to flash a more effective light signal to the photoelectric cell.

This achievement is possible only because of the free-floating construction of the photoelectric reproducer; its lightness and flexibility make the jewel’s tiny arm an additional source of energy and result in transmission of the high notes with a clear fidelity never before achieved, Philco states.

Another construction feature involved building and hooking-up a special shielded transformer to play the current generated by the photoelectric cell to an amplifying tube.

Still another contribution to the science of sound transmission is presented by the floating jewel itself. Carefully ground to the most exacting dimensions, this floating jewel has a rounded tip instead of the old-fashioned needle’s dagger-like point. As a result it moves through the record groove without digging into the record in an injurious manner. Because a freely floating sapphire jewel has replaced the steel needle to detect what is on the record, wear and tear are reduced to a minimum, and gouging and fraying of the record are virtually eliminated. The jewel has a life of 8 to 10 years. The instrument “caught on” rapidly, and from its inception it has been extremely popular both with professional entertainers and amateur musicians. Affording an opportunity of accompanying the piano music with sustained notes it makes possible many pleasing effects. The listener is further tripped by the quality of Solovox music, which persuades no other instrument, though close to the organ or violin.

In the studio where space is precious, the Solovox is especially adaptable, for it takes up no extra room. It is entirely electrical in operation and by means of a tuning knob can be tuned to the piano with which it has been assembled. The 14 standard, inexpensive radio tubes—the heart of the instrument—may need replacement only in the course of several years’ playing time. Radio men will note that the comparatively low cost of the Solovox (under $200) places it within the range of small as well as large radio stations. (Dealers give to purchasers, without charge, what little instruction may be necessary.)

Labatory Standards... Precision DC and AC Instruments... Instrument Transformers... Sensitive Relays... DC, AC, and Vacuum Switchboards and Panel Instruments.

RANGES

D-C Voltage—Measurements from 0 millivolt to 1000 volts; 100,000 volts per volt in full scale ranges of 0.1/0.5/1.0/5.0/10.0/50.0 volt.

A-C Voltage—Measurements from 0.1 to 750 volts (0.1 volt with rings to 0.5 volt, in full scale ranges of 0.1/0.5/1.0/5.0 volt).

D-C Current—Measurements from 0.1 microampere to 50 amperes, in full scale ranges of 0.1/1.0/5.0/10.0 amperes. Higher ranges, with external shunt.

A-C Current—Measurements from 0.1 to 10 milliampere, in full scale ranges of 0.1/1.0/10.0/milliampere. Higher ranges, up to 1000 milliampere, with external current transformer.

Resistance—Measurements from 0.1 to 10 megaohms, in full scale ranges of 0.1/1.0/10.0 megohms, Center scale values are 32/320/3,200/32,000/320,000 ohms.

WESTON MODEL 785 Industrial Circuit Tester

Laboratories and Workshops... Precision DC and AC Instruments... Instrument Transformers... Sensitive Relays... DC, AC, and Vacuum Switchboards and Panel Instruments.

For over 55 years leaders in electrical measuring instruments

FOR OVER 55 YEARS LEADERS IN ELECTRICAL MEASURING INSTRUMENTS

For a vocalist, the Solovox provides a full, well-rounded background. The fact that all the technical difficulties, such as perfect pitch intonation, smooth vibrato, tonal attack, and quality control are all taken care of in the design of the instrument makes the Solovox the easiest of all orchestral instruments to play. No special training is necessary, for anyone who can pick out a tune by ear on the piano can play it effectively.

The new instrument “caught on” rapidly, and from its inception it has been extremely popular both with professional entertainers and amateur musicians. Affording an opportunity of accompanying the piano music with sustained notes it makes possible many pleasing effects. The listener is further tripped by the quality of Solovox music, which persuades no other instrument, though close to the organ or violin.

In the studio where space is precious, the Solovox is especially adaptable, for it takes up no extra room. It is entirely electrical in operation and by means of a tuning knob can be tuned to the piano with which it has been assembled. The 14 standard, inexpensive radio tubes—the heart of the instrument—may need replacement only in the course of several years’ playing time. Radio men will note that the comparatively low cost of the Solovox (under $200) places it within the range of small as well as large radio stations. (Dealers give to purchasers, without charge, what little instruction may be necessary.)
AN UP-TO-DATE TUBE CHECKER

The tube checker shown in the accompanying diagram is relatively easy to operate. The cost of construction is very low; yet it furnishes free floating filament and cathode connections. It will be understood by the constructor that the sockets shown blank can be hooked up to the proper connection numbers.

It provides the following services:
1. Tests filament continuity.
2. Shorts, hot or cold (and if desired, which element has the short).
3. Automatically furnishes short test, before emission test can be taken.
4. Emission test with all elements tied together.

The circuits from all elements are brought out to banana jacks and continue to the positive bus bar, being interrupted to the latter by individual S.P.S.T. toggle switches. Three banana jacks are connected as shown to the filament transformer. The filament and cathode connections are set up as required by three flexible wire jumpers with plugs. This action is more deliberate than circuit switches and tends to eliminate the possibility of a wrong setup and shorts in so doing. A 5,000 ohm variable resistance can be switched in on one side of the filament to lower the 1.5 volt tap to that required for heating aid tubes. A multiplier shunt is held in the circuit across the milliammeter by a spring return switch. This guarantees protection for the meter in the case of rectifiers and mercury vapor tubes. In the case of other tubes this switch is pressed to obtain low scale. The emission test switch "T" is also spring return and keeps the positive bus connected to the neon bulb so as to give the short test first. Pressing this switch gives the emission test. A 400 ohm resistor, with a shorting switch is connected in series with the meter to be used when testing such tubes as the 6H6, so as not to damage the tube, but the difference in emission current must be marked on the chart or tube manual.

For example, to test a type 6K7 tube close all circuit switches except Nos. 2 and 7. Adjust the filament tap FS to 6.3 volts. Plug one jumper between jack B and No. 7. If cold short exists from filament, neon bulb will glow. Plug A to jack No. 2. This heats the filament. If no short shows, open circuit switch 8 and plug jack B to cathode jack No. 8. If a short shows it is only necessary to open each circuit switch in turn to find out which element causes the short. Finally press switch "T" which gives the emission check.

Ballast tubes can be checked for continuity by opening the requisite circuit switch and plugging B to the jack on the same circuit. If OK the neon bulb will glow.

In the case of testing the filament type tubes it is not necessary to use the cathode jumper, as the negative side of the transformer is already connected when the filament connection is made.

Care must be taken when testing tubes with tapped filaments (pilot light connection) to open the circuit switch connecting the tap, before the tube is plugged in.

Of course the tube base chart or tube manual must be used with this tester. There are so many new tubes on the market that this book must be used in every case.

No provision was made for line voltage adjustments, as the variation shown on the milliammeter will not be so great as the case when a "BAD-GOOD" meter is used with its accompanying shunts.

SIMPLE CODE-PRACTICE OSCILLATOR

GOOD radio operators are urgently needed by our Armed Forces. Men who are interested in radio and who expect to get into the Service in the future should make preparation to meet the requirements of a radio operator of the Armed Forces by being able to send and receive the code at a speed of not less than ten to fifteen words per minute. The code can be quickly learned by two or more persons getting together regularly and practice sending to each other while the others copy. The only real requirement is a suitable code-practice oscillator.

The code-practice oscillator to be described can easily be made from parts found in any junk-box. The transformer (T) is a push-pull input transformer (in the case of the author, the primary winding was open) or it may be a push-pull speaker transformer. The tube may be any type tube that a power supply to operate it is available. A 1A5G/GT tube works extremely well when used with a 1½ volt "A" battery and a 45 volt "B" battery. The condenser (C) is necessary to get the "feed-back" for the circuit to oscillate. Any capacity condenser of about .001 mfd. is suitable. Rheostat (R) may be any available of about 30 ohms resistance and is used to drop, the "A" battery voltage to the required tube filament voltage. The "on and off" switch (Sw) may be on the rheostat or: it may be separately mounted. In most cases the 'phones may be substituted by a P.M. speaker with a suitable speaker transformer. The key is placed as it is in the circuit to eliminate "key-clicks".

This code-practice set may be assembled on a bread-board type arrangement or it may be assembled in a cigar-box with the "A" and "B" batteries being made up of flashlight batteries and inclosed in the cigar-box also. The author has built several of these sets and has yet to experience any difficulty in obtaining satisfactory results.
2A3's in class AB2, and put out about 30 watts undistorted, and as I recall, I had the gain up pretty high. It didn't sound loud in the garage.

Of course I turned it down as soon as my wife came in the little door holding her ears and wearing an agonized expression but three of the neighbors never did speak to us again. Loud? The police said they could hear it easily in the station house a mile and three-quarters away. A Scotsman called on us and thanked us for the concert but most of the people just don't appreciate bagpipes. Even yet.

I changed records and I turned it way down and then I listened. It was great—that's all—it was fine. I borrowed some equipment and the curves showed a noticeable improvement in the response except for one thing: The high frequencies seemed to be concentrated in a rather narrow beam, and even as much as 30 degrees off the axis would cause considerable attenuation of the "highs." We hung the mike about 10 feet away, in a direct line, over by the kitchen window, to get the curve shown. The other line is the response in a flat baffle with which I experimented after we were evicted from the house.

One thing seemed notable. The music sounded more natural. There was a clearer sense of reproduction throughout the range—even with records. This intrigued us and we looked further (while the landlord filled out papers). We found that it came out to harmonic distortion. A tone of 50-cycles had less apparent loudness with the big horn, than it had in the tuned box, and that puzzled us. We set things up to have the two units side by side, and keyed back and forth, and found a noticeable second and third harmonic in the tuned box, and a fairly pure tone in the horn. It was a true bass and a clean bass. I was about to make an exponential plug to insert in the horn to spread the high frequencies when we had to move again. We left the horn in the garage and the new tenant made a rabbit hutch out of it.

Of course, after that we didn't feel satisfied with a box, but we were tired of moving, and the size of a 50-cycle horn prohbits its use inside anything but a skating rink or a convention hall. We couldn't fold the horn (as they do in theaters) because then we would lose the high notes.

We fiddled around with flat baffles for a while in the new home. Tried various shapes and sizes, and came to the conclusion that there's not an awful lot to be done with a flat baffle. The larger it is the lower the response attained, but it's still not like a horn.

About then we got into some vital work for Uncle Sam and our experiments are strictly on war lines, but we have traded and managed to acquire the makings of a two-way system. At present it consists of a 15-inch Lansing cone speaker in a tuned box, and a Western Electric 555 driver with a 12-cell horn. The high unit has a cut-off of 750 cycles, thus indicating a crossover frequency of about 800 cycles. The fellow we traded it from considered it a fine unit but we have plans for after the war. We are going to build a folded horn for the low frequencies, and then by golly we'll be able to get the results we want in a living room—it'll just take up only one wall. At present we're stuck because we have a housing shortage in this city and are living in a trailer. Our only radio measures less than two cubic feet complete and at times we begrudge it that space. But after the war.

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Back the Attack—Buy More War Bonds

1943-1944 RADIO-ELECTRONIC REFERENCE ANNUAL
SOUND control apparatus developed at Stevens Institute of Technology has been used experimentally during recent rehearsal periods at the Metropolitan Opera, according to an announcement made last month by Edward Johnson, General Manager.

The experiments have been devoted primarily to creating acoustic conditions on the stage which are as satisfactory to the actor as the acoustic of the theater, to the audience. Through the use of several elements of this “Robeson Technique,” it is now possible for offstage choruses and upstage recording of the orchestra to be heard as easily as if they were standing by the footlights. Orchestral balance can be preserved backstage in a manner not possible by traditional methods. Acoustic conditions are being assisted by the use of the acoustic envelope announced recently at the Chicago meeting of the Acoustical Society of America. By the use of this technique, a singer on the stage is able to hear himself as if he were in a small, highly reverberant room. The audience is totally unaware that the Technique is in operation.

The experiments which have been in progress since October are being undertaken as a cooperative enterprise by the Metropolitan Opera Association, Stevens Institute of Technology, The Rockefeller Foundation, and Theatrical Protective Union Local No. 1. They are being conducted under the supervision of Harold Burris-Meyer of Stevens Institute of Technology, who pioneered much of the sound control technique now used in radio, motion pictures, concert and the legitimate theatre. The Robeson Technique has yet to be tried out for recording or radio but the desirability of its use seems probable.

Concert singers and instrumentalists perform by choice in small, highly reverberant rooms since in them they are able to hear themselves easily. However, they deplore the acoustic conditions of most large concert halls and auditoriums. The nature of the complaint is that the artist cannot hear himself.

The results of not being able to hear are the catalogue of the artist’s woes: inability to relax, a feeling of being ill at ease, of low vocal efficiency, forcing the voice in an effort to project, using a higher key than he had ever used before, that number in concert, “The enthusiasm of the artists who have tried it beats anything of the sort I have encountered,” comments Professor Burris-Meyer.

In spite of its small size, it is a surprisingly efficient little amplifier. While this set was built to work with an external loud speaker, one could readily be designed with a self-contained unit.

Amplifiers in concert halls bring their own problems, some of which are solved by this control method.

The first step in devising the system was to find out what it was about the acoustics of the small, reverberant room that was significant as far as the artist is concerned. It was found that the artist heard himself if he could perceive a difference in any characteristic of sound between the original sound as it leaves him and the reproduced sound as it comes back. It is the difference which counts.

Time differences are most useful. If the artist hears the reproduced sound later than the original one, he is perfectly satisfied that he is hearing himself, and he is able to do this even though the reproduced sound be of much less intensity than the original one. It seems entirely logical that time difference should be satisfactory since time difference is a characteristic of long reverberation or room resonance.

Time difference is achieved by placing a directional speaker 50 feet or more from the artist, or by pointing it at a surface which will reflect the sound to the artist so that the path from the speaker to the artist is more than 50 feet. See Fig. 1.

Low frequencies lack directional characteristics; they are not easily absorbed by wall surfaces or audience; and, when a footlight microphone is used, the system will pick up low-frequency sounds transmitted by the floor if the system responds to low frequencies. High frequencies from the orchestra, on the other hand, are directional enough to be kept away from the audience and are absorbed readily enough so that they are below background if they ever do get out.

The response curve is not particularly critical, and as shown in Fig. 2, is cut off below 500 cycles, has a flat peak at 2,000 cycles from which it drops off slowly, and is down 10 decibels at 6,000. Thus only the significant harmonics are projected to the artist.

The Technique is fully effective when the sound level, at the position of the artist, is not measurably affected by turning the system on or off. A level set well below the point of regeneration for the empty house is safe and more than adequate for the full house.

In the first concert in which the Technique was tried at Carnegie Hall, Mr. Robeson was able to sing “Water Boy” in a lower key than he had ever used before for that number in concert. “The enthusiasm of the artists who have tried it beats anything of the sort I have encountered,” comments Professor Burris-Meyer.

CALIBRATED UHF OSCILLATOR

(Continued from page 19)

Fig. 2. Frequency characteristic of equipment used in the Robeson Technique. Only “significant” frequencies are fed back to the performer. The selected frequency band constitutes a highly directional beam, at an optimum intensity level, which only the performer can hear.

Dial upon which you can mark the wavelength values. You could also plot a calibration curve (wavelength or frequency values vertically and dial-setting values horizontally, for example).

In Fig. 2, you will find the complete dimensions for the high frequency wave-meters. Build up some simple tuned circuits having shield front case and large plain 4-inch dial and the back open so you can couple small coil to oscillating circuit.

Fig. 3 shows the calibration curves. I took a lot of readings using one of these oscillators having parallel wires and plotted values all the way from 75 centimeters to 10 meters which took quite a little time. The results are shown in Fig. 3.

As an example of how to use the graphs of Fig. 3, the lines show that 80 mc. is found within a wire length of 2 ft., is used in each wire of the two parallel wires of the oscillating circuit. The wires in the oscillating circuit were always each of the same length, which is the basis for the curves of Fig. 3. If you don’t like “feet,” change it to inches by dividing a foot length line into twelve. Remember that 3.28 ft. is one meter. As another example of the use of the curves, in this case the other curve which uses the other two scales, the lines show 240 mc. at .35 ft. length for each oscillating circuit wire from right at the tube seal to the condenser terminals themselves.
A MIDGET AMPLIFIER
THE A.C.-D.C. "3-in-2"

The amplifier here described and illustrated fills a long-felt demand for a small, compact, economical unit, which can easily be constructed by any technician.

In spite of its small size, it is a surprisingly efficient little amplifier.

By utilizing 2 tubes whose filament voltages add up to 120 volts, ballast resistors are unnecessary. A single multiple condenser provides suitable bypassing in both the filter and cathode circuits. As the 70L7GT tube is a combined beam power amplifier and diode rectifier, it can be used as a combination voltage amplifier and power supply for the 50L6GT beam power amplifier. See the schematic diagram above.

The beam power section of the 70L7GT is used as a resistance-capacity coupled triode to drive the 50L6GT output tube, which is capable of delivering 1½ watts.

A constant-voltage, inverse-feedback circuit is employed through the use of one 50,000-ohm resistor, which is connected between the plate of the output tube and its triode driver.

By connecting a 0.003-mf condenser in place of the 0.25-meg resistor normally employed, the crystal pickup is dependent upon the load into which it feeds. When it is fed into a 1-megohm load, a 12-db. boost is available at 70 cycles. When it is fed into a 0.25-megohm load, its response is substantially flat from 70 cycles on to 6,000 cycles. As the volume is decreased, the 0.25-megohm shunt is gradually removed from across the pickup, so that bass boost takes place. At the higher levels, however, the 0.25-megohm shunt is across the pickup, so that normal response is encountered.

While this set was built to work with an external loud speaker, one could readily be designed with a self-contained unit.

A 0.003-mf condenser provides maximum high-frequency attenuation when connected from grid to ground of the output tube. The degree of attenuation is made available by utilizing a control in place of the 0.25-meg. grid-return resistor normally employed.

Here is a 2-Tube, Low-Power, Multi-Use Amplifier admirably adapted for low-level, high-fidelity phonograph reproduction, and for radio (receiver output) amplification.

That is why every one of the UNIVERSITY REFLEX SPEAKERS illustrated here are now being used by the ARMY - NAVY - AIR CORP and the leading DEFENSE FACTORIES in the U. S. A.

From the smallest to the largest every UNIVERSITY REFLEX SPEAKER has been specially designed to overcome every known type of difficulty or adverse condition.

The list below gives for some of the illustrated speakers a few of the specific and important applications on which enthusiastic reports have been received by us.

(1) Model 1B8... 10 watt "Booster" Speaker for Police Squad Cars also for Tank Intercommunication Systems and Defense Factory Paging.

(2) Model 2YH... "Baby Bull" 50 watt Radial Reflex Speaker for single speaker installation in Army Camps, etc.

(3) Model 2YH... "Baby Bull" 50 watt Reflex Speaker For Air Raid Alarm Sound Systems, For Airport Directional Systems used in talking directly from observer to plane.

(4) Model CR... 20 watt "Booster" Speaker, For Marine and Battle-ship use... For Marine Jeep Car Sound Systems (listening instruction).

(5) Model 1LH... 25 watt Radial Reflex Speaker... for combination paging and music installation in large Defense Factories.

The rest of the speakers illustrated are the standard line of UNIVERSITY Reflex Speakers and Driver Units.

For complete technical information on any defense application, write direct to engineering department.
It was desired to use the D.C. voltmeter with the galvanometer to form a slide-back A.C.-D.C. V.T. voltmeter, but it was necessary that this should not interfere with the use of the D.C. voltmeter for its normal function. Moreover, it was desired to use the D.C. voltmeter as an ohmmeter, a function it had not previously performed.

Also, it was necessary to build into the set a multipurpose circuit which would supply the ohmmeter as well as the V.T. voltmeter. Tubes, transformer, choke, condensers, meters, etc., would all have to go into the original case together with the voltmeter and milliammeter already described. The voltmeter, ohmmeter, and V.T. voltmeter circuits were worked out as shown in Fig. 3.

The ohmmeter circuit has three ranges: Low range, center-scale equals 10,000 ohms; medium range, center-scale equals 100,000 ohms; and high range, center-scale equals 1.0 megohm. As the meter scale is not calibrated in ohms, a table was prepared having four columns, the first giving meter readings from 1 to 100, and the other three giving the corresponding ohms for each of the three ranges. The second ranges are "parallel ohmmeter" circuits, and as the resistances to be measured are thrown in parallel with (1), the twenty-ohm meter, or (2), the 10,000 ohm resistor of the 10 volt scale, the numbers in the first two "ohms" columns were determined by use of the formulae (1) and (2).  

\[ Rx = \frac{100}{ \text{reading} } \]  

The third range is a "series ohmmeter" circuit; in this case the resistance to be measured is thrown in series with the 100 volt supply, the 100,000 ohm resistor of the voltmeter, and the 1 ma. meter. "Ohms" values in the high range column were determined by use of the formula:

\[ Rx = \frac{100,000}{ \text{reading} } \]

In practice the ohmmeter is used as follows: Sw. 2 is thrown to position 3, and Rf is adjusted for full scale deflection of the meter. For low and medium ranges, the resistance to be measured is connected across the meter, or the 10 volt range, respectively, and the reading on the 100 scale noted. A glance at the table (which has been glued on the side of the case) reveals the corresponding ohms resisting in the circuit. For the high resistance range, the adjustment to full scale deflection is made as before; Sw. 2 is then thrown back to position 2, and the resistance to be measured is connected across the pin jacks provided for this purpose. By approaching to within 5% of scale length to the end of the scale, readings from 1 ohm to 2 megohms may be made. Ohmmeter accuracy depends on the same factors as does voltmeter accuracy, but also it becomes rapidly more difficult to read the ohmmeter properly as departure from center scale. On this basis, this should be a more than ordinarily accurate ohmmeter.

**SLIDE-BACK V.T. VOLTMETER**

If you like the slide-back type of V.T. voltmeter this circuit may please you. It will be noted that Rm, the zero-adjustment resistor of the ohmmeter circuit, also serves to supply the balancing voltage to the grid in the V.T. voltmeter circuit. With Sw. 2 in position 1, the balancing voltage applied by Rm may be used on the D.C. voltmeter. The V.T. voltmeter is used as follows: With Sw. 2 in position 1, and with Rf set to zero, the galvanometer is balanced by means of Rm. Test prods are applied to the voltage to be measured. Rf is adjusted to bring the galvanometer back to zero; the value of the balancing voltage may then be read on the D.C. voltmeter.

In the V.T. voltmeter circuit, Sw. 1 is a D.P.S.T. switch used for changing the input circuit for use on A.C. or D.C. This switch is in the circuit in which a considerable difference of potential exists between the plate and cathode voltages, and A.C. voltages of audio frequency only can be measured in this way. Also, for D.C. voltages, the test prod, which connects to the grid of the 24A, must be applied to the positive side of the voltages to be measured; this is because the balancing voltage is in the form of a negative grid bias, and can only be used to balance a positive voltage.

As the diagram shows, access to the V.T. voltmeter may also be had by means of ordinary test cords. The "tube on cable" method may be used when the only available source of potential is a few volts D.C.

The balancing circuit is a simple bridge, in which Rm is the 30 ohm rheostat of the 10 volt scale, the 200 volt scale, the 1000 volt scale, and the 2000 volt scale of the V.T. voltmeter. The grid is connected to one side of the grid circuit, and the other side to the voltage to be measured. The balancing voltage is applied to the grid of the cathode tube by means of plug and shielded cable. It should be noted that in using this balance circuit, the unknown voltage is always that applied to the grid of the tube. The grid voltage is then obtained by subtracting the balancing voltage from the grid voltage of the tube.

The balancing circuit is a simple bridge, in which Rm is the 30 ohm rheostat of the 10 volt scale, the 200 volt scale, the 1000 volt scale, and the 2000 volt scale of the V.T. voltmeter. The grid is connected to one side of the grid circuit, and the other side to the voltage to be measured. The balancing voltage is applied to the grid of the cathode tube by means of plug and shielded cable. It should be noted that in using this balance circuit, the unknown voltage is always that applied to the grid of the tube. The grid voltage is then obtained by subtracting the balancing voltage from the grid voltage of the tube.

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IMPROVED EXPANDER - COMPRESSOR

(Continued from page 51)

limits of the control you will find that expansion or compression is quite great. As a matter of fact, it is possible to over-compress; take care to prevent distortion.

PARTS LIST

Knight Parts:
1 - Power transformer, sec. 650 V. A.C. at 40 ma., C.T., 5 V. at 2 A., 4.2 V. at 16 A.
1 - Filter choke; 25 hy. at 21 ma., 850 ohms
1 - 8 mf., 400 V., upright electrolytic
1 - 450 V., tubular electrolytic
1 - 25 mfd., 22 V., tubular electrolytic
1 - 0.05 mfd., 400 V., tubular paper condenser
1 - 25,000 ohm, 1 watt, carbon resistor
1 - 500,000 ohm, 54 watt, carbon resistor
1 - 25,000 ohm, 1/2 watt, carbon resistor
1 - 500,000 ohm, 1/2 watt, carbon resistor
1 - 1 megohm, 54 watt, carbon resistor
1 - 500 ohm, 1 watt, carbon resistor
1 - 100,000 ohm, 1/2 watt, carbon resistor
1 - 3,000 ohm, 1/2 watt, carbon resistor
1 - 100,000 ohm, 1/2 watt, carbon resistor
1 - 250,000 ohm, 1/2 watt, carbon resistor
1 - 1 megohm, 1/2 watt, carbon resistor
1 - Olympic wafer sockets
1 - 4-prong wafer socket

I.R.C. POTENTIOMETER:
1 - 1 megohm, C.T.-VC-539X

H. & H. TOGGLE SWITCH:
1 - S.P.S.T. line switch

Miscellaneous:
1 - Knob for potentiometer
1 - Jewelled type pot. socket and 6.3 V. bulb socket
1 - Line cord and plug
1 - Insulated pin jacks
1 - Plain binding post
1 - 25MM, 400 V., tubular paper condenser
1 - 250,000 ohm, 3 watt, carbon resistor
1 - 20,000 ohm, 1/2 watt, carbon resistor
1 - 500,000 ohm, 1/2 watt, carbon resistor
1 - 40,000 ohm, 1/2 watt, carbon resistor

TWO-BY-FOUR RECEIVER

(Continued from page 29)

the microtubes. A bead to one side of the tube's terminals should be used as a guide for the bending of the wires. The wire nearest the bead is the No. 1 terminal, as can be seen from the illustration, which in addition shows the actual size of the microtube when compared to an average small-sized paper clip.

Two L brackets fastened to the sides of the case serve as "stops" to hold the B battery in place. The battery has snap-on terminals, and the wires are electrically connected to the L brackets. Thus the front panel can easily be removed by loosening two 6-32 1-inch long screws, which in addition disconnect the B battery for replacement.

The back cover is a thin piece of Bakelite cut to fit snugly so it will snap into place.

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by GEORGE F. MAEDEL, A.B., E.E.
Chief Instructor, R.C.A. Institutes

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(329 pages)

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Page 43
A NEW COMPACT HEARING AID

(Continued from page 71)

taken from an old carbon hearing-aid. The receivers on these old instruments are fairly good, even when the rest of the old instrument is plain junk. Ten ohms output winding on the transformer will match practically any of them; with the exception of one make, which requires a higher impedance of 200 ohms.

For all crystal phones, including the miniature, the output chokes listed should be used.

If desired, one can make room for a tone control in this hearing-aid by using a "Half and Half" telescoping tobacco tin, and expanding the two halves enough to make room for the other control. In this case the cords are brought in through small holes drilled in the top wherever possible. This control would be ½ megohm, wired in series with the crystal receiver.

Considerable variation of tone may be had by selecting the proper choke, and by the usual tone control methods of series resistor and shunting condensers.

If the user does not require the maximum volume of the instrument, the inverse feedback arrangement is very satisfactory.

Figure 8 shows how to adapt a cheap two-cell flashlight case to use one cell from a Burgess 4 FH 1.5 volt battery. These cells, of which there are four in each battery, make an inexpensive and durable "A" supply.

The writer has had the personal experience of being utterly unable to reconcile his hearing needs with any audiometer chart. My hearing test chart shows excessive loss of high frequencies; yet, any attempt to emphasize the highs, and thus (according to audiometer theory for fitting hearing- AIDS) replacing the loss, invariably caused me dissatisfaction and no noticeable increase in intelligibility. The high pitched sounds, even though made very loud, do not seem clear, and cause me annoyance by interfering with the lows, which I do understand. Therefore, in my opinion, if a serviceman adjusts the tone of an instrument to make it agreeable and comfortable to the user, he is doing all any one can do for the user.

HOW TO FIND CUSTOMERS' NEEDS

The best way to learn the requirements of a prospective customer is to have a couple of sets made up, with tone control, to be used by the customer for a day or two. If the customer wants a set with tone control—very well—it adds a profit for you, but it won't be used much after the first month.

No large line-operated hearing-aid should be supplied with more power output than two type 6C5 tubes in push-pull, unless an automatic volume control is used.

Briefly, hearing- aids represent a nice business, and price competition is not desired by anyone but the hearing-aid user; licensing would be a neat way to shut out the radio serviceman.

The Astatic Model 218 is a good choice when the customer is extremely hard of hearing, or for bone-conduction sets.

Parts List

RESISTORS

One-1.R.C. ½-W., 10 megs.
One-1.R.C. ½-W., 2 megs. (for feedback, if desired)
Two-1.R.C. ½-W., 3 megs.
One-I.R.C. ½-W., 1 megs.
One-I.R.C. ½-W., 2 megs.
One-I.R.C. ½-W., 10,000 ohms.
One-I.R.C. ½-W., 1,000 ohms.

CONDENSERS

Three-Cornell-Dubilier, ½ mf., 200 V., paper.
Two-Aerovox, .01 mf., 200 V. "Postage Stamp" size mica condenser.

MISCELLANEOUS

One—"Pipe Tobacco" tin.
One—Astatic Microphone Co., Model L-1 (Crystal) microphone (with three-foot cord), or Model 218 for bone conduction instruments.
Optional—Share Bros. No. 74-B Lapel Mike.
One—Brush Development Co., A or B Crystal microphones.
One—Goldmine Corp. of America, D.P.S.T. Slide Switch.
One—2-Cell Flashlight Case.
One—4 FH 1.5 Volt Dry Battery (contains four cells, for feedback).
One—Eveready Hearing-Aid Battery No. 455 and connectors, 45 Volt.
Two—RCA Radiotrons, 155.
One—RCA Radiotron, 3Q4.
One—Cornell-Dubilier "Beaver" Dry Electrolytic, Capacity 8 mf., 150 Volts.
One—Cornell-Dubilier "Beaver" 10 mf., 25 Volts.
when it is desired to use the power supply for other purposes without the load of the receiver, the shorting jumpers on the chassis will impress the filament winding. The filament and the "B" voltages of the tracer are switched by means of a D.P.S.T. switch on the 500-ohm, 0.05-mfd, volume control.

In order to secure maximum R.F. gain, the plate resistor of the 6K7 should be 2400-ohms, and the screen resistor 0.1 megohms. The coupling condenser should not be over 100 mmfd. Use a bias cell or a small flashlight battery in the grid lead of the 6SQ7 at the volume control end. Don't forget to include the .001-mfd, condenser from 6SQ7 plate to ground, or the 0.005-mfd. This condenser from plate to cathode of the 6C5, or serious feedback trouble will be encountered. The grid lead of the 6SQ7 should be shielded with "snakeskin", as this is a high-gain tube.

The signal tracer may be tested when complete by connecting a tuning condenser with coil and aerial and ground to the 6K7 input. The grid should come in very loud and clear. When used to check a receiver, the chassis of the signal tracer should be grounded and connected to the receiver under test. It is not necessary or advisable to use coax-axial cable for the R.F. test lead. Use an ordinary test lead, but no longer than two feet. The shorter the better. As long as the bakelite handle of the test lead is grasped, and not the wire itself, the circuits under test will not be thrown out of tune sufficiently to be noticeable. A very small condenser, however, must be used on the end of the test prod itself.

Turn up the gain control of the signal tracer to about half-way, and hold the test prod to the input grid of the receiver under test. Tune-in a local station, or signal generator, on the set under test. When the signal is tuned-in it should be quite audible in the headphones. Proceed from grid to plate on through, noting gain if any, until the I.F. stage is reached. At this point it is advisable to use the small condenser from plate to cathode of the 6C5, or serious feedback trouble will be encountered. The gain control will quit coming through when the dead spot is reached. When making an R.F. search, always be sure to use the small condenser on the end of the test lead and not a resistor, because if the latter is used, very feeble audio currents if they exist anywhere in the chassis will feed through and be amplified and confuse the search.

If it is desired to check the second detector with any R.F. amplification obtained from the signal tracer, connect the test prod to the chassis as near it as possible and then turn up the gain control of the signal tracer. If the chassis is shielded with "snakeskin", as this is a high-gain tube, the signal will quit coming through when the dead spot is reached. When making an R.F. search, always be sure to use the small condenser on the end of the test lead and not a resistor, because if the latter is used, very feeble audio currents if they exist anywhere in the chassis will feed through and be amplified and confuse the search.

For audio frequency and hum search, connect the test prod to terminal No. 3, and use a 50,000-ohm resistor on the end of the test prod. As very high voltage-amplification is secured, a piece of shielded crystal micro-phone cable with the shield grounded to the chassis of the signal tracer should be used. This cuts out hum and other stray signals so well that it is well worth the trouble of making up this kind of a lead. In making this test it will be found very easy to trace down sources of hum. With the gain control turned all the way up, hum will be indicated with just actual hum reaching to the source of trouble, by just bringing the test prod near it.

Connecting terminal No. 4 to the A.V.C. circuits will provide the use of the GES for alignment purposes and to check voltages, etc.

A.C. continuity checks may be made with test leads at terminals Nos. 6 and 12, with a jumper between 7 and 11. Remove the ground connection between the signal tracer and the chassis under test.

Condenser leakage tests may be made with prods at 8 and 12, with jumper between 14 and 11 for 250-300 volts D.C.; or test prods at 9 and 12 for 110-volts D.C. Be sure to include sufficient resistance in series with the neon lamp before testing with voltages over 115 volts.

If an audio-frequency signal is desired to test out an amplifier, this may be generated by connecting the jumper between the headphones output terminal and terminal No. A. Adjust the gain control until the desired tone is secured. The output may be had by connecting to terminal No. 3. This will give the audio-frequency voltage through a 0.01-mfd. condenser.

MINIATURE A.C.-D.C. POWER PACKS (Continued from page 30)

made to only these elements.

To operate the receiver on A.C. the four-contact plug is plugged into the receiver, and the A.C. plug is connected to the 115-volt A.C. 60-cycle supply, and the set will operate when the cover is opened (It contains the "on-off" switch.) provided, of course, the power switch on power supply is closed, and selecting the right time interval during which the rectifier tubes are heating up, the set will be operating on batteries with some distortion as the 800-ohm hi-fidelity tone is used in the receiver. The 65-ohm section of the voltage divider in the power supply. However, as soon as the power supply takes over, the volume and tone will improve considerably better than when set is operated on batteries.

A 5000-ohm variable resistor is shown in the power supply; this, however, is to adjust the plate voltage so that it will be exactly equal to the "B" battery voltage, in order that no current will be drawn.

To adjust this resistor, remove the B+ lead on the "B" battery and connect a 0 to 15 MA meter in circuit, then adjust the variable resistor until meter reads 0; now remove meter, reconnect B+ lead to "B" battery, and adjustment is finished.

When it is desired to use the radio as a battery-operated portable, the 4-contact plug is pulled out of the set and the receiver is ready to play anywhere on batteries.

The writer has used this outfit for over 10 years improving and perfecting the famous Loftin-White circuit.
If increased volume is required, turn the volume control until the quality clears. Such as actual transmitters, if distortion is not capable of 100% modulation, over-modulation.

Crystal pickup is that of guarding against frequency from shifting under modulation, that is, preventing the oscillator from drifting in frequency, or preventing the frequency from shifting under modulation, will improve results. The simple means of tuning the plate winding of the coil instead of the grid winding is usually sufficient.

One precaution that must be observed when using any phono-oscillator with tor circuits. In general, we want a simple oscillator circuit which will radiate a weak signal in the broadcast band. While frequency instability is not a serious factor in the average phono-oscillator, we should not overlook this point altogether. Any simple means of increasing the stability of the average phono-oscillator, we should not be fitted into individual phonograph record-players. The completed assembly may then present the exterior appearance of the unit shown in photo F.

LIST OF PARTS

This point is shown in photo F. The diagram shows the end view of the coil, the side view of which looks just like an I.F. transformer without the shield can.

All of these phono-oscillators are available in kit form and with complete instructions for home assembly. A complete parts list for the unit shown in Fig. 5 is given below. All of these phono-oscillators may be fitted into individual phonograph record-players. The completed assembly may then present the exterior appearance of the unit shown in photo F.

LIST OF PARTS

**RESISTORS**

- 1-8 mfd. 250 volt electrolytic
- 2-50,000 ohm potentiometer
- 2-20 megohm 1/4 watt carbon
- 3-400 ohm 10 watt adjustable (adjust to 380 ohms)
- 1-100 ohm 1 watt

**MISCELLANEOUS**

- 1-Amphenol octal socket
- 1-Amphenol 4-prong plug
- 1-50,000 ohm potentiometer
- 1-S mfd. 250 volt electrolytic
- 3-Magneto coil for tent poles
- 1-100 ohm 5 watt
- 1-400 ohm 10 watt adjustable (adjust to 380 ohms)
- 1-100 ohm 1 watt

**TUBES**

- 1-Ceratron CE-T gas-filled, cathode photo-cell
- 1-Knight 50LG6
- 1-Knight 50LG6G
- One, 50,000 ohms, 1/4 watt
- One, 1,500 ohms, 1/4 watt
- One, 280-ohm line cord with built-in antenna
- Two, 6 mfd., 150-volt tubular electrolytic
- Three, 1 mfd., 400-volt paper tubular
- One, 50 mfd., mica

**CONDENSERS**

- One, 6 mfd., 150-volt tubular electrolytic
- Three, 1 mfd., 400-volt paper tubular
- One, 50 mfd., mica

**MISCELLANEOUS**

- One, 6-prong wafer socket
- One, octal wafer socket
- One, Knight No. N2292 drilled chassis
- One, Knight No. 2279 oscillator coil with trimmer
- One, Knight No. N2294 package hardware
- One, 6A8 tube
- One, 2625 tube
- One metal tube grid cap
- One, S.P.S.T. toggle switch
- One, input jack strip marked Phono

**HOW TO BUILD PHONO OSCILLATORS**

(Continued from page 27)

<table>
<thead>
<tr>
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**MISCELLANEOUS**

- 1-Amphenol octal socket |
- 1-Amphenol 4-prong plug |
- 1-50,000 ohm potentiometer |
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**TUBES**

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- 1-Knight 50LG6G |
- One, 50,000 ohms, 1/4 watt |
- One, 1,500 ohms, 1/4 watt |
- One, 280-ohm line cord with built-in antenna |

**CONDENSERS**

- One, 6 mfd., 150-volt tubular electrolytic |
- Three, 1 mfd., 400-volt paper tubular |
- One, 50 mfd., mica |

**MISCELLANEOUS**

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- One, Knight No. 2279 oscillator coil with trimmer |
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| 1-Knight 50LG6 |
| 1-Knight 50LG6G |

**HOW TO BUILD PHONO OSCILLATORS**

(Continued from page 27)
the connections of the lamp, and placing these near each pad. Thus the lamp replaced the patient. Use a 100 watt bulb.

The pads are made of spring brass covered with 1/16" thick white felt (sewed) this being covered with rubberized cloth (also sewed). Plugs are provided at the end of 4 ft. rubber-insulated cords, which connect to jacks which are completely insulated from their mounting panel. This insulation is important to avoid an R.F. burn when plugging in or out. Various sized and shaped pads can be made for different treatments if desired. The pads shown in the sketch are good for general use.

Diathermy machines have a tendency to interfere with short-wave reception in their immediate vicinity. This one does not have any effect whatsoever on the broadcast bands. If it is found that interference is being caused, put an R.F. filter choke in the power cord input at the machine. (Ohmite makes one especially for this job.) If some interference is still found to he caused it will be necessary to shield the room in which the machine is used.

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of the battery through the 1,500-ohm variable resistor, through the fixed 2,000-ohm resistor, through the meter, and out the negative terminal. To and through the resistor to be measured. Then back to the positive D.C. pin jack and through point 6 on the gang-switch, to the negative end of the battery.

The medium range was made by shunting a resistor of slightly more than 300 ohms (made from the old Davohm) across the variable and fixed resistors and the meter. Now the current has two paths, the same one as before, and a new one—through the shunt, through the resistor under test, and back to the battery. By carefully removing turns of resistance wire from the shunt till it reaches the right value, the medium-ohms scale can be made to fall right on top of the high-ohms scale; 1,000 ohms on the medium being the equivalent of 10,000 on the high. Nine-tenths of the current from the battery goes through the shunt and the unknown resistor, and only one-tenth goes through the circuit with the meter in it.

**The Shunt Ohmmeter**

Low-ohm resistors are measured across the pin jacks at the top of the instrument. These are connected direct to the positive and negative terminals of the meter. The D.C. positive and negative pin-jacks are short-circuited and the zero adjustment made with the 1,500-ohm variable resistor. Then the unknown low-ohm resistor is connected to its jacks.

The meter is a shunt-type instrument when used on this range, and the readings are in the opposite direction from those of the high-ohm and medium-ohm ranges. The low-ohm range was calibrated in a few minutes with the help of a decade box with resistors from 1 to 1,100 ohms, in 1-ohm steps.

These two terminals are also used for the 1.5-ma. scale. To avoid possible accident, the switch may be turned to one of the high-voltage scales during measurements on this range. Points 8 to 11 on the gang switch are milliamperes ranges. The internal resistance of this meter is 60 ohms. This was discovered by setting the meter to full scale with the help of a variable resistor and a dry cell, then shunting various resistances (from the decade box) across the meter terminals till it dropped to half scale. Since half the current is flowing in each circuit, the external resistor must be equal to the resistance of the meter, and the external resistance read 60 ohms.

To get a reading of 15 milliamperes we need 10 current paths, each one with the same resistance as the meter. Then one-tenth of the current, or 1.5 ma., will flow through the meter and the other nine-tenths will flow through the external shunt. In other words, to get a 15-ma. reading (or to multiply the meter range 10 times), we have to have a shunt 1/9th the resistance of the meter. To multiply the meter range 100 times, the shunt would have to be 1/99th of the meter resistance, etc.

Our 15-milliamperes shunt, by this calculation, had to have a resistance of 60 ohms. The 75-milliamperes shunt (1/49th the resistance of the meter) was roughly 1.2 ohms. These were cut to the approximate size from a spool of fine nichrome, and adjusted to the proper size by twisting the nichrome wire to the termination. If this is done the nichrome will have great difficulty in getting away.

One of the pin jacks at the top was originally connected to the top A.C. terminal through a cap and used for output measurements. The output meter was abandoned in favor of the low-ohm range. When used with the present voltmeter and used for the A.C. range, the switch set for the A.C. range which gives the best results.

The only change necessary to adapt this multitester to a 1-ma. meter is to use a 3-volt battery in the ohmmeter instead of the present 4.5 volt one, or to increase the total resistance in the ohmmeter circuit from the present 3,000 ohms to 4,500, 500-milliammeter shunts have to be adjusted to the internal resistance of the particular meter. If used with the present voltmeter resistors, the top voltage reading will be 500 volts instead of 750 volts, and so on down the lower ranges. There is no reason why a 2-ma. meter should not be used, with slight changes to suit the user.

It will be noted that no marks were made on the scale of the meter. It is marked with only one range—0 to 1.5 milliamperes, calibrated at 0.1, 0.2, etc., milliamperes. For the 1.5, 15 and 150-volt or milliamperes scales, the reading is direct. Readings are multiplied by 5 for the 7.5, 75 and 750 scales and doubled for the 300 (milliamperes) scale. The same is true of ohms. A chart giving the ohms for each milliamperes reading on the scale is attached to the bottom of the meter. This is good for the high- and medium-ohms scale. The low-ohms scale, not so often used, is kept on a piece of paper in a drawer. A typewritten chart was found more convenient than a graph.

Attached to the bottom of the meter is a short shunt, giving the range of the setting of the switch. Probably it would be much better to have the switch-plate engraved, but as stated at the beginning of the article, this is a genuine junk-box set.
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