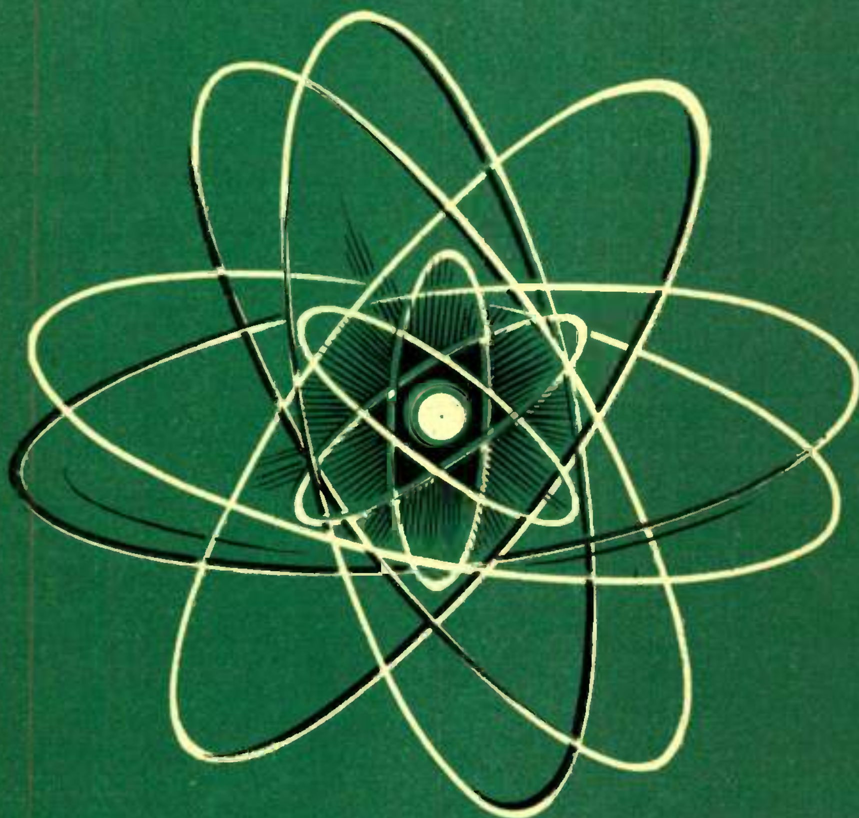
[redacted]

RADIO-ELECTRONIC REFERENCE-ANNUAL



1944

PUBLISHED BY

RADIO-CRAFT

RADIO-CRAFT
25 WEST BROADWAY
NEW YORK, N.Y.

Voice communications on every front...

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

Available from stock, 1700U series microphone. Single button carbon type, push-to-talk switch, etc. For trainers, intercommunication and general transmitter service.

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.

UNIVERSAL MICROPHONE CO. LTD.

INGLEWOOD, CALIFORNIA

FOREIGN DIVISION, 301 CLAY ST., SAN FRANCISCO 11, CALIF. • CANADIAN DIVISION, 560 KING ST. W., TORONTO 2, ONTARIO

1943-1944

Radio-Electronic REFERENCE ANNUAL

CONTENTS

SECTION I
POPULAR ELECTRONICS

SECTION II
USEFUL ELECTRONIC DEVICES

SECTION III
SOUND AND RECORDING

SECTION IV
TEST INSTRUMENTS

SECTION V
RADIO CONSTRUCTION

SECTION VI
SERVICING

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

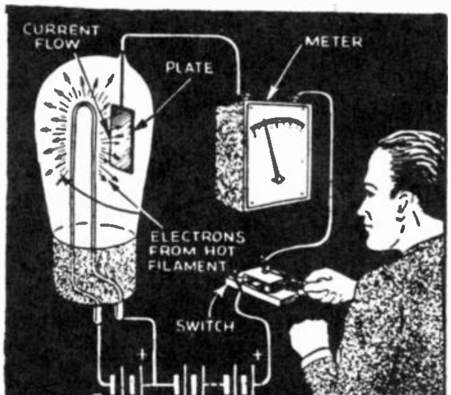


FIG. 1

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 currents we use in such terms.

However, the electron is a very real thing and its mass and charge were accurately measured by scientists many years ago.

In addition to the extremely small charge it carries, the other unusual property of the electron is the enormous speed at which it can travel under proper conditions; a speed that can approach that of light. Here again, we do not express this speed in such terms as miles per hour because the number of zeros after the figure would make it too bulky to use. Instead we speak of the voltage used to accelerate the electrons.

Now, let's go back to the idea of free electrons, because that is important. Until scientists created the so-called vacuum tube for these electrons to perform in, they were not free to be moved about as desired and their interesting and useful properties could not be studied and used.

(Right here, let us bring up the point that the words "electron tube" and "vacuum tube" are used to describe the same device, it being a matter of personal preference which term is used.)

What goes on inside a high-vacuum electron tube depends on two basic components. The first is some source of free electrons and the second includes elements so that the motion of the electrons can be definitely guided. Fig. 1.

The first we can liken to heating water to the boiling point to liberate steam. Heating a metal red hot liberates electrons from the surface in somewhat the same way.

Now, if that red-hot piece of metal is inside of a highly evacuated bulb, then this cloud of electrons coming out from the surface is very mobile.

Then comes the second step. You have all noticed that, when a comb becomes charged electrically, it will attract dust and bits of paper. In a similar way, the liberated cloud of electrons may be caused to move toward a positively charged terminal placed inside the bulb. Therefore, electrons pass from the hot plate, which is called a cathode, to the positively-charged cold plate, which is called an anode, and the resulting continuous transfer of electrons constitutes a flow of electric current.

If this were all there was to the matter, one might well ask, why all this complication simply to provide a flow of electric current when an ordinary piece of copper wire might accomplish the same purpose? The answer is that this electronic method of conducting electric current offers possibilities of controlling the current 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 getting the electrons out of the metal and the second is getting them across the space to the other electrode. It is only during this second step, their trip across the space, that they are subject to control by additional electrodes.

Because such a huge number of electrons are required to carry an appreciable amount of current and because they move so rapidly, the flow of current through the tube can be subject to variations of an extraordinary degree as regards speed and nature of the variation.

This means that, if a wire carrying a small current is cut and this elementary vacuum tube is inserted in this gap in the circuit, you have great opportunities for unusual control of current in that circuit. When I say, cut the wire and insert the tube, I mean that one of the free ends 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. Fig. 2.

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 "no" 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

(Continued on page 42)

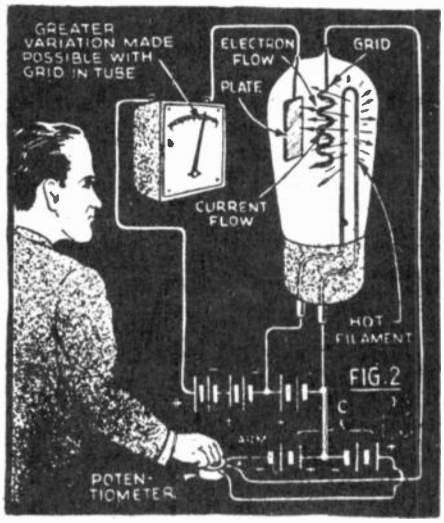


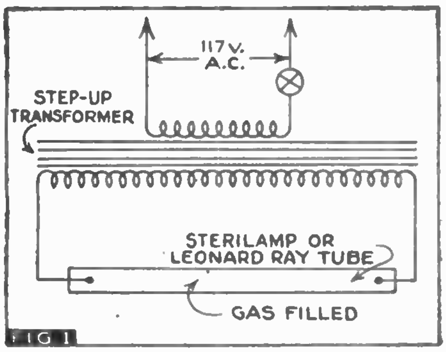
FIG. 2

*Engineer in Charge, General Electric Electronics Laboratory, Schenectady, N. Y.

ELECTRON-TUBE OPPORTUNITIES

A New Field for the Progressive Serviceman

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.



Basic circuit of the Sterilamp, the widely used bactericide.

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.

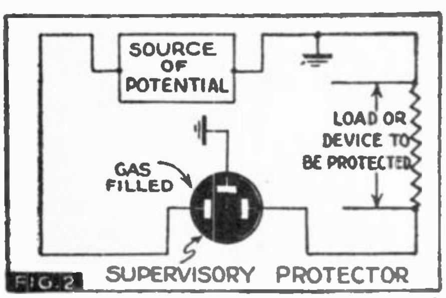
Possibly some radio men have been frightened away by such names as *Sterilamp*, *Thyratron*, *Grid-Glow*, *Supervisory Protector*, *Ignitron*, *Leonard Ray* and *Phanatron*. Perhaps others felt that circuits involving these vacuum tubes require an engineer for installation. Heretofore this lassitude 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

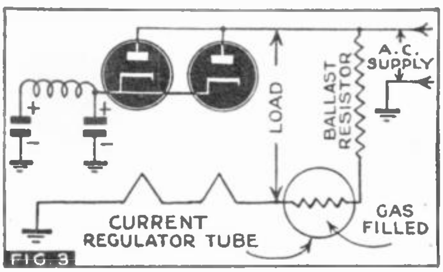


Hook-up of a supervisory protector.

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 shrinkage, 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.



Current regulator tube stabilizes heater potential when A.C. supply fluctuates.

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.

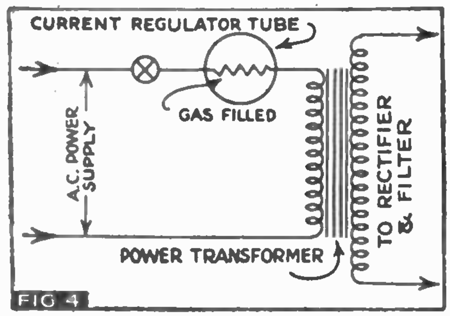
Sterilamp's life-saving potentialities make it A1 material for active military service. Install it in barely equipped combat hospitals, and slice the startling mortality from infection of the last war, to a minimum.

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 radioman'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 forecasts 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,



Current regulator used to stabilize power supply input voltage.

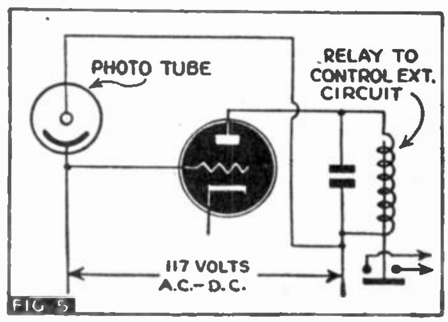
fruit flies, locusts and house-flies can be electrocuted instantly when they pass through the beams from this tube. The radioman can commercialize the Leonard Ray with installations in hot-houses, food-markets and other places where disease-carrying insects are likely to do considerable damage.

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



Phototube controls a relay circuit.

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 following article describes the new and remarkably ingenious Solovox, invented by Laurens Hammond who created the Hammond Organ and the Novachord, and tells how this 14-tube device may be used as an electronic musical supplement to any piano.

◄ The photos at left illustrate various elements of the Solovox. At A, the attachment in use on a grand piano, a set of 12 control tablets giving any piano an indefinite variety of tone colors that simulate the organ (Note individual volume control.); B, close-up of upper portion of the Solovox showing how the control tablet add-on device is tilted to produce a desired effect; C, the Solovox keyboard being attached to the piano keyboard by thumbscrews.

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 cascaded 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 possible frequencies (one 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-TENOR-CONTRALTO-SOPRANO" controls are employed.

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.*

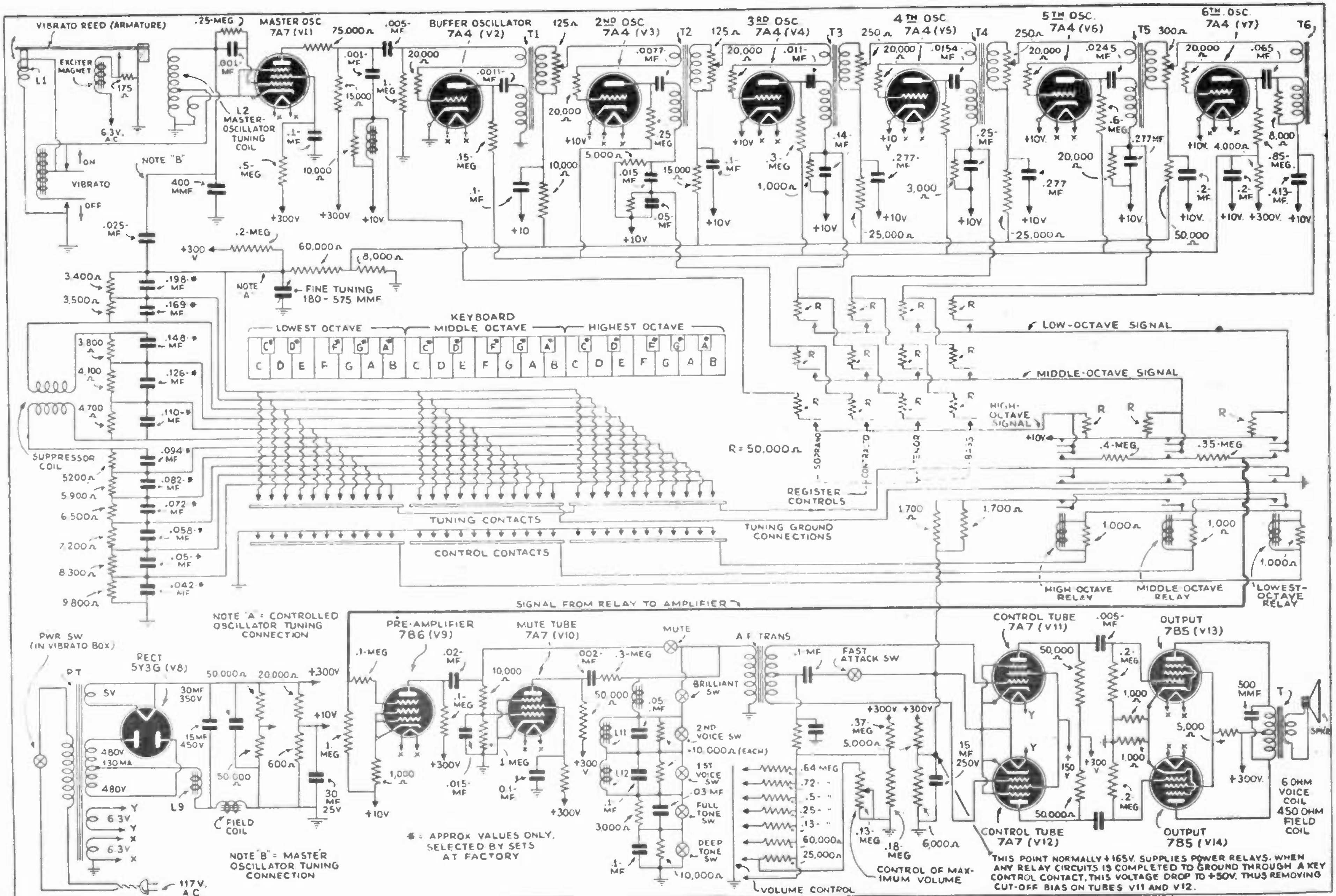
USES

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.

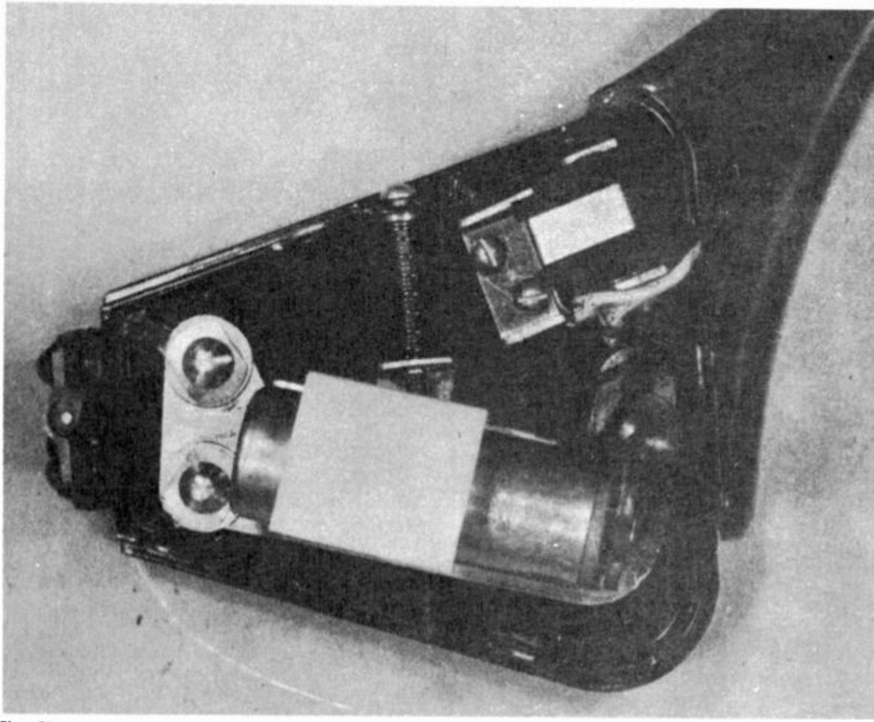
(Continued on page 57)



Diagram, model J Solovox. Following are circuit notations, including omissions, not located in time for inclusion in the diagram. Tube V9 (7B6): consider the grids, connected to the cathode, as diode 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, 0.4-meg.; V10 S.-G. filter 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; ditto, 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 fed by a radio-frequency current is reflected from a mirror, about 1/4- x 3/8-in. high, and paper-thin to a selenium "electric eye."

THE basis of 5 important advantages in the reproduction of recorded music, speech, etc., has been found in the use of a new "Electric Eye" Pickup in which a weightless ligntbeam reflected from a featherweight, vibrating mirror, acts to generate a comparatively strong current in a light-sensitive cell.

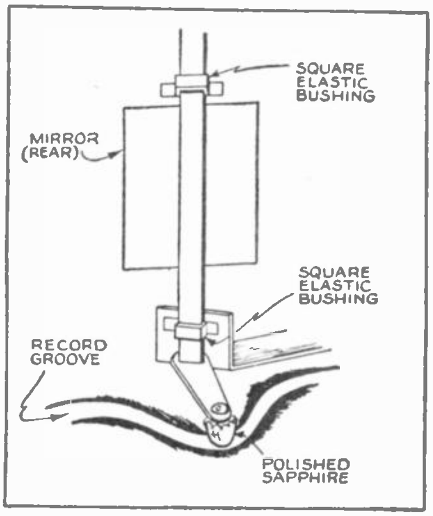
These advantages are the following: (1) elimination of the necessity of frequently changing a needle; (2) record life increase of at least 10 times; (3) greater reproduction fidelity, especially in respect to cleaner bass notes and clearer high notes; (4) greater volume and tonal range with obviously 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,



The rounded sapphire tip, which supplants the usual, less-unyielding steel needle, rides in the record groove with a pressure said to be only about 0.9-oz.; its side-to-side motion in a lateral-cut record groove wobbles the mirror at audio frequency (*and can be operated into the supersonic region, it is said), the resulting changes in light intensity on the light-sensitive cell generating a voltage which is then amplified.

*A laboratory worker is said to have obtained response out to about 28,000 cycles by resting the sapphire on a crystal speaker driven by a beat-note oscillator.—Editor

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,* acoustical 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 silvered 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.

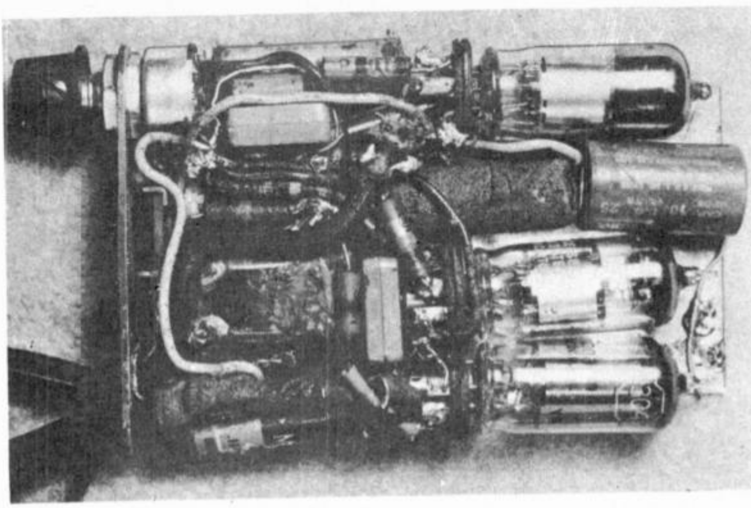
To meet technical requirements as to size and weight a tiny bulb filled with *argon gas* to lengthen the life of the filament was designed—the first of its kind commercially produced to have the refinements of the regular high-powered domestic bulb.

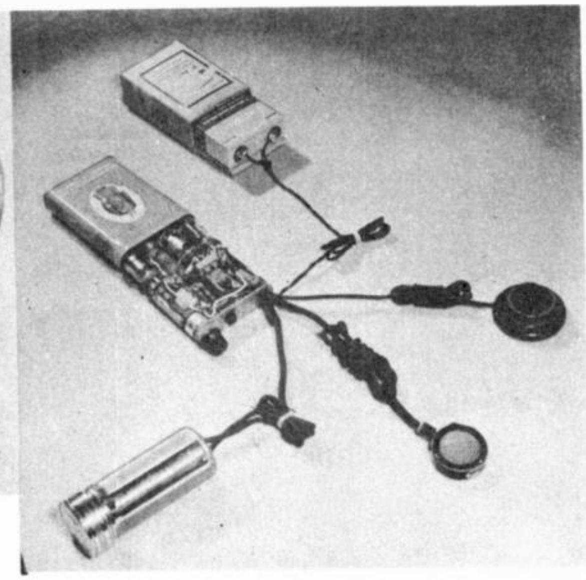
It was also necessary that the beam of light at its source have no waver or flicker as this would register on the sensitive photoelectric cell in addition to the music and result in a hum in the loudspeaker. Consequently, the household alternating current which operates the radio-phonograph had to be transformed into a steady flow of light by an oscillator which generates high-frequency currents, stepping up ordinary domestic A.C. from 60 cycles to 1,800,000 cycles (1.8 mc.).

In this same connection—to insure a steady and unvarying flow of light—it was necessary to build the filament supports in the little bulb in the photoelectric reproducer of extra heavy wire to minimize any shaking on the part of the filament. Otherwise the musical reproduction would be marred by microphonic howl or noise generated by the flickering beam of light.

Still another problem solved by the engineers was to cover the entire range of

(Continued on page 37)





Two photos above show chassis and also exploded view with mike, batteries, crystal microphone and lightweight crystal earpiece

A NEW COMPACT HEARING AID

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 hearing-aids; particularly those to be worn on the person. However, hearing-aids are a necessity, and a lucrative business. Therefore, the serviceman should inform himself of the essential facts of the business, and take his rightful place in this field. These facts are as follows:

(1) An instrument will not restore the easy and quick perception associated with normal hearing and an active mind, so don't be discouraged if a customer doesn't understand everything said to him immediately.

(2) The instruments overload easily, so don't try to demonstrate *full power* in a noisy place or with radios on loud.

(3) The receivers must be of the best quality, sensitive, and fit the ear absolutely close. Leakage of sound in the phone's rear chambers, such as through the cord entrance, must be sealed with wax to prevent feed-back, and loss of quality. If miniature phones are used, an individually molded earpiece is essential; it must fit the ear and the receiver *perfectly*—allowing no leakage of sound. Otherwise, all quality is lost, and the high-grade microphone and vacuum tube amplifier are of no great benefit.

Most any dentist can and will insert a greased cotton plug a quarter inch into the ear canal and make a plaster cast of the ear, which can then be sent to S. S. White & Company for a *molded earpiece*.

(4) A standard circuit, using standard parts—with the usual crystal receiver—will give satisfactory results in practically all cases. A few people, perhaps, have peculiar hearing losses of a short frequency range, rather than the usual extensive loss of either, the high, the low, or perhaps the middle range. These people are likely to be dissatisfied with any hearing aid, whether it is fitted from an audiometer hearing test or not. The usual customer can be satisfied easily by selection of microphone, receiver, and circuit tone adjustment.

(5) In a "pocket type" hearing aid, one thing 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 poor-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 ¾" thick x 3" wide x 4¼" long, approximately; a convenient size for personal wear.

The bottom is fastened in by a fold of the metal over the end. This is filed 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—upside 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 ¼" x ½". 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.)

Cut a piece of thin sheet metal 2⅜" x 4⅜" and solder on the top along the side for a base for the parts and sockets. (Fig. 5.)

Take the wafer sockets and remove the excess material as shown in Fig. 6.

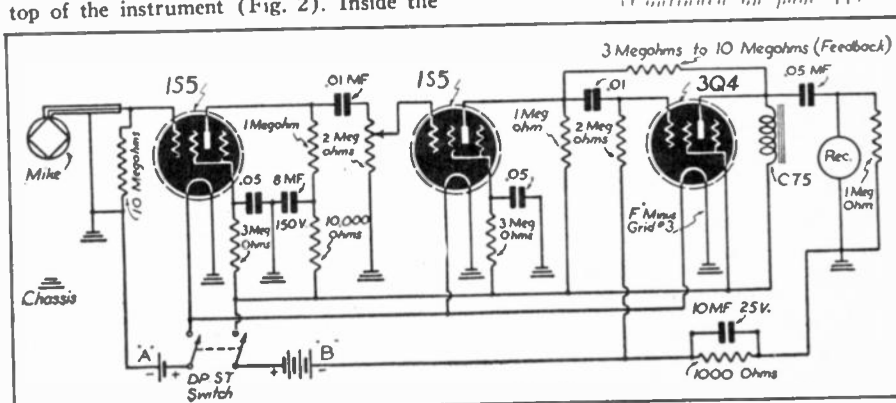
The sockets are mounted by soldering their filament minus prong tab directly to the chassis. Two and one half inches from top of tin to bottom of glass base of tube.

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

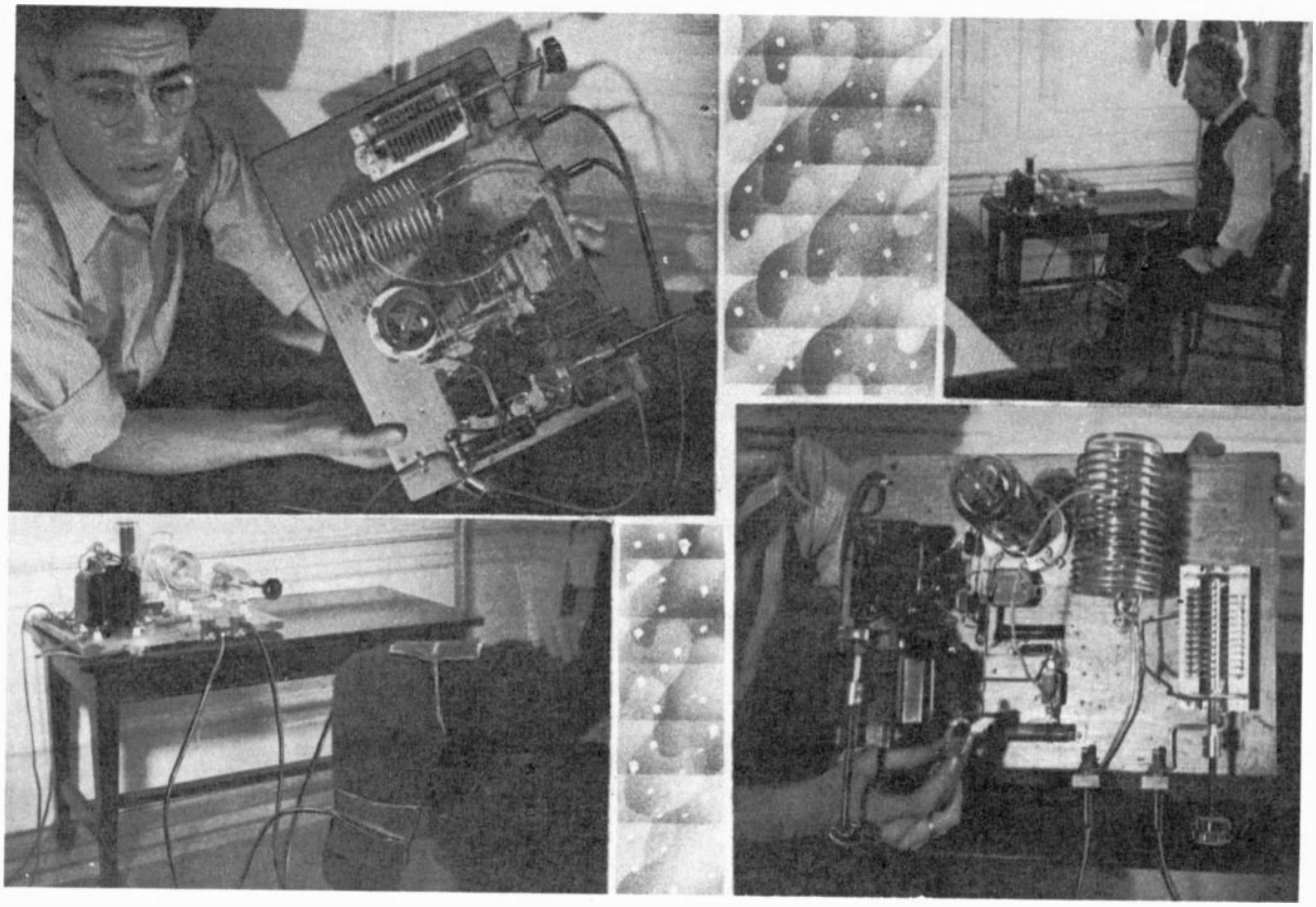
The exact position of each item may be determined from Fig. 7. Keep grid and plate leads separated as far as possible—particularly, those belonging to separate tubes. Use spaghetti tubing and thin fibre insulation in tight spots.

The output transformer or choke should be mounted with the iron core parallel to the base plate. The transformer shown, is one I bought to match a miniature receiver,

(Continued on page 11)



The ultra-small hearing aid tubes and a carefully-designed circuit with the application of inverse feedback are combined in a very effective instrument which compares well with commercial devices



Several views of the "home-type" short-wave diathermy apparatus here described are illustrated above, some showing the apparatus in use.

ELECTRON-TUBE DIATHERMY

With the simple home-type short-wave diathermy machine here illustrated and described, excellent heating effects have been produced in various parts of the body. The apparatus, while of nominal size and cost, will produce a heating effect of surprising magnitude.

● 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 sceptics 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.

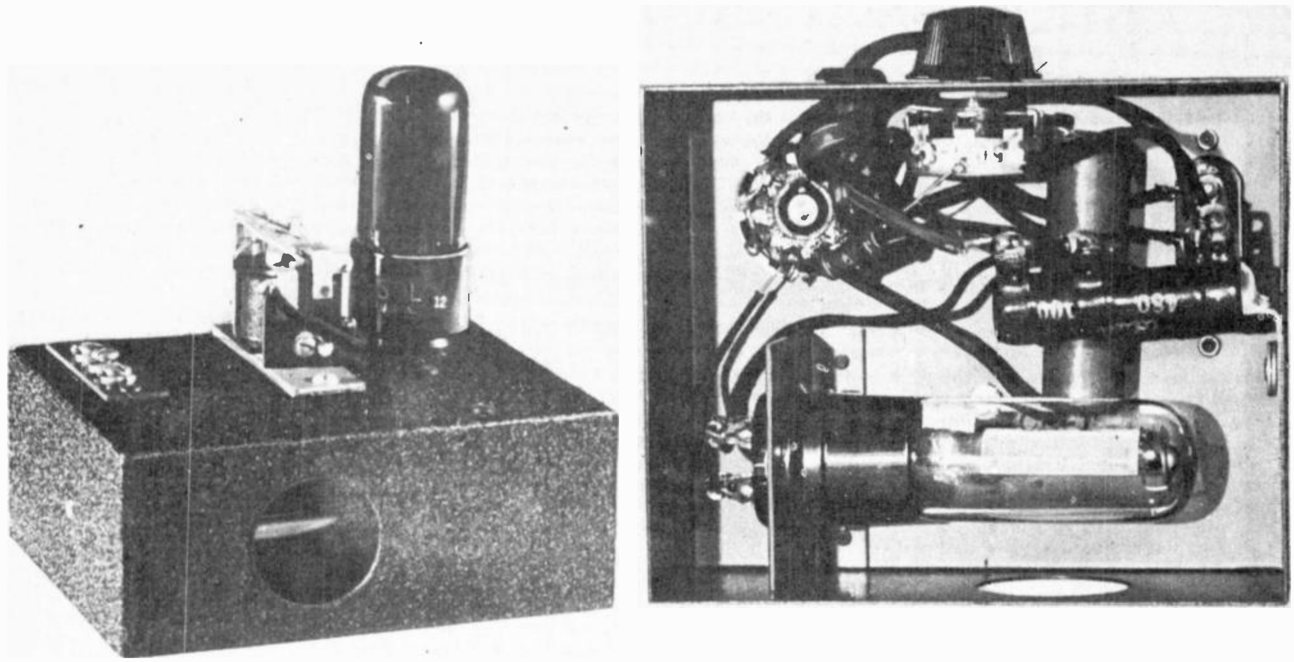
The machine consists of a self-excited oscillator with A.C. plate and filament voltage supply, and a patient coupling circuit. The plate voltage is obtained from an amateur type 1,200 volt 200 mil c.t. (center-tap) transformer with a 6.3 volt winding (used for pilot) which cost $2.95. The filament voltage 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 feed-back 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 47)



These two views of the experimental photo-cell relay show the simplicity and ease of construction which make it practical to build and operate.

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 burglar 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 1¼" 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 it 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 volts 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 16)

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 "wireless" *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 serrations in the 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 as nearly as the inventor 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 should 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 bottle-neck 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 6C5 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 ½-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-holding stylus or armature, the 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.

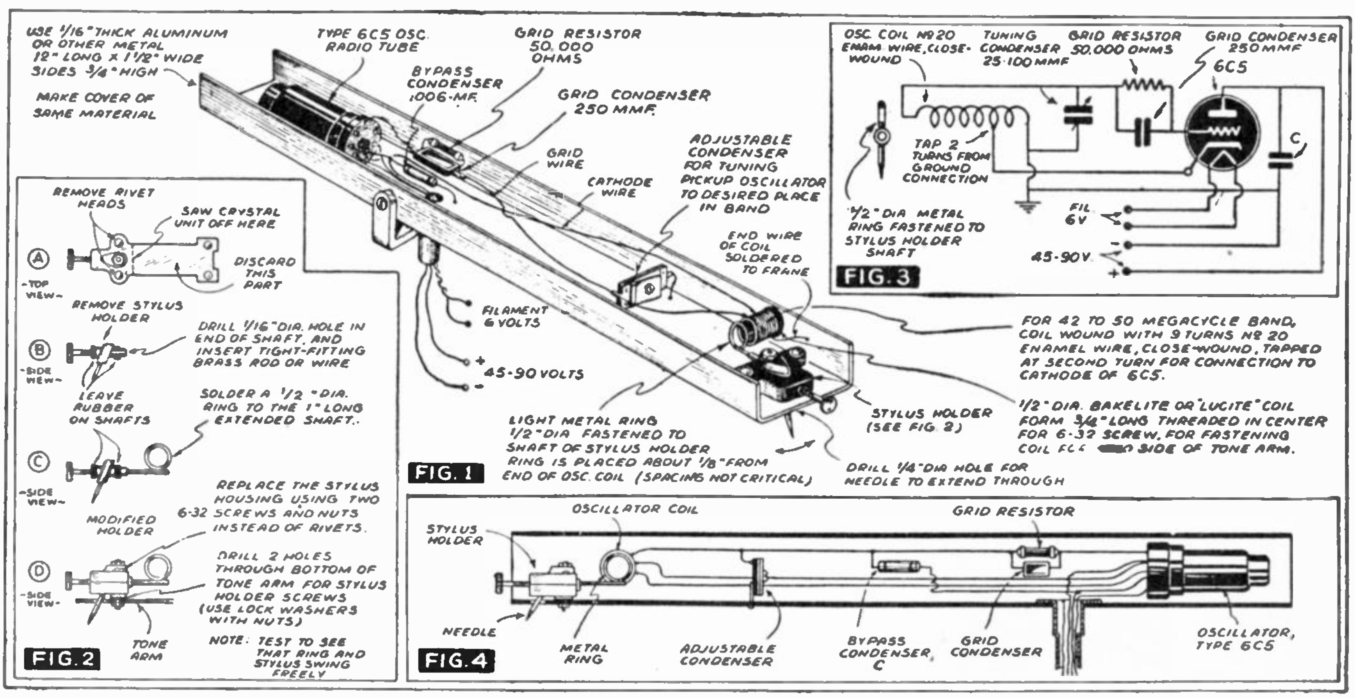
The body of the pickup was made from an old, cast-off crystal pickup. The oscillator tube for shortest possible leads is mounted directly on the pickup arm. The reader may wish to improve upon the method of mounting the stylus and can usually do so. The method shown in the drawings is simple and very 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 ½-in. ring used in this pickup can be an ordinary brass curtain ring found in most 5c-and-10c 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 direct 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.



Construction details of the new Frequency Modulation Phono Pickup system. The circuit of the accompanying F.M. oscillator is given in Fig. 3.

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.

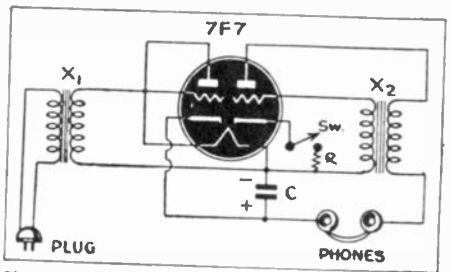
Without mounting the two transformers and filter condenser, move them around like chessmen until you find the most convenient placement for each part. Mark and drill the mounting holes for them. Then drill a hole for the power cord, then two pairs of holes for the phones and key jacks. Then sandpaper 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 typed 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.



The greatest simplicity consistent with good design marks this oscillator.

After testing oscillator the components may be bolted in place beneath the chassis. Now the long connecting leads may be shortened to proper length or they may be tucked in as desired. The oscillator is now complete.

The 7F7 is a loktal, single-ended dual-purpose tube containing two independent triodes in one envelope. Consider the left hand triode first, as shown 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.)

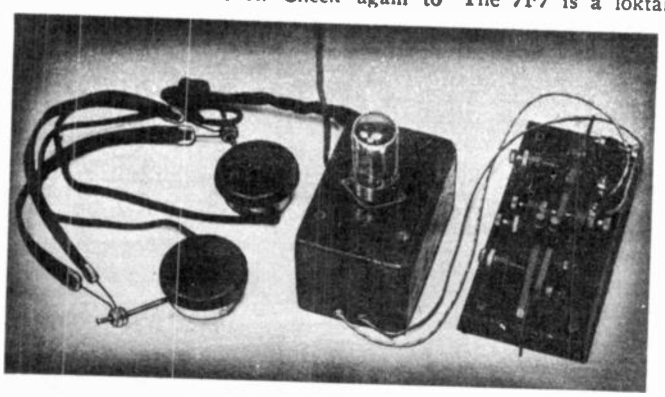
The output of the filament transformer goes to the plate and grid connected together, forming a diode half-wave rectifier. The direct current is taken off the rectifier cathode. This is filtered by the 25 mfd. condenser. This is a competent filter. The D.C. passes through the headphones to the primary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



The oscillator hooked up for use, with speed key and phones. Line disappearing out of the top of picture is the line cord. Note size of the complete oscillator—actually smaller than the "bug" key.

- X_1—Filament transformer (6.3 v.)
- X_2—Audio transformer (any ratio)
- Sw—Telegraph key
- R—2000 ohm (1 watt) resistor
- C—25 mfd. 25 volt condenser
- PJ—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

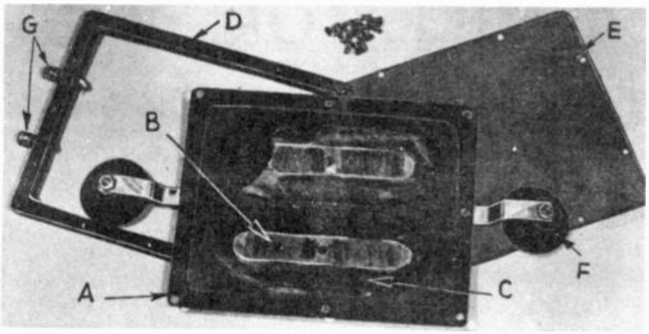


Fig. A. Exploded view of the pickup; A, brass plate; B, saw blade core; C, winding; D, frame; E, fibre back; F, suction cup mounts; G, terminal posts. Note the insulating compound.

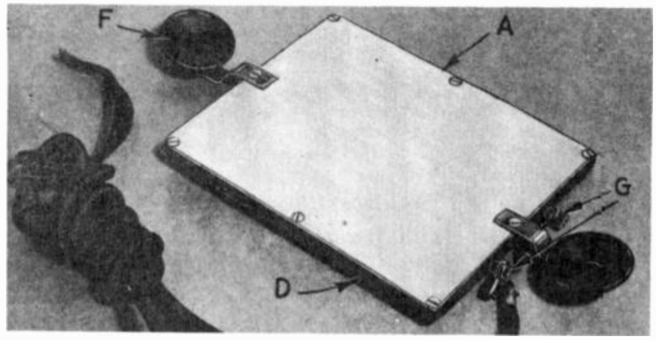


Fig. B. The electromagnetic pickup, when placed beneath the steel strings of a guitar, will permit amplification of the music to any degree. The letters correspond with those of Fig. A.

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.

Heretofore, 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 clarity 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-area 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

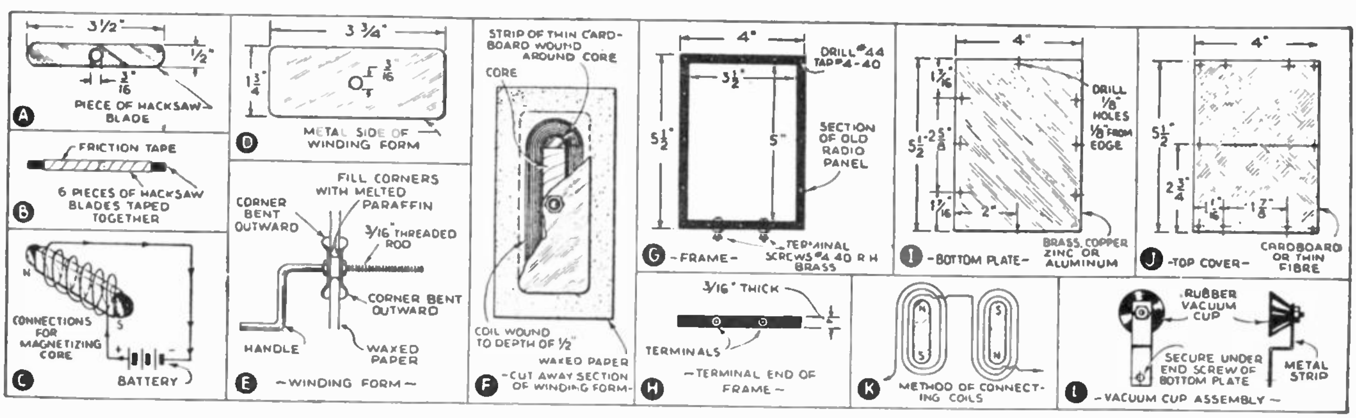


Fig. 1. Complete pictorial presentation of the construction stages of the electromagnetic string-music pickup. See text for details.

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 covering 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, and if hard blades are not obtainable it will be necessary to temper the whole section after it has been shaped.

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 small wire slipping down between 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 enameled wire will be required for each coil. This wire may be obtained from the secondary of an old *ignition coil.* (Remove the primary coil and all of the insulating 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, so that the crank will turn freely. Wrap several turns of the ignition-coil

Every orchestra should have at least one electronic music instrument in its ensemble. Mr. Kendall Ford's unique pickup may be used with any steel-stringed instrument.

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 one piece. Since the wire is extremely small, 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 a 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 spread out on the sides 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 down frequently with a strip of stiff cardboard, the coil will be the same depth all around. The coil should be wound to a depth of ½-in. and if a mark is placed inside the form before the winding is started it will be easy to determine when the required depth is 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, 3/16- or ¼-in. thick, cut to the size and shape shown at Fig. 1G. If a series of holes are drilled around the inside edge, the center may be easily removed with a hacksaw or coping saw. Drill and tap holes around frame, as shown at Fig. 1G. Provide terminal screws at end of frame, as shown at Figs. 1G and 1H.

Cut a bottom plate to the size shown at Fig. 1I. Cardboard or thin fibre may be used for this plate, but metal is recommended on account of the possibility of other materials warping when hot insulating wax is poured over the coils. If metal is used, it must be non-magnetic such as brass, copper, zinc or aluminum. Drill ⅛-in. holes in bottom plate where indicated.

Make a top cover from fibre or cardboard and drill as shown at Fig. 1J.

You are now ready to secure the bottom plate to the frame (with No. 4-40 flat-head machine screws) and to place the coils in the case. A North and a South pole of the core must be opposite, and the windings must be in opposite directions, as shown at Fig. K.

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 a permanent soldered connection between the coils, and to 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 allowed 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 merely 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 not greater than 3/16-in. 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 instrument or it may be held in place by means of small rubber vacuum cups and metal brackets, as shown at Fig. 1L. 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. Of course, strings 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 feeble 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 below admirably suited not only to the electro 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 nontechnical 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

(Continued on page 36)

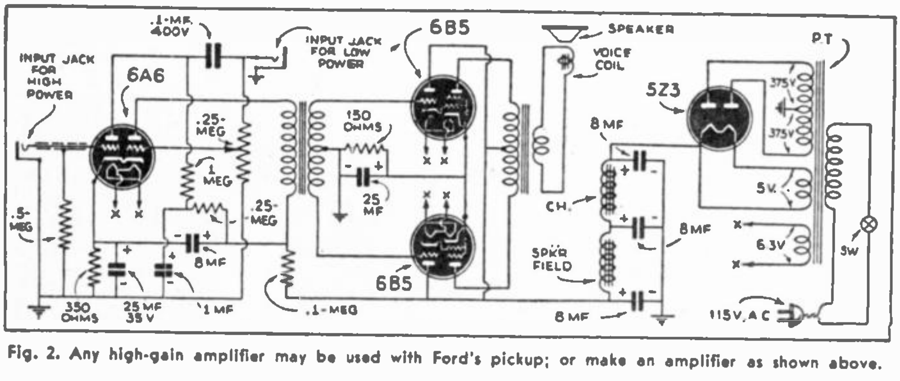
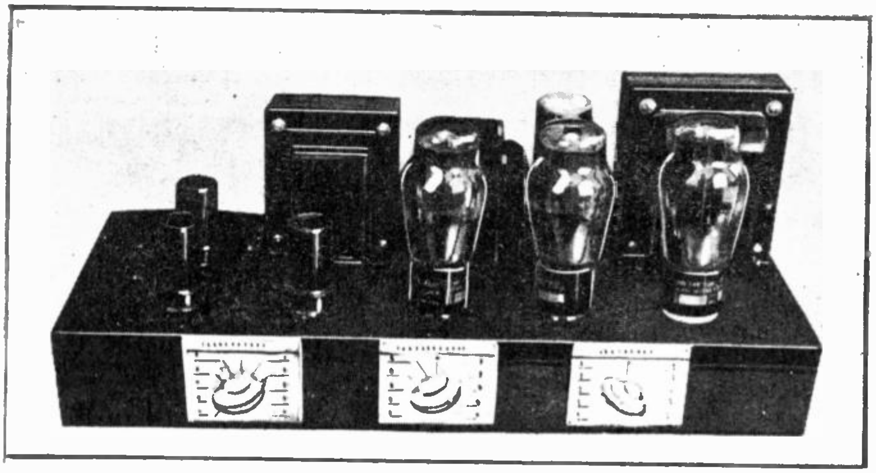


Fig. 2. Any high-gain amplifier may be used with Ford's pickup; or make an amplifier as shown above.



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.

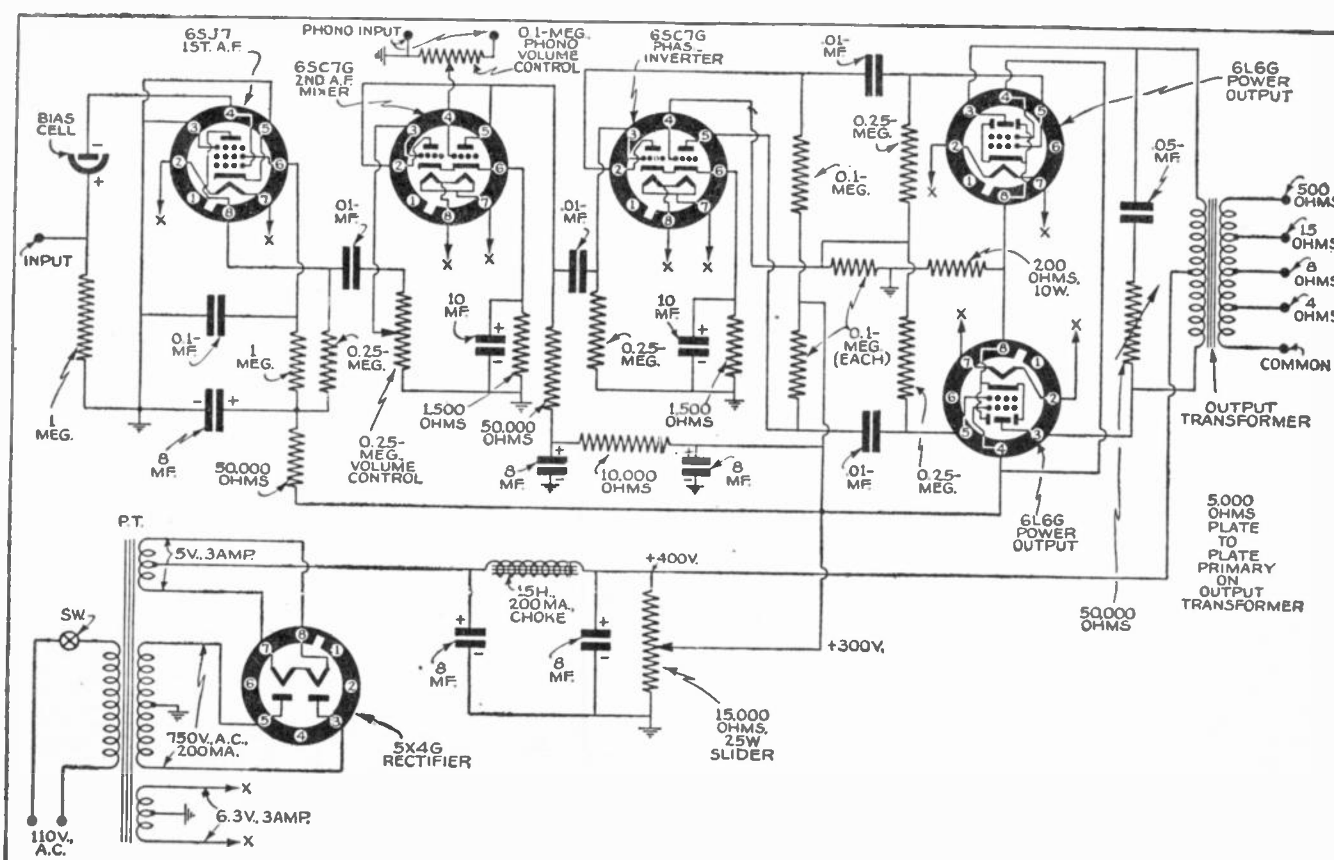
A HIGH-FIDELITY AMPLIFIER

For Phonograph, Public Address or Radio

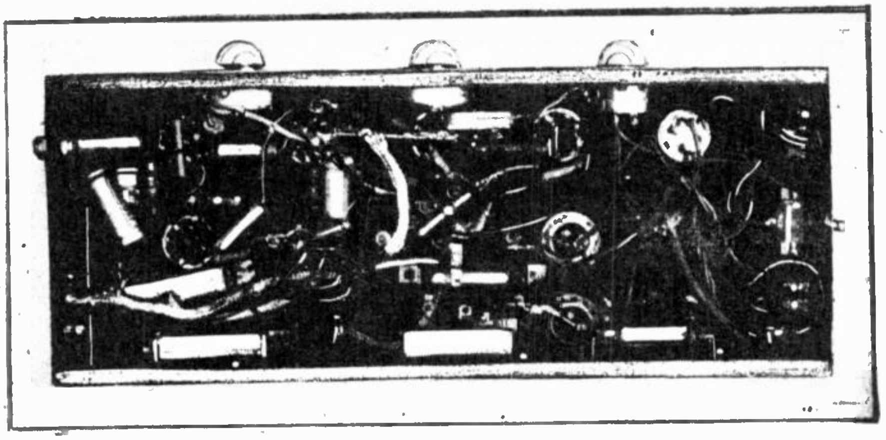
● THE "HF-20" amplifier answers the need for an extremely compact audio system capable of considerable power output with *high* fidelity. Giving a full undistorted output of 20 watts this amplifier is excellent for phonograph or radio amplification, or for general *public address* work. It may also be 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 ±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.

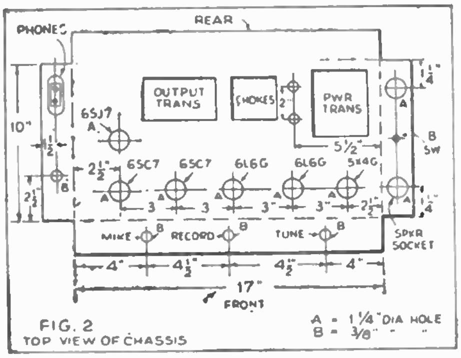


the 6SJ7 input stage may be omitted, the mike being connected directly to the first 6SC7 grid. The space normally occupied by the 6SC7 may then be devoted to a peak limiting circuit for automatic percentage modulation control.

In the construction of this amplifier, it should be pointed out from a hum level standpoint it is advantageous to bring *all* ground circuits to a common point on the chassis. This is easily accomplished by connecting all component grounds to a grounding bus wire, which is connected to the chassis at one central point. This precaution will eliminate the possibility of high gain circuits amplifying small A.C. circulating currents on the chassis.

Matching Speaker Impedances

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 con-



Details for laying out chassis.

nected in parallel across the 4 ohm impedance output, or two 15 ohm speakers 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 across 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. In the event that a 5000 ohm output is desired, connection to the two plate ends of the output transformer through 0.1 mf., 600 volt condensers, as shown in the diagram, may be made.

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.

KENYON (Transformers)

1—Power transformer, 750 v. A.C. center-tapped, 200 ma., 5 v. at 3 amp. and 6.3 v. at 3 amperes
1—Filter choke, 15 henries, 200 ma.
1—Output transformer, 5000 ohms primary; secondary 4, 8, 15 and 500 ohms

I.R.C. (Resistors)

2—Metallized fixed resistors, 1 megohm, ½ watt
4—Metallized fixed resistors, ¼ megohm, ½ watt
2—Metallized fixed resistors, 50,000 ohms, ½ watt
3—Metallized fixed resistors, 100,000 ohms, 1 watt
2—Metallized fixed resistors, 1500 ohms, 1 watt
1—Metallized fixed resistor, 10,000 ohms, 1 watt
1—Wire-wound bleeder, 15,000 ohms, 25 watts. Slider type
1—Wire-wound bleeder, 200 ohms, 10 watts
1—Volume control, ¼ megohm
1—Volume control, 100,000 ohms
1—Volume control, 50,000 ohms

MALLORY (Condensers)

4—Paper tubular condensers, .01 mf., 600 volts
1—Paper tubular condenser, .05 mf., 600 volts
1—Paper tubular condenser, .1 mf., 600 volts
3—Electrolytic condensers, 8 mf., 450 volts. Cardboard
2—Electrolytic condensers, 8 mf., 450 volts. Can. heavy duty
2—Electrolytic condensers, 10 mf., 50 volts. Tubular

PAR METAL

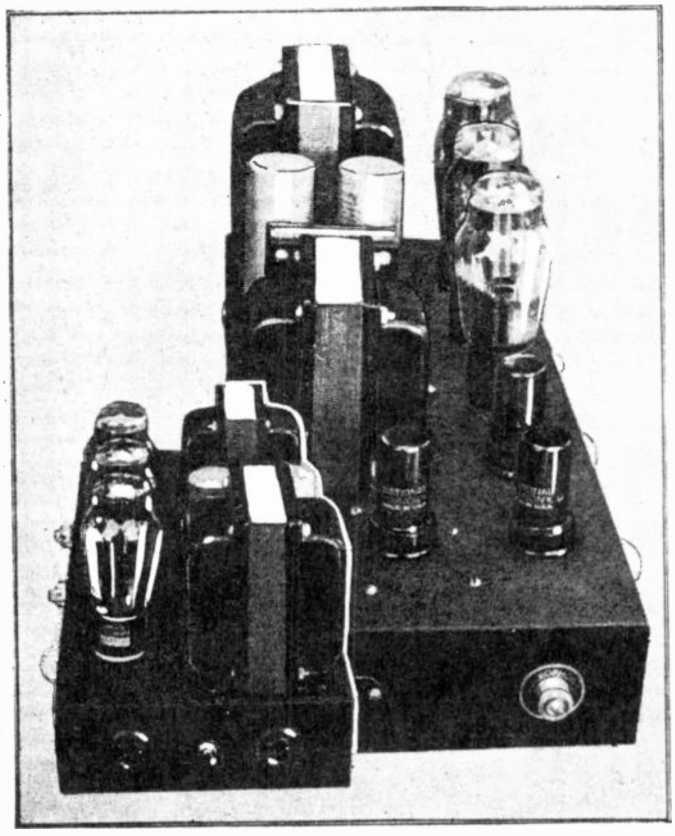
1—Black crackle steel amplifier chassis foundation 10 x 17 x 3" with bottom plate

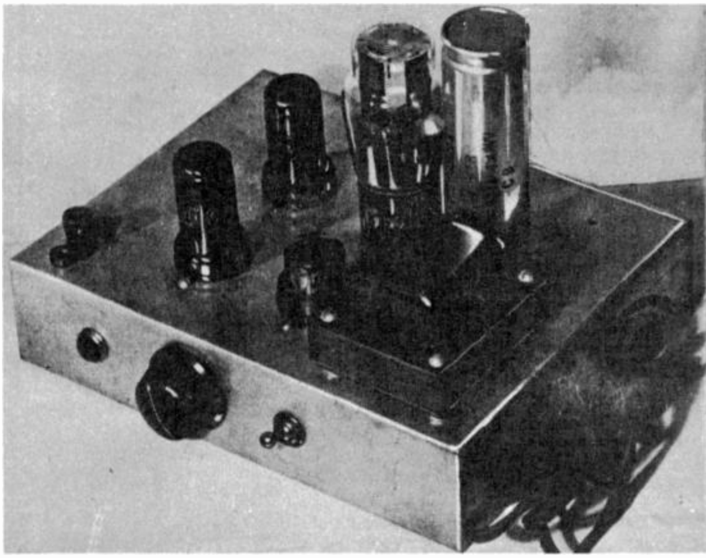
AMPHENOL

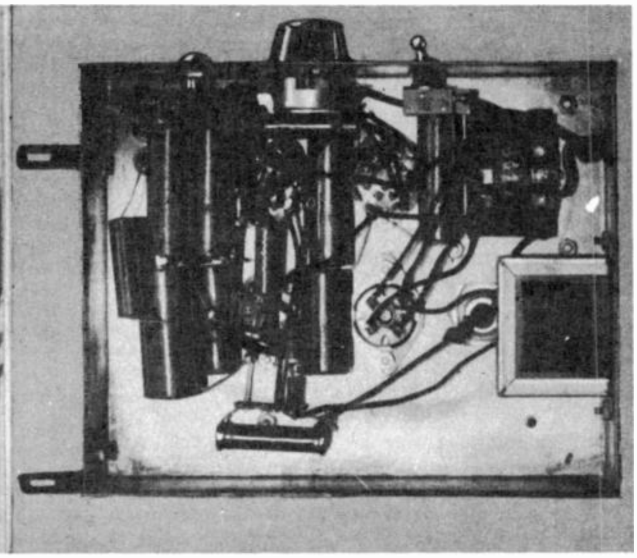
6—Octal sockets
2—4-prong sockets
1—Microphone chassis connector

3—Knobs
3—"Mike," "Phono" and "Tone" dial plates

Right.—Two views taken from opposite ends of the 20-watt amplifier here described. The tube lineup consists of a 6SJ7 input tube, a 6SC7G intermediate stage and phonograph mixer, one 6SC7G phase inverter, and a pair of 6L6G's in the push-pull Class-A output stage. The rectifier tube is a 5X4G. The amplifier has a frequency response practically flat from 60 to 15,000 cycles per second.







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 a public address amplifier what automatic volume control 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 superhets. 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 input. 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 is 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 into 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

(Continued on page 43)

SEMI-PRO RECORDING METHODS

Slight Improvements in Technique Pay Well in Results

For the phone amateur who has a good speech amplifier especially, and for other experimenters in general, here is an excellent idea. Slight changes in a transmitter speech amplifier, (or other good amplifier), render it suitable for home recording, one of the most interesting electronic hobbies.

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 home recording 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 will vary with the different voice frequencies. At one frequency the impedance of the cutting head may match that of the output transformer, while 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.

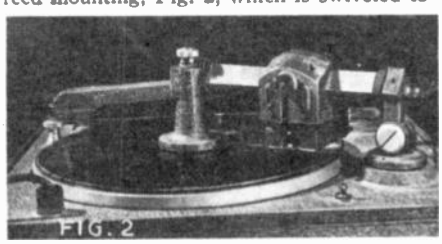
It is not within the scope of this article to enter upon a complete discussion of the relative merits of constant-amplitude vs. constant-velocity recordings. But, to assist the uninitiated, it might be explained that a constant amplitude recording is one wherein the displacement of the cutting stylus is uniform for a given signal voltage, no matter what the frequency affecting the cutting head is; and a constant velocity recording is one where the displacement 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 power-switch, 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 chokes are mounted beneath the chassis, near the power transformer.

CUTTING HEAD

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 swiveled 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.

MOTOR

The motor should have enough power to turn the turn table at an even speed. This can be tested by actually cutting a record with an audio tone being recorded. (Station WWV 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 few minutes of cutting, they 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 needle 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 coated 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 bumps 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 coarse hair. (When the cutting depth is about 0.003 inch).

When recording at 33 1-3 r. p. m., care

Turntable Speed 78 r.p.m.		
Disc Dia.	PLAYING TIME	
	(96 lines per inch)	(112 lines per inch)
6"	1¼ mins.	1½ mins.
6½"	2 mins.	2¼ mins.
8"	2½ mins.	3 mins.
10"	3¾ mins.	4½ mins.
12"	5 mins.	5¾ mins.
Turntable Speed 33⅓ r.p.m.		
12"	7¼ mins.	8 mins.
13¼"	9 mins.	10 mins.
16"	13 mins.	15 mins.

Fig 3 —Recording times for blanks of several different diameters, both at 78 and 33⅓ RPM.

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

7-FOOT EXPONENTIAL HORN FOR VOLUME AND FIDELITY

ANY speaker sounds good if you put it in a big enough box. We were respectful—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 until 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 outfit, and placed a mike 10 feet from the speaker. Then we hitched up another amplifier and an output meter (also borrowed) to see what the speaker would do without any baffle. We plotted a fine curve with response down five DB at 8000 and 70 cycles. It was and is about the best single speaker on the market in our opinion: Cinaudagraph with a 2½-inch voice-coil, curvilinear cone and a big chunk of Alnico magnet on the back end! We decided, since our low response fell off about 70 cycles, it would be nice to make our box resonate around 50-cycles, (that gives a nice big bump) and design the outlet to reinforce a 30-cycle tone. Then we got the plywood.

We had trouble until we hit on the simple angle of thumping the box and then listening to a tone from the oscillator. Then we found we'd cut the wood a little too short and narrow, and had to be content with a resonance at 55-cycles, and even that was with the back butted on the box instead of fitted inside. Then we thought we'd design the slot to give a half-wave at 30-cycles for the sound from the back of the cone to travel. We looked up some figures on the speed of sound in average air and found that a 30-cycle tone has a wavelength of nearly 40 feet. This was out of the question in a box the size of ours, so we decided 55-cycles was low enough for us to hear anyhow.

After the box was painted and we'd listened for some time we thought we'd try a slot anyhow. So we did, and listened. Then we'd cover up part of the slot with a board and listen again. We found that we could extend the bass down to a good 45-cycles without any falling off at all—and what is more important, we could play with the shape of the slot and smooth out two dips in the overall response at 1100 and at 2200-cycles. Our last curve showed a response within 3-DB from 45 to 7500 cycles and within 5-DB from 42 to 8000 cycles.

It was just after that time that we moved to a larger house and experimentation was dropped for awhile, and we turned to pick-ups and equalizers. We didn't get going on speakers and baffles again till about a year or so later.

We had been studying radio and sound, and noted that while a cone speaker has an efficiency of about 10 to 15%, that that of a horn approaches 50%. This idea intrigued us and we dug into the subject a bit. We found curves comparing exponential, conical, and parabolic horns, with the exponential type way ahead of the other two, as to efficiency and response. We corroborated what he had suspected: That a cone speaker can be driven only so far before the amount of second harmonic *produced by the cone itself* becomes noticeable. Therefore it is desirable to operate the unit at a lower level and use the higher efficiency of a horn to make it louder. So we decided we'd experiment a bit with a horn.

Using our nice cone speaker again to drive the horn we built a monstrosity in the garage. Here's how we went about it.

First we dug up the formula:

$$S_x = S_1 e^{mx}$$

where

S_1 is the area of the horn at the throat
S_x is the area at any distance x
x is the distance from the throat
e is 2.72
m is a flare constant for the horn

Also the book said that for good results the distance across the mouth of the horn should be not less than ¼-wavelength of the lowest frequency to be emitted. That was when the XYL decided it would be built in the garage instead of in the house. We were planning to emit 50-cycles anyhow (our original thought had been 30), and ¼-wavelength at 50-cycles is about 68 inches. We decided to increase this to 80 inches—let's do it right, huh?—that idea.

Proceeding further with the design—with the help of the book—we discovered that a horn whose area doubled every 12 inches would have a cut-off at 64 cycles, and a horn whose area doubled every 6 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:

$$\frac{64}{D} = \frac{50}{12}$$

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_1 would equal (13 x 13) or 169 square inches, and the area at 15.36 inches would be (2 x 169) or 238 square inches. This meant that we could find the value of "m" in the horn formula, by substituting 15.36 for "x" and 238 for S_x: $238 = 169 \times 2.72^{15.36m}$.

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: $S_x = S_1 e^{.045x}$, and in our case with S_1 fixed at 169 square inches, $S_x = 169 \times 2.72^{.045x}$. From that relationship we were able to calculate the exact measurements of the horn.

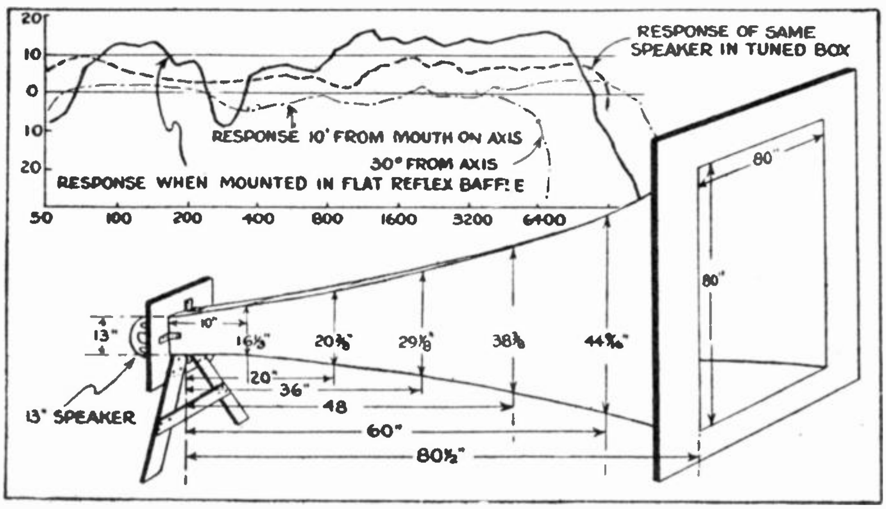
The building of it took some pains as we were not carpenters, but we did manage to bend some ¼ inch plywood to the dimensions shown, and by judicious bracing, were reasonably sure it would stay that way.

The thing was a whisker over 80 inches long (6 feet 8 inches if you prefer) and the mouth size (80 x 80) 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 using the smaller door 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 in the driveway along with some curious neighbors to hear the nice concert. I screwed the speaker onto the throat of the horn and hitched 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 outdoor music—sort of.

The amplifier in question had a pair of

(Continued on page 39)



The seven-foot exponential horn. All necessary dimensions are given.

A CALIBRATED U.H.F. OSCILLATOR

The increasing use of wavelengths in the order of a few meters demand test equipment adapted to high frquency. This high-frquency 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.

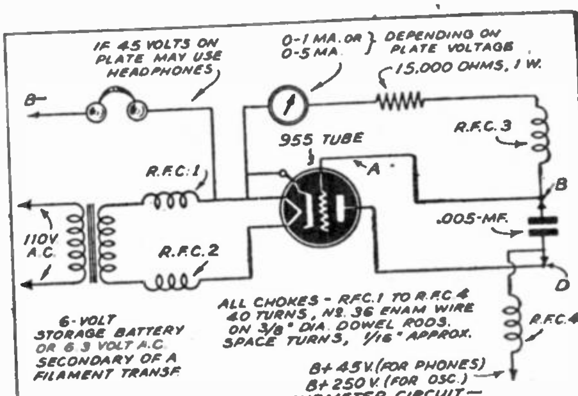
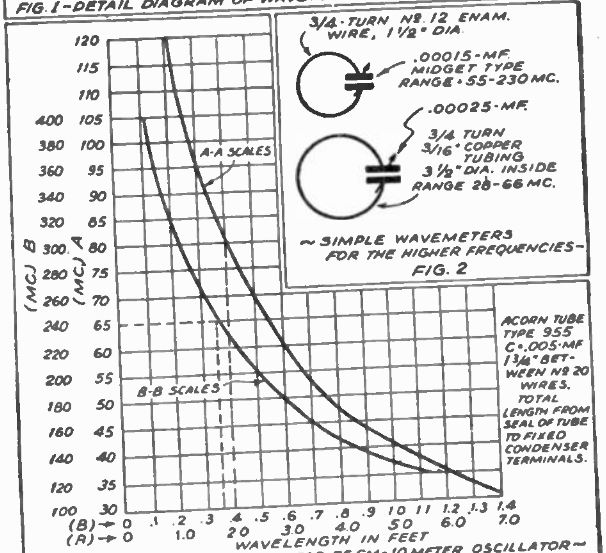


FIG. 1—DETAIL DIAGRAM OF WAVEMETER CIRCUIT—



— SIMPLE WAVEMETERS FOR THE HIGHER FREQUENCIES— FIG. 2

FIG. 3 — CONSTRUCTION CURVE FOR 75 CM - 10 METER OSCILLATOR—

A wiring diagram of the Calibrated Oscillator is shown at the top of the diagram. Hook-up of simple wavemeters for high frequency shown at Fig. 2; Fig. 3 shows how to draw a curve for a typical oscillator.

● 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 alone a calibrated one, that will pick up oscillations at a wavelength of 10 meters and lower.

I have perfected a new type of wavemeter 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 very near 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 beatnotes with other oscillators or regenerative receiver, connect as shown. If headphones are not needed, omit the phones and close the lead. If you use a gridmeter as shown, and it is 0/1 milliampere D.C. 1 maximum scale, shunt it with a resistor so it reads 1/5 milliampere when 1 milliampere 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. Boil 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 I tell you 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 near 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 very 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.

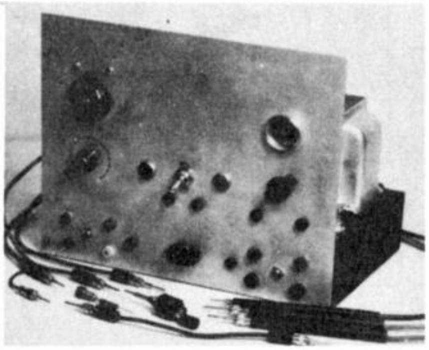
It will be seen at once that you can calibrate your oscillator for different lengths of wires by first calibrating the dial of your regenerative receiver. This receiver need have only one tube. A simple '30 tube regenerative detector can be used if desired.

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

(Continued on page [illegible])

A Handy and Reliable SIGNAL TRACER

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 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.



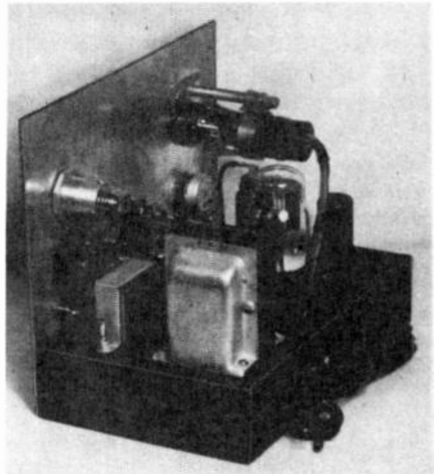
Neat attractive appearance of the tester and signal tracer.

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 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

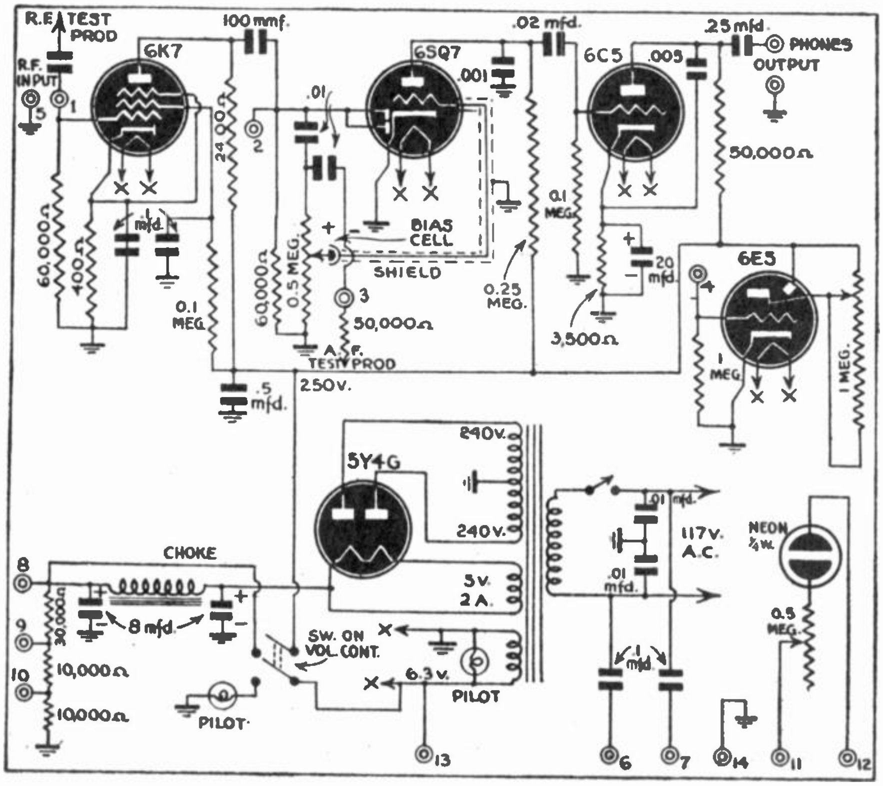
A 6E5 tuning indicator tube is provided for handy connection to the receiver under test for alignment purposes and measurement of A.V.C. voltages. This is a very simple arrangement of a 1-megohm variable resistor between target and plate with a calibrated scale. When the shadow angle is adjusted to zero by moving the resistor control, the A.V.C. 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 cut-off 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.



Chassis layout and parts arrangement present a professional-looking job.

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 ¼-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.

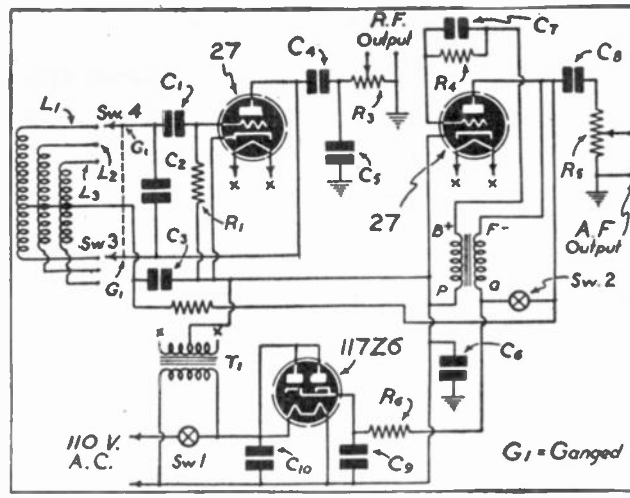
PILOT LAMPS

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

(Continued on page 4[illegible])

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.



Above: Wiring diagram for signal generator.

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.

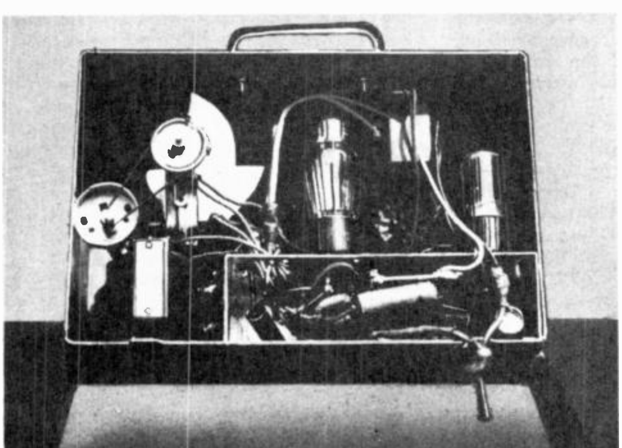
As the filament transformer had only the 2.5-volt winding it became necessary to use a 117Z6 tube. It has a 117-volt filament and gives well over 110-volts of rectified voltage.

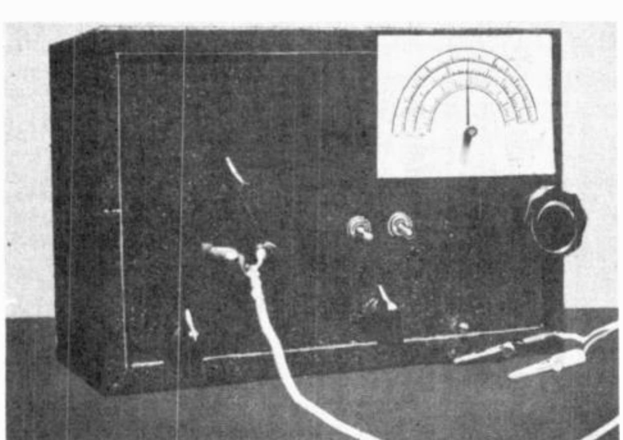
In wiring the 117Z6, it is necessary to connect one side of the A.-C. line to the *B* return or you will have no voltage in the signal generator. I first grounded one side of the A.-C. line to the chassis of the unit but found that it was unsatisfactory. The best method is to fasten a piece of bus wire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





To the left: Two views of the handy Signal Generator.

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 ½" in diameter and the windings were jumble or scatter wound. In the coil table please note that the coils are not to be over ½" to ¾" long and that all coils are center-tapped. When the coils are finished (I wound all 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.

COIL TABLE

	Range	Turns	Wire	Coil Length	Coil Form
L1	75- 220 Kc.	1100	No. 34 D. C. C.	¾"	½" dia.
L2	200- 500 Kc.	450	No. 28 Enamel	½"	½" dia.
L3	500-1500 Kc.	175	No. 22 Enamel	½"	½" dia.

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.

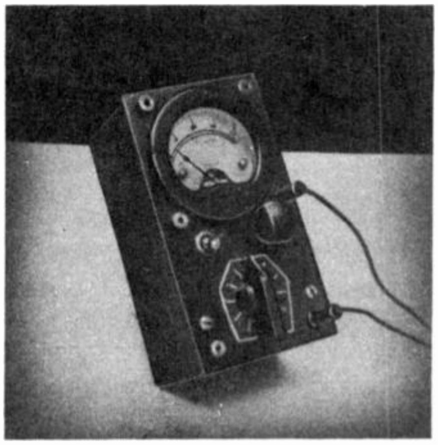
Modulation is obtained by leaving the switch S2 in the open or off position; when the switch is closed, you will receive an unmodulated signal.

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

(Continued on page 31)

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.



The Ya Mei multimeter. Test leads are shown in the D.C. jacks.

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 measures voltages from 7.5 to 750 in 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 as such 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, 12-point switch. This latter was manufactured by the Asiatic-American (Ya Mei) Radio Company of Shanghai, otherwise known as the Amateurs' Home. Hence the name of the unit.

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-reading 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 as compact a job as this one, at least not as a 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 disadvantages of trying to make too small an instrument remain to this day.

Mount the meter first, then the pin jacks, the variable resistor for ohmmeter, the zero adjustment, the toggle and gang-switch, 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-jacks in order to cover all 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 switch for milliammeter and 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 by 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 750-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 voltage 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 radioman'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 90% 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 rectifier, REC., using the D.P.D.T. switch. 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 scales 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 "0.6" 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 in size till the meter 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.

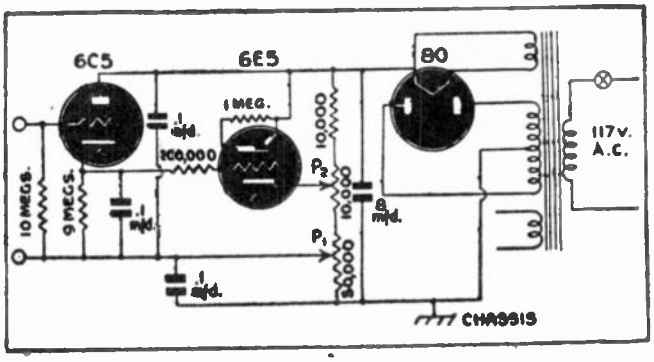
THE OHMMETER CIRCUIT

The high-ohm range reads to about 200,000 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)

ELECTRON-RAY VOLTMETER



The Electronic Voltmeter above dispenses with expensive meters, using an ordinary 6E5 electron-ray tube as indicator. If proper care is exercised in its calibration and use, it should be accurate enough for all radio service applications.

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 an output and a.v.c. indicator.

This meter uses only five resistors and four condensers, so any great amount of advice on construction would be out of place. The reader already understands that high-grade components, which will not change their resistance or capacity under load, are necessary in any type of meter.

The power pack may supply any voltage from about 200 to 250. Little filtering is necessary on account of the small current drawn, so the 8 mfd. condenser across the resistor bank will be plenty. The 50,000-ohm volume control should be a heavy-duty type, as it has about one-half watt of power to dissipate.

Excellent insulation is required, especially around the posts to which the prods are connected. If the resistance here should fall as low as 200 megohms, this would mean an error of 5% in readings. This is true of all V.T.V.M.'s, because of their high ohms-per-volt ratio.

HOW THE METER OPERATES

A word as to the theory may help the beginner. The relative potential of the grid and cathode of the 6E5 control the opening and closing of the eye. This relative voltage can be controlled by making the cathode more positive or negative with the potentiometer P_2. A closed eye indicates that the grid is negative enough (cathode positive enough) to stop current flow. In practice the bias is adjusted so that the eye is just closed.

The grid of the 6E5 is attached directly to the cathode of the 6C5. (Any low-mu tube may be used here in place of the 6C5 shown). The cathode resistor is large enough so that no current flows. Now if a voltage—either A.C. or D.C.—is applied between the two input points, the grid will become more positive and current will flow. This will cause a voltage drop across the cathode resistor, and raise the voltage of the 6E5 grid, opening the eye.

Note that the bias can be varied by adjusting either P_1 or P_2. If the arm of P_1 is at the top (in the diagram) and the arm of P_2 at the bottom, the two are at the same potential. We can change the bias by moving either one. Having already set our voltmeter to the no-shadow point with P_2, we now compensate for the voltage being measured by moving the arm of P_1 until the eye just closes again.

In other words, we make the grid just negative enough to compensate for or neutralize the applied voltage being measured. Perhaps this example may make the principle clear. To measure the speed of a person walking *up* a downward-travelling escalator, regulate the escalator until the person is getting exactly nowhere, then measure the speed of the escalator.

CALIBRATING THE VOLTMETER

This measuring—or calibration—may be done with the aid of a source of several known voltages (say a battery, potentiometer and a good voltmeter), various voltages being applied and the position of P_1 noted. It is an excellent idea to put a long pointer on P_1 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 .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_1. 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_1 in "top" position) for zero adjustment of the eye. Then adjust P_2 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_1 till the eye *just closes*, and read the voltage on the calibrated scale under the pointer of P_1.

The accuracy of your readings depends a great deal upon the care with which the adjustment of P_2 and P_1 are made, as they must be brought to the point of exact closing, and no further.

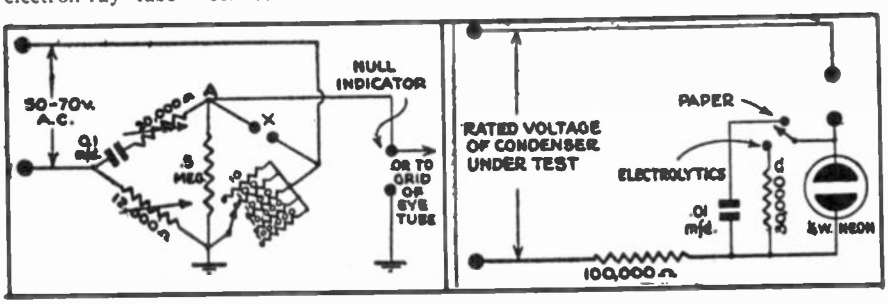
A CONDENSER ANALYZER

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.

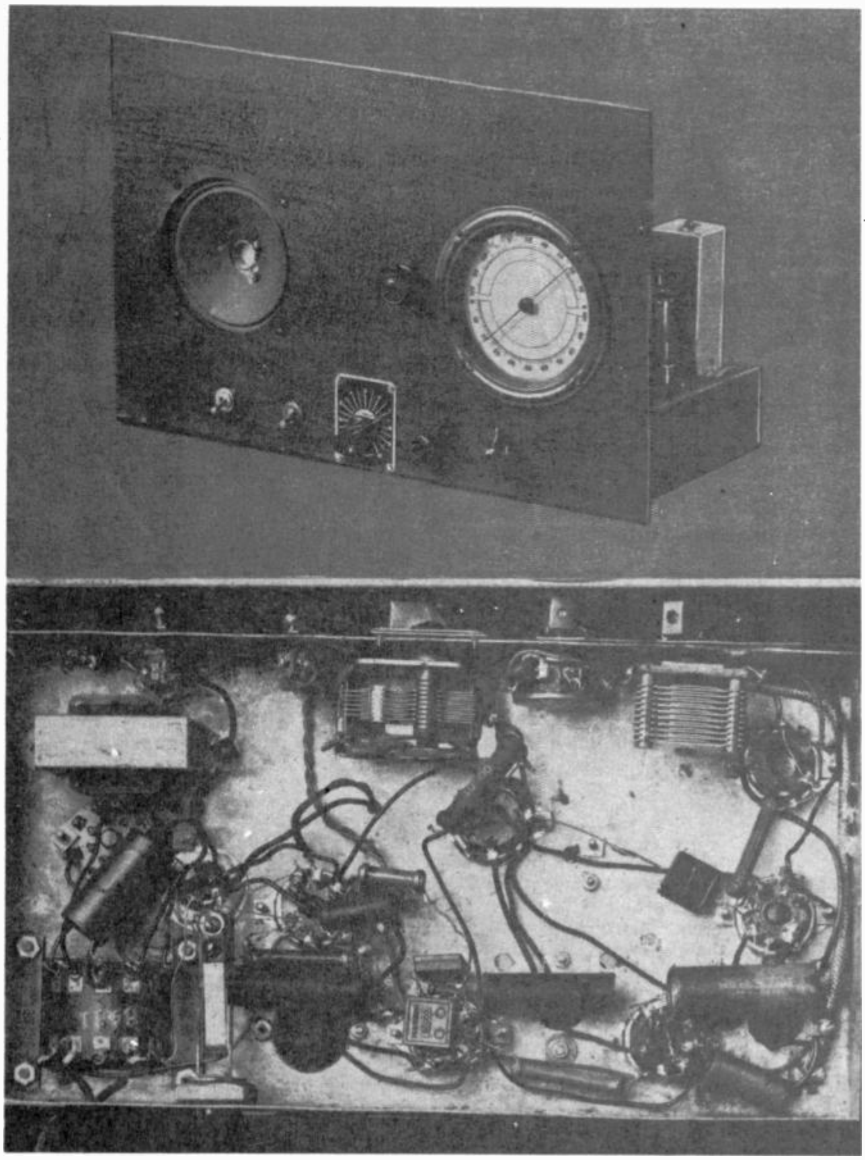
Care must be exercised in building the leakage tester. It is built to indicate leakages through many megohms, and so all apparatus used in its construction must be almost perfect insulation, or leakages through the instrument itself will neutralize its action.

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-Tube Short-Wave
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 it's 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. The low cost of the parts is rather due to the use of double-purpose tubes, and to the design of the circuits around tubes which require a minimum of circuit components.

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 admirably 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 electralloy or galvanized chassis base, 7" x 12" x 2". The panel is 15" x 9". The bandspread 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 for such work, and is always quite willing to 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 pay you to make friends with your tinsmith.

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 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 1/8" 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 L4 coils 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 Illini 8 mf., 450-V. tubular condenser, C1
Two Aerovox dual 8 mf., 450-V. upright can elect. condenser, C2, C3
Two Illini, 10 mf., 35-V. elect. condenser, C4, C8
One Aerovox .01 mf., 600-V. condenser C5
Two Aerovox .00025 mica condenser, C6, C7
One Aerovox .0001 mica condenser, C10
One Aerovox .1 mf., 200-V. condenser, C11
One 30 mmf., variable condenser, C12
One 150 mmf. variable condenser, C13
One 140 mmf. variable condenser, C14.

RESISTORS

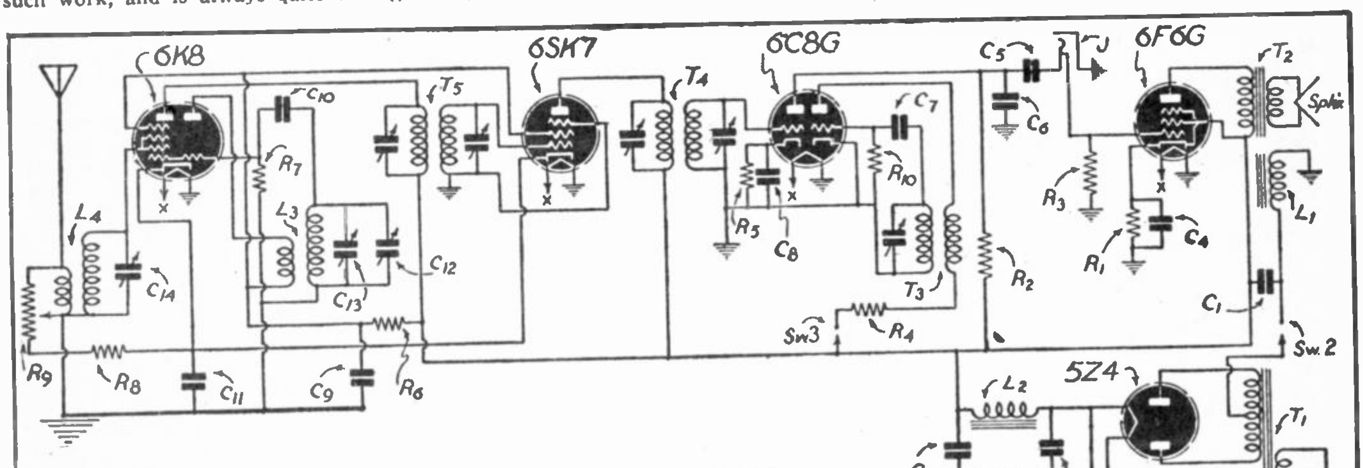
One Ohmite [illegible]00 ohm, 1-W. resistor, R1
Two Ohmite [illegible]0,000 ohm, ½-W. resistors, R2, R10
One Ohmite 250,000 ohm, ½-W. resistor, R3
Two Ohmite 50,000 ohm, ½-W. resistors, R4, R7
One Ohmite 100,000 ohm, ½-W. resistor, R5
One Ohmite 10,000 ohm, 10-W. resistor, R6
One Ohmite 300 ohm, ½-W. resistor, R8
One Centralab 10,000 variable resistance resistor, R9.

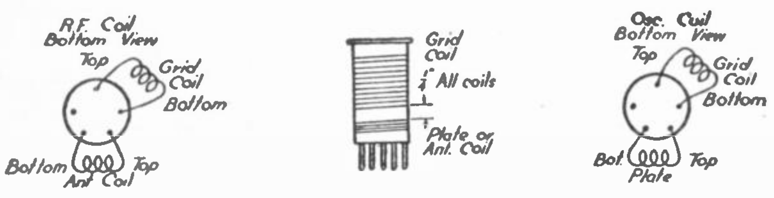
TRANSFORMERS

One Stancor power transformer, T1 6.3 V. @ 1.2A, 5-V. @2A., 600-V. C.T.
One Stancor Output transformer, T2
One Meissner BFO transformer, T3
One Allied 1500 Kc. iron core I.F. transformer, T4
One Allied 1500 Kc. iron core I.F. transformer, T5.

MISCELLANEOUS

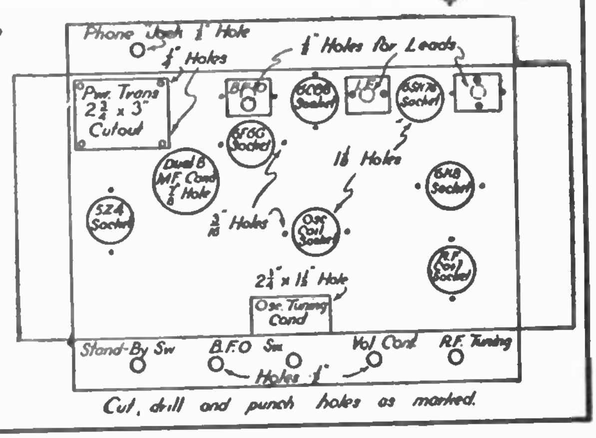
One 450-ohm speaker field, L1.
One UTC 30 hy. choke, L2
One osc. plug-in coil, L3
One R.F. plug-in coil, L4
One S.P.S.T. on volume control, Sw1
One S.P.S.T. toggle, Sw2
One S.P.S.T. toggle, Sw3
One 4½-inch dynamic speaker
One Bud circuit-opening jack, J1.

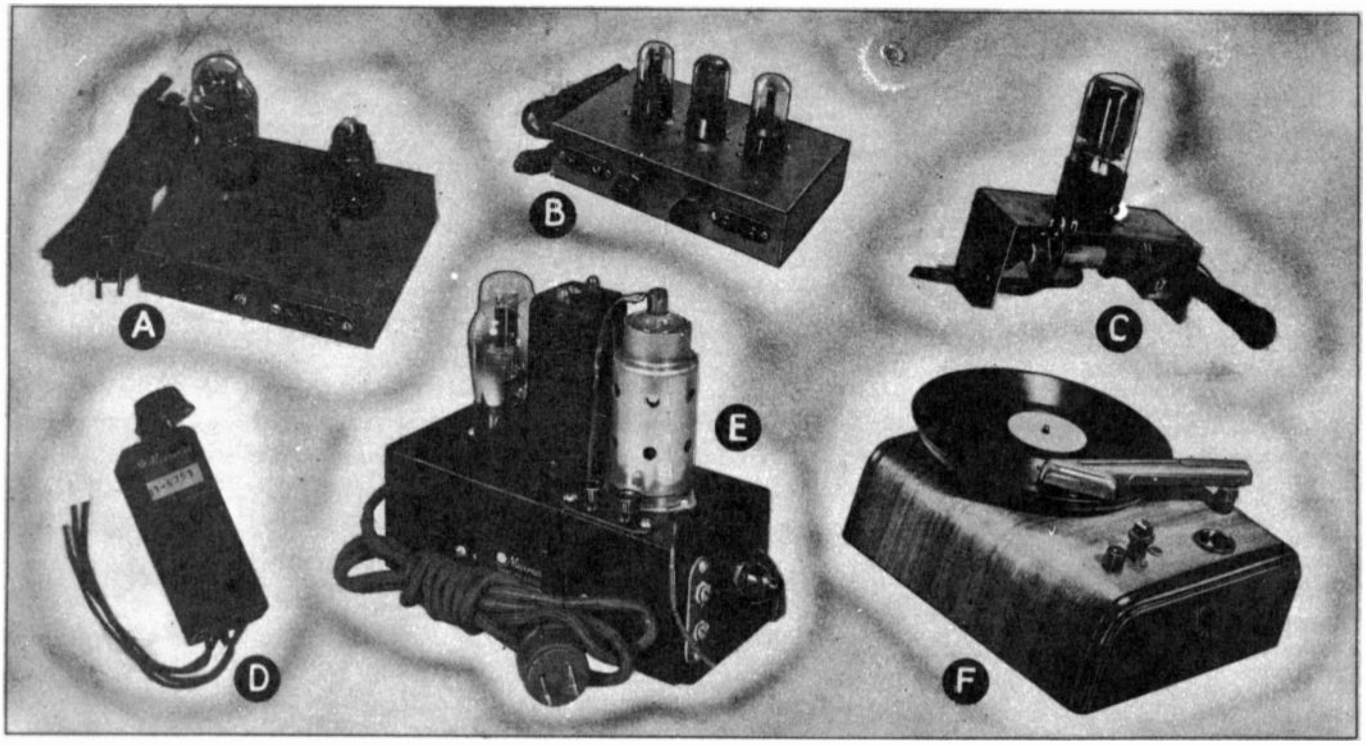




	Band A	Band B	Band C	Band D
Oscillator Grid	56 Turns #30 Close Wound	22 Turns #30 Spaced 20 per"	10 Turns #30 Spaced 10 per"	4 Turns #30 Spaced 6 per"
Oscillator Plate	10 Turns #30 Close Wound	8 Turns Close Wound	6 Turns #30 Close Wound	4 Turns #30 Close Wound
R. F. Antenna	66 Turns #30 Close Wound	27 Turns #30 Spaced 20 per"	13 Turns #30 Spaced 10 per"	5 Turns #30 Spaced 6 per"
R.F. Grid	14 Turns #30 Close Wound	9 Turns #30 Close Wound	7 Turns #30 Close Wound	4 Turns #30 Close Wound

All coils wound on 1/4" ribbed 5 prong forms





Six Useful and Interesting
WIRELESS PHONO-OSCILLATORS

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.

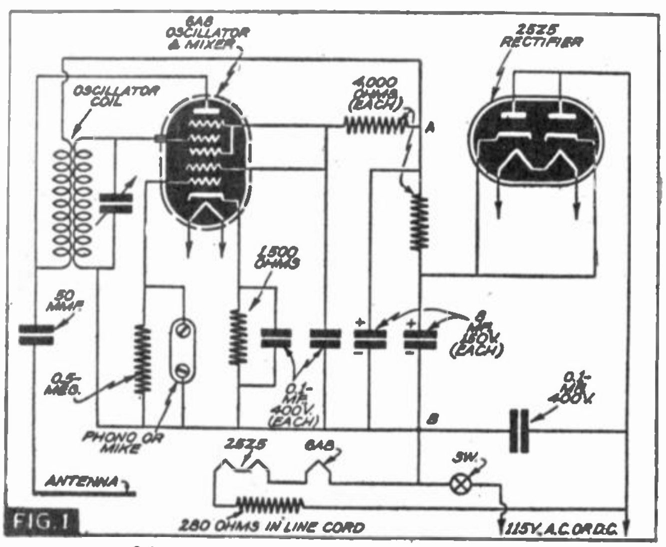


FIG. 1

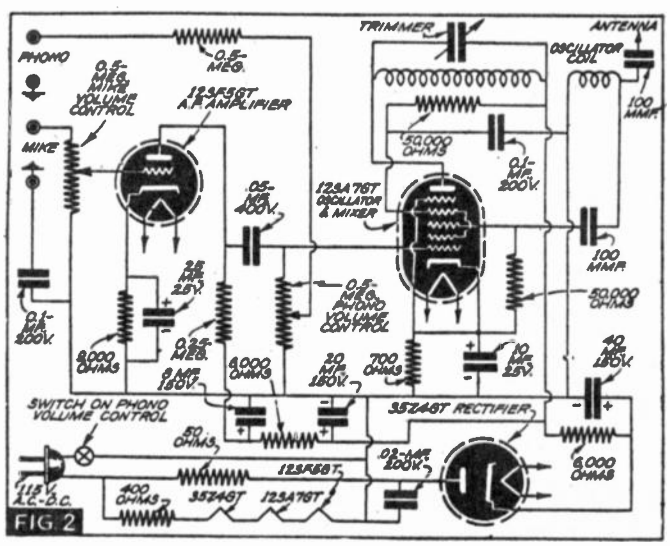


FIG. 2

Schematic circuits of 2 of the Phono-Oscillators described in the accompanying article, and illustrated at top of page pictorially.

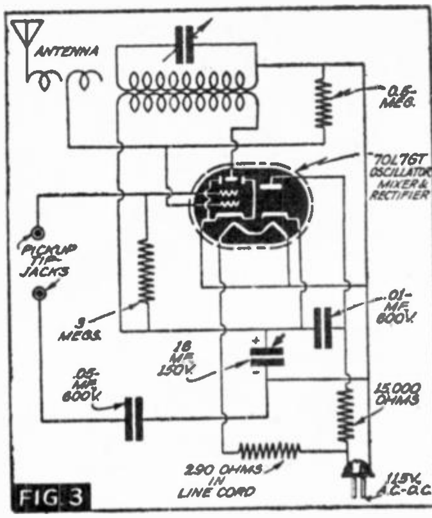


FIG 3

A 1-tube Phono-Oscillator designed for A.C.-D.C. operation. The 70L7 incorporates in one envelope the functions of oscillator, converter, and rectifier.

A 2-tube unit with the triode-pentode 6F7 as amplifier and oscillator. Such a set will give better results than a 1-tube set.

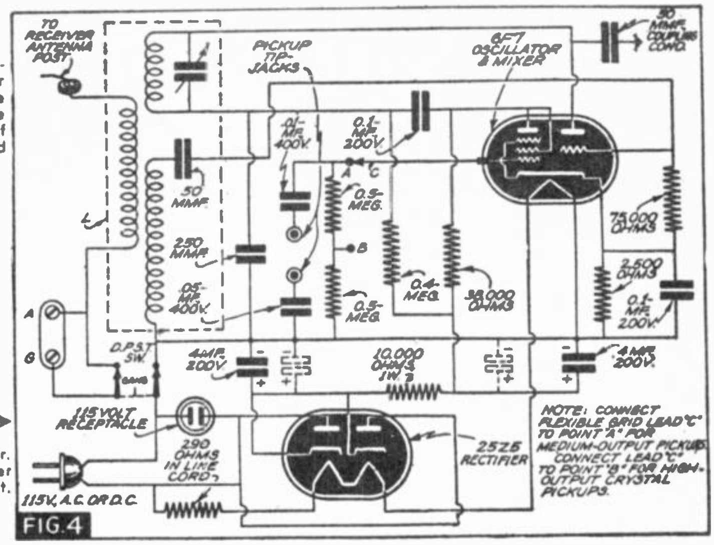


FIG.4

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 and Serviceman should take advantage of.

Most Servicemen know how to connect a phono pickup to the average radio receiver. But "radios" that are not of superhet. type do not lend themselves well to phono-pickup connection. The midget T.R.F.s, for example, which are so numerous on the market today are among those to which connections cannot easily be made. In many cases too, the radio dealer or Serviceman prefers not to tamper with the customer's radio receiver, but would rather sell their customer a unit which can be used to play phonograph records through their radio set but without direct connection to it. Here is where the "wireless phono-oscillator" plays its part.

The *wireless phono-oscillator* is exactly what the name implies. In simple words, it is a broadcast station, which when modulated by the voltage generated by a phonograph pickup transmits a signal to the radio receiver. The oscillator usually consists of a simple receiving-type tube in an oscillatory circuit. A multi-element tube is used—in which at least one extra grid is available for modulation purposes.

For the Serviceman with some spare time and some spare parts, here are a few phono oscillator circuits that can be built at very low cost. We suggest that one or two of the various models be built up and kept on hand for immediate sale. While basically the circuits are similar, each of them differs slightly and have their particular application. Let us review these circuits and explain their function.

2-TUBE "6A8" PHONO-OSCILLATOR

Figure 1 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 not much current is used by the oscillator tube, resistance-capacity filtering is employed. This type of filtering is economical and entirely adequate.

The grids in a 6A8 tube which are normally used for input and output 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 "electron-modulation," the modulation voltage having very little effect upon the stability of the oscillator.

A simple oscillator is used and plate feedback is employed. The variable condenser is 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-mmf. condenser.

The completed unit is shown in photo A.

DE LUXE "12SA7GT" PHONO-OSCILLATOR

Figure 2 represents a de luxe type of phono-oscillator, in which an additional tube is used to provide sufficient gain for microphone 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 phono and mike, the volume of each control being independently adjusted. The additional amplification of the 12SF5GT tube adds sufficient gain to the circuit so that crystal mikes or the popular priced P.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.

1-TUBE UNIT

Figure 3 is a circuit of a 1-tube phono-oscillator using a 70L7GT 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.C. 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 in 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 used again. The pentode section of the 6F7 amplifies the signals of the phono pickup and *plate modulates* the oscillator section.

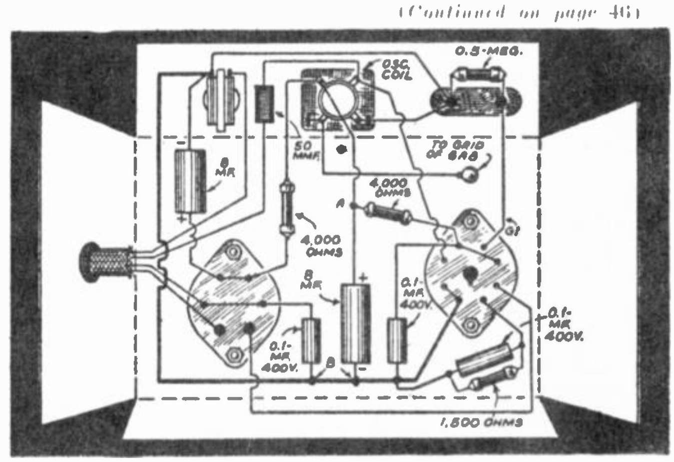
This circuit is based on the use of a Meissner type 17-9373 coil, L, pictured in photo D. This circuit when wired and assembled will look something like photo E.

The circuits shown here are representa-

(Continued on page 46)

FIG. 5

Pictorial diagram of the Phono-Oscillator shown schematically in Fig. 1.



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.

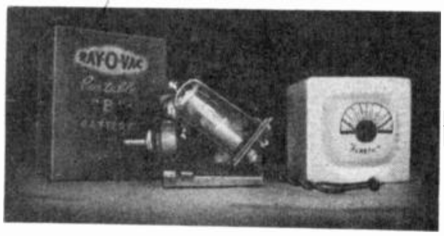
It is battery-operated and might be objected to on these grounds, but bear in mind the fact that the chassis can be used for other experiments, and also can be used after the war when batteries are available again. For those who have, or can get batteries, this description will be useful.

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.

It is wired directly to the plate of the 1H5GT, with its center tap connection soldered to one side of the tickler winding. Its other terminal goes to the earphones. (The earphones, by the way, can be a pair of 2000-ohm type. It was found they gave good audibility.)



The compact size of the receiver, and the handsome appearance of the home-made plastic case, is shown herewith.

The grid and tickler coils can be wound by the constructor if he desires, but the grid coil used in this receiver was the secondary winding 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 middle of the grid coil. If one wishes to wind both coils, a coil form 1-inch in diameter by 2½ inches long will be sufficient, with 125 turns of No. 28 enameled wire, to tune with a .000365 mfd. tuning condenser of the midget type.

The grid coil is wound first. Then place two layers of wax-paper over the grid coil, lapping one side of the paper so as to hold the starting winding. Both these windings are wound in the same direction, and to hold the primary winding tightly to the grid coil, a layer of "coil dope" may be applied, looping both ends of the coil form. It may be found necessary to juggle with the tickler winding, removing or adding a few turns to get the correct amount of oscillation. The wood chassis used, was 2½ x 3 inches x ¼-inch thick. The tube was mounted at an angle in order to give room to the other parts.

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-minus, and B-plus 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 whistles 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.

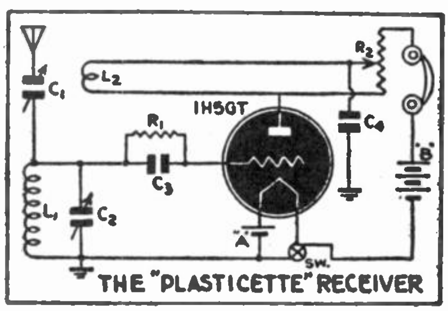
Slowly turn the tuning dial over its range and note the many station whistles, with the regeneration control turned up. If this does not occur, check over the tickler winding and reverse the connection, and try again, until oscillation begins. When a sharp signal is heard, rotate the tuning dial until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



The top and bottom pieces are 3 by 3 inches. The bottom piece has two ⅛-inch holes drilled 2 inches apart, with two small wood screws fitted into the wood chassis. The two side pieces are 3 inches square, with one side having a ⅜-inch hole about 1 inch from the back of the receiver.

The front is also 3 inches square, with a ½-inch hole drilled into the middle of the panel. If you have a pair of tinsnips, you can start with a piece of record that will give a 3-inch square, approximately with an additional 1-inch clearance. Hold the material well above the flame and in a few seconds it will become limp. It can then be easily cut with the tinsnips.

The process of record plastic molding is simple and any person with a gas range or a hot flame can do a neat job. For a pattern mold, the author used a small 3-inch square ash tray with a fancy edge. It was about ½-inch deep.

To mold the front panel place the heated record over the ash tray, 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.

After the mold is completed, square all the sides measuring 3-inches, heat again and cut off the excess material. To give a smooth slick 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 ¼-inch strips of record and lay in the file furrow, and mold the sides together. (The molder 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 bevel all corners with the hot file and follow up with the fine rast file.

A striking finish can be acquired by applying a coat of aluminum paint, then a coat of white enamel.

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

The knob was taken from the cap of a fingernail polish bottle. A ¼-inch hole was drilled about three-fourths of an inch through the middle of the cap and tapped with 3/16-inch tap.

The wood chassis is 2½ x 3 inches and ¼-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

CONDENSERS
C1—Antenna trimmer, 0-35 mfd.
C2—.000365 midget variable
C3—.00025 mfd., mica
C4—.005 mfd., mica
RESISTORS
R1—3 meg.
R2—25,000 volume control "baby" type
MISCELLANEOUS
B—45-V "B" Battery
A—1½-V. penlite cell
1—toggle switch
1—1H5GT RCA tube

How To Build A

TWO-BY-FOUR RECEIVER

From the earliest portable receivers — which were carried in a suitcase —— to this unit, little more than 2 x 4 inches in its dimensions, is a far cry. This receiver has a built-in speaker, which is held to the ear.

GONE are the days when experimenters sought to make sets larger and more elaborate. The tendency today—based on scarcity of parts, among other factors—is to make sets smaller and better, using, of course, only currently available materials.

Until the introduction of microtubes, which were introduced principally for hearing-aid devices, tubes required so much space that anything resembling vest-pocket receivers couldn't possibly be accomplished.

I was able to construct a complete receiver using three microtubes and an improvised loudspeaker, all of which, including an A battery and a 45-volt B battery, fits into a single box measuring 2¾ x 4 inches.

Lest there be any misunderstanding, I should like to state that the circuit diagram did not originate with me. In fact, it was designed by L. M. Dezettel, whose instructive articles are familiar to *Radio-Craft* readers. Whereas, Mr. Dezettel's receiver (described in Popular Mechanics) was built in a box measuring 3 x 3 x 2½ inches, the *A* and *B* batteries and earphones were not incorporated within the box, the belief that the complete receiver, including all accessories, could be made even smaller prompted me to undertake the mechanical redesign of his miniature portable.

As will be seen from the photograph, the complete receiver that I built fits into the palm of the hand and requires only that it be held near the ear to enjoy a broadcast program.

The complete receiver was assembled on a 2¾ x 4 inch panel, with all parts and the *A* securely mounted to the panel to permit ease of wiring and future removal from the case for battery replacement. The case measures 2 inches deep and houses the *B* battery. The *A* battery is fastened by a clamp to the back of the panel.

The microtubes have no bases and pins as do larger tubes, and therefore have their leads connected to the necessary terminals. Two of these tubes (one M74 and M54 audio tubes) are held in place by the wiring. To prevent possible breakage of terminals or shorting of terminals, I used two strips of celluloid, one on each side of the tube wires, cementing them together with acetone into one solid piece. The soldered joints were made below the point where the wires project.

The detector stage required shielding. This was done by wrapping a piece of thin sheet copper around the M74 detector tube to a fairly tight fit, sliding the shield away from the tube and soldering it to form a cylinder, leaving a small amount of copper extending beyond the joint to be able to solder a connection for the ground. This tube was placed adjacent to the trimmer condenser, which in this case serves as the tuning condenser.

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 ⅛ 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. I removed the cap and made a correspondingly sized washer, 1/16 inch in thickness, 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 125 to 350 mmf. 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.

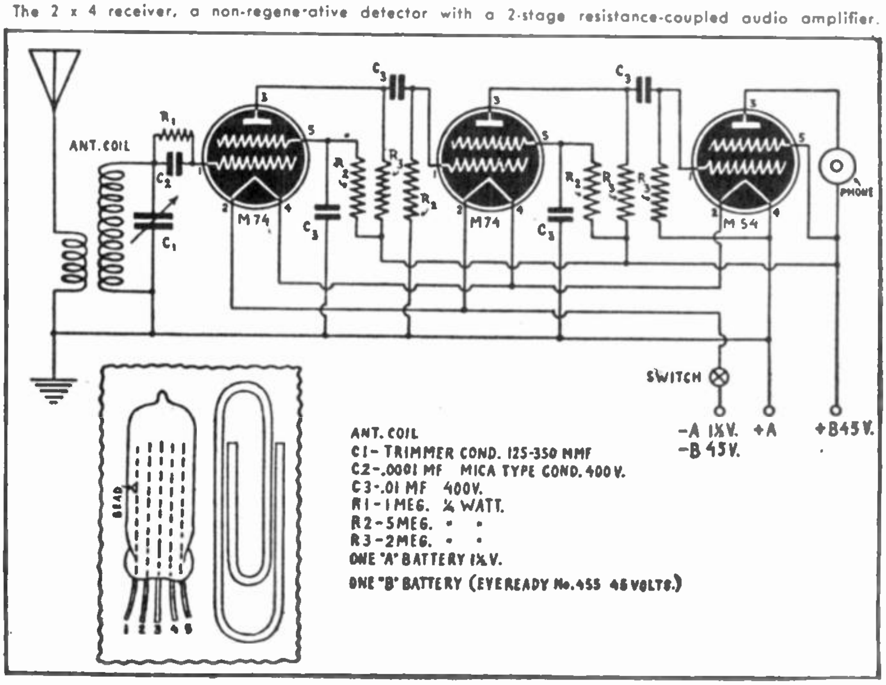
The case was assembled from scrap pieces of Bakelite put together by small L angles fastened by screws. Some of these screws had to be removed and replaced by rivets to permit the battery (No. 455 Eveready, 45 volts) to slide into the back of the case.

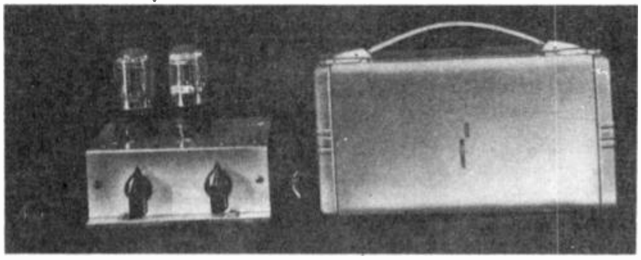
Although some form of aerial was required for reception, I found a ground connection unnecessary.

Precautions should be taken in wiring

(Continued on page 43)

The 2 x 4 receiver, a non-regenerative detector with a 2-stage resistance-coupled audio amplifier.





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 any more and the "A" batteries, which are ordinary flash-light 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 *Poket-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 mils. of filament current while the other tubes draw 50 mils. 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 mils. 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 in to 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 on 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 from 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 chokes for 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 this to be 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.

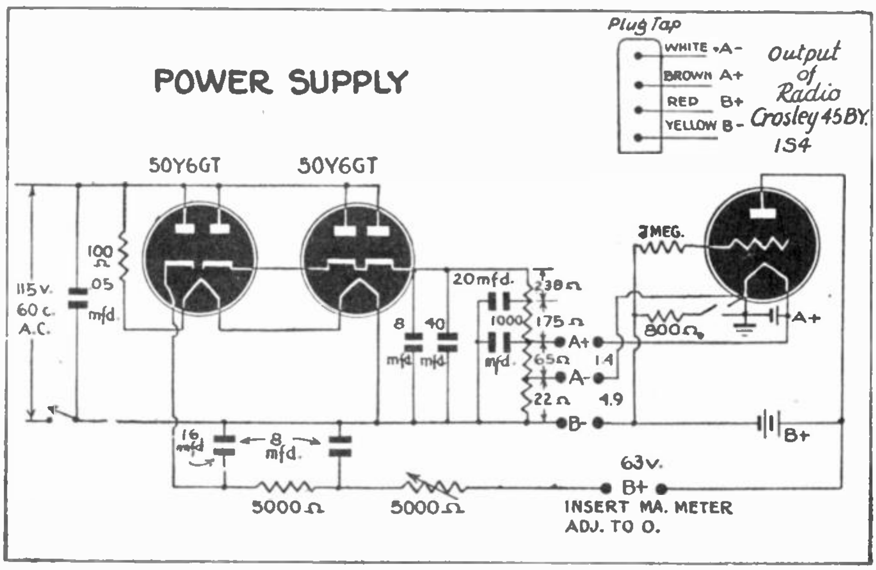
The remaining cathode of the rectifier tube was used for the "B" supply and is connected in a conventional half-wave circuit using a 5000-ohm resistor in place of the usual choke, and a 16-8 mfd. dual filter condenser. A 5000-ohm variable resistor is included for adjusting the "B" output.

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 load resistor equal to the filament load of the receiver 1.4/250=5.6-ohms, across (A+, A–) 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 whatever. 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 are shown in the schematic drawing, as connections are

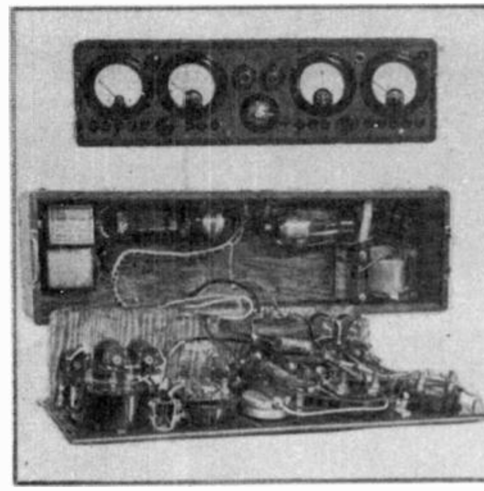
(Continued on page 45)



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

How to Modernize
AN OLD TEST SET

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 as a means of changing ranges, and I determined to place the pin jacks of the 400-B on the panel for this purpose. The analyzer had featured numerous switch-jacks 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 switchjacks was retained.

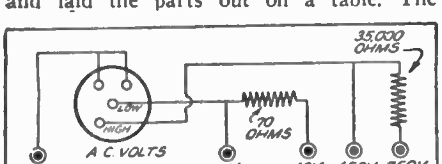
A.C. VOLTMETER

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 ohmmeter 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.

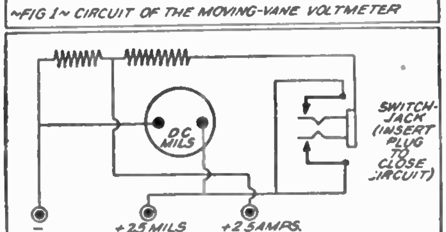
D.C. MILLIAMMETER

The milliammeter is designed to give full scale deflection with a current of 25 mils. 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 12)

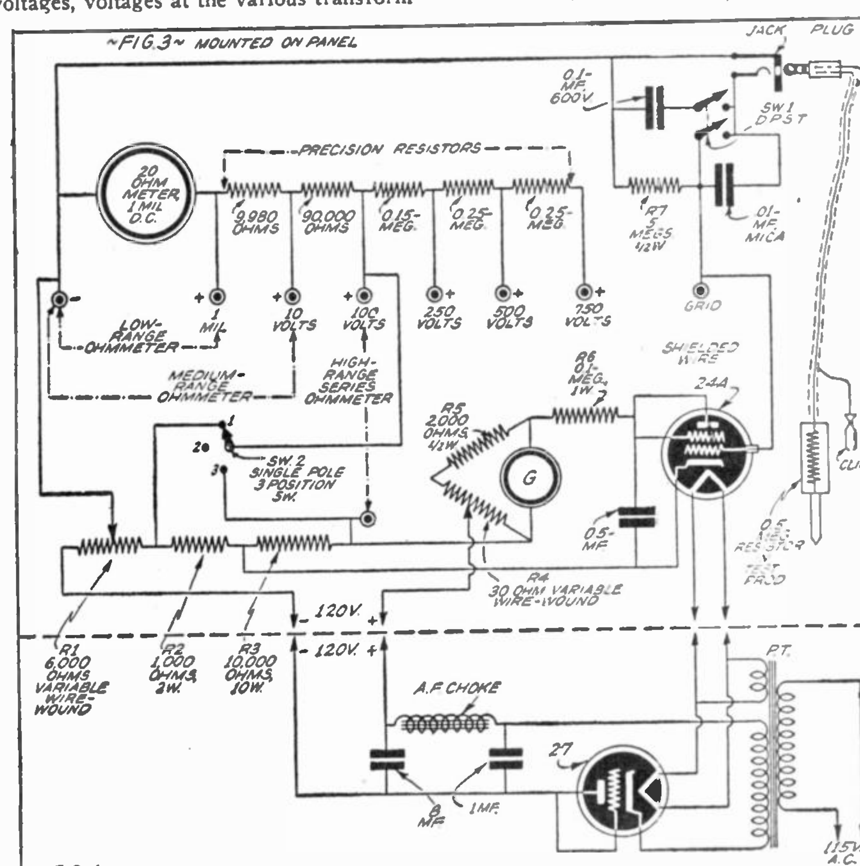


~FIG 1~ CIRCUIT OF THE MOVING-VANE VOLTMETER



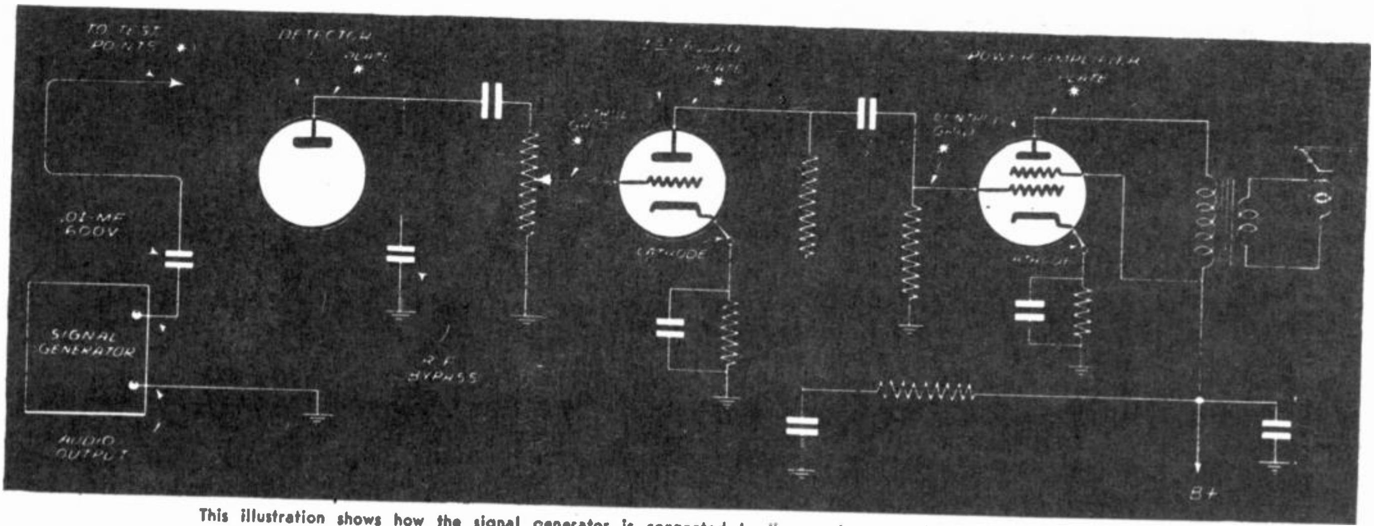
~FIG 2~ CIRCUIT OF THE D C MILLIAMMETER

Some details of the A C. and D.C. meter circuits



~FIG.3~ MOUNTED ON PANEL

~FIG.4~ MOUNTED IN CASE



This illustration shows how the signal generator is connected to the receiver; asterisks (*) show where, in a representative circuit, the test prods make connection.

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 suppose 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. If the Serviceman prefers not to, tubes need not be checked.

Whether tubes are checked or not, the power supply should be checked with a multimeter. If voltages are incorrect, steps should be taken to correct them. Since all Servicemen are acquainted with power supply failures, nothing further need be said.

Having now found our power supply working properly we can begin dynamic testing. Note however that if the power supply is found defective, steps should be taken to correct it at once, to prevent further damage; and also because that may be all of the trouble with the receiver being serviced. All types of dynamic testing assume that the power supply has been checked before the dynamic testing begins.

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 condenser 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 multimeter 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 multimeter 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.

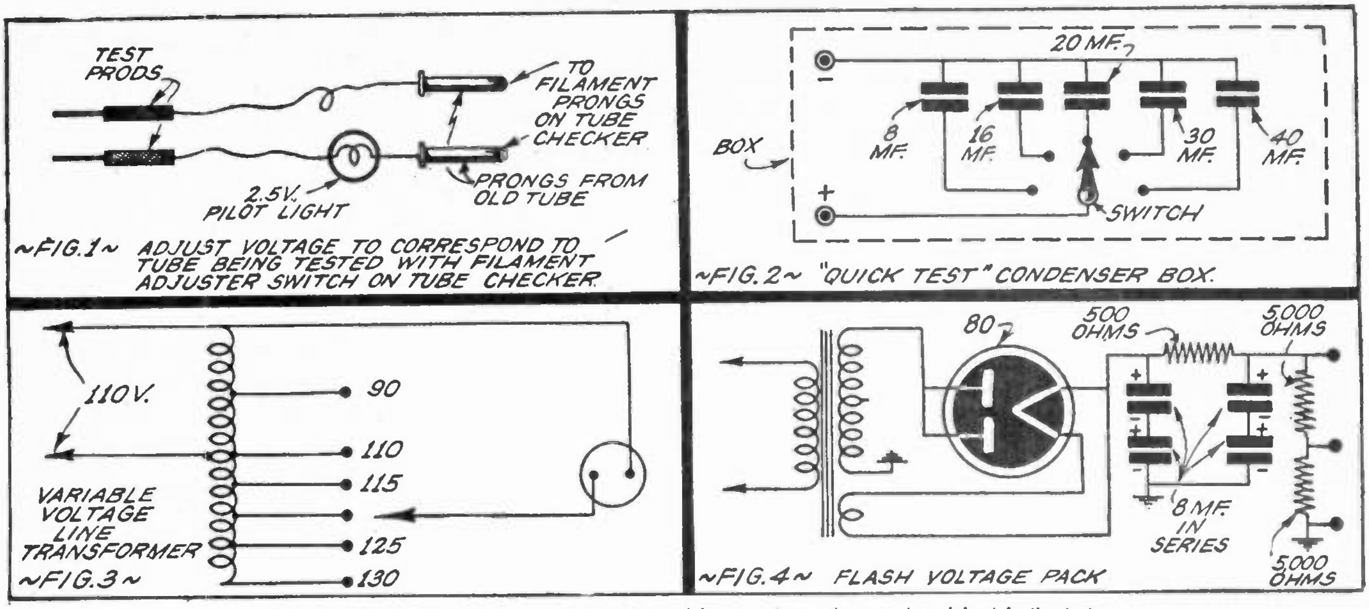
I.F. AMPLIFIER TESTING

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. amplication. If the signal becomes effected, 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

(Continued on page 34)



Several methods which will help to speed up servicing are shown above and explained in the text.

SPEEDY SERVICING

Speed is the secret of commercial success in radio service, and the man who can turn out good jobs in quantity has a natural advantage over his competitor whose work is as good but slower. The hints on speeding up radio repair should be valuable to many of the newer radio repairmen, and any suggestions on speeding up intermittents will interest all of them.

THE 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 jabber 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*. In 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 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 from the tube-checker through the pilot lamp and to the tube as the test prods 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 around in the set 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 increase 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, open fields* and *output transformers* and I-F's. 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 alignment can be 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 .0001 or .00025 mf. condenser. Feed in an I-F signal and stop the oscillator by placing a finger on the oscillator section of the tuning condenser. This stopping of the oscillator is not always necessary but is advisable. Adjust I-F's to maximum signal with set volume control "wide open" but oscillator turned down to where the signal is barely audible. If a low signal is used, the set can be peaked by ear, without hooking up an output meter.

When the I-F's have been aligned, the R.F. and 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. The latter method 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 ply-wood, 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 solve intermittents consistently. The busy service man can save himself much trouble and time by proceeding cautiously when he is called to service an intermittent receiver. If the set is cutting out only occasionally and if there is nothing that can be done to make it cut out, it can best be 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.

If, 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 that this writer has found is to break the defective part down. 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 short a good condenser or open a good resistor or winding, will often break down defective parts. In the case of AC-DC sets, the voltage has to be reduced 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 scratching 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 case 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 both *above* and *below* the normal value. Low voltage will cause a weak oscillator to cut out or it will cause *distortion* and *drifting.*

When the set is checked on high voltage it 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 parts that can usually be found lying around. The gadget will save many hours, and if used to final check all sets that go through the shop, the number of kick-backs will be reduced to a minimum. The parts 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 into the hands of others that part of the service work that does not require technical knowledge. This represents removing sets from cabinets, 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 how long 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. Or at least they should be on a *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.

DYNAMIC TESTING

(Continued from page 32)

heard a check of the circuit will disclose the trouble.

If a signal is heard, the generator should be switched to Broadcast Band (modulated R.F.), and tuned to resonance with the receiver. If no signal is heard the oscillator is not functioning. If the oscillator is found "dead," yet all voltages and parts are found in good condition, then irregardless of whether the tube tests good it is usually a good idea to replace it. A tube that will produce oscillation in some circuits will not necessarily cause oscillation in another. The receiver can now be tested at any frequency to determine if the oscillator goes out of oscillation. It is only necessary that the receiver and generator be tuned to resonance.

RADIO-FREQUENCY AMPLIFIERS

To test R.F. amplifiers the procedure is the same as for I.F. amplifiers; be sure, however, that the generator and the amplifier under test are both tuned to resonance.

CHECKING OF BYPASS CONDENSERS

To test a cathode bypass condenser in the A.F. section, feed an audio signal into the cathode. If the signal is heard; the condenser may be assumed to be defective. If no signal is heard and the condenser is known not to be shorted, then the condenser is operating properly. The effectiveness of any bypass condenser can be determined by feeding into the circuit a signal of the order it is required to bypass. Note however that in some circuits, although the circuit is functioning properly, a signal will be heard; experience will quickly teach you to recognize in what circuits to expect response, and how much.

CONCLUSION

This method of testing has proven quite helpful to me in my service work, and if you fellows will give it a try I am sure you will also find it helpful. This article is not intended to discourage the purchase of test equipment, but rather to aid the Serviceman who is financially unable to purchase more equipment. It is the hope of the author, that this type of testing will help the Serviceman who uses it, to do faster and better service work.

SIGNAL GENERATOR

(Continued from page 21)

screening, you will find it does the job nicely.

List of Parts

CONDENSERS

C1—.002 mfd. mica CD
C2—.00035 mfd. CD
C3—.05 400 volt CD
C4—3-30 mmfd. trimmer Mallory
C5—.0005 mfd. mica Aerovox
C6—.01 mfd. 400 volts CD
C7—.01 mfd. 400 volts CD
C8—.04 mfd. 400 volts CD
C9—20 mfd. 150 volt electrolytic
C10—.05 mfd. 400 volt CD

RESISTORS

R1—50,000 ohms ½ watt IRC
R2—200,000 ohms ½ watt IRC
R3—1 meg. pot. Centralab
R4—25,000 ohm ½ watt IRC
R5—3 meg. pot. Centralab
R6—500 ohm 1 watt IRC

MISCELLANEOUS

T1—Thordarson 2.5 filament transformer
T2—Input audio transformer
SW1, SW2—2 SPST switches
SW3, SW4—D.P. 3P switch Mallory
2—27 Sylvania tubes
1—117Z6 Sylvania


ARMY
E
NAVY
FIRST . . .
Hallicrafters has the honor of being the 1st exclusive radio manufacturer to receive the Army-Navy Production Award for the 3rd time!
BUY MORE BONDS!
hallicrafters
The World's Largest Exclusive Manufacturer of Short Wave Radio Communications Equipment

ELECTRON TUBE OPPORTUNITIES

(Continued from page 3)

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 spottedly 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 the bill for precision temperature-control; for automatic motor control, and as a time delay switch.

It may be used to control articles passing on a conveyer belt, by placing the grid lead of the tube so as to be sensitive to objects approaching it.

For thermostatic safety control there is the grid-glow tube, a cold-cathode triode in which the grid electrostatically controls the current flow. This tube may be utilized as an automatic controller for oil-burners with the conductivity of the furnace flame operating it.

This is just a hint of the wide range of jobs, for war and peace, that the electronic tube can master. America's engineers have developed these exceptional instruments.

It's up to America's radiomen to "keep em rolling."

STRING MUSIC PICKUP

(Continued from page 13)

pickup into either of the input jacks provided.

The schematic wiring diagram of the amplifier is shown at Fig. 2. The lead from the input jack to the grid 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 its own 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.

LIST OF PARTS

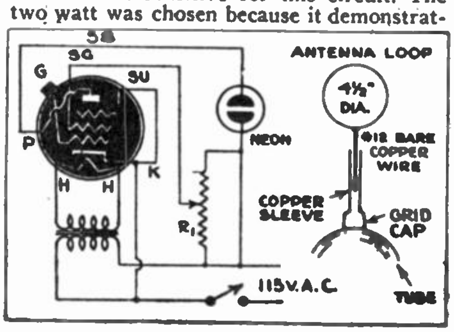
1—Metal chassis, 6 x 12 x 2 ins.;
1—Power transformer, 750 V., center-tap, 6.3 V., 5 V.;
4—Cornell-Dubilier filter electrolytic condensers, 8 mf., 500 V.;
1—Cornell-Dubilier filter electrolytic condenser, 1 mf., 400 V.;
2—Cornell-Dubilier filter electrolytic condensers, 25 mf., 35 V.;
1—Cornell-Dubilier bypass paper condenser, 0.1-mf., 400 V.;
1—4-prong wafer socket;
2—6-prong wafer sockets;
1—7-prong wafer socket;
1—I.R.C. carbon resistor, 0.5-meg., 1 W.;
1—I.R.C. carbon resistor, 0.25-meg., 1 W.;
1—I.R.C. carbon resistor, 0.1-meg., 1 W.;
1—I.R.C. carbon resistor, 1 meg., 1 W.;
1—I.R.C. carbon resistor, 350 ohms, 1 W.;
1—I.R.C. carbon resistor, 150 ohms, 3 W.;
1—Centralab potentiometer (volume control), 0.25-meg., with line switch;
1—Push-push input transformer;
1—Filter choke, class "B" input, max D.C., 175 ma.;
1—Phone jacks, single circuit;
1—Sylvania type 5Z3 rectifier tube;
1—Sylvania type 6A6 tube;
2—Sylvania type 6B5 tubes;
1—Loudspeaker (and case) to match into 2—6B5's in class B.

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 elemental 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 58 best suited the purpose.

In the selection of the light indicator, the two or three watt neon lamp was found to be the most sensitive 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 20 volts for 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 function of the screen grid to reduce the space charge and plate-to-grid capacitance.

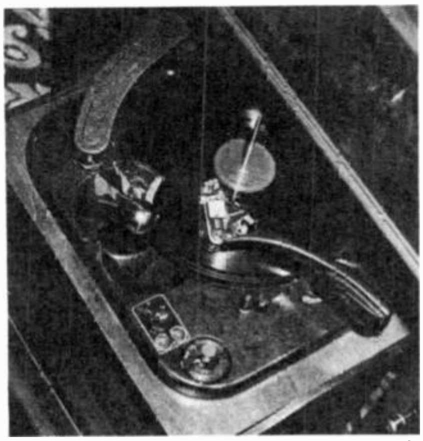
In demonstrating the control grid, the resistance must be regulated according to the type of charged body, distance, and type of antenna used. The best working voltage on the screen grid is about forty volts at a distance of one foot or less from the antenna. By careful adjustment of the light, the control 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 rubbed with wool, as it will give sufficient charge to trip the grid. For the best results, use a rubber or wax rod about one foot long and one-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)

the piano, reproducing the bass notes without any thumping sound and yet reproduc-



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

ing the high notes to the desirable maximum range without transmitting the hiss and record noise audible at these high frequencies on ordinary phonographs.

This faithful reproduction of highest frequencies is made possible by employing both mechanical resonance and electrical resonance. Electrical resonance is produced in the ordinary manner when the vibration of the jewel in the groove is translated into a varying flow of electric current operating the loudspeaker.

Mechanical resonance—an extra contribution to the tone value—is achieved by having the tiny arm which supports the floating jewel made of phosphor bronze of the exact thickness and length required to make that arm vibrate when a high note is reproduced. In other words, both the jewel and the 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 elay 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. Use of it increases the life of records so greatly that they may be played 1,000 times.

Such is the newest miracle of modern science—a phonograph which like talking pictures, reproduces sound on a beam of light!

ELECTRONIC SOLOVOX

(Continued from page 4)

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, smooth 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 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 intrigued by the quality of Solovox music, which resembles no other instrument, though closest 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 1 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 hearing 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.

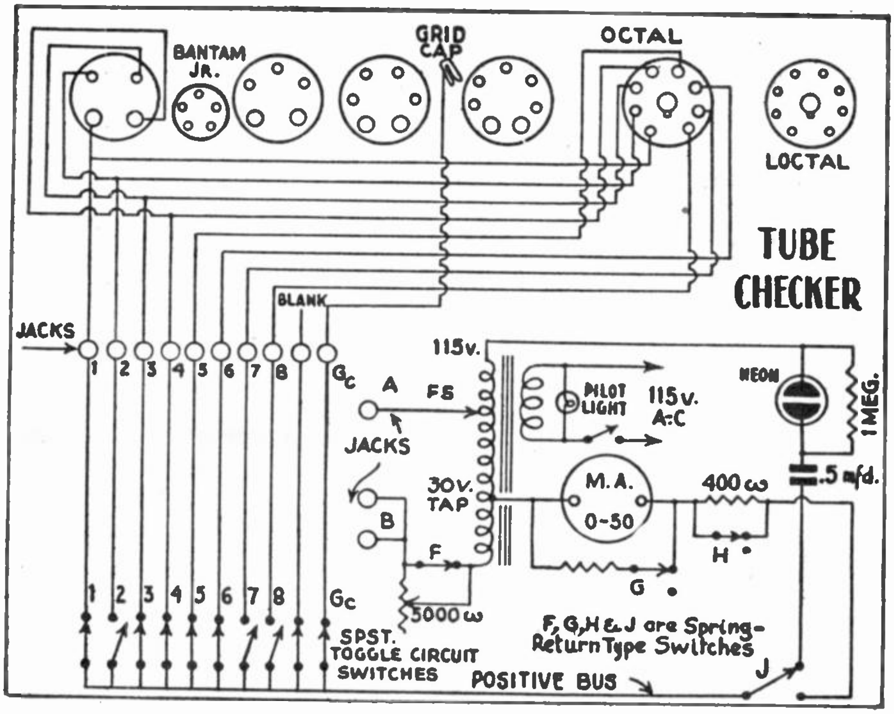
Ballast tubes can be checked for continuity by opening the requisite circuit switch and plugging B to the jack on the same circuit. If OK the neon bulb will glow.

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.

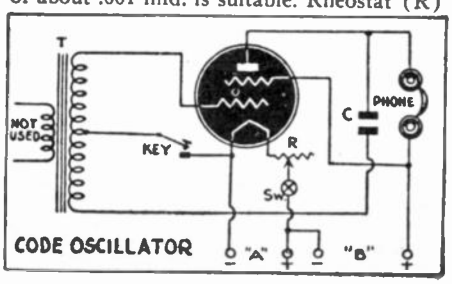
No provision was made for line voltage adjustments, as the variation shown on the milliammeter will not be so great as the case when a "BAD-?-GOOD" meter is used with its accompanying shunts.



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.

EXPONENTIAL HORN

(Continued from page 18)

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 grand—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 *cleanness* 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 prohibits 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. . . .

Courtesy Philadelphia Evening Bulletin

Robeson Technique of ACOUSTICS CONTROL

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

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 artists as the acoustics of the theatre are to the audience. Through the use of several elements of this "Robeson Technique," it is now possible for offstage choruses and upstage singers to hear the orchestra as easily as if they were standing by the footlights. Orchestral balance can be preserved backstage in a manner not possible by traditional methods. Soloists 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: tension, 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 is best for the song in an effort to get out more volume and fill up the house.

Several years ago, Mr. Paul Robeson discovered that if he stood in front of the speaker of a public address system which was being used in the concert, he enjoyed some of the desirable acoustic conditions usually associated with the small studio. Last winter, on the occasion of the stereophonic recording of the first Forest Scene from *The Emperor Jones*, technicians of Stevens Institute discovered the possibility of using this phenomenon to surround the performer by an "acoustic envelope" tailored to his demands. Experiments were conducted in the Maplewood (New Jersey) Theatre which has many acoustic limitations. A simple set of equipment was then devised for Mr. Robeson and used by him on a concert tour.

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 hears himself if he can 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; are not readily 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, 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.

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.

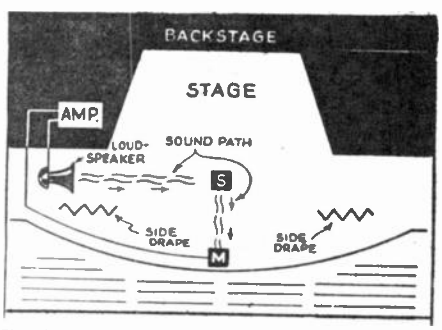


Fig. 1. Diagram showing instrument placement on concert stage for Robeson Technique. The letter S indicates the position of the singer; M represents the microphone (located in the footlights trough);

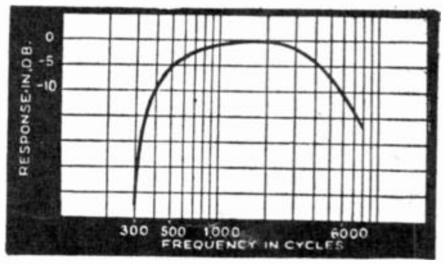


Fig. 2. Frequency characteristic of equipment used in the Robeson Technique. Only "significant" frequencies are fed back to the performer. The selected frequency band constitutes a highly directional beam, at an optimum intensity level, which only the performer can hear.

CALIBRATED UHF OSCILLATOR

(Continued from page 19)

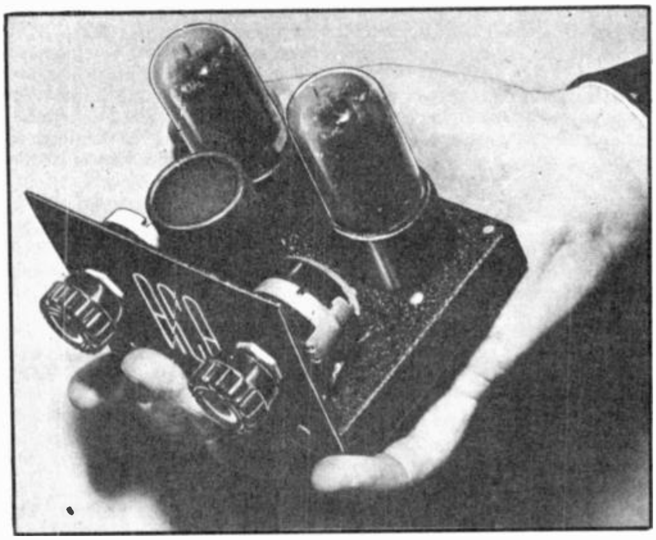
dial upon which you can mark the wavelength values. You could also plot a calibration curve (wavelength or frequency values vertically and dial-setting values horizontally, for example).

In Fig. 2, you will find the complete dimensions for the high frequency wavemeters. 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 when 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 twelfths. 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"



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.

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.

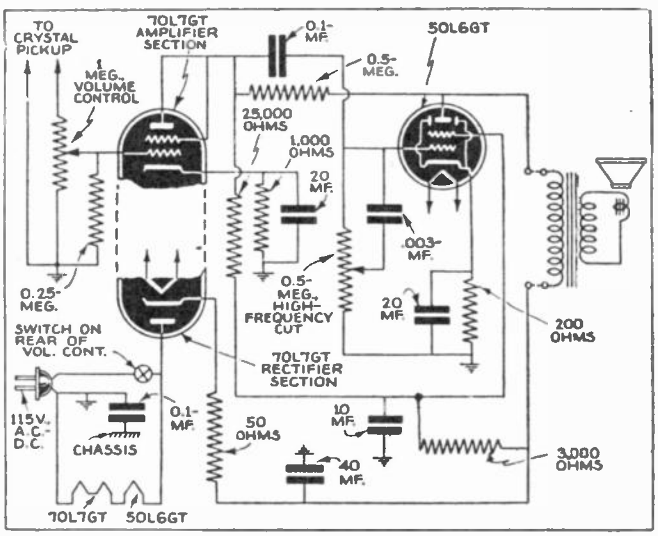
The beam power section of the 70L7GT is used as a resistance-capacity coupled triode tc drive the 50L6GT output tube, which is capable of delivering 1½ watts.

A constant-voltage, inverse-feedback circuit is employed through the use of one 500,000-ohm resistor, which is connected between the plate of the output tube and its triode driver.

By connecting a ½-meg. resistor from center arm to the ground on the side of the crystal pickup control, an *automatic bass compensating* or A.B.C. network is made available. It will be noted, that as the volume is increased, a shunt resistor is placed directly across the pickup. The response characteristic of 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 ¼-megohm shunt is gradually removed from across the pickup, so that bass boost takes place. At the higher levels, however, the ¼-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 ½-meg. grid-return resistor normally employed.



(Continued from page 31)

OHMMETER CIRCUIT

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 power-supply 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, center-scale equals 20 ohms; medium, center-scale equals 10,000 ohms; and high, center-scale equals 0.1 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 first two 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)

$$Rx = 20 \frac{\text{reading}}{100\text{-reading}} \quad \text{and (2)}$$

$$Rx = 10{,}000 \frac{\text{reading}}{100\text{-reading}}$$

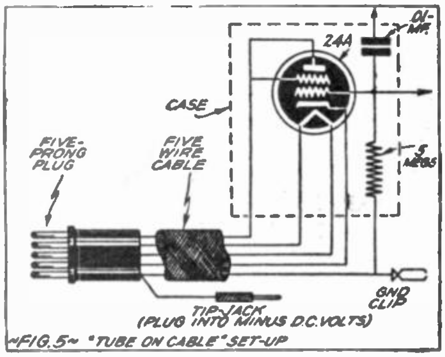
The third range is a "series ohmmeter" circuit; in this case the resistance to be measured is thrown in series with the 100 volt supply, the 100,000 ohm resistor of the voltmeter, and the 1 ma. meter. The "ohms" values in the high range column were determined by use of the formula

$$Rx = 100{,}000 \frac{100\text{-reading}}{\text{reading}}$$

In practice the ohmmeter is used as follows: Sw. 2 is thrown to position 3, and R_1 is adjusted for full scale deflection of the meter. For low and medium ranges, the resistor 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 resistance. 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 is made 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 R_1, 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 R_1 may be read on the D.C. voltmeter. The V.T. voltmeter is used as follows: With Sw. 2 in position 1, and with R_1 set to zero, the galvanometer is balanced by means of R_4. Test prods are applied to the voltage to be measured, and R_1 is adjusted to bring the galvanometer back to zero; the value of the balancing voltage may then be read on the D.C. voltmeter.



Circuits of the test meters and cable set-up.

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 of the jack which gives access to the V.T. voltmeter input by means of plug and shielded cable. It should be noted that if the V.T. voltmeter is used in this way, the shielded cable tends to capacitatively short out R.F. 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 also be used.

The balancing circuit is a simple bridge, in which R_4 is the 30 ohm rheostat of the old 400-B converted for use as a potentiometer. The galvanometer gives full scale deflection on a current of 660 microamperes. A 1 ma. meter would serve just about as well. If a 1 ma. meter were used, the 0.1 megohm resistor, R_6, in the plate circuit of the 24A, could be reduced in value somewhat, so as to give equal sensitivity. This resistor reduces the sensitivity of the circuit somewhat but serves to limit the plate current to a value such that the plate circuit meter cannot be injured.

Whether the slide-back type of V.T. voltmeter is better or worse than other types, depends largely on the use to which the meter is put. The slide-back type is accurate, it has no calibration to maintain, and it has the advantage of measuring peak A.C. volts as well as D.C. volts. In this application, sensitivity is limited to voltages that can be read on the 100 volt scale of the D.C. voltmeter. The maximum range is about 40 volts; however, the range could be extended by changing the value of R_1 so as to allow a greater range of adjustment of the balancing voltage. Also, if a 5 megohm resistance is inserted in the lead to the grid of 24A, the voltage measured will be double the reading obtained.

The power supply for this unit should furnish 2.5 volts for filaments, and approximately 120 volts D.C. This voltage is not critical, and need only be such that R_1 can set the ohmmeter voltage to 100 volts. However, good regulation is essential, as in most instrument power supplies. Also, a transformer type power-supply is necessary in order to avoid accidental injury to meters, etc., through shorting to the power line.

Bringing out heavy, insulated wire for the leads, and fastening it on securely so as not to depend on the fine wire for its support, a high voltage secondary of fine enameled wire (taken from an old choke coil) was wound on by hand. One hundred turns were wound to the layer, and these were wound in groups of ten, so that no two turns in which a considerable difference of potential existed, would be in proximity. Between layers, a thin piece of paper, stuck on with shellac, and covered with the same liquid, was placed. 900 turns were used to give 150 volts A.C.; there is considerable loss in the winding, in the tube (27) used as a rectifier, and in the filter circuit, which has a very low capacity input.

WHAT ABOUT ELECTRONICS?

(Continued from page 21)

slow compared with the time required for them to move from one electrode to another.

The second reason that electron tubes are unique is their ability to control electrical currents smoothly. Most devices that are used to vary an electric current do it step-by-step. The charge carried by each electron is so exceedingly small that the rhythmic increases and decreases of current to reproduce music or the human voice are easily, accurately, and smoothly accomplished.

The third feature is their ability to control the movement and velocity of the speeding electrons by merely changing the electrical potential of one of the electrodes inside the tube. This requires only a very small amount of electrical power. (This is just another way of expressing the well-known fact that electron tubes are amplifiers and can reproduce, at a greatly increased power level, the impulses fed to them.)

The fourth feature is their ability to pass current only in one direction or, as it is often expressed, to act as rectifiers.

If one considers electron tubes in the light of these four unique characteristics, it is readily seen why they are so essential to modern radio. It is because these tubes possess and can utilize simultaneously some or all of these properties. In turn, modern radio needs just these properties. It is easy to understand this when we remember that radio is inherently a science of very high electrical frequencies; that it requires complicated wave forms, and that at the receiver one must pick up the very minute amount of power received from space by a few inches of wire and increase it to a point where the reproduced sound is at a relatively high power level or, as we say, has been greatly amplified.

Electron tubes are now available in an almost bewildering array of kinds and sizes and are now in use for many purposes in addition to radio. However, in all their applications, they represent that vital link in the electrical circuit where the current flowing in that circuit is no longer in a wire but rather of such a nature that it can be controlled in unique and useful ways "free from the bondage of wires." Such is the essence of electronics.

IMPROVED EXPANDER - COMPRESSOR

(Continued from page 16)

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.

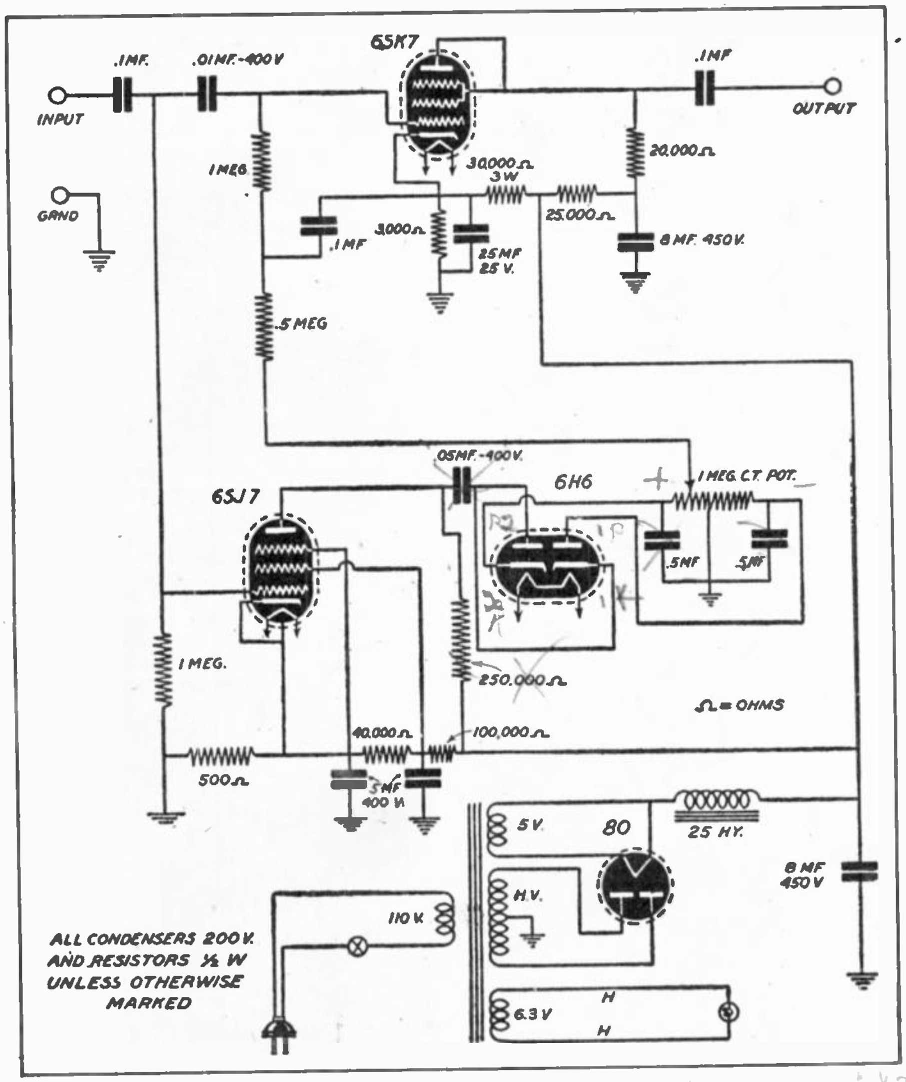
PARTS LIST

KNIGHT PARTS:
1—Power transformer, sec. 650 V. A.C. at 40 ma. C.T., 5 V. at 2 A, 6.3 V. at 16 A.
1—Filter choke; 25 hy. at 25 ma., 850 ohms
1—8 mf., 450 V., upright electrolytic
1—8 mf., 450 V., tubular electrolytic
1—25 mf., 25 V., tubular electrolytic
1—1 mf., 200 V., tubular paper condenser
4—.5 mf., 200 V., tubular paper condensers
2—.1 mf., 400 V., tubular paper condensers
1—.05 mf., 400 V., tubular paper condenser
1—.01 mf., 400 V., tubular paper condenser
1—30,000 ohm, 3 watt, carbon resistor
1—25,000 ohm, ½ watt, carbon resistor
1—20,000 ohm, ½ watt, carbon resistor
1—40,000 ohm, ½ watt, carbon resistor
1—100,000 ohm, ½ watt, carbon resistor
1—3,000 ohm, ½ watt, carbon resistor
1—500 ohm, ½ watt, carbon resistor
1—500,000 ohm, ½ watt, carbon resistor
1—250,000 ohm, ½ watt, carbon resistor
2—1 megohm, ½ watt, carbon resistor
3—Octal 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 pilot lite socket and 6.3 V. bulb
1—Line cord and plug
2—Insulated pin jacks
1—Plain binding post
Hardware, wire, etc.



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 determining the numbering 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.

A NEW COMPACT HEARING AID

(Continued from page 7)

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 feed-back 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 extensive 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.

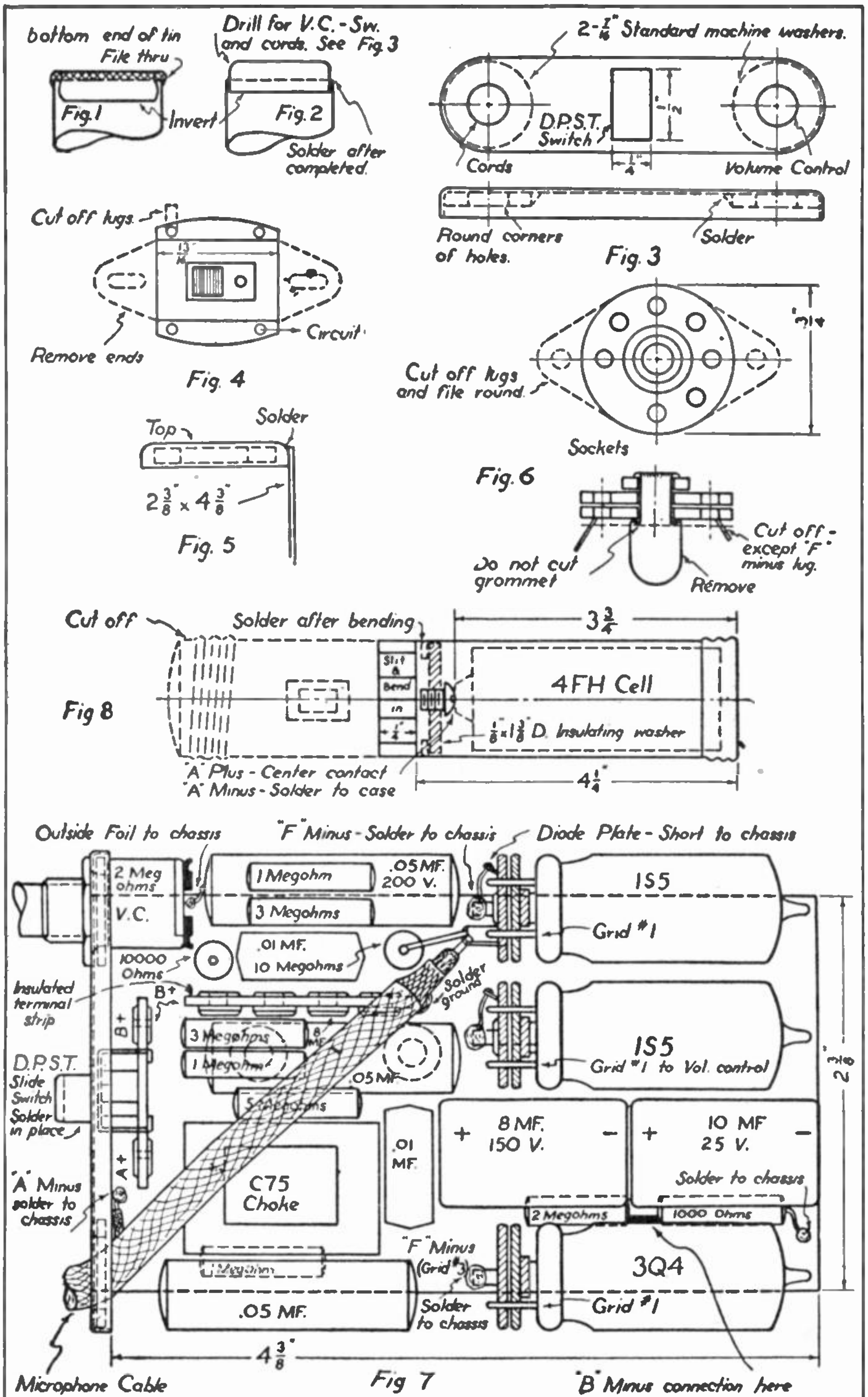


Diagram of the amplifier together with microphone, and details of construction are shown.

Parts List

RESISTORS
One—I.R.C., ½-W., 10 megs.
One—I.R.C., ½-W., 5 megs. (for feedback, if desired)
Two—I.R.C., ½-W., 3 megs.
One—I.R.C., ½-W., 2 megs.
Three—I.R.C., ½-W., 1 meg.
One I.R.C., ½-W., 10,000 ohm.
One I.R.C., ½-W., 1,000 ohm.

CONDENSERS
Three Cornell-Dubilier, .05 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—Shure Bros. No. 76-B Lapel Mike.
One—Brush Development Co., A or B Crystal Headphone.
One—Stancor Hearing-Aid Chokes (Five Part Numbers available for Various Tubes and Tone Response. Nos. C65, C66, C67, C75).
One—Central Lab. Vol. Control, "Elf," 2 megs.
One—Insuline 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).
One—Eveready Hearing-Aid Battery No. 455 and connectors, 45 Volt.
One—Cornish Wire Co., 20 ft. Replacement Antenna Lead Wire (for A & B battery leads).
Two—RCA Radiotrons, 1S5.
One—RCA Radiotron, 3Q4.
One—Cornell-Dubilier "Beaver" Dry Electrolytic, Capacity 8 mf., 150 Volts.
One—Cornell-Dubilier "Beaver" 10 mf., 25 Volts.

HANDY TESTER AND SIGNAL TRACER

(Continued from page 20)

when it is desired to use the power supply for other purposes without the load of the rest of the rig, and a green pilot light across 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,-000-ohm 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 plate coupling condenser should not be over 100 mmfd. Use a bias cell or 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 005-mfd. 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. Local stations 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 co-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 may be necessary to slightly retune the set under test, as the R.F. stages are very sensitive to even very minute changes in capacity. Once the I.F. circuits have been reached however, no such disturbance will be manifest. Proceed right on to the second detector with the R.F. prod. 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.

If it is desired to check the second detector without any R.F. amplification obtained from the signal tracer, connect the test prod to tip jack terminal No. 2.

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 microphone cable with the shield grounded to the chassis of the signal tracer should be used. This cuts out hum and other strays 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 well up, hum will be indicated without actually making contact 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 6E5 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 with the signal tracer by connecting the jumper between the headphones output terminal and terminal No. 2. 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 turned on. During the short time interval during which the rectifier tubes are heating up, the set will be operating on batteries with some distortion as the 800-ohm bias resistor in the receiver is in parallel with the 65-ohm section of the voltage divider in the power supply. However, as soon as the power supply takes over, the volume and quality of reception will be considerably better than when set is operated on batteries.

A 5000-ohm variable resistor is shown in the B+ circuit of the power supply. This 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.

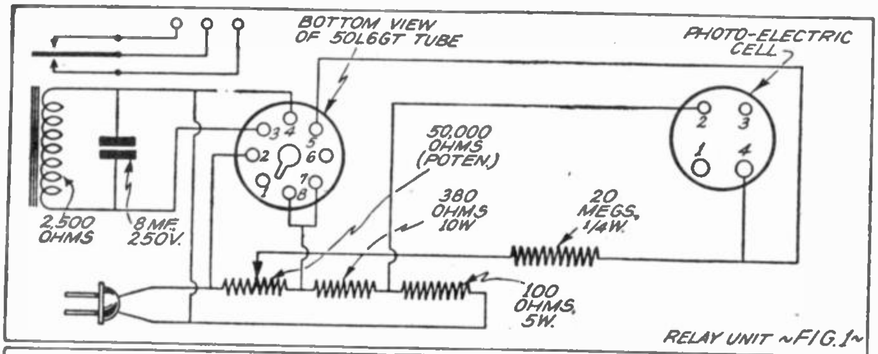
To adjust this resistor, remove the B+ lead on the "B" battery and connect a 0 to 15 MA meter in circuit, then adjust the variable resistor until meter reads 0; now remove meter, reconnect B+ lead to "B" battery, and adjustment is finished.

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.

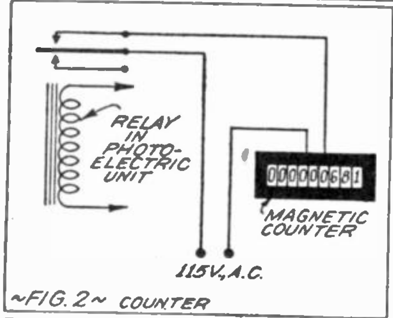
The writer has used this outfit for over a year as a portable during the day and as an A.C. outfit in the evenings while at home. The reception is very good. The use of this power pack prolongs the life of the existing batteries and since it will work when the "A" and "B" batteries are completely removed from the set, it provides a means of enjoying radio reception with the miniature portable when the batteries are exhausted and no replacements are forthcoming.

EXPERIMENTAL PHOTO-CELL RELAY

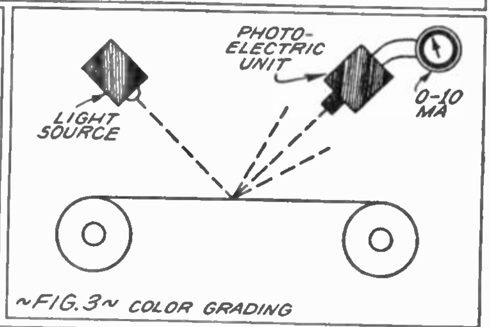
(Continued from page 9)



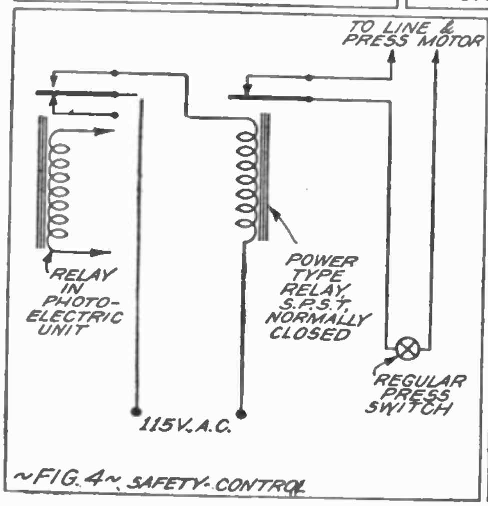
RELAY UNIT ~FIG. 1~



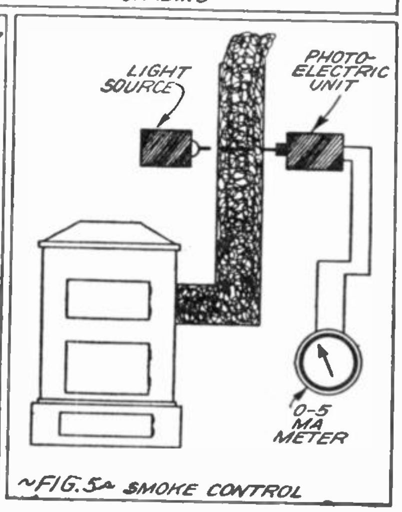
~FIG. 2~ COUNTER



~FIG. 3~ COLOR GRADING



~FIG. 4~ SAFETY-CONTROL



~FIG. 5~ SMOKE CONTROL

using the meter as for grading will register the relative density of the smoke passing through the chimney breach.

LIGHTING CONTROL

The unit may be made to turn on lights in stores and factories or on outdoor signs as evening approaches. The relay unit is installed outdoors, but in glass so that it is weatherproof. It is positioned so that light from the sky, reaches the photo-cell. It can be adjusted so that if the sky light drops below a certain minimum, the relay will be actuated. It, in turn operates a power relay which turns on the lights.

BURGLAR ALARM

First we need an *invisible* light beam. The source is the same as mentioned, but it must be built into a light-tight box. An infra-red filter is fastened over the light exit. The human eye is not sensitive to *infra-red* light but a photo-cell is. The beam of light is installed to protect doorways, windows, etc., and a bell connected to the relay contacts as described for announcing.

MISCELLANEOUS USES

There are literally dozens of other applications for a photo-tube circuit of this kind, such as measuring the turbidity of liquids, checking light-transmission characteristics of various materials, surface-polish measurements, checking heights of liquids, etc. These can be realized by using a meter in the plate circuit of the 50L6.

PARTS LIST

CONDENSERS

1—8 mf. 250 volt electrolytic

RESISTORS

1—50,000 ohm potentiometer
1—20 megohm ¼ watt carbon
1—400 ohm 10 watt adjustable (adjust to 380 ohms)
1—100 ohm 5 watt

MISCELLANEOUS

1—Amphenol octal socket
1—Amphenol 4 prong
1—3 screw terminal strip
1—Line cord and plug
1—Potter-Brumfield 2500 ohm relay (type MRS-291)

TUBES

1—Cetron CE-T gas-filled, caesium photo-cell
1—Knight 50L6GT

HOW TO BUILD PHONO OSCILLATORS

(Continued from page 27)

tive of nearly all Wireless Phono-Oscillator 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 method of increasing the stability of the frequency, 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 a crystal pickup is that of guarding against over-modulation. Unfortunately phono-oscillators are not capable of 100% modulation such as actual transmitters. If distortion occurs turn down the record player volume control until the quality clears up. If increased volume is required, the volume control of the radio set should be turned up. If this precaution is observed good-quality reproduction can be expected from any one of these units.

For those of you who would like to build the simplest one of these circuits, we include Fig. 5 which is a pictorial diagram of Fig. 1, photo A. 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

Two, 4,000 ohms, ½-watt;
One, 50,000 ohms, ¼-watt;
One, 1,500 ohms, ¼-watt;
One, 280-ohm line cord with built-in antenna.

CONDENSERS

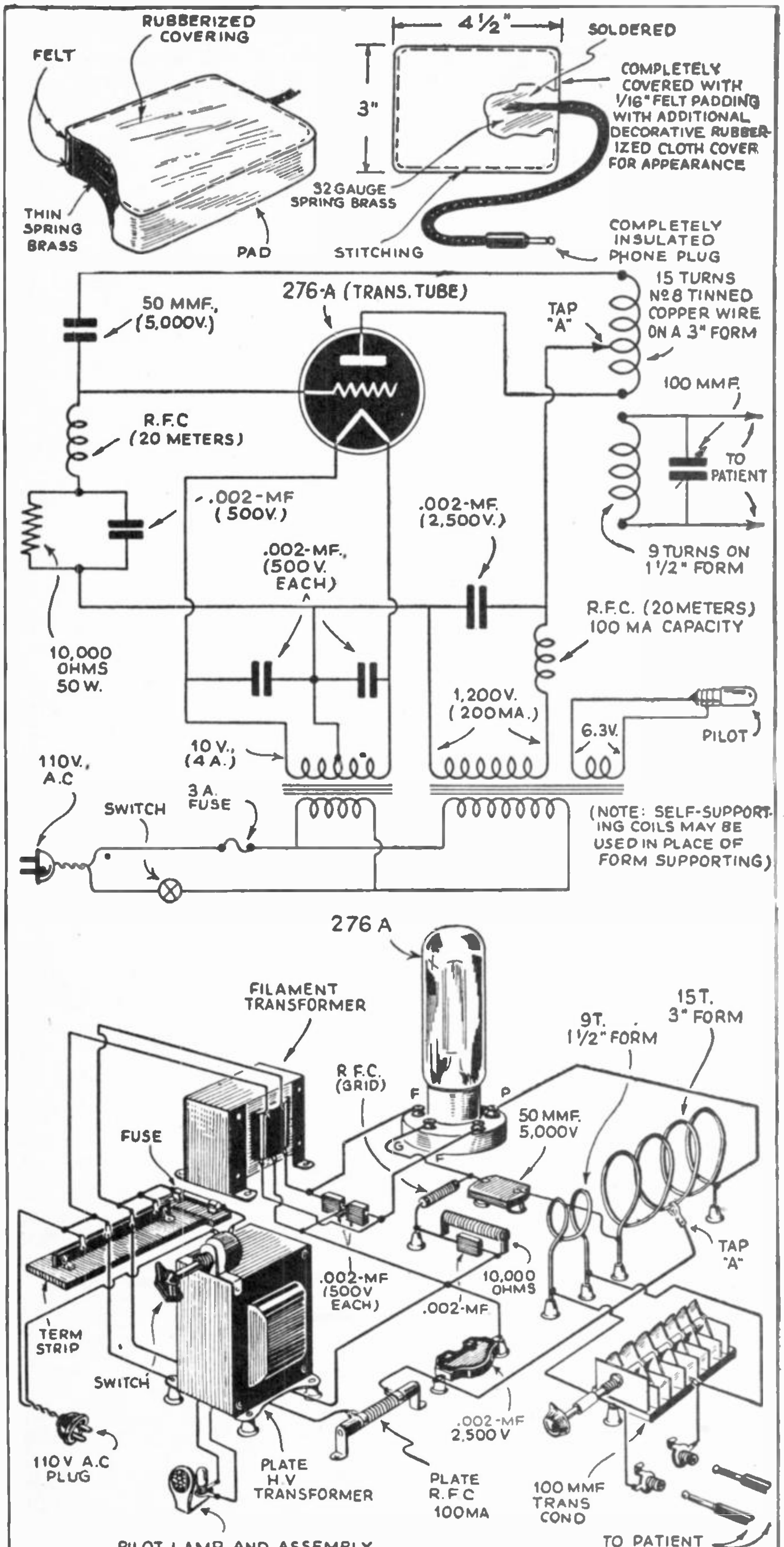
Two, 8 mf., 150-volt tubula. electrolytic;
Three, 1 mf., 400-volt paper tubular;
One, 50 mmf., mica.

MISCELLANEOUS

One, 6-prong wafer socket;
One, octal wafer socket;
One, Knight No. N2925 drilled chassis;
One, Knight No. 2279 oscillator coil with trimmer;
One, Knight No. N2924 package hardware;
One, 6A8 tube;
One, 25Z5 tube;
One metal tube grid cap;
One, S.P.S.T. toggle switch;
One, input jack strip marked Phono.

SIMPLE HOME DIATHERMY APPARATUS

(Continued from page 8)



Top picture shows detail of diathermy treatment pad or electrode, two of which are required. Both schematic and picture diagrams are shown, so that wiring becomes an easy matter.

the connections of the lamp, and placing these each near one 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 work.

Diathermy machines have a tendency to interfere with short-wave reception in their immediate vicinity. This one does not have any effect whatever 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 be caused it will be necessary to *shield* the room in which the machine is used.

A VERSATILE MULTITESTER

(Continued from page 22)

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 1100 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.

D.C.		A.C.
1	250 volts	1
2	15 volts	2
3	75 volts	3
4	15 volts	4
5	7.5 volts	5
6	High Ohms	–
7	Medium Ohms	–
8	300 M.A.	–
9	150 M.A.	–
10	75 M.A.	–
11	15 M.A.	–
"DOWN"	Switch Position	"UP"

OHMMFTER

100	13.5	2,000	8.7
200	13	3,000	6.75
300	12.75	4,000	6
400	12.5	5,000	5.5
500	12	7,500	4.5
600	11.5	10,000	3.3
700	11.25	15,000	2.5
800	11	25,000	1.5
900	10.75	50,000	0.8
1,000	10.5	100,000	0.3

This chart is glued to the bottom of the case. Ohmmeter readings are "for example only"

Points 8 to 11 on the gang switch are milliampere 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-milliampere shunt, by this calculation, had to have a resistance of 6.67 ohms. The 75-milliampere 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 till they were right. Nichrome wire was used for all the shunts, several of the fine wires being twisted into a cable for the higher ranges.

Copper wire could have been used, but it changes resistance with changing temperature, and the nichrome made shorter and smaller shunts possible. It is hard to solder, so the connections were made by twisting the nichrome wire around the lugs of the switch firmly to make a good electrical connection, then flowing in solder and rechecking to see that the conductivity of the shunt had not been changed by the soldering. The connection between the solder and the nichrome is purely mechanical, so the contact lugs must be well cleaned and an excellent soldering connection made to them. 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 condenser and used for output measurements. The output meter was abandoned in favor of the low-ohm range. When it is necessary to measure output, the meter is connected up to the output circuit under test through a 0.5 mfd. condenser, and the switch set for the A.C. range which gives the best results.

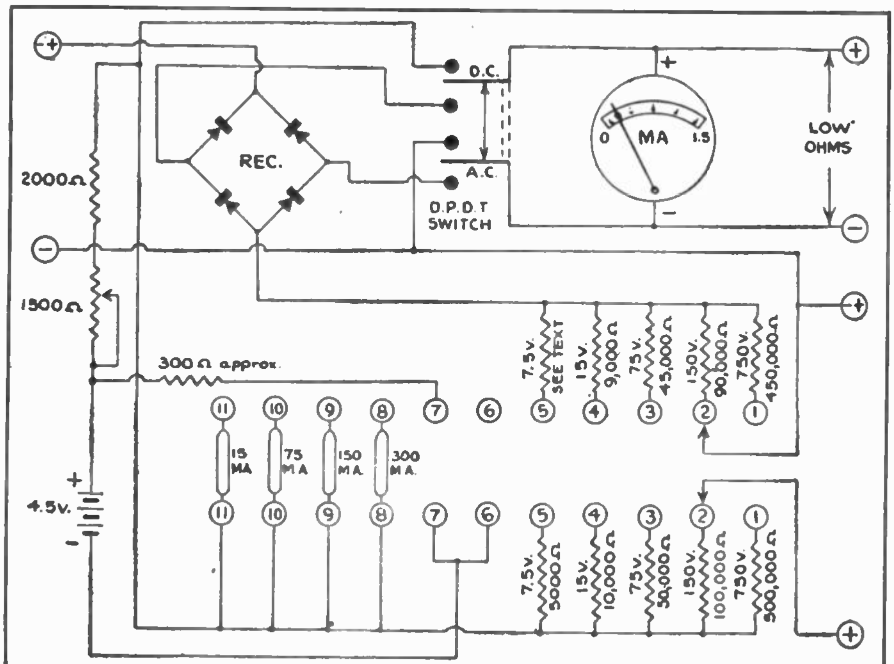
The only change necessary to adapt this multitester to a 1-ma. meter is to use a 3-volt battery in the ohmmeter instead of the present 4.5 volt one, or to increase the total resistance in the ohmmeter circuit from the present 3,000 ohms to 4,500 ohms. Milliammeter shunts have to be adjusted to the internal 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 other 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 milliampere, calibrated at 0.1, 0.2, etc., milliamps. For the 1.5, 15 and 150-volt or milliampere scales, the reading is direct. Readings are multiplied by 5 for the 7.5, 75 and 750 scales and doubled for the one 300 (milliampere) scale.

The same is true of ohms. A chart giving the ohms for each milliampere 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 sheet showing the range for each 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.



Maximum of function with minimum of parts is made possible by using one side of the gang switch for D.C. and the other for A.C., and by the ingenious cross-over connection between the two circuits.


COMMUNICATIONS FOR
VICTORY!
BOUGAINVILLE
GUADALCANAL
NEW GUINEA
AUSTRALIA
New Supreme "Hairline Accuracy" Meter
Allied lives . . . Allied victories . . . depend upon the Communication waves and wires. These channels of contact must be kept open. Our fighting men rely on the accuracy, dependability and ease of operation of Supreme Instruments and Meters, assured by Supreme's 15 years of experience.
Supreme Radio Testing Equipment Keeps Communications Open.
Combination Tube and Set Testers
SUPREME
SUPREME INSTRUMENTS CORP.
GREENWOOD, MISSISSIPPI, U. S. A.
Multimeters, Electronic Voltmeters
Cathode Ray Oscillographs
Signal Generators

AUDELS AIRCRAFT WORKER.........$1
Answers Your Questions on 1—Aircraft Materials, Terms, Parts. 2—Blueprints, Working Drawings. 3—Mathematics, How to Figure. 4—Layout & Bending. 5—Tools & Machines. 6—Riveting, Spot Welding & Hints. 7—Fabrication, Blocking, Angles, etc. 8—Assembly, Fuselage, Wing & Final—How to Use Tools. 9—Tables & Data, Symbols, Army and Navy Specifications, etc. 240 Pages Fully Illustrated.

AUDELS SHEETMETAL PATTERN LAYOUTS................$4
Developed by Experts for Sheet Metal Workers, Layout Men & Mechanics. A Practical Encyclopedia in 10 Sections, size 7 x 10 x 2—1125 Pages—350 Layouts—1600 Illustrations. 1001 Key Facts. Fully indexed for ready reference in answering your layout problems. Covers all phases of sheet metal work including Pattern Cutting, Pattern Development & Shop Procedure.

AUDELS SHEETMETAL WORKERS HANDY BOOK....................$1
Practical inside information. Fundamentals of Sheet Metal Work. 388 pages. Fully illustrated. 11 sections. Clearly written. Essential & important facts, figures, pointers in everyday language. Ready Reference Index.

AUDELS WELDERS GUIDE............$1
A concise, practical text on operation and maintenance of all welding machines for all mechanics. Over 400 pages, fully illustrated. Covers all methods of electric and acetylene welding including airplane work.

AUDELS ANSWERS ON BLUE PRINT READING.............$2
For Mechanics & Builders. Covers all types of blue print reading including ship & airplane. 376 pages, fully illustrated. New, complete.

AUDELS NEW MACHINIST & TOOLMAKERS HANDY BOOK......$4
Covers modern machine shop practice in all its branches. 5 practical books in 1. New from cover to cover. Tells how to set up & operate lathes, screw and milling machines, shapers, drill presses and all other machine tools. 1600 pages, fully illustrated, 5 x 6½ x 2. Indexed. 5 sections. 1—Modern Machine Shop Practice. 2—Blue Print Reading & How to Draw. 3—Calculations & Mathematics for Machinists. 4—Shop Physics. 5—How to Use the Slide Rule. 60 chapters. Easy to read and understand. A shop companion that answers your questions.

AUDELS MATHEMATICS & CALCULATIONS FOR MECHANICS.$2
Mathematics for home study or reference. 700 pages, 550 illustrations. Practical mathematics from beginning. How to figure correctly. New, easy, correct methods covering a complete review. Illustrated & Indexed.

AUDELS AUTOMOBILE GUIDE........$4
A practical quick ready reference book for auto mechanics, service men, operators & owners. Explains theory, construction and servicing of modern motor cars, trucks, buses & auto type Diesel engines. 1540 pages, fully illustrated. 55 chapters. Indexed. A standard book for mechanics.

AUDELS DIESEL ENGINE MANUAL....$2
A practical, concise treatise with questions and answers on the theory, operation and maintenance of modern diesel engines including General Motors 2 cycle Diesel. 384 pages, fully illustrated, flexible binding, pocket size. All details plainly brought out, this book is of extreme value to engineers, operators & students.

AUDELS SHIPFITTERS HANDY BOOK.$1
288 pages of information, instruction, pictures & reference charts, together with many short cuts & trouble savers for shipfitters in their work.

AUDELS RADIOMANS GUIDE.........$4
A key to the practical understanding of radio including Frequency Modulation, Television, etc., Aircraft & Marine Radio. For radio engineers, servicemen, amateurs. 772 pages. 400 Illustrations & Diagrams. Photos. Review Questions & Answers, Reference Index. Authentic, clear, concise.

AUDELS MECHANICAL DICTIONARY.$4
950 pages. Over 17,000 new and standard mechanical terms, words, phrases, tables, formulas, helps, hints, short-cuts and practical suggestions. The right word when needed most.

AUDELS HANDY BOOK OF PRACTICAL ELECTRICITY..........$4
For maintenance engineers, electricians & all electrical workers. 1440 Pages, 2600 Illustrations. Covers important electrical information in handy form—including Marine Wiring, Radio Principles, Welding. Fully indexed. The key to a practical understanding of electricity.

AUDELS CARPENTERS & BUILDERS GUIDES—4 Vols. $6
A practical illustrated trade assistant on modern construction for carpenters, joiners, builders, mechanics and all woodworkers. 4 vols., 1600 pages, 3700 illustrations, flexible covers. Each volume pocket size. Sold separately $1.50 a vol.

AUDELS PLUMBERS & STEAMFITTERS GUIDES—4 Vols. $6
A Practical Trade Assistant & Ready Reference. Explaining in plain language & by clear illustrations, diagrams, charts, graphs, pictures the principles of modern plumbing practice including Marine Pipe Fitting and Air Conditioning. 4 Vols.—1670 Pages—3642 Diagrams. Each Vol. Pocket Size. Sold Separately $1.50 a Vol.

AUDELS WIRING DIAGRAMS $1
210 Pages, Illustrated. Gives practical facts on wiring of electrical apparatus. It explains clearly in simple language how to wire apparatus for practically all fields of electricity. Each diagram is complete & self-explanatory. A Highly Endorsed Pocket Companion.

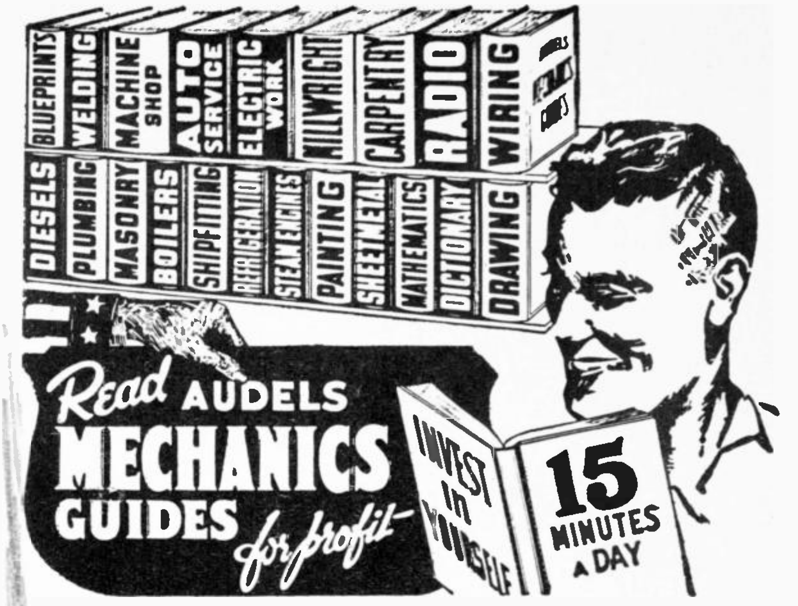
AUDELS ELECTRIC DICTIONARY.....$2
For Every Worker Who Has To Do With Electricity. Enables you to understand and explain electrical problems. Defines more than 9000 words, terms & phrases in plain, unmistakable language, compiled with accuracy & thoroughness. Alphabetically arranged, reference index.

AUDELS MILLWRIGHTS GUIDE $4
Practical up-to-date Information on Plant Installation, Operation and Maintenance. 1200 pages completely illustrated, fully indexed. 1000 facts at your fingertips in 6 convenient sections with ready reference.

GUETHS MECHANICAL DRAWING...$1
A Concise Drawing Course. 150 pages, 50 plates. A complete instructor & reference work. Gives many helpful hints & suggestions on How to Draw.

AUDELS ELECTRONIC DEVICES......$2
Tells What You Want to Know About Electric Eye. Easily Understood Covering photo-electric cells & their applications. Amplifiers, illumination, frequencies, voltage, photocell, tubes, Ohm's Law, wiring diagrams, etc

AUDEL, PUBLISHERS, 49 W. 23 St., N.Y.



Information in a Handy Form!

AN AUDEL GUIDE IS A GOOD FRIEND!

Use the brains and experience of others in these Guides of the Trades. Save time and money with right methods, short cuts, labor-saving ideas—"Learn more to earn more." Use our generous 7-day free examination privilege and our dollar a month payment plan. Become a Master in your Trade, *and understand the Trades that tie into yours.*

How to obtain these Guides for examination. Mark X on the order blank the Guides desired. Every Audel Guide is complete, up-to-date, easily understood with Questions and Answers, fully illustrated and indexed. They speak for themselves. Send for yours today at our risk and expense. Ask to see them.

Check NOW!

You Can Look Over Any Guide In Your Own Home

—

Start the Easy Payments If Satisfied

MAIL THIS TODAY

------- CUT HERE -------

MAIL ORDER

THEO. AUDEL & CO., 49 West 23rd Street, New York

Please mail me for 7 days' free examination the books marked (X) below. I agree to mail $1 in 7 days on each book or set ordered, and to further mail $1 a month on each book or set ordered until I have paid purchase price.

If I am not satisfied with Guides I will return them.

- ☐ Audels AIRCRAFT WORKER . . . $1.
- ☐ Audels SHEET METAL PATTERN LAYOUTS . . . 4.
- ☐ Audels SHEET METAL WORKERS Handy Book . . . 1.
- ☐ Audels WELDERS GUIDE . . . 1.
- ☐ Audels ANSWERS ON BLUEPRINT READING . . . 2.
- ☐ Audels MACHINISTS & TOOLMAKERS Handy Book 4.
- ☐ Audels MATHEMATICS and CALCULATIONS . . . 2.
- ☐ Audels AUTO GUIDE . . . 4.
- ☐ Audels DIESEL ENGINE MANUAL . . . 2.
- ☐ Audels SHIPFITTERS Handy Book . . . 1.
- ☐ Audels RADIOMANS GUIDE . . . 4.
- ☐ Audels MECHANICAL Dictionary . . . 4.
- ☐ Audels Handy Book of PRACTICAL ELECTRICITY . 4.
- ☐ Audels CARPENTERS and Builders Guides (4 vols.) . 6.
- ☐ Audels PLUMBERS and Steamfitters Guides (4 vols.) . 6.
- ☐ Audels WIRING DIAGRAMS . . . 1.
- ☐ Audels ELECTRIC Dictionary . . . 2.
- ☐ Audels MILLWRIGHTS and Mechanics Guide . . . 4.
- ☐ Gueths Mechanical DRAWING Course . . . 1.
- ☐ Audels ELECTRONIC DEVICES . . . 2.
- ☐ Audels MARINE Engineers Guide . . . 3.
- ☐ Rogers Mechanical DRAWING and Design . . . 2.
- ☐ Rogers MACHINIST GUIDE . . . 2.
- ☐ Audels MASONS and Builders Guides (4 vols.) . . . 6.
- ☐ Audels ENGINEERS and Mechanics Guides Nos. 1, 2, 3, 4, 5, 6, 7 and 8 complete . . . 12.
- ☐ Audels Answers on Practical ENGINEERING . . . 1.
- ☐ Audels ELECTRICAL POWER CALCULATIONS . . . 2.
- ☐ Hawkins ELECTRICAL Guides at $1. each Nos. 1, 2, 3, 4, 5, 6, 7, 8, 9 and 10
- ☐ Audels Answers on REFRIGERATION . . . 2.
- ☐ Hawkins Aids to ENGINEERS EXAMINATION . . . 2.
- ☐ Master PAINTER and DECORATOR . . . 2.
- ☐ Audels GARDENERS & GROWERS GUIDES $1.50 a Vol.
- ☐ Audels NEW ELECTRIC LIBRARY at $1.50 a Volume Vols. I, II, III, IV, V, VI, VII, VIII, IX, X, XI, XII.

Name..

Address..

Occupation..

Employed by.. L.A.M.