ELECTROPHONE
An Inexpensive Condenser Microphone for the Home Experimenter

. . . . . . ARTICLE ON ELECTROPHONE STARTS ON PAGE 2

Announcing the New UHF Miniature MAGNETRON

SEE PAGE 5 . . . . .

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ELECTROPHONE

Many items sound al-
must any ham shack be home-
many amateurs make their own trans-
makes. They use their own receivers, but very
few amateurs have ever made their own micro-
phones. This has been due primarily to the fact that it is
time-consuming and expensive to make a microphone of
good quality. The micro-
phone must be so de-
scribed is the exception to the
make and is a good
quality microphone.

The Electrophone is a
microphone of novel construc-
construction which requires no external source of
power. It is an electrophone. Very
few parts are required to make the Electrophone, and
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CONSTRUCTION MICROPHONE

The regular type of condenser microphone consists of
a small capacitance which may be varied by the
pressure of sound waves impinging on one of the
condenser plates. If a source of direct current is
placed in series with this condenser, the current will vary
as the capacitance changes. If this current is
passed through a relatively high resistance a varying
voltage drop will exist across this resistance. The
variable-voltage drops will take place at an audio
rate, and if the high resistance is placed in the
same circuit as the condenser, the audio frequency voltage
may be amplified in a normal manner.

The tubing used as the space which permits the direct current
called a polarizing voltage. This voltage serves, in a
customary microphome, in the same way as the voltage in a
bath of water, although the action of the
two types of microphones is quite
different.

No external polarizing voltage is necessary with the
Electrophone, because it supplies its own internal source of
voltage. This voltage is supplied in an
Electrophone electric.

An electrophone may be compared to a permanent
magnet. In a permanent magnet, a
magnetic is a continuous source of
magnetism lines of force, whereas an
electrophone is a continuous source of
electricity. It is usually made in the form of a disk of insu-
lating material which has permanently impressed on its
two flat surfaces electrical charges equal but opposite in
sign.

Fig. 2 shows the manner in which the electrophone, hav-
ing a positive charge on its upper surface and a
negative charge on the lower, induces charges on

the two plates forming the
condenser microphone.

The electrophone may be thought of as a
transformer, where the primary may be thought of as
traveling along the magnetic lines of
force in the permanent magnet with a north and
a south pole.

Electrophones themselves are not new, nor are con-
denser microphones em-
ploying electors new, that
is, it has always been
theoretically possible to make a microphone in this
manner. The Electrophone is a practical example of
this sort of thing. The world
ElectroHONE was coined by Oli-
ver Heavann in the latter
part of the nineteenth century to denote a perma-
nently charged material, but the first electrophone
was not made until 1924.

REMOVING THE ELECTRON

The electron is the heart of the Electrophone, and
should be made as carefully as possible. The general
procedure is to take a piece of suitable insulating
material and apply heat to it while a d-c voltage is
applied across the two faces. Both the heat and the
voltage necessary are critical, although not sufficiently
critical to cause the constructor any trouble.

It is absolutely necessary to use the proper insulat-
ing material in preparing the electron. Those ma-
erials recommended are Lutite, Plesite or Kel-F. The
material which will not work is polystyrene. If you are in doubt as to whether or not a material is polystyrene,
Plesite or Lutite, a simple flame test may be made. Polystyrene gives off a blue flame, while Lutite and Plesite burn with a
clear blue flame.

Once you have the proper material, select a piece about one-sixteenth inch thick and cut it to the
shape of a circle. The exact diameter of the circle will depend upon the microphone case you use. These
details will be discussed later. Next, procure a heavy pan or thick
piece of metal (see Fig. 3). The purpose of the large
mass of metal is to maintain a uniform temperature as
possible on the electrophone.

The next item necessary is a power supply which
will give a voltage of anything from 1000 volts to
15,000 volts. A higher voltage than this is used, the better the microphone you will have.
A lower voltage may be used as high as 1000 volts, and as low as
1000 volts, and as low as
1000 volts. If you want to do a superior job, use
10,000 volts. The job of providing a power supply is
certainly is as difficult as it may sound, because only a few
microamperes of current are required.

In case you haven’t already guessed it, the best
place to obtain a high voltage which is capable of
only a small amount of current is a television receiver.
An r-f power supply of this type is not overly suited, not only because the voltage runs quite high, but also because there is much less danger involved in using such a power supply. However, regardless of the type of voltage supply used, remember that high voltages are dangerous and extreme caution must be exercised.

If you are unable to obtain a high voltage supply, one may be put together for the purpose. Fig. 2 is shown a suggested circuit for a high-voltage power supply.

Once everything is ready, we may proceed to make the electrot. Place the large pan or piece of metal on a source of heat. A burner in a gas or electric stove is quite suitable. Arrange the insulating material on top of the pan as shown in Fig. 3. Proceed to a top electrode (you may use the top of the microphone case as explained later) and place it on top of the insulating material, making sure that it is centered so as to prevent arc-over.

Next, connect the negative voltage supply to the bottom electrode, and also to the stove, then connect the positive lead from the power supply to the top electrode. Now, leaving the voltage supply turned off, tune on the heat and bring the insulating material up to temperature. Flexiglas and Lucite should be brought to a temperature of 140 degrees Centigrade (283 degrees Fahrenheit) and K eo-I should be heated to 200 degrees Centigrade (390 degrees Fahrenheit).

These temperatures are not too critical and one may use the softening point of the plastic as a convenient guide instead of using a thermometer. Each of the temperatures listed is the point at which the insulating material begins to soften. If desired, a small piece of the material may be placed in the pan and used as a test piece. Examine it with a fork periodically and when it becomes soft the larger piece of material may be put in.

At the moment when the plastic has reached the proper temperature, turn on the high voltage supply and leave it on for two hours. During this two-hour period the temperature of the plastic may fluctuate slightly maintained at the temperatures previously mentioned. In general, the heat will have to be turned up a bit in order that the temperature is not increased. Keeping air even temperature is not difficult if a large body of metal is used as indicated. After two hours, turn off the heat, but keep the high-voltage supply on. When the insulating material has cooled down to room temperature, disconnect the high voltage.

If you wish to check the actual temperature of the electrot to ascertain if it is cool, remember to turn off the high voltage. Also, do not touch the face of the electrot, either at this time or any later time, as continuous handling of the electrot will eventually ruin it. When you have finished with the electrot, wrap it in metal foil until you are ready to mount it in the microphone. Any spare electrot you may have made should also be stored in this manner.

**COMPLETING THE MICROPHONE**

Amateurs with machine shop facilities will no doubt be able to make a very fancy housing for the microphone, but metal pit boxes or olive cans, three inches in diameter and one inch thick are available at most drug stores for supply boxes, and these make an ideal case for the Electrot. The photograph shows quite clearly how these olive cans are employed. The top of the olive can be used as the top electrode when making the electrot, as it has a rounded and cupped-up edge which helps prevent voltage flashover.

After the can top has been used in this manner, the center of it may be cut out as shown in Fig. 1. The hole should have a diameter of approximately 21/4 inches. A standard metal patch may be used, or the area may be chiseled out neatly.

The next step is to provide the main body of the olive can with a connector of some sort. The type shown in Fig. 6 is a standard microphone connector.
of the sort that you might normally put on the chassis of your speech amplifier. Mount this connector in any convenient manner.

Referencing to the cross-section view of the Electrophone, Fig. 4, you will note that an isolating spacer is required. This can be almost any substance, although the regular plastics will probably work the best. Its diameter should be such as to clear the inside of the can for ease of mounting. The height of the cross section should be such as to keep the diaphragm away from the edge of the can. A piece of felt or plastic foam should be inserted between the can and the diaphragm to keep it from vibrating with the sound vibrations.

A clearance hole for the output connector must be bored into the plastic, and also a hole must be drilled through the plastic in the center, in order to make contact with the foil at the bottom of the can. To mount the insulating spacer, first solder a piece of bare wire to the output connector, then slip the insulating spacer into the can while feeding the wire through the center hole in the spacer. Next, fasten the spacer down with the machine screws and cut off the wire that protrudes above the spacer.

With a hot soldering iron a little depression about 1/4 inch in diameter is melted out around the wire and a ball of solder formed in this depression. The solder should protrude slightly above the surface of the spacer so that it may serve as a hot contact point.

It is now time to take the electret out of its protective wrapper and mount it in the can. Before this is done, however, you must prepare a piece of metal foil—preferably aluminum foil of the sort that is sold in grocery stores—to use as the back electrode on the electret. Cut a circle of foil with a diameter one-fourth inch less than that of the electret. Place this piece of foil on one side of the electret, and press it firmly in place. Make sure that you get it in right position to come in contact with, and not under, the electret. A suggested way to do this is to place the electret face down on a large piece of foil, then carefully place one edge of the circular piece about one-eighth of an inch from the side of the top face of the electret, and slowly lower the piece of foil, keeping hold of it until you are sure that it is centered. Once it is on center, but firmly, press the foil against the electret.

Finally, cut a larger piece of foil to use as a diaphragm, and place it over the top of the can (before the electret is put in) and fold it around the sides, trimming the edges to make a neat job. Now, remove the large piece of foil, place the electret in position, place the large piece of foil over the electret, and put the top of the can in place. The electret should now look as shown in Fig. 1. Ideally the top piece of foil should come in contact with the outer surface of the electret—flush fitting as completely as possible, but in the practical sense it does not matter if the foil touches the electret in a few spots. However, do not press the outer foil against the surface of the electret, as the contact area that exists, the less output you will get from the microphone.

Many modifications of this construction will undoubtedly suggest themselves to the experimenter. The important thing to remember is that dimensions are not critical and an experimenter need not be hesitant to construct a working microphone of this type.

**Performance**

Several Electrophones have been in use at WIFUL for over a year and no decrease in the output voltage of 0.02 to 0.03 volts has been observed. Some experimenters have observed electrophones for twelve years without noticing any substantial decrease in charge. No attempt was made to protect them from humidity other than keeping them in their mounting cases.

No feedback troubles have been experienced and the Electrophone was merely plugged in to an existing crystal microphone input jack on the speech amplifier. Generally it is good and on-the-air tests showed the Electrophone to compare favourably with a crystal microphone.
The New UHF Miniature Magnetron

The new miniature magnetron tube recently announced by the General Electric Television Division will undoubtedly find itself in many home circuits in the near future. This tube is capable of operating continuously from 30 to 900 megacycles at a quarter-watt output.

Although designed primarily for television receivers operating in the proposed ultra-high-frequency television band, the Z-2061 will find wide use wherever a low power oscillator at these frequencies is required. The price of the Z-2061 will be comparable with other television receiver tube prices, which means that the amateur finally will be able to procure a low cost tube for operation on the ultra-highs.

Up to this time, magnetrons have been used to generate the high power required for radar equipment and counter-radar equipment used extensively during World War II. During this time the magnetron was not generally thought of as a practical device for TV home receivers, but through the combined efforts of the G.E. Laboratories and the Tube Division, the magnetron principal has now been successfully applied to make it a useful tube for the proposed UHF television band.

Generally speaking, a magnetron is a diode which, when operated in a magnetic field, can be made to generate radio frequency oscillations. In the case of the Z-2061, the magnetic field is supplied by a doughnut-shaped magnet, which fits over the tube. The magnetic field strength required is approximately 600 gauss. When the tube circuit is initially adjusted, it is necessary to rotate the magnet until the magnetic field is in the proper position for operation.

A typical test oscillator for the miniature magnetron is pictured in Figs. 8 and 9. This oscillator in appearance is not unlike others with which the amateur is familiar. The circuit of the test oscillator is given in Fig. 10. It is not particularly intended to be duplicated by amateurs or experimenters but it does indicate how simple a circuit may be used.

Tuning, in the test oscillator pictured, is accomplished by changing the position of the steering bar on the two anode lines. The oscillator pictured may be tuned over the range from 300 to 900 megacycles. Output may be obtained by coupling to the anode lines in a manner similar to the method used with other parallel line oscillators.

Internally, the Z-2061 consists of eight vanes arranged in a circle around the cathode. Alternate vanes are connected together, so that each anode consists of four vanes. The entire tube is therefore seen to consist of 8 vanes, a cathode and a filament. Dimensions internally are large enough so that no critical spacing is involved.

Tests indicate that the tube has good frequency stability, both for voltage changes and magnetic field variations. Further, the hum and noise level is down more than 60 db below carrier level.

An early issue of the Ham News will give constructional data on equipment designed for amateur services and employing the Z-2061.

---Lighthouse Larry

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**Fig. 8. Experimental test arrangement for Z-2061 magnetron**

**Fig. 9. Underside view of Z-2061 test setup**

**Fig. 10. Circuit diagram of Z-2061 test set**
The practice of testing an amateur transmitter while it is coupled to an antenna is quite common, despite the fact that the P.C.C. frowned on such doings. While testing its antenna system, of course, it is necessary to be on the air, but for most transmitters a dummy load is desirable. Use of a dummy antenna not only obviates unnecessary QRM but, if a known dummy load is employed, quantitative measurements of actual power output can be obtained.

The purpose of this article is to explain how to procure a good dummy load, and how to use it.

**Types of Dummy Loads**

Anything which will absorb power and not act as an efficient radiator may serve as a dummy load. As we know, an electric light bulb can be used. As a matter of fact, it is possible to use a tub of salty water as a dummy load. In actual practice most amateurs use either a light bulb or non-inductive resistors. Electric light bulbs have one big disadvantage, and that is, their resistance varies with the amount of current passing through them. If the resistance of a dummy load is not known accurately, then it is impossible to make any accurate output measurements. Moreover, in the case of the light bulb, most amateurs judge output by the amount of brilliance in the lamp. Unfortunately this can be most misleading, because a large change in the amount of power dissipated may be indicated by an imperceptible change in brilliance.

Non-inductive resistors are perhaps the logical choice for use as dummy loads, if only because they have fewer disadvantages than other types of loads. The cost of these units is surprisingly low, and proper use will ensure a pay-off in a permanent investment. For this reason all further discussion will be restricted to the use of resistors as dummy loads.

**Measurements in Series**

Many different types of resistors are currently manufactured, but those in widespread use fall into two general categories: the composition type and the wire-wound type. Composition resistors are seldom used for dissipation of more than 0.5 watts, although they are available in 5 watt units. Wire-wound resistors are available with dissipation ratings up to 200 watts.

Composition resistors of 1/4, 1/2 and 1 watt ratings are made in resistance values from 10 ohms to 20 megohms. For lower resistance values, some wattage ratings can be obtained in wire-wound units only. For example, one manufacturer makes 1/2 watt wire-wound units in the resistance range from 0.47 ohms to 820 ohms. Wire-wound units can be obtained in resistance ranges from a few tenths of an ohm up to 500,000 ohms, but not all wattage ratings and styles are available over the complete resistance range.

All resistors will not serve as usable dummy loads. Those which are usable are the composition type and the non-inductive wire-wound type. The criteria here is lack of inductance. A wire-wound inductive resistor will not serve as a dummy load at radio frequencies because its relatively high inductance will not permit a current flow unless a tremendous voltage is available.

For example, assume that a regular inductive resistor has an inductance of 100 millihenrys, and a resistance of 100 ohms. An inductance of 100 millihenrys at 14 megacycles is an inductive reactance of 9,000,000 ohms. One-tenth of current, representing a real power of 90,000 ohms, would have to flow in the resistor. Since the inductive reactance would require that 9,090,000 volts be applied to the resistor. This example assumes that the inductive resistor had zero capacitive reactance, which is not possible, but the example does serve to illustrate why it is difficult to get power into an inductive resistor at these frequencies—unless a difficult tuning job is attempted.

**Composition Resistors**

A simple equivalent circuit of a composition re-

Fig. 11. Arrangement used for testing resistors

Fig. 13. Equivalent circuit

Fig. 12. Equivalent circuit

ister is shown in Fig. 12-A. White R is the d-c resistance and C the total capacitance across the resi-

Fig. 11. Arrangement used for testing resistors
Now that we have a general idea of the power rating we may need, let’s see what resistors we can use for various power levels.

For measurement or antenna matching work, where you usually use your VFO or a grid-dip meter for a power source, half-watt composition resistors are adequate, power-wise. For impedance values of 50, 75, or 100 ohms, single unit 1/2 watt resistors are good up through 150 megahertz. For 300 ohm work, a single 300 ohm resistor is not satisfactory, as the effective reactive resistance starts to show up at 150 megahertz. However, two 150 ohm 1/2 watt resistors in parallel are satisfactory up to 330 megahertz.

No tests were made on resistors of more than 300 ohms resistance, as such resistors are generally only used with the positive reactive reactance being a factor to be considered, so that higher and higher values of resistance will be "pure resistance" only for lower and lower frequencies.

Dummy loads capable of handling sixty watts (the output of a 150 watt input transmitter) can be made by employing 1 watt composition resistors. Ten 1 watt resistors will dissipate twenty watts, which, with our factor of three employed, allows their use as 60 watt loads. Obviously, these resistors can be placed either in series or in parallel, but tests indicate that it is desirable to make these loads as follows:

For a 60 watt load use ten 300 ohm resistors in parallel. For a 75 ohm load, use ten 75 ohm resistors in parallel. For a 300 ohm load, use ten 30 ohm resisters in series. All of these combinations give good results as dummy loads up to 350 megahertz.

The proper way to parallel resistors is indicated in Fig. 13. Make two circular disks of copper or brass, and drill ten holes, equally spaced around the edge of each disk. Mount the resistors between the disks and solder each lead to the disk. If desired, a coaxial fitting may be mounted, as shown, or broad strips may be soldered to the two disks.

If you use a 300 ohm load, the resistors should be in series. The best way to do this is to make two sets of

![Fig. 14. Examples of high-power resistors](image)

![Fig. 13. Examples of parallel-connected resistors](image)

![Fig. 15. Low-power resistor examples](image)
five colas, each set in a straight line, then connect end and end of the two sets together. This brings the two leads of the composite resistor adjacent to each other. All leads in the series string should be as short as possible.

Dummy loads capable of handling 300 watts can be made from ten 30 watt non-inductive resistors. For a 50 ohm load, use ten 300 ohm resistors in parallel. For a 75 ohm load use ten 750 ohm resistors in parallel. For a 300 ohm load, use ten 3000 ohm resistors in parallel. All three combinations are usable to 150 megacycles if the units are paralleled as described before.

Dummy loads for powers above 300 watts can be made in a variety of ways. The best load, as indicated by a series of tests, is a series-parallel combination of ten 1500 ohm, 10 watt resistors in series with ten 150 ohm, 10 watt resistors in parallel, connected in series with a similar unit, giving a 300 ohm load capable of handling 400 watts.

Higher wattage resistors can also be used, and tests have been run on all the resistors shown in the photographs. In general, it becomes increasingly difficult to make good dummy loads as the power requirements are raised. Non-inductive resistors with power ratings of 50, 100, 150 and 160 watt ratings have too much residual inductance to be used, singly, at frequencies higher than approximately ten megacycles, unless compensating capacitance is used in series with the resistors.

For example, a typical resistor with a residual inductance of two microhenrys requires a series capacitance of approximately 100 microfarads at ten megacycles in order to be a "pure resistance."

Placing these higher-wattage resistors in parallel will decrease the effective inductance, but not sufficiently, unless a large number of them are so connected. They can be used singly, or in pairs, if you wish to "work out" the series inductance by means of a series expeditor.

**SELECTION & DUMMY LOADS**

There are a few precautions to be observed when connecting a dummy load to a source of power. One, make as direct a connection as possible, and use low inductance leads, such as copper straps. Two, keep the dummy load away from metallic objects, in order to avoid an unbalance to ground. Three, keep the dummy load well in the clear so that adequate air circulation is assured.

**FINAL WORDS**

The information just given on non-inductive resistors is intended as a general guide to the selection of such resistors. Rigorous and complete tests are quite difficult to make, especially when a large variety of resistors is considered. Most of the data given was determined by the test arrangement shown in Figs. 11, which consists of a Miller grid-dip meter and an Eden Antennacope. This sort of test permits a practical answer to be obtained quite easily.

The wire-wound resistors tested were made by W. A. Philips. As far as is known, all three companies have standard lines of non-inductive resistors which are readily available.

--Lighthoone Barry

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