How to Use Meters in Your Receiver

The Meter is a Comparatively Inexpensive and Valuable Refinement—How Meters Work and How to Use Them for Best Results

By JAMES MILLEN

THIS article might have an alternative title, "How to Get More Out of Your Receiver," for that is exactly what will happen if Mr. Millen's suggestions are followed. It is easy enough for anyone to tell how a radio receiver is operating acoustically, but electrically, meters are required to tell the operator how the circuits are functioning. The addition of the proper meters to any set is neither an inordinately expensive matter nor a very difficult one. The mere assurance that one is using his tubes at the proper filament voltage is enough reason for installing the meters. In addition, the use of a plate current milliameter will register instantly the slightest distortion occuring in the audio circuit, after the fashion described by Mr. Crom in his article in RADIO BROADCAST *for October. Mr. Millen's excellent suggestions can aid every home constructor and not a few of those who have manufactured sets which they would like to improve.*

—THE EDITOR.

NOT a few broadcast listeners have the idea that meters in a radio receiver, if they are built in at all, are there for appearance and not for any good they may do in enabling the operator of the set to use his receiver more effectively. Of course, everybody knows that a set will work without a meter, but few know how much the proper meters will help in obtaining economy and quality performance.

A small voltmeter, connected in the filament circuit enables one quickly to turn the control rheostats to the proper point so that enough current is flowing

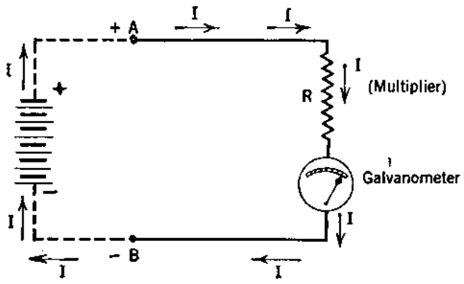


FIG. 1

This diagram shows how a resistance and a current measuring device are employed to determine voltage

through the circuit to heat the filament wire to insure emission of electrons in the proper quantity. This is one of the conditions for the production of good quality. At the same time, the filament is not operated above its rated voltage. This prolongs the life of the tube. When a tube is used with a very slight increase over its rated voltage, its life is greatly reduced.

Depleted B batteries are frequently a source of noise and distortion in radio receivers. And when, as is frequently the case, the B batteries are located in the cellar or some out-of-the-way place, it is inconvenient to test them frequently with a pocket voltmeter. So they are often neglected and as a result the quality of reception becomes poorer, all unnoticed by the owner, because the process is gradual. But some evening, when the receiver is put into operation it refuses to work. Had the set been provided with a conveniently arranged panel voltmeter, the operator could have made a frequent and easy check on the condition of the batteries.

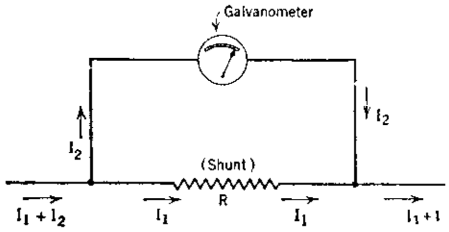


FIG. 2

A shunt resistance is employed in order that only a small percentage of the total current in the circuit passes through the meter

The third meter which helps toward good quality and economical operation is a plate-current milliammeter. A plate milliammeter primarily indicates the rate at which energy is being drawn from the B batteries. If this plate current is excessive, the life of the batteries and the tubes will be seriously impaired. By means of proper C voltages it is possible to vary the plate current and thus secure the value specified by the manufacturers of the tube for any given plate voltage.

A second, but not a lesser important function of the plate milliammeter, is to indicate how an amplifier tube is "modulating." For quality reception it is absolutely essential that the d. c. component of the space current of a tube, as indicated by a d. c. milliammeter does not vary. If the needle on the milliammeter drops down on a strong signal, the tube is said to be "modulating down" and the C voltage must be increased. If, on the other hand, the needle advances on a strong signal, the amplifier is said to be "modulating up," which indicates that the C voltage is too high for the plate voltage being used. Should the needle fluctuate violently in both directions, the tube is very much overloaded and both B and C voltages must be materially increased.

MANY USES FOR METERS

THERE are also a number of other uses for meters in connection with radio receiving sets, but with the equipment as available at present, their use is of value mainly in the laboratory. Such a meter is an ammeter for indicating the rate at which a storage battery is being charged. As the charging rate on the majority of home battery chargers is not variable, there is little to be gained by the use of a meter in such cases.

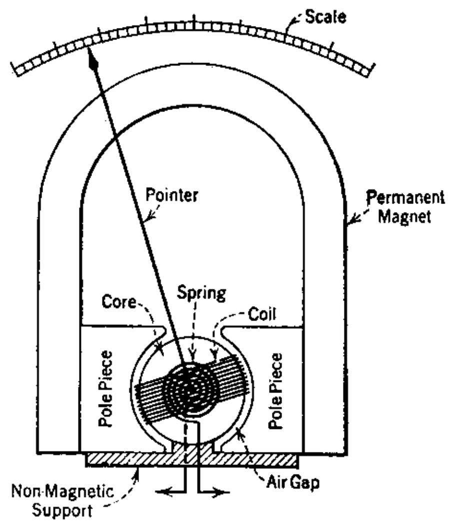
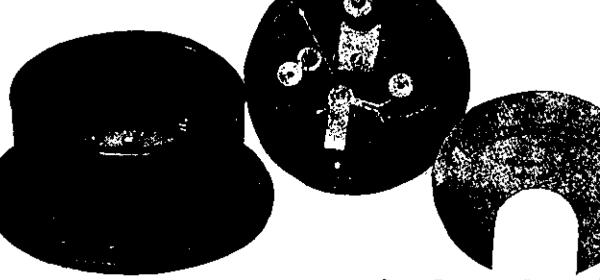


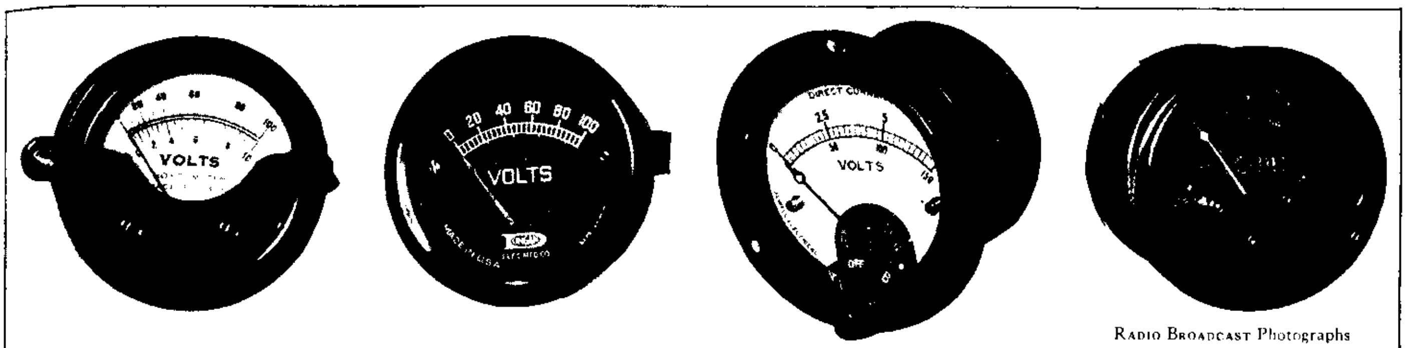
FIG. 3

The most accurate meters are of the moving-coil type, such as shown in this diagram. The photograph below shows a meter of the moving coil type, apart. The D-shaped piece on the base of the meter, center, is the permanent magnet



RADIO BROADCAST Photograph

FIG. 3A



Radio Broadcast Photographs

FIG. 4

There are a number of different concerns making meters for radio use. The products of Hoyt (Burton and Rogers), Dongan, Jewell, and Cellokay are shown

Another such meter is a wavelength or frequency meter, but this too may be dispensed with in the modern radio broadcast receiver by the simple expedient of calibrating the dials on the receiving set.

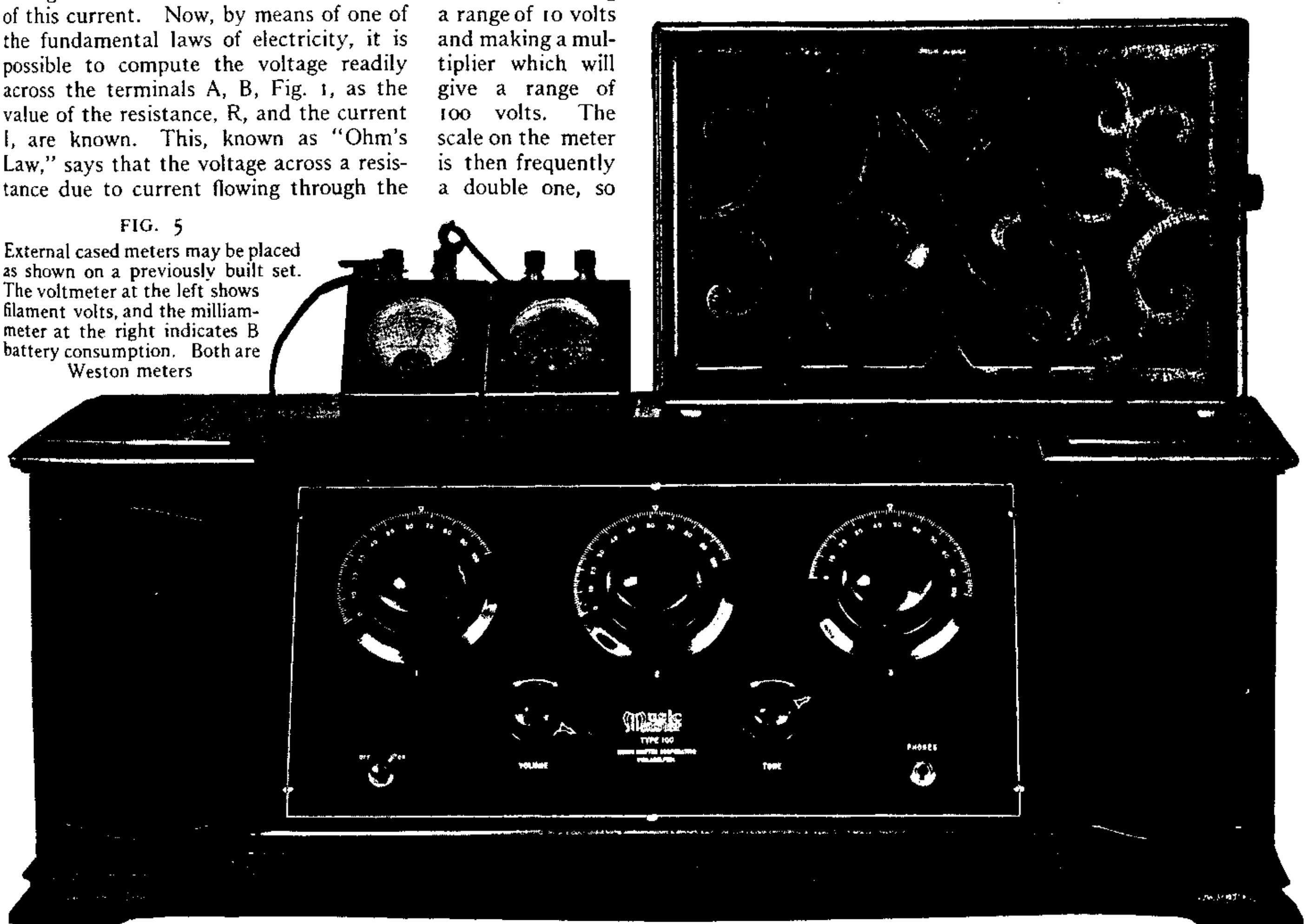
All of the meters referred to above with the exception of the wavemeter are fundamentally the same—that is, they are essentially galvanometers, or devices for indicating current flow. If a voltage is to be measured, then a high resistance unit, called a multiplier, is connected in series with a galvanometer and the combination connected to the source whose voltage is to be measured. This arrangement is shown in Fig. 1. A small current will flow through the resistance and galvanometer. The galvanometer will indicate the value of this current. Now, by means of one of the fundamental laws of electricity, it is possible to compute the voltage readily across the terminals A, B, Fig. 1, as the value of the resistance, R, and the current I, are known. This, known as "Ohm's Law," says that the voltage across a resistance due to current flowing through the resistance is equal to the product of resistance in ohms and the current in amperes, which, in symbols is $E = IR$.

Of course, it is not convenient to make even this simple calculation every time one wants to know the voltage of his batteries, so the manufacturers put a special scale on the galvanometer which reads directly in volts. Then they go still another step farther and build meters having an inherent resistance of such a magnitude that, for voltages under say 50 volts, the use of an external resistance or multiplier is dispensed with. For higher voltages, such as B battery voltages, it is generally customary for the meter manufacturers to take a lower voltage meter, such as one having a range of 10 volts and making a multiplier which will give a range of 100 volts. The scale on the meter is then frequently a double one, so that either the 0–10, or 0–100-volt scale may be referred to depending upon whether or not the multiplier is being used.

Ammeters are also fundamentally galvanometers, which would be burned out if a heavy current were to be passed through them. In order that they may be used to measure heavy currents, resistances are connected across them so as to "by-pass" most of the current and thus let only a small fraction of the total current pass through the meter. This "by-pass" resistance is known as a shunt and in the case of the small panel mounting type of milliammeters used for radio work, the shunt generally consists of a small piece of resistance wire contained within the meter case.

FIG. 5

External cased meters may be placed as shown on a previously built set. The voltmeter at the left shows filament volts, and the milliammeter at the right indicates B battery consumption. Both are Weston meters



Radio Broadcast Photograph

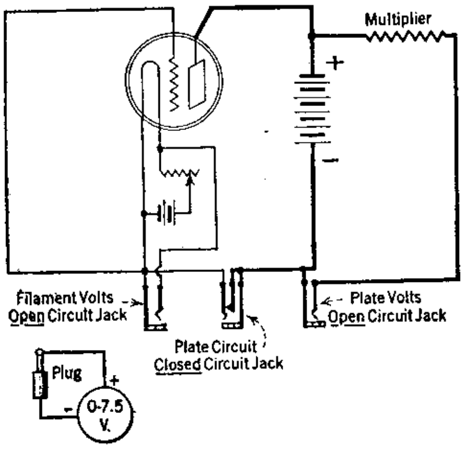


FIG. 7

By connecting three jacks in each tube circuit, it is possible to use one meter for many different purposes. In order that several different multipliers will not be required, one multiplier may be arranged with a short-circuiting switch in the plug circuit

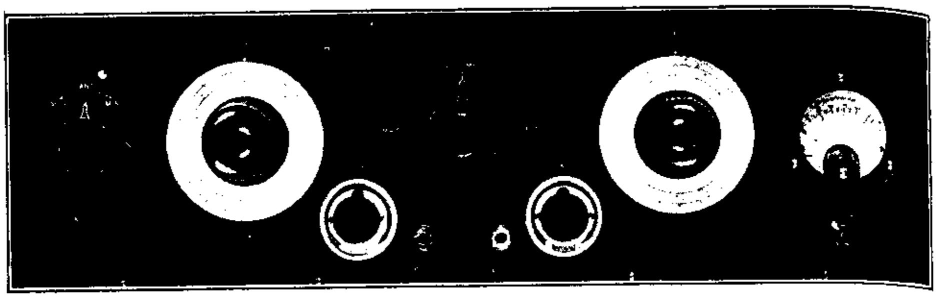


FIG. 9

This is the panel view of the "Aristocrat" receiver shown in Fig. 4 on page 196 of this issue. The switch below the meter at the right side of the panel allows the meter to read either filament or plate voltages

HOW THE METER WORKS

THE galvanometer units generally, in the higher grade instruments, consists of a movable coil, to which is affixed a pointer, pivoted in a strong magnetic field set up by a permanent magnet of the "horseshoe" type. This arrangement is illustrated in Fig. 3. When a current passes through the coil, an electro-magnetic field is set up which reacts with that set up by the permanent magnet and the coil tends to rotate. It is held back by a small hair spring. The force (or as it is technically called, torque) tending to rotate the coil is directly proportional to the current flowing through the coil. Furthermore, the deflection of the coil is governed by the spring, whose deflection with certain limits, is directly proportional to the torque. Thus the deflection of the galvanometer is directly proportional to current.

Instruments, such as the Weston and the Jewel employ the movable coil type of movement illustrated in Fig. 3. The less expensive meters, especially the small pocket volt and ammeter used for testing dry cells are of what are known as either the plugger, and iron vane type. The iron vane type consists of a small electro-magnet with a soft iron core. When a current is passed through the winding of the electro-magnet a small iron "vane," which is mounted on a shaft, is attracted. The vane is held back by the permanent magnet, and a pointer is affixed to the shaft so as to indicate the deflection.

The electro-magnet in an ammeter of this type consists of a half dozen turns of very heavy wire, whereas the voltmeter electro-magnet is wound with many turns of very fine wire.

In the past, instruments of the iron vane type have not been considered very accurate for high grade work. Furthermore, they consumed considerable power, and thus could not be left in a circuit for any length of time, as they would run the batteries down. This is especially true of voltmeters since they are shunted across the supply and if left in circuit would deplete the batteries very rapidly.

At present, however, there are at least two well-known concerns manufacturing improved instruments of this type which are well suited for radio use, particularly for measuring B battery voltages. Such a meter mounted on the panel of a tuned radio frequency receiver is shown in Fig. 8. Two push buttons are provided so that either the detector or the amplifier B voltages may be instantly read with the same meter. When push-buttons are used for this purpose there is no danger of the meter remaining connected to the B batteries for long periods and thus unnecessarily running them down.

Fig. 4 shows a group of different meters for mounting on the panel of a radio receiving set. The meters may be mounted in small cases, and connected to the set with flexible lamp cord. Such an arrangement is shown in Fig. 5.

Fig. 6 shows how these meters are connected in a RADIO BROADCAST Four-Tube Knockout receiver. By carefully examining the way in which the meters are connected in this circuit, the manner in which they should be connected in any circuit will be evident.

If a meter is equipped with an ordinary phone plug and flexible cord, jacks may be arranged on the panel of the receiver so that it may be plugged into any part of the circuit. Fig. 7 indicates how to connect the jacks in a circuit.

Instead of having three separate meters —A voltage, B voltage, and plate current—for use with the set in Fig. 7, one meter may be made to serve the purpose most excellently. If a 0 to 7.5 voltmeter is available it may be used directly to read filament volts, with a resistance in series (8825 ohms for Weston 0-7.5-volt No. 301) to read up to 150 volts (multiply scale readings by 20) and without any attachments, as a milliammeter. For the model 301 Weston meters, a full scale deflection requires 16.1 milliamperes or for the 0 to 7.5 volt Weston meter, each division is equal to 2.146 milliamperes or approximately 2 milliamperes.

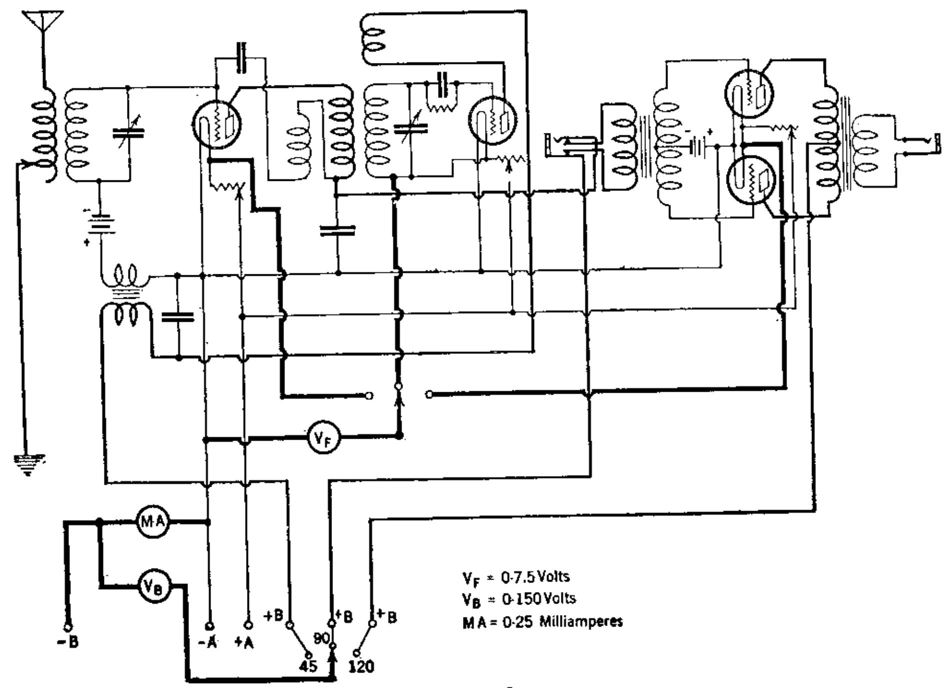


FIG. 6

This circuit diagram shows how to connect a filament voltmeter, a plate voltmeter, and a plate milliammeter in a RADIO BROADCAST Four-tube Knockout receiver