Impedance Measurement

Q. *How may I determine the impedance of a device such as a phonograph pickup or microphone? Ira Jamieson, Rockville Centre, New York*

A. *Figure* 1 shows the normal wiring of such a device. R_L is shown in parallel with the device, and its value is so chosen that it will be equal to the impedance of

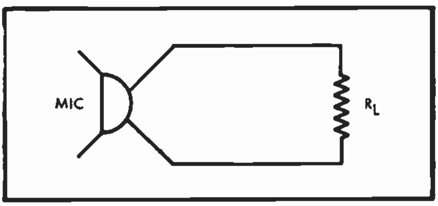

Fig. 1

the device. In many cases, where the impedance is low, a transformer is substituted for the resistor. To determine the impedance of the device, feed a signal into it. In the case of a microphone, this is accomplished by placing it near a loudspeaker and feeding this speaker in turn with a tone whose frequency is approximately 400 cps. If the device is a phonograph cartridge, use a frequency record. Connect the output terminals of the device under test to the input terminals of an a.c. voltmeter whose impedance is at least ten times that of the device under study. A VTVM with an input impedance is a few megohms and a sensitivity of around 1 millivolt can work well with most devices. (If the unit being measured is a crystal microphone, its probable impedance is 5 megohms, so that a VTVM with an input impedance of at least 50 megohms would be needed and this is not usually available.) *Figure* 2

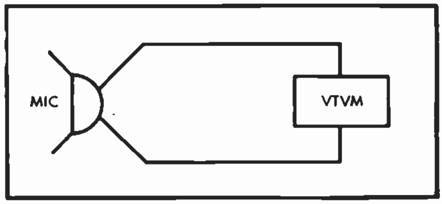

Fig. 2

shows the equipment under test wired to the measuring instrument. Note the voltage read under these conditions. Now connect a variable resistance across the device as shown in *Fig.* 3. Adjust this resistance until the output has dropped 6 db (which occurs when the voltage reading is half that of the original, or unloaded, voltage). If, regardless of the setting of the resistor, the voltage does not rise to this value, the maximum resistance is too small and a larger one must be substituted. If the adjustment is critical and falls close to the minimum resistance of the element, it would be better to substitute a smaller unit for the one originally used. At any rate, once you have arrived at the point where the voltage has been dropped 6 db, disconnect the resistor from the circuit

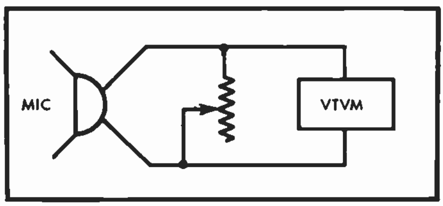

Fig. 3

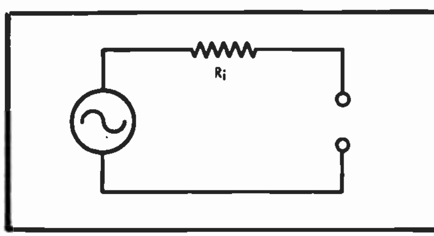

Fig. 4

and measure its value with an ohmmeter. The ohmic value of this resistor is equal to the impedance of the device being tested.

The impedance of amplifiers may be measured by similar means. A signal is fed into the amplifier and the unloaded secondary winding of the output transformer is connected to the indicating meter.

This time, however, a vacuum-tube-voltmeter need not be used. The standard 20,000-ohms-per-volt movement will work very satisfactorily, as will an output meter whose impedance is as low as 100 ohms. Be sure that you do not apply too much signal to the input terminals of the amplifier because the voltage across the terminals of the output transformer will rise to a level which might be sufficient to cause arcing within, and this would probably ruin the transformer. The variable resistor is adjusted as before. The impedance read this time will be the source impedance of the amplifier. This is something quite different from the impedance into which the amplifier is designed to work. An amplifier might have a source impedance **of 0.5 ohm,** but the impedance into which it is intended to work is 8 ohms.

The question naturally arises as to why putting a resistor in parallel with a cartridge or amplifier can yield the impedance. You place almost any number of appliances in parallel across a 117-volt line without causing much drop across the line. All that is proved by this logic is that the impedance of the line is very low. Do not use the foregoing means to measure the line's impedance, for the least that can happen is that you will blow the house fuse in the attempt, and cause serious overheating of the wiring. The answer to this lies in our reconsidering the internal structure of the pickup. The resistor used to measure the impedance of the pickup is really in series with it and not in parallel with it. The pickup may be considered as being composed of a generator of zero resistance in series with the internal impedance of the pickup. This is shown in *Fig.* 4. When the load resistor, or test resistor, is placed across the pickup, we are actually placing it in series with the pickup's internal resistance or, more accurately, its internal impedance, R_i in *Fig.* 4. ***Figure*** 5 shows that the generator, the pickup's internal impedance, R_i, and the external load or test resistance, R_L, are in series. R_L and R_i form a voltage divider. When R_L is large with respect to R_i, a larger voltage will be developed across it than R_i. In fact, the voltages will divide in accordance with the ratios of the values of the resistances. Therefore, when the two resistances are equal in value, the voltage drops across them will be equal. The generator is supplying a constant voltage to the two resistors. When R_L is infinite and R_i some finite value of resistance, all the voltage available will develop across R_L. As the value of R_L is reduced, more voltage is dropped across R_i and less across R_L. When the values of R_i and R_L are equal, equal voltage drops will appear across the two resistances. Because the voltage of the generator has remained constant, the voltage across R_L is half as much as it had been when R_L was infinite. (When the test instrument has an impedance at least ten times that of the device being tested, the impedance of the meter may be considered infinite, and therefore will have negligible effect on the results of the test.

The reason for measuring impedance in this manner, rather than directly with an ohmmeter is that inductance and/or capacitance in the device to be measured cause it to have an impendance value different from the *resistance* value that which would be shown on an ohmmeter.

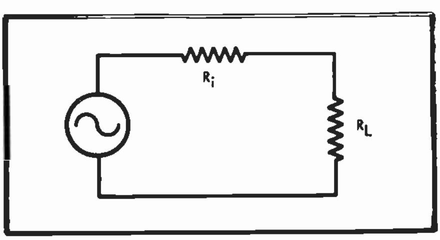

Fig. 5