fischertechnik® l-e3

Voltmeter

for Experiments with the fischertechnik Expansion Kit

Elektro-Mechanik e-m1

Elektro-Mechanik e-m2

Licht-Elektronik l-e1

Licht-Elektronik l-e2

®

Order No. 30083

Fischer – Werke · 7241 Tumlingen
Printed in Germany · Ref. No. 33-8/70/5

1. Technical Data:

1.1 Electrical Voltmeter: Art. No. 31185

Moving Coil Meter. Full deflection:10 Volt DC
Internal Resistance: 3 Kilo-Ohm per Volt (kΩ/V)
Input range stretched. Suitable as a "null" instrument.

1.2 Potentiometer:

1 Kilo-Ohm (kΩ) with linear Characteristic.

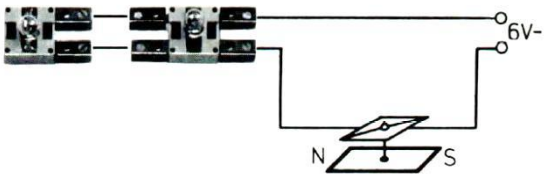
Current Rating: max 100 mA

1.3 Cable:

2 Pce. with green Plugs, 30 cm	Part. No. 31379
1 Pce. with red Plugs, 30 cm	Part. No. 31380
1 Pce. Double cable with Plugs, 100 cm	Part. No. 31042

2. Operation of the Moving Coil Meter

If a current flows through a wire, a magnetic field is produced around the wire.
With a compass needle, that is a freely rotating magnetized steel plate, you can build the following experiment to prove this phenomenon:

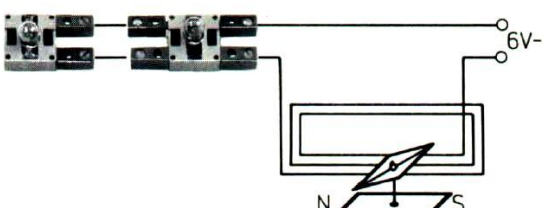


The electrical wire should be passed as near as possible above or below the magnetic needle.

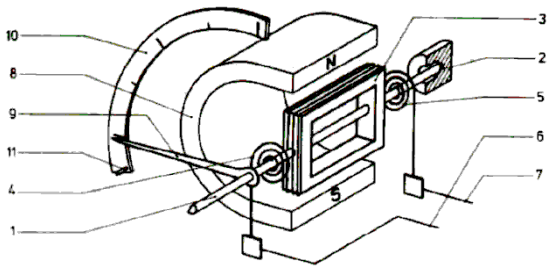
When the current is switched on, the needle is deflected. The effect and magnitude of the deflection depends on the direction in which the current flows through the wire and on the magnitude of the current.

This physical effect is used in electromagnets and in electrical measuring instruments.

The described effect on the magnetic needle is strengthened by using multiple turns of the current-carrying wire or ring-shaped winding and thus passing the current several times past the magnetized needle.



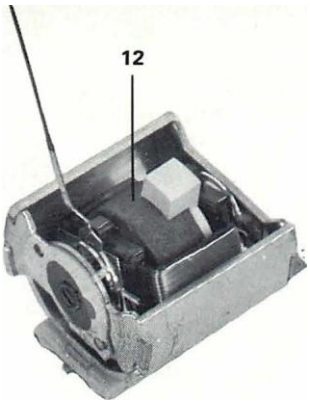
This principle is reversed in the type of electrical measuring device called a "moving-coil meter" which is often used in industry. The coil is mounted in a movable manner and the permanent magnet remains fixed.



The instrument's measuring unit is mounted on a shaft 1 with "tips" at each end; one tip is inserted into the rear bearing 2 and the other into the front bearing (not shown). The coil 3 is wound with several 1000 turns of the finest enameled copper wire and is electrically connected to two external terminals 6 and 7 via two spiral springs 4 and 5 that are insulated on the shaft. The coil is located between the north and south poles of a permanent magnet 8.

If current flows through the winding of the coil, a magnetic field is formed around the coil which, depending on its polarity, rotates the coil left or right. The magnitude of the rotation depends on the magnitude of the current, the number of windings, the strength of the magnet, the distance between the magnet and the spring force of the spiral springs. If the current flow is interrupted, the magnetic field generated around the coil collapses and the two spiral springs 4 and 5 turn the coil back to the "zero position". The pointer 9, rigidly connected to the coil, indicates on the scale 10 the magnitude of the current.

Instead of the horseshoe-shaped permanent magnet shown in the principle sketch, we use a "magnetic core" in the fischertechnik voltmeter - see 12 below. The coil sits inside the magnetic core and the effect is exactly the same as in the case of an "external magnet".



By means of a suitable arrangement of the spiral springs and other features, the fischertechnik measuring unit ensures that the zero position is sufficiently from the left hand stop 11 that a move to the left (reverse polarity) is clearly visible. By means of a "non-linear" characteristic of the measurement unit high initial sensitivity is achieved such that even a very small current flow leads to a clear deflection of the pointer. The measuring device can therefore be used as a null indicator in a bridge circuit.

Our measuring unit with fixed magnet and rotating coil – therefore called a "moving-coil meter" – only measures direct current. If alternating current flows through the measuring unit, the coil cannot follow the change of current direction quickly enough. It therefore remains in the zero position.

3. The Operation of Voltmeters

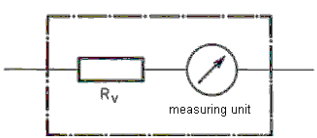
In the last section it was explained why an electrical measuring device indicates the magnitude of the electrical current flowing through the coil. How then is an electrical voltage measured?

The very thin wire used in the coil - simply referred to as the "winding" - has a certain electrical resistance R. In order to achieve a certain deflection of the measuring device, a certain current must flow through the "winding". This is achieved by applying a voltage which is easily calculated according to the Ohm's law $V = I \times R$. The resistance of the winding is about 1500 Ohm. The max. deflection is reached at about 0.3 milliampere. Therefore a voltage of 0.45 Volt is needed for maximum deflection.

With the fischertechnik voltmeter, however, voltages up to a maximum of 10 Volts are to be measured. Therefore, an additional resistor - a "series" resistor - is connected within the voltmeter's housing.

A value of about 32 kilo-ohms is connected in series with the winding of the measuring unit. This series-resistor limits the current in the winding to the desired value of 0.3mA, when a DC voltage of 10 volts is applied to the sockets of the voltmeter.

We therefore have the following circuit:



We have called the resistance of the coil pickup of the measuring unit "R_U" and the connected series-resistor as "R_V". The sum of the two corresponds to the internal resistance "R_i" of the voltmeter or $R_i = R_U + R_V$.

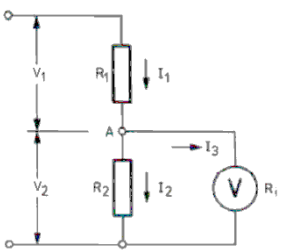
4. Circuit diagram of a voltmeter

You can either draw a circle or a rectangle with the letter V within it.

This symbolises an "ideal" voltmeter, which does not affect our circuit in any way.

5. Effects when using a Voltmeter

Let's now turn our voltmeter to measuring a voltage, for example, in the voltage-divider circuit shown below we must consider whether the voltage ratios in the circuit to be examined are altered by the parallel connection of the resistance of the voltmeter.



At point "A", the current flowing through the resistor R_1 branches into 2 partial currents. Only if the partial current I_3 flowing through the voltmeter is significantly smaller than the partial current I_2, the voltage V_2 to be measured changes so insignificantly that the change of this voltage by the connection of the voltmeter is considered negligible.

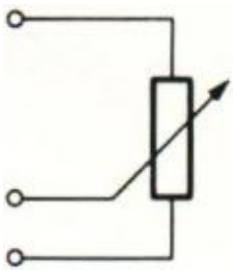
To simplify calculations, it is sufficient to have a voltmeter resistance Ri of at least five times the resistance that is in parallel with it.

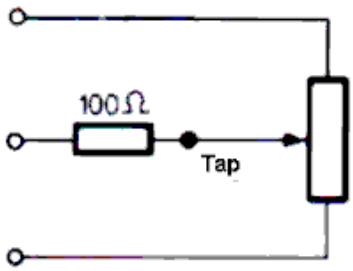
6. Potentiometer with 1 Kilo-Ohm Resistance

A potentiometer is installed in the housing of the fischertechnik-Voltmeter. It is not connected to the voltmeter itself.

A "potentiometer" is a resistance with a changeable centre "tap".

Standard circuit diagram

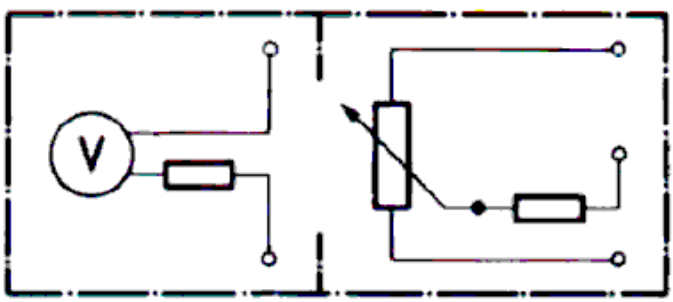




A potentiometer can be used as a voltage divider or as a variable resistor. In the latter case, only 2 terminals are connected.

Since the thermal (= heat) load capacity of the entire potentiometer is a maximum of 1 Watt, the potentiometer must not allow a current of more than 100 milliampere to flow. A protective resistor of 100Ω, which is located before the tap, prevents a short circuit in the event of a fault.

7. Complete circuit diagram



Translated by: Peter King, www.procontechnology.com.au
with the assistance of Google.