Sept. 27, 1966 W. D. HUSTON 3,275,936

ELECTRIC METER INCLUDING PIVOTED MAGNET ROTOR SURROUNDED BY CONTINUOUS POLE FACES

Filed May 4, 1962

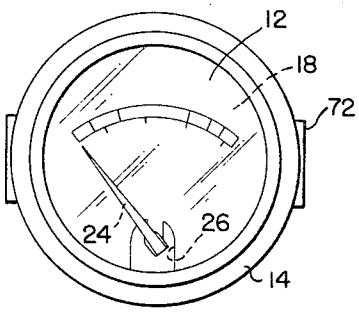



FIG. 1.

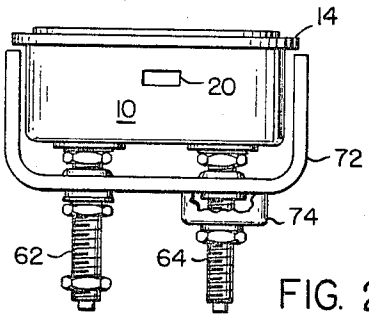



FIG. 2.

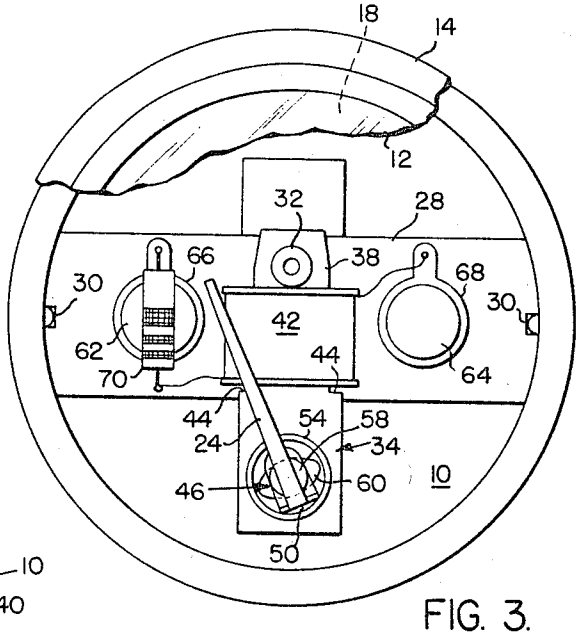



FIG. 3.

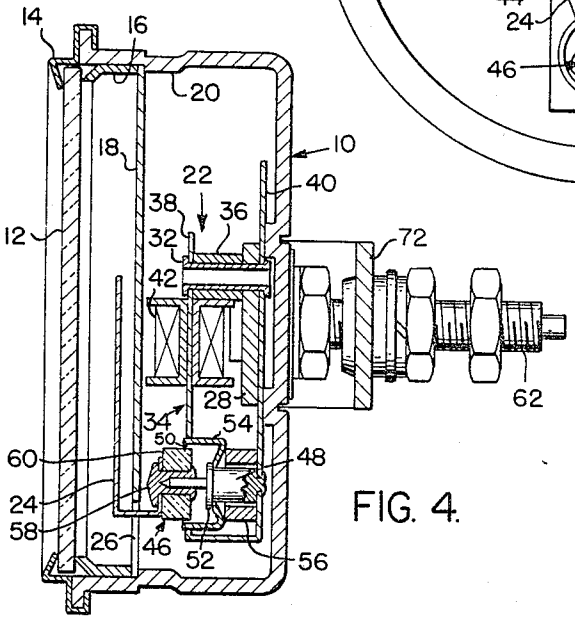



FIG. 4.

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3,275,936

Patented Sept. 27, 1966



3,275,936

# ELECTRIC METER INCLUDING PIVOTED MAGNET ROTOR SURROUNDED BY CONTINUOUS POLE FACES

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Filed May 4, 1962, Ser. No. 192,452
3 Claims. (Cl. 324—146)

The present invention relates to voltmeters, and has to do primarily with a voltmeter of the general type having a coil mounted on a fixed armature, and a rotor including a permanent magnet.

Voltmeters of this type are inexpensive and rugged. Heretofore, however, they have been subject to relatively severe limitations with regard to their accuracy and sensitivity, because of the inherent tendency of the permanent magnet to align itself with the armature due to its own magnetic field. Because of this effect, it has heretofore been thought necessary in voltmeters of this general type to provide a relatively large spacing between the rotor permanent magnet and the pole faces of the armature, thus leaving a relatively large gap in the magnetic circuit of the armature. This construction makes for relatively high reluctance in the armature circuit; and previous meters of this type, therefore, have been characterized by a lack of sensitivity.

Accordingly, one important object of the present invention is to improve the sensitivity of voltmeters of this type without sacrifice of accuracy, reliability and other desirable characteristics.

Another object is to provide a voltmeter of the stated type in which the pivoted permanent magnet may be closely spaced from the pole faces of the armature without developing an angular bias on the magnet due to its own magnetic field.

Another object is to provide a voltmeter of the stated type which may be easily and quickly calibrated, thereby facilitating production.

A general object of the invention is to provide a voltmeter of the stated type which is relatively inexpensive to manufacture, compact, requires a minimum number of parts, yet is rugged and of long-lasting construction, and is well suited for mass production by relatively unskilled personnel.

The foregoing and other objects and advantages of the invention will become apparent from the following detailed description of a representative embodiment thereof, taken in conjunction with the drawing, wherein:

FIG. 1 is a front elevational view of a voltmeter made according to the presently preferred embodiment of the invention;

FIG. 2 is a plan view of this voltmeter;

FIG. 3 is a front elevational view, on an enlarged scale but with parts broken away, of this voltmeter, showing the arrangement of the internal parts thereof; and

FIG. 4 is a cross-sectional view of this voltmeter.

The voltmeter of the present invention, like previous voltmeters of the type having pivoted permanent magnet rotors, is of rugged construction, especially adapted for use on motor vehicles where relatively severe vibration and shock may be encountered. The voltmeter of the invention, however, has improved accuracy and sensitivity. It includes a magnetic armature, which mounts an energizing coil to which the voltage to be measured is applied. The magnetic gap is preferably formed by a circular aperture in the armature, within which the permanent magnet rotor is pivoted for rotation in response to magnetic flux developed in the armature by current passing through the coil. By making the gap in the form of a circular aperture centered on the pivot axis of the rotor, the rotor is made insensitive to the relative orientation of the armature, and no torque is produced on the rotor due to the interaction of the magnetic field of the rotor magnet and the armature. The spacing between the poles of the pivoted permanent magnet and the armature is the same for all angular positions of the armature.



In the illustrated embodiment, a biasing, or restoring magnet is fixed relative to the armature adjacent to the rotor for urging the rotor toward a selected zero indicating position.

The meter movement forms a sub-assembly, which may be quickly and easily calibrated prior to mounting in the meter case, by simply bending one leg of the armature toward or away from the opposite leg. This action adjusts the reluctance of the magnetic circuit, and thereby adjusts the sensitivity of the movement by varying the magnitude of the flux produced in the armature in response to a given applied voltage.

Referring now to the drawing by numerals of reference, the voltmeter shown includes a cup-like case **10**, preferably made of a magnetic material such as sheet steel so that it will shield the meter movement from external magnetic fields. The open end of the case **10** is covered by a crystal **12**, which is held in place by a conventional bezel **14** and a spacer ring **16**. A graduated dial **18** is held in position near the open end of the casing **10** between the spacer ring **16** and inwardly extending bosses **20**, which are struck from the sidewall of the case **10** at spaced points therearound.

The meter movement **22** is mounted within the case **10** mostly behind the dial **18**, and includes a pointer **24**, which extends through an aperture **26** in the dial **18**, and which is arranged to swing across the dial to indicate the value of the voltage being measured. The movement **22** is secured by a grommet **32** to an insulating plate **28**, which extends across the back wall of the case **10** and is angularly fixed relative thereto by engagement with diametrically opposed bosses **30** struck inwardly from the side wall of the case **10**.

The movement **22** includes an armature or core **34** made of a paramagnetic material such as a silicon steel alloy having relatively low reluctance and low coercive force. The armature or core **34** is in the form of a relatively thin ribbon bent in a U-shape, and is secured to the insulator plate **28** by the grommet **32**, which extends through both legs **38** and **40** of the armature, and which is of a non-magnetic material such as brass. A spacer bushing **36** is fitted around the grommet **32** between the front leg **38** of the armature and the insulating plate **28** to maintain the desired spacing between the two legs **38** and **40** of the armature. The bushing **36** is also of a non-magnetic material such as brass. The back leg **40** of the armature or core passes behind the insulating plate **28** and rests against an inwardly-protruding central boss on the back wall of the case **10**. The energizing coil **42** is mounted on the front leg **38** of the armature or core, and is retained thereon between the grommet **32** and a pair of laterally extending shoulders **44** on the armature.

There is a circular aperture **50** in the front leg **38** of the armature or core **34** near the bight portion thereof,

constituting a gap in the low reluctance flux path of the armature or core. A rotor **46** is pivoted within the aperture **50** for rotation in response to a magnetic flux developed in the armature or core. The rotor **46** is pivoted on a stem **48** staked to the rear leg **40** of the armature or core in axial alignment with the aperture **50**. The stem **48** includes a flange **52** for engagement by a non-magnetic retainer cup **54**, which fits within the aperture **50** in the front leg of the armature or core, and which serves the dual purposes of maintaining the stem **48** in coaxial alignment with the aperture **50** and of retaining a restoring magnet **56** upon the stem. The restoring magnet **56** is annular in form, and is fitted around the stem **48** between the retaining cup **54** and the rear leg **40** of the armature or core. The restoring magnet **56** is magnetized in a direction parallel to the plane of rotation of the rotor **46** and at about 45° from the direction of the length of the armature or core **34**. The rotor **46** includes a hub or bushing **58**, which fits upon the stem **48** and is freely rotatable thereon, and a permanent magnet **60** of generally oval shape, which is staked, or otherwise fixed on the hub or bushing **58** along with the pointer **24**. The rotor magnet **60** is magnetized in a direction parallel to its plane of rotation and approximately normal to the length of the pointer **24**.

The movement **22**, including the insulating plate **28** constitutes a sub-assembly, and is secured in the case **10** by a pair of studs **62** and **64**, which extend through the insulating plate **28** and through the back wall of the case **10**. The studs **62** and **64** are electrically insulated from the case by appropriate insulating bushings and washers (not separately designated). The coil **42** is connected to the studs **62** and **64** by terminal rings **66** and **68**, which are positioned between the heads of the studs **62** and **64** and the insulating plate **28**. A resistor **70** is connected in series with the coil **42** between the ring **66** and the coil for limiting the current in the coil **42**. The value of the resistor **70** is selected in accordance with well known principles in view of the magnitude of the voltage it is desired to measure with the voltmeter.

In operation, the restoring, or biasing magnet **56** urges the rotor **46** and the pointer **24** toward zero indicating position by reason of the magnetic attraction between the restoring magnet **56** and the rotor magnet **60**. The rotor magnet **60** tends to align itself with the restoring magnet. When current passes through the coil **42** in response to a voltage applied between the studs **62** and **64**, a magnetic flux is established in the armature or core **34**, and rotates the rotor **46** in proportion to the magnitude of the current. This flux tends to urge the rotor **46** in a clockwise direction as viewed in FIGS. 1 and 3. The manner in which the flux operates to rotate magnet **60** is not fully understood; but it is surmised that the narrow areas at opposite sides of the aperture **50** in a direction transverse of the armature or core tend to constrict the electrically induced flux, thus producing a saturated condition. The flux is, therefore, directed through rotor **60** as the easiest path.

The restoring magnet **56** is oriented, and the direction of current flow in the coil **42** is chosen so that the rotor **46** is driven across the 135° angle between the restoring magnet **56** and the armature or core **34** rather than the complementary 45° angle. Full scale deflection may include an angle of 90°, or more, without encountering severe variations from a linear response relative to the current passing through, and of the voltage applied across the coil **42**. When the voltage is removed, the magnetic flux in the armature or core **34** ceases, and the restoring magnet **56** draws the rotor **46** back to its zero indicating position.

With the magnet **60** positioned in the center of the circular aperture **50**, the magnet is not influenced by the soft iron armature or core **34** in any direction until coil **42** is energized. The soft iron armature or core insures that the magnetic flux will be concentrated in one direction, to rotate the magnet **60**. The magnet **60** can be of a length approximately equal to the diameter of the aperture **50**; only mechanical clearance is required between the aperture and the rotor magnet **60**. The armature or core **34** extends completely around the rotor magnet **60**, and the aperture **50** is circular so that the forces produced between the permanent magnet **60** and the armature or core **34** by the permanent magnet **60** are independent of the angular position of the magnet **60** and do not include an angular component for any position of the rotor **46**.

The magnet **56** serves not only as a return magnet but also to retain the rotor **46** on the stem **48**. No other retaining device is included. The dial **18**, however, extends over the rotor **46** and serves as an abutment stop to keep the rotor **46** from escaping from the stem **48** in the event of exceptionally severe shocks.

A mounting clamp, or strap **72** is carried by the studs **62** and **64** for easy mounting of the meter on the instrument panel of a vehicle, or the like. The clamp **72** is insulated from the studs **62** and **64** by appropriate insulating bushings and washers (not separately designated). When the meter is to be used in a vehicle wherein one of the battery terminals is grounded, a shorting cup **74** is provided on one of the studs **62** and **64** for grounding the corresponding terminal of the meter to the mounting bracket **72**.

In manufacture, preliminarily to mounting the movement **22** in the case **10**, the movement **22** is calibrated by applying a voltage of known magnitude to it, and then bending the upper, free end of the rear leg **40** of the armature toward or away from the front leg **36** until the proper deflection of the pointer **24** is noted. Bending the rear leg **40** toward the front leg **38** reduces the overall reluctance of the magnetic circuit of the armature **34**, thereby increasing the flux produced in response to a given voltage, and increasing the meter reading. Bending the rear leg **40** away from the front leg **36** increases the reluctance, reduces the flux, and reduces the reading.

While the invention has been described in connection with a specific embodiment thereof, it will be understood that it is capable of further modification, and this application is intended to cover any variations, uses, or adaptations of the invention following, in general, the principles of the invention and including such departures from the present disclosure as come within known or customary practice in the art to which the invention pertains and as may be applied to the essential features hereinbefore set forth, and as fall within the scope of the invention or the limits of the appended claims.

Having thus described my invention, what I claim is:

**1.** An electrical meter comprising

(a) a generally U-shaped core comprising a single sheet of thin, soft magnetic material,

(b) an electric coil mounted on one leg of said core for producing magnetic flux therein upon energization of said coil,

(c) said core having a circular aperture in one leg with a continuous circular wall, said aperture extending across the major part of the width of the core whereby two magnetically saturable portions of the core are disposed at either side of the aperture,

(d) a permanent magnet, means pivoting said permanent magnet in said aperture, said magnet being polarized in the plane of said aperture, and

(e) means for biasing said magnet toward a preselected angular position relative to said core,

and means for adjusting the reluctance of said core for calibrating said meter.

**2.** An electrical meter as claimed in claim **1**, wherein, for the purpose of calibrating said meter, one leg of said core is bendable toward and away from the opposite leg thereof.

**3.** An electrical meter as claimed in claim **1**, wherein said biasing means is an annular magnet coaxial with

said pivoting means, and said permanent magnet is rotatable about the axis of said pivot.


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