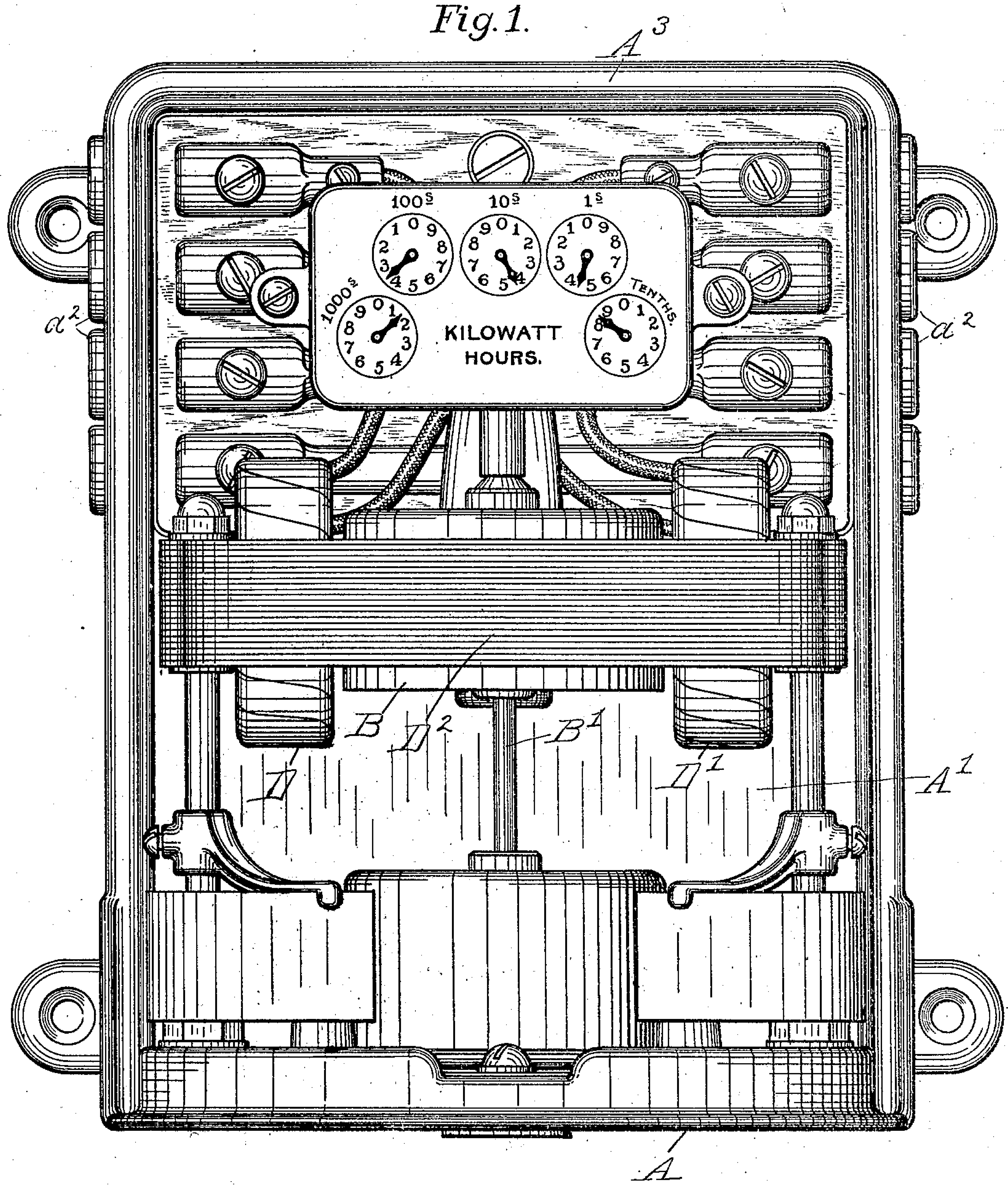
(No Model.) 6 Sheets—Sheet 1.

T. DUNCAN.

ELECTRIC METER.

No. 604,461. Patented May 24, 1898.

*Fig. 1.*




Witnesses
S. R. Buchtel
John J. Muir

Inventor
Thomas Duncan
By his Attorneys
Carter & Graves

(No Model.)

T. DUNCAN.

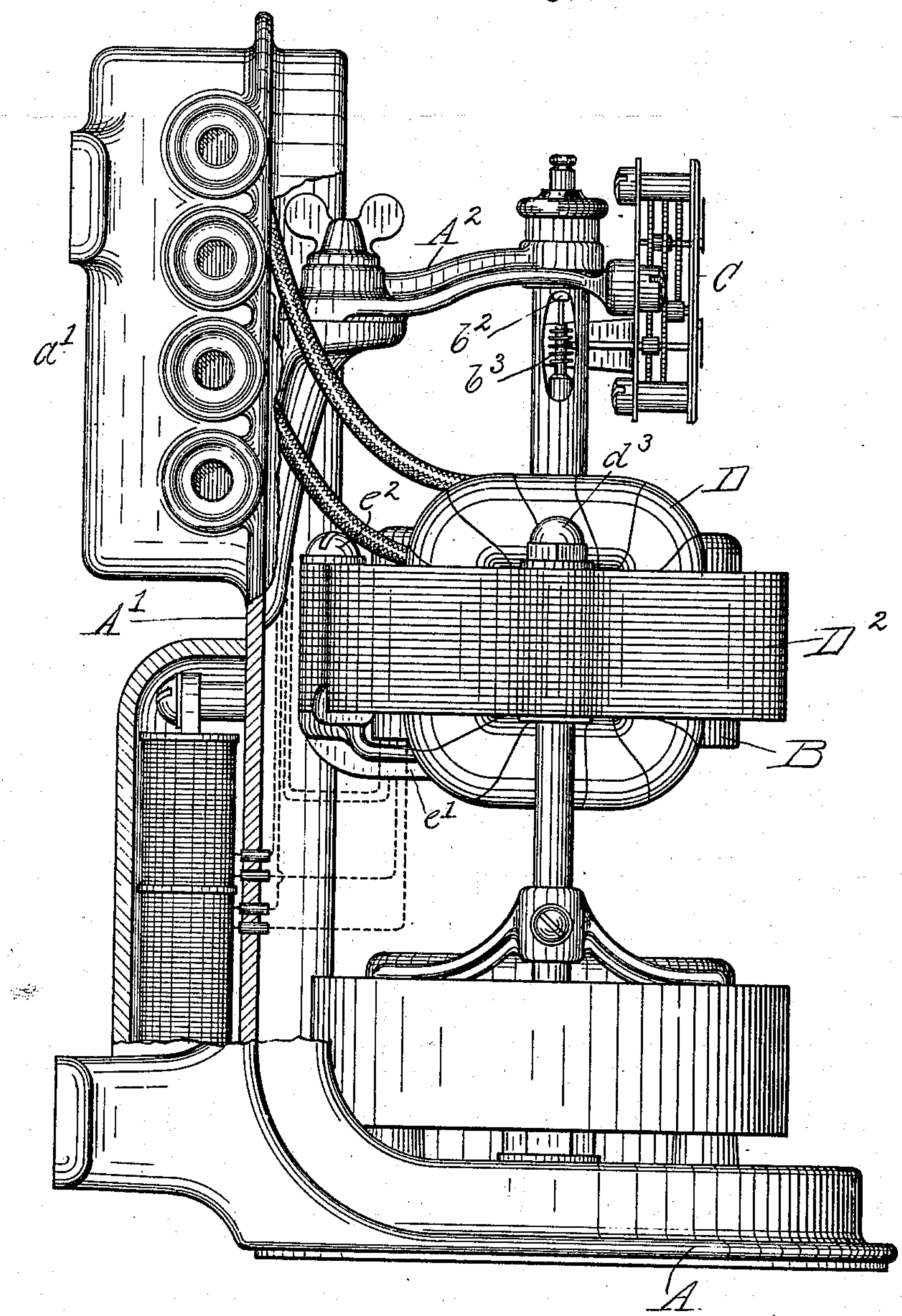
ELECTRIC METER.

6 Sheets—Sheet 2.

No. 604,461.

Patented May 24, 1898.

*Fig. 2.*




Witnesses

S. R. Bachtel.

John J. Muir

Inventor

Thomas Duncan

By his Attorneys

Carter & Graves

(No Model.)

6 Sheets—Sheet 3.

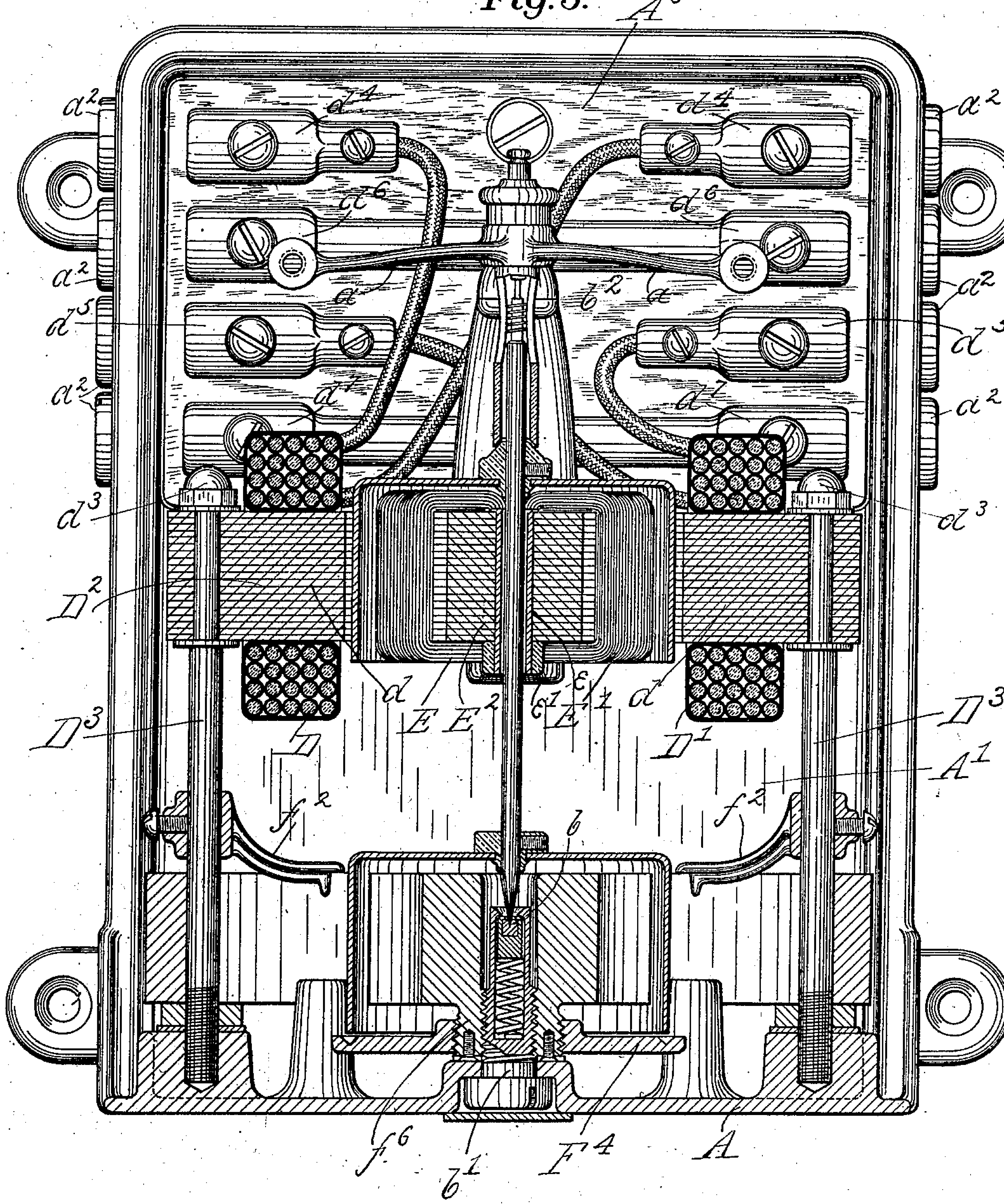
T. DUNCAN.

ELECTRIC METER.

No. 604,461.

Patented May 24, 1898.

*Fig. 3.*




Witnesses
S. R. Bachtel.
John J. Muir

Inventor
Thomas Duncan
By Attorneys
Carter & Graves

(No Model.) 6 Sheets—Sheet 4.

# T. DUNCAN.

## ELECTRIC METER.

No. 604,461. Patented May 24, 1898.

*Fig. 4.*

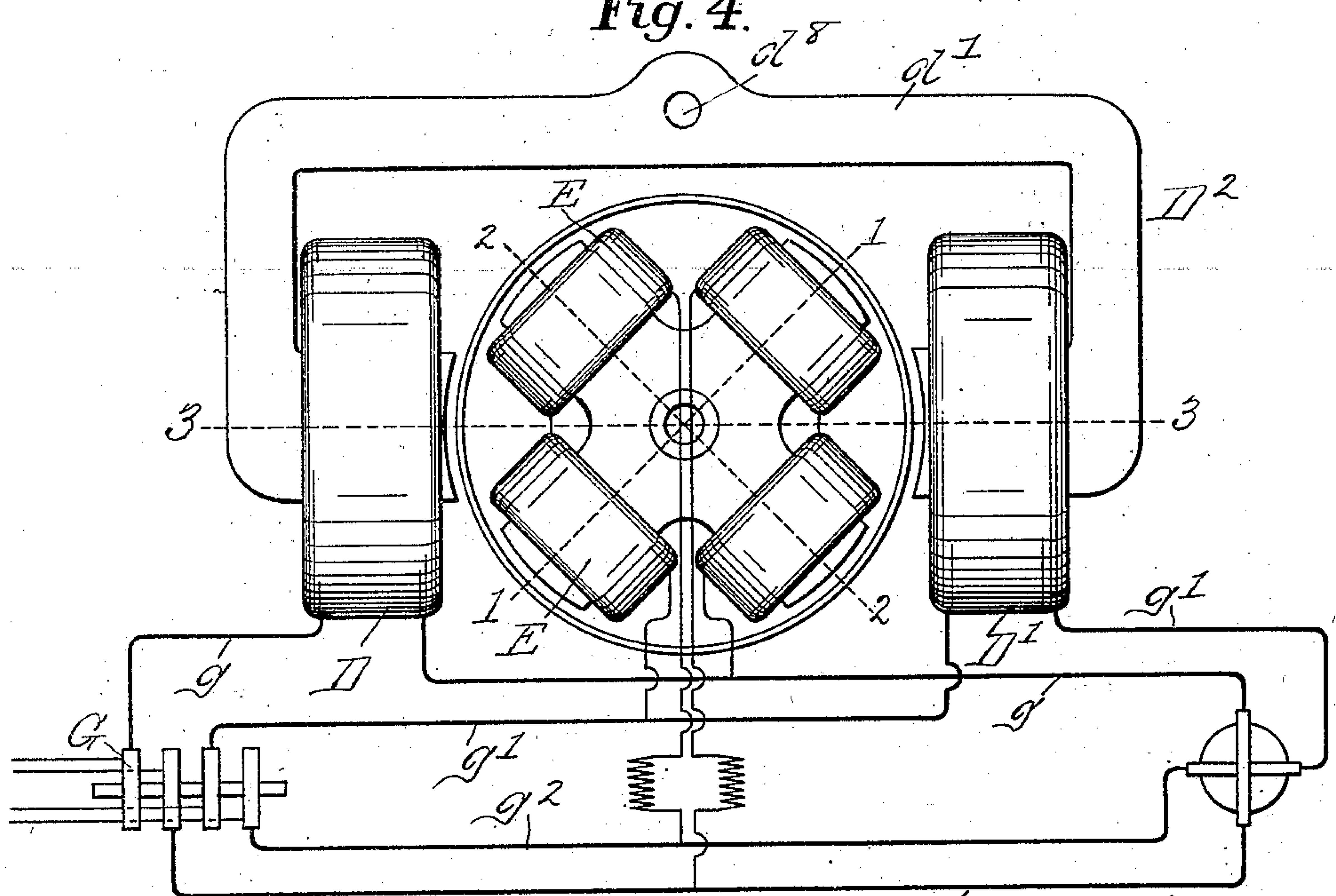
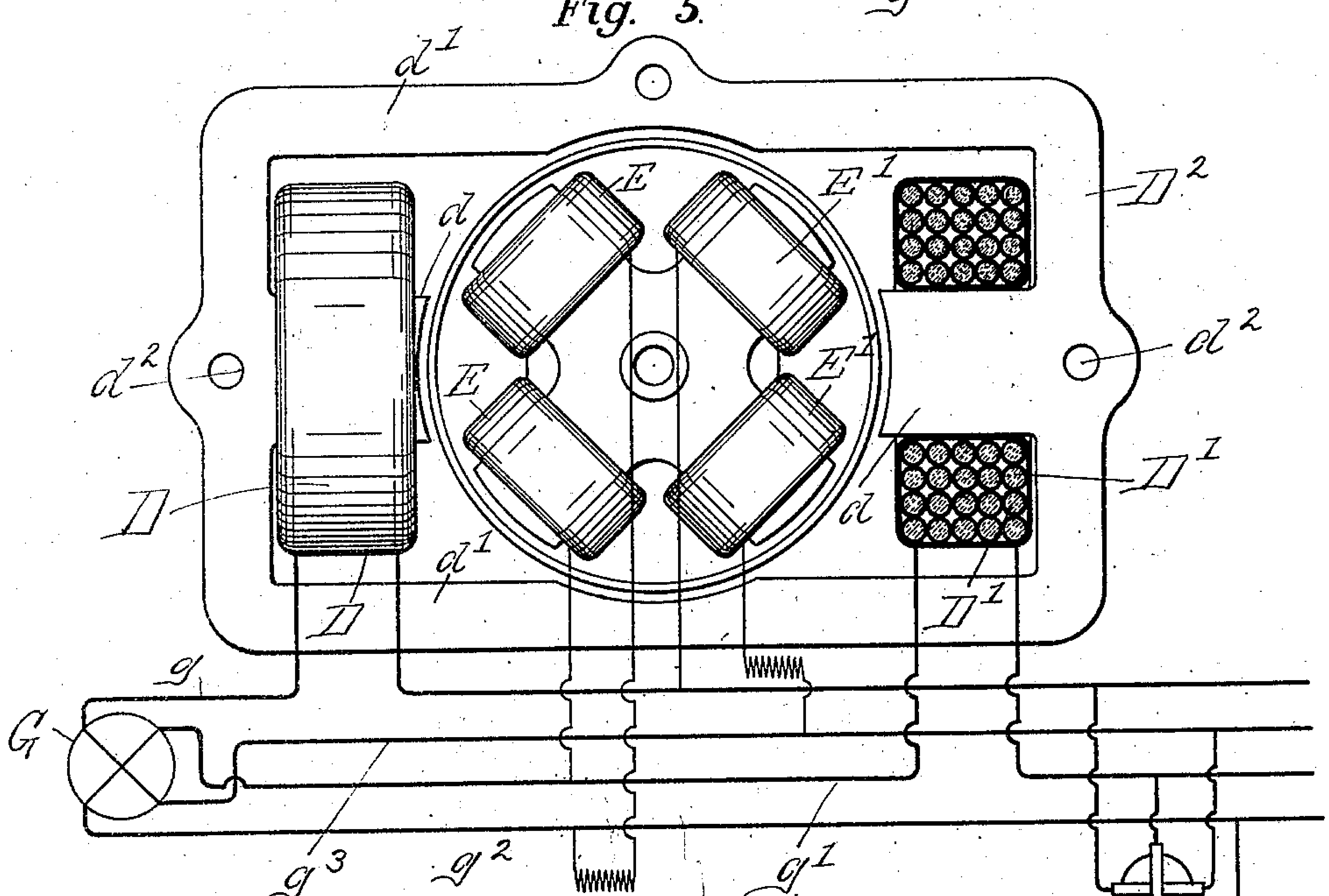



*Fig. 5.*




Witnesses
S. R. Bachtel
John J. Muir

Inventor
Thomas Duncan
By his Attorneys
Carter & Graves

(No Model.)

6 Sheets—Sheet 5.

T. DUNCAN.

ELECTRIC METER.

No. 604,461.

Patented May 24, 1898.

*Fig. 6.*

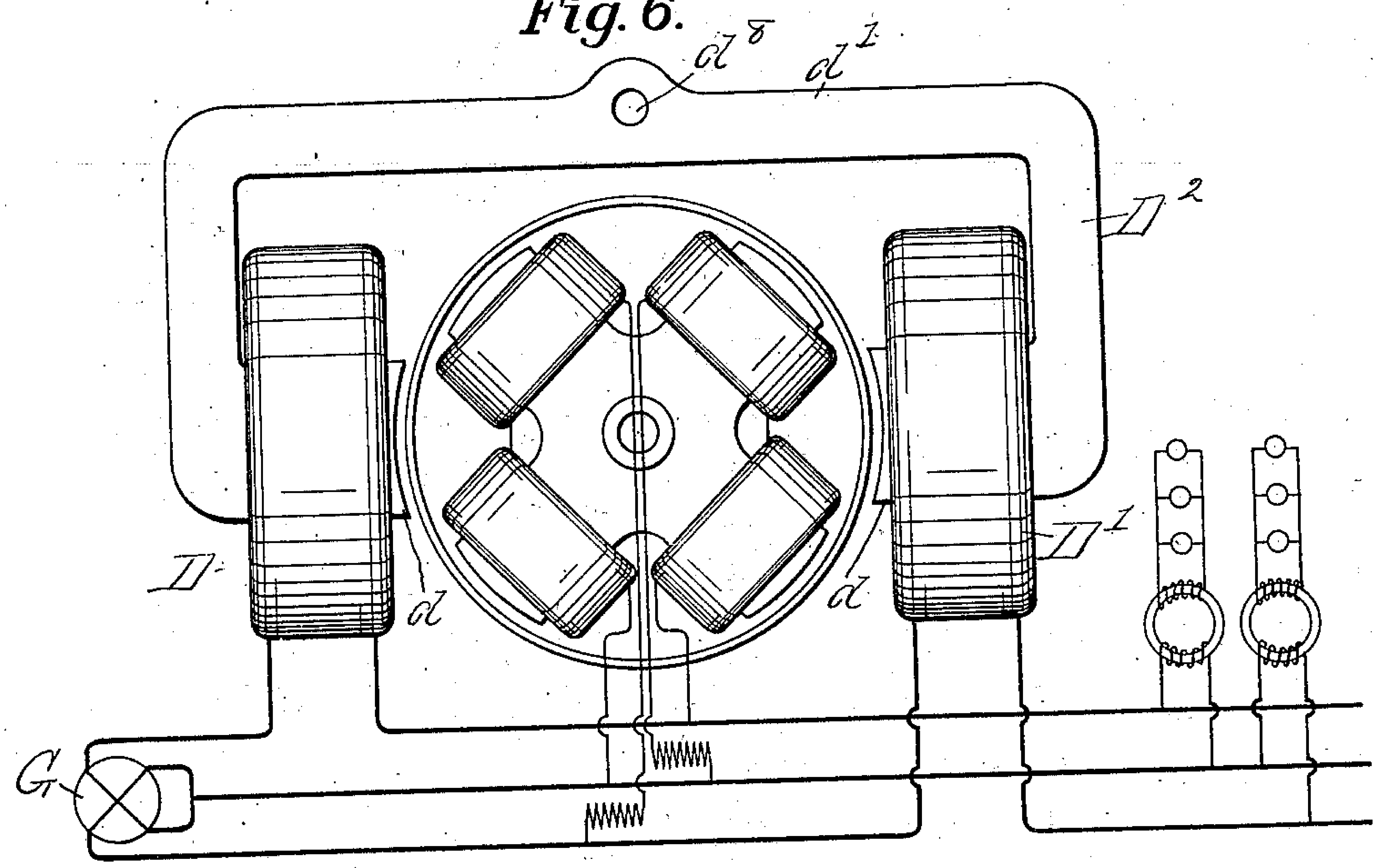
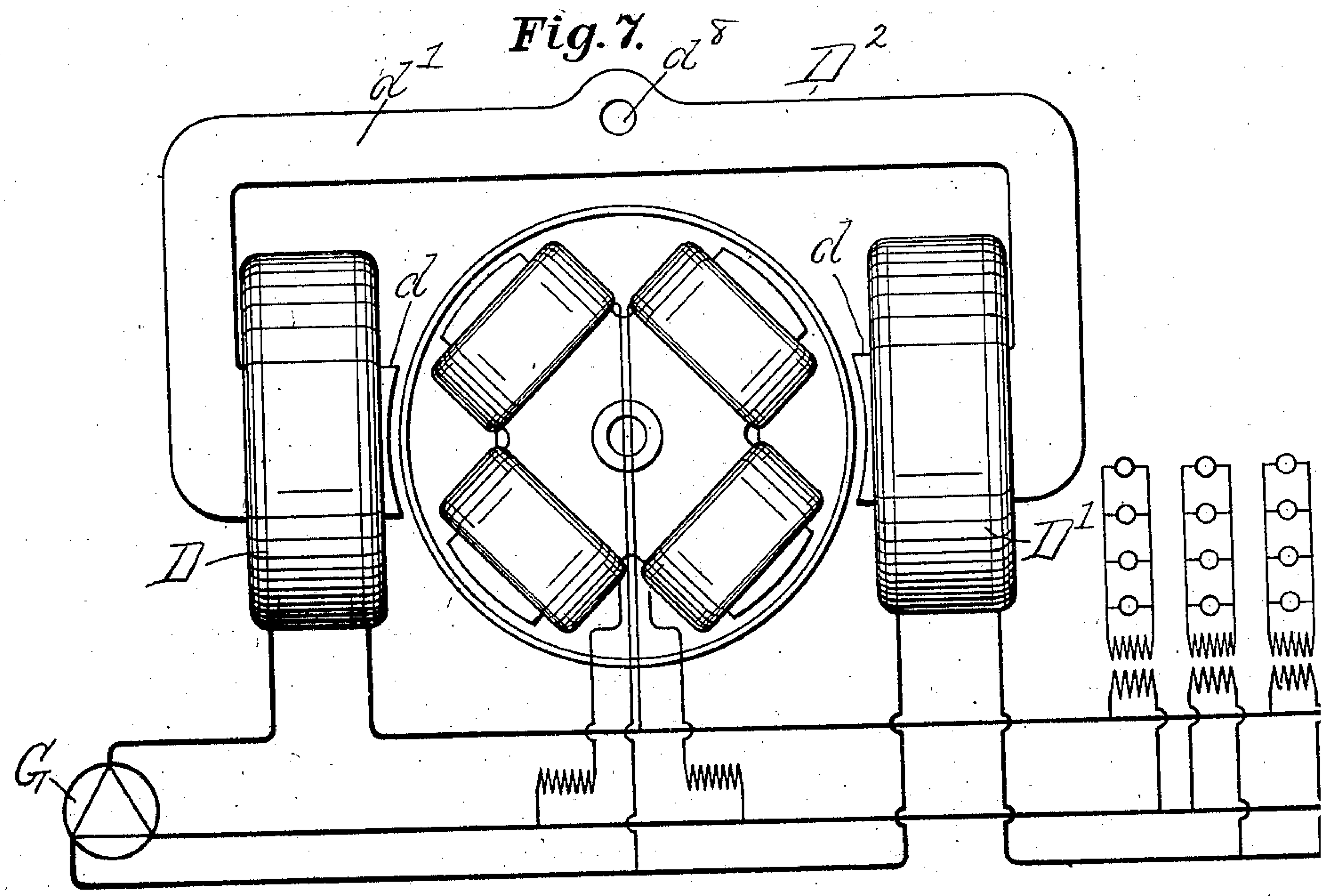



*Fig. 7.*




Witnesses

S. R. Bachtel

John J. Muir

Inventor

Thomas Duncan

By his Attorneys

Carter & Graves

(No Model.)

6 Sheets—Sheet 6.

T. DUNCAN.

ELECTRIC METER.

No. 604,461.

Patented May 24, 1898.

*Fig. 8.*

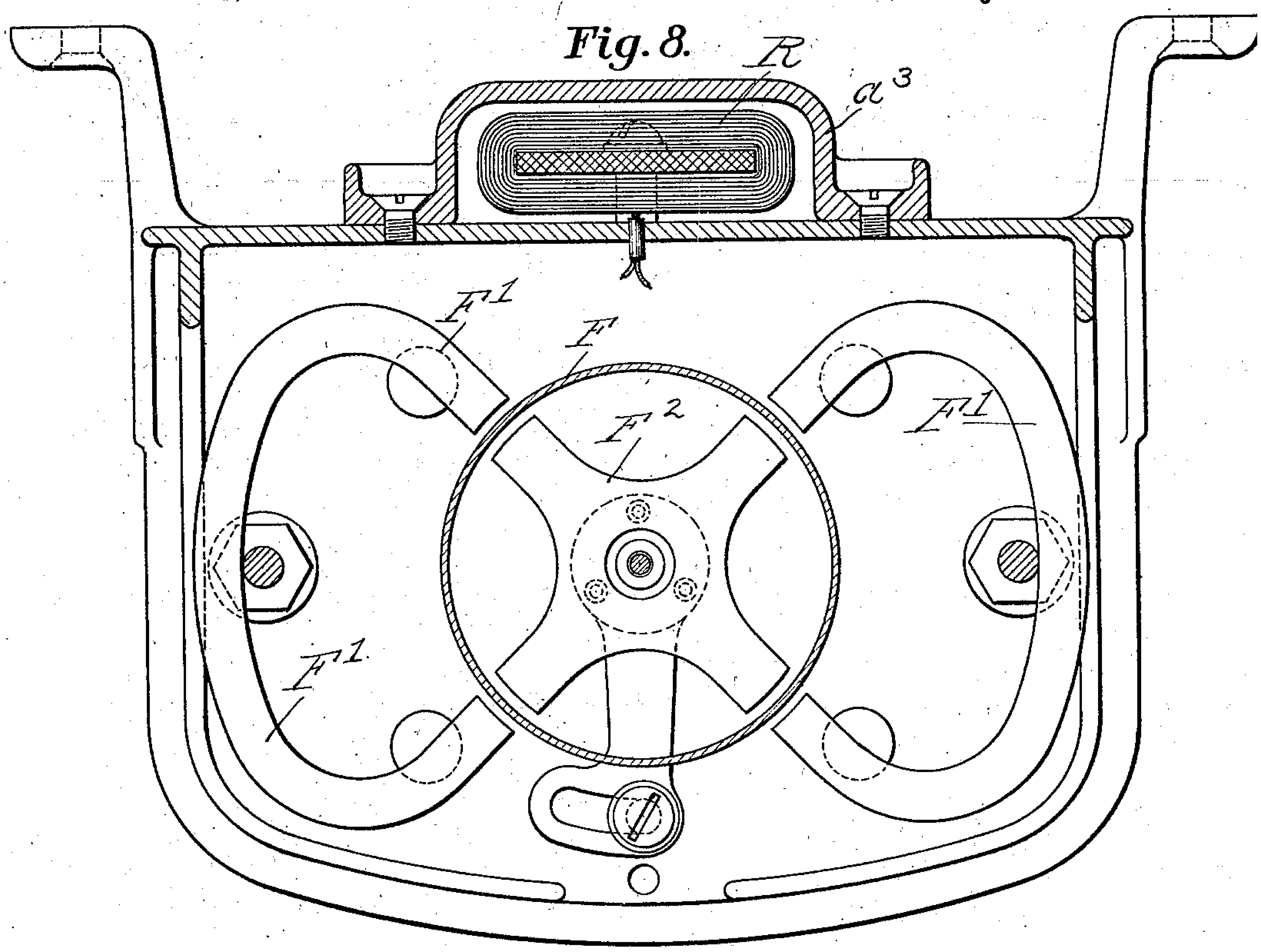
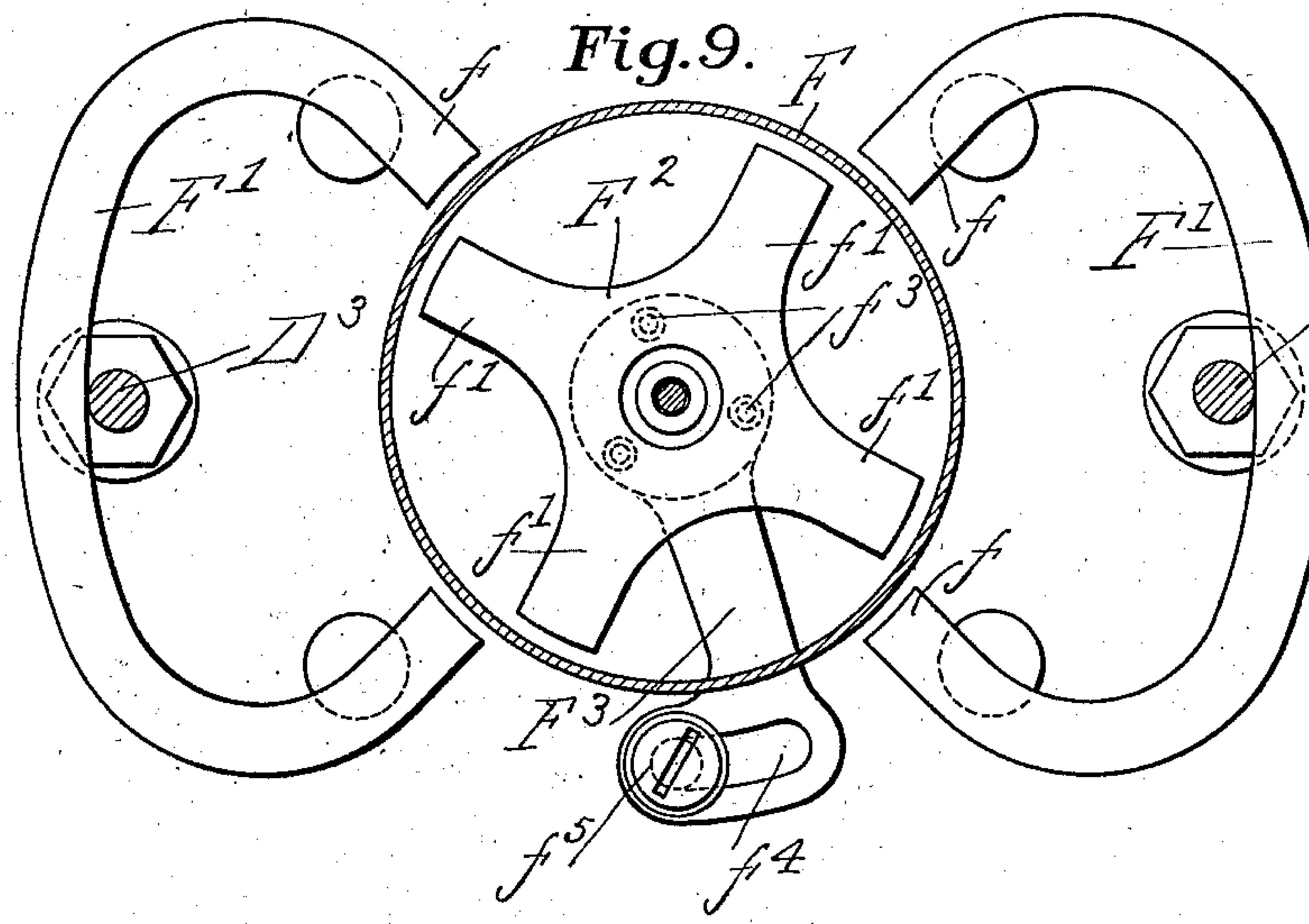



*Fig. 9.*




Witnesses

S. R. Bachtel.

John J. Mais

Inventor

Thomas Duncan

By his Attorneys

Carter & Graves

# UNITED STATES PATENT OFFICE.

THOMAS DUNCAN, OF FORT WAYNE, INDIANA.

## ELECTRIC METER.

SPECIFICATION forming part of Letters Patent No. 604,461, dated May 24, 1898.

Application filed August 6, 1897. Serial No. 647,305. (No model.)

*To all whom it may concern:*

Be it known that I, THOMAS DUNCAN, of Fort Wayne, in the county of Allen and State of Indiana, have invented certain new and useful Improvements in Electric Meters, of which the following is a specification.

This invention relates to alternating-current meters of that class in which a rotary armature is set in motion by the inductive action of two or more fields of differing phase, and it relates more particularly to that type of such meters in which the rotary armature is of annular or cylindric form and the magnetic fields are set up by inductive agencies, of which part are placed inside of and part exterior to the armature. In some of its features, however, the invention is applicable to other types of meters, as well as to that more particularly referred to.

A principal object of the invention is to provide an improved wattmeter for multiphase work, and the forms shown in this application are particularly designed for use in two-phase systems of distribution.

The invention consists in the matters herein set forth, and particularly pointed out in the appended claims.

In the accompanying drawings, Figure 1 is a front elevation of a wattmeter embodying my invention. Fig. 2 is a side elevation thereof, partly in section. Fig. 3 is a sectional elevation taken on the axis of the armature. Figs. 4, 5, 6, and 7 are diagrammatic views showing method of connecting the meter in circuit. Fig. 8 is a top plan section showing the magnetic drag. Fig. 9 is a similar view showing a different adjustment of the drag.

In said drawings, A designates the base of the meter-frame, and A′ its back wall.

B is a rotary armature of cylindric form rigidly secured to a vertical spindle B′ to rotate therewith. At its lower end the spindle B′ rests in a jeweled bearing $b$, carried by a screw-post $b'$, which is inserted through the base of the meter-frame. The upper end of the spindle is journaled in a bearing $b^2$, carried at the outer end of an arm $A^2$, that is detachably bolted to the back wall A′ of the meter. Said arm $A^2$ also supports the registering-train C on transverse brackets $a$, the worm-wheel of said train intermeshing with a worm $b^3$ at the upper end of the spindle.

D D′ designate the outer or series coils of the meter. As herein shown, they are wound upon the opposing inturned poles $d$ of a laminated core $D^2$, which extend around the armature D and may be made with a single connecting-bar $d'$, as in Fig. 4, or may be made double, as in Figs. 1, 2, 3, and 5. Said core is conveniently supported upon posts or standards $D^3$, which rise from the base of the meter. The several laminæ of the core are apertured at $d^2$ to slip over said standard and are clamped down upon shoulders of the standards by cap-nuts $d^3$. The coils D and D′ are herein shown as separately connected with binding-posts $d^4$ and $d^5$, respectively, mounted upon an insulating-block $A^3$, that is located in a pocket $a'$ in the upper part of the rear wall A′. Said binding-posts $d^4$ and $d^5$ are designed to be connected in two of the leads of a two-phase system of distribution. The other leads may be conveniently connected through the meter by connected binding-posts $d^6$ and $d^7$, that are also mounted upon the block $A^3$. Suitable apertures insulated by bushing $a^2$ admit the leads to the binding-posts through the side walls of the pocket $a'$.

To insure a maximum torque with a minimum expenditure of energy in operating the meter, its inner or shunt fields are herein shown as so arranged with reference to the outer or series field as to set up three axes of armature polarization after the manner more fully set forth in my pending application, Serial No. 647,303, filed concurrently herewith. To this end two pairs of shunt-coils E E and E′ E′ are mounted within the armature B upon the four poles of a cross-shaped core $E^2$, the axes 1 1 and 2 2 of which are arranged approximately at right angles to each other and at angles of approximately forty-five degrees with the axis 3 3 of the series coils. Said core may be supported within the armature in any suitable manner, and in this instance is mounted upon a tubular sleeve $e$, which surrounds the armature-shaft B′. At its lower end said sleeve is seated in a bracket-arm $e'$, that is shown as clamped to the series core $D^2$ by a screw $e^2$, which enters an aperture $d^8$ in said core.

The manner of connecting the meter in circuit is shown in the diagrammatic views of the drawings. For example, in Figs. 4 and

5, where G indicates a generator supplying two alternating currents differing in phase by ninety degrees, the series coil D is connected in the lead $g$ of one circuit from the generator, and the other coil D' is connected in the lead $g'$ of the other circuit from the generator. The two shunt-coils E, adjacent to the coil D, are connected in series with each other in a shunt-circuit between the two leads $g'$ and $g^2$ of the second circuit from the generator, and the two shunt-coils E', adjacent to the other series coil D', are similarly connected in series with each other in a shunt-circuit between the leads $g$ and $g^3$ of the first generator-circuit. In other words, the adjacent series and shunt coils at each side of the meter are connected in separate circuits from the generator, so that a difference in phase results in the inducing-fields set up thereby. Each series coil will then be energized by a current displaced by ninety degrees from the current which energizes its adjacent shunt-coils, and a shifting resultant field tending to rotate the armature is thus produced at each side of the meter. Since the generator itself in this case effects the necessary phase displacement, no impedance-coils are required in the shunt-circuits, and ordinary resistance-coils R are used instead. Such coils are conveniently located, as shown, at the back of the meter, below the pocket $a'$ thereof, and are inclosed by a protecting-cover $a^3$. In Fig. 6 the manner of connecting the meter in a three-wire system of two-phase distribution is illustrated. The series coils D and D' in this case are connected as before, one in each of the outer leads from the generator, and the two sets of shunt-coils E and E' are connected, one in a shunt-circuit between one of the outer leads and the intermediate lead and the other in a shunt-circuit between the other outer lead and the intermediate lead. The operation of the meter is, however, the same as in the four-wire system.

In the three-phase system shown in Fig. 7 the connections are substantially the same as in Fig. 6.

The magnetic drag provided in this instance embraces a second cylindric armature which may conveniently be made a counterpart of the actuating-armature B. This drag-armature F is rigidly secured to the lower end of the spindle B' and rotates between drag-magnets F', that are made of general horseshoe shape, with converging poles $f$. They are conveniently held in place by adjustable clamps $f^2$ on the standards $D^3$, which support the series core and coils. Within the drag-armature is a cross-shaped magnetic core $F^2$, the poles $f'$ of which normally stand substantially opposite the poles $f$ of the magnets and serve to draw the flux from the magnet through the annular wall of the armature. Regulation of the drag is conveniently provided for by making the core $F^2$ capable of oscillatory adjustment, so that its poles may be moved out of alinement with the poles $f$ of the magnets. As herein shown the core is secured in place by being centrally apertured and threaded to screw over the bearing-post $b'$, which projects upward through the base of the meter to support the lower spindle-bearing. To the lower surface of the core a lever $F^3$ is secured by screws $f^3$. Said lever projects from beneath the armature and is provided at its outer end with an arc-shaped slot $f^4$, through which a clamping-screw $f^5$ is passed into the base of the meter. This clamping-screw is conveniently located at the front of the meter, where it is readily accessible, and the construction thus described therefore enables the speed of the meter to be readily adjusted without removing it from its place on the wall by simply adjusting the lever $F^3$ to the necessary position within the limits of its slot $f^4$. When the poles of the magnetic core are exactly opposite the poles of the drag-magnets, as shown in Fig. 8, the drag will be at its maximum, and a gradual decrease of drag will result as the lever $F^3$ is moved to rotate the poles out of such alinement. This constitutes, therefore, a very simple, ready, and successful means of regulating the speed of the meter at any time. The lower end $f^6$ of the core $F^2$ is furthermore shown as reduced in size and threaded to carry a large thumb-nut $F^4$, which projects beneath the lower edges of the armature F and serves to lift the spindle from its jeweled bearing when it is desired to handle or transport the instrument.

It will be understood that while the particular construction and angular arrangement of the parts herein illustrated have been found to produce the best results thus far they are susceptible of various changes and rearrangements without departing from the spirit or losing the advantages of the invention, which is accordingly broadly and specifically herein claimed. It will also be understood that the manner of connecting the meter in circuit is deemed to be novel and advantageous and is also made a subject of appended claims.

I claim as my invention—

1. The combination with a multiphase generator, of a meter provided with a rotary armature, a pair of series coils, one connected in one circuit from the generator and the other connected in another circuit from the generator, and two sets of shunt-coils, the set adjacent to each series coil being connected in the other circuit from that in which its adjacent series coil is connected.

2. The combination with a two-phase generator, of a meter provided with a rotary armature, two series coils, adjacent to the armature, one connected in each circuit from the generator and two shunt-coils opposite each series coil on the other side of the armature-wall therefrom, the shunt-coils opposite each series coil being connected across the other circuit from that in which said series coil is connected.

3. The combination with a two-phase generator, of a meter provided with a rotary armature of annular form, a pair of series coils exterior to the armature, one connected in each generator-circuit and two sets of shunt-coils within the armature, the set adjacent to each series coil being connected across the other circuit from that in which said series coil is connected.

4. The combination with a multiphase generator, of an electric meter provided with an annular armature and a plurality of magnetic fields part of which are set up within and part without the armature, one field being set up upon an axis extending between two fields located on the opposite side of the annular wall of the armature from the first field, means for connecting the first field in one of the generator-circuits, and means for connecting the opposite two fields in the other generator-circuits.

5. The combination with a multiphase generator, of an electric meter provided with an annular armature, a magnetic field set up exterior to the armature upon an axis extending between two magnetic fields set up within the armature, means for connecting the first field in one of the generator-circuits, and means for connecting the opposite two fields in the other generator-circuits.

6. The combination with a multiphase generator, of an electric meter provided with an annular armature, a magnetic field set up exterior to the armature, and magnetic fields set up within the armature on intersecting axes extending at an angle of approximately forty-five degrees with the axis of the outer field, means for connecting the outer field in one generator-circuit, and means for connecting the opposite inner field in another generator-circuit.

7. The combination with a two-phase generator, of a meter provided with a cylindric armature, a pair of series coils, one connected in each of the generator-circuits, and two sets of shunt-coils mounted within the armature upon the poles of a cross-shaped magnetic core, the set adjacent to each series coil being connected across the other circuit from that in which that series coil is connected.

8. A magnetic drag for electric meters comprising an armature, magnets arranged with the poles adjacent to said armature, a magnetic core arranged with its poles opposing and on the opposite side of the armature-wall from the magnet-poles and means for adjusting the relative positions of the opposing magnet and core poles.

9. A magnetic drag for electric meters comprising an annular armature, magnets exterior to said armature with their poles approaching the armature, a magnetic core within the armature having poles arranged opposite the poles of the magnet and means for adjusting the relative positions of the magnets and core.

10. A magnetic drag for electric meters comprising an annular armature, magnets exterior to said armature with their poles approaching the armature, a cross-shaped magnetic core within the armature adapted to stand with its poles in alinement with the magnet-poles and means for giving the core an oscillatory adjustment about the axis of the armature to vary the position of its poles with reference to the pole.

In testimony that I claim the foregoing as my invention I affix my signature, in presence of two subscribing witnesses, this 2d day of August, A. D. 1897.

THOMAS DUNCAN.

Witnesses:
CHARLES C. MILLER,
ROBERT F. HARDING.