(Model.)

8 Sheets—Sheet 1.

J. A. TILDEN.

ROTARY FLUID METER.

No. 324,503. Patented Aug. 18, 1885.

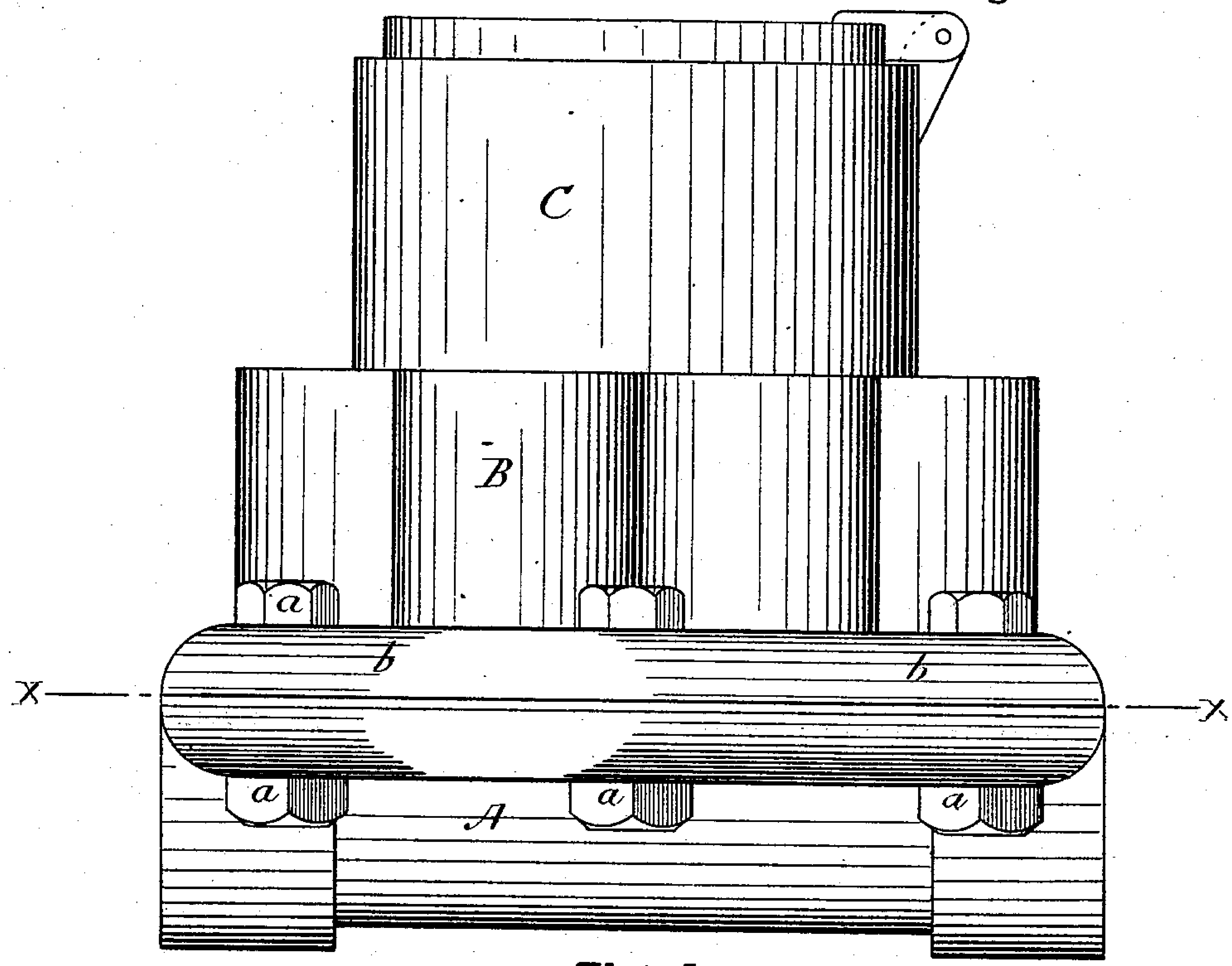
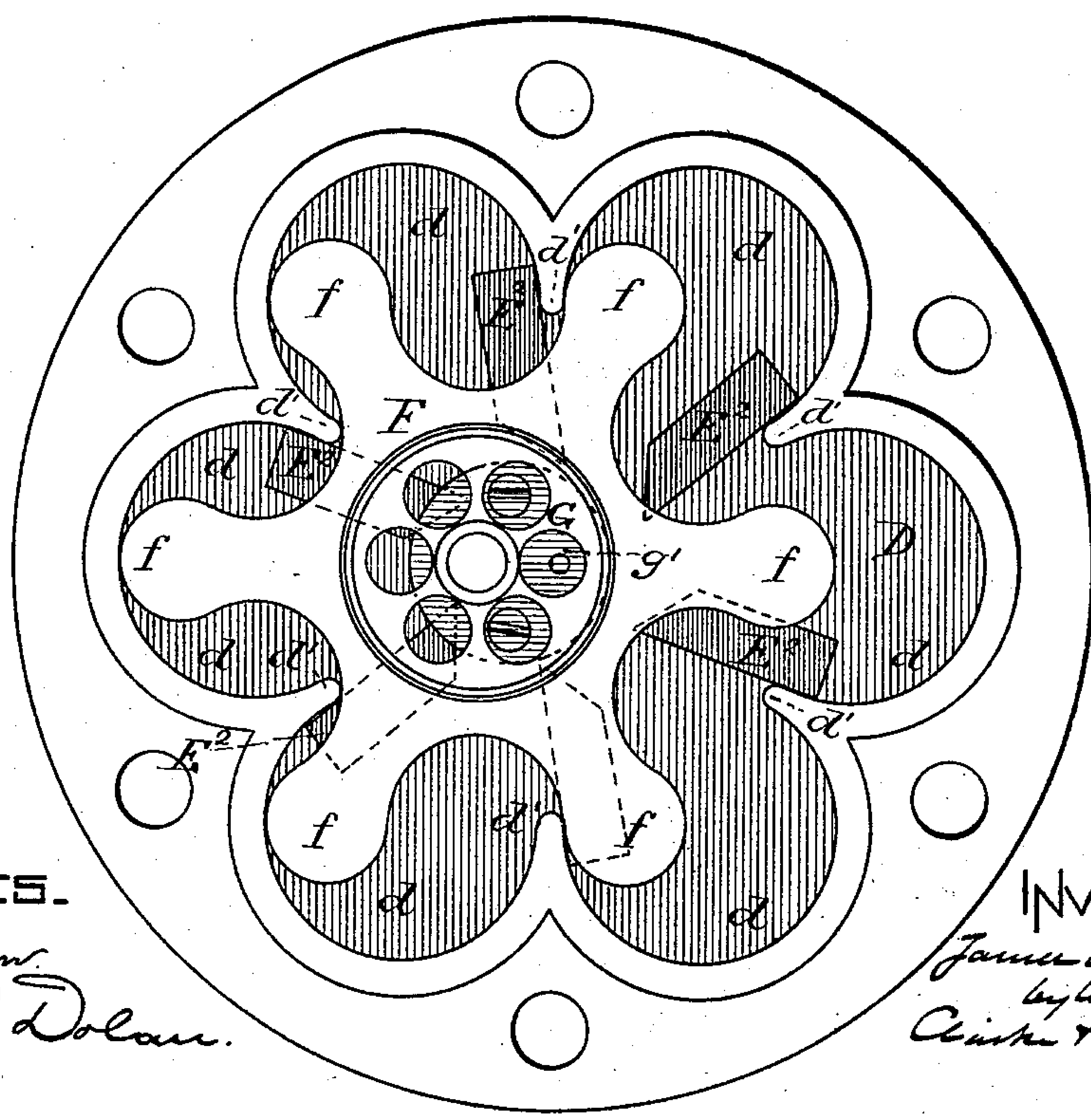


Fig. 1.

Fig. 2.



WITNESSES.
J. M. Dolan.
Fred. B. Dolan.

INVENTOR.
James A. Tilden
by his attys
Clarke & Raymond.

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(Model.) 8 Sheets—Sheet 2.

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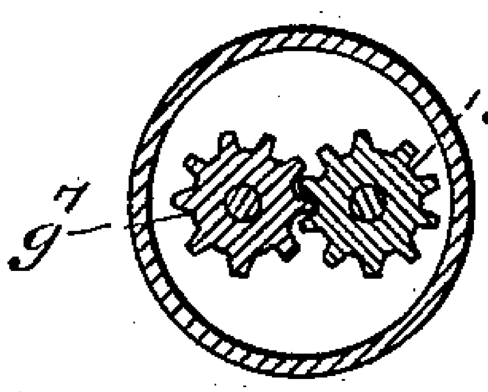

Fig. 20.

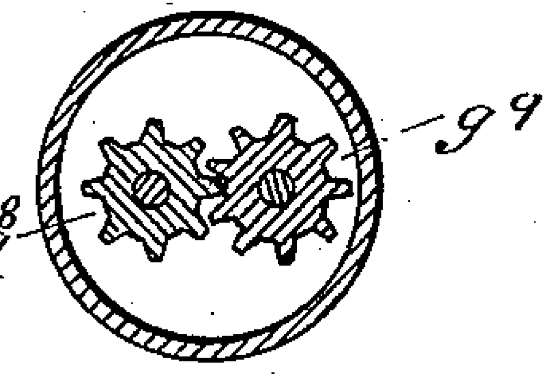

Fig. 21.

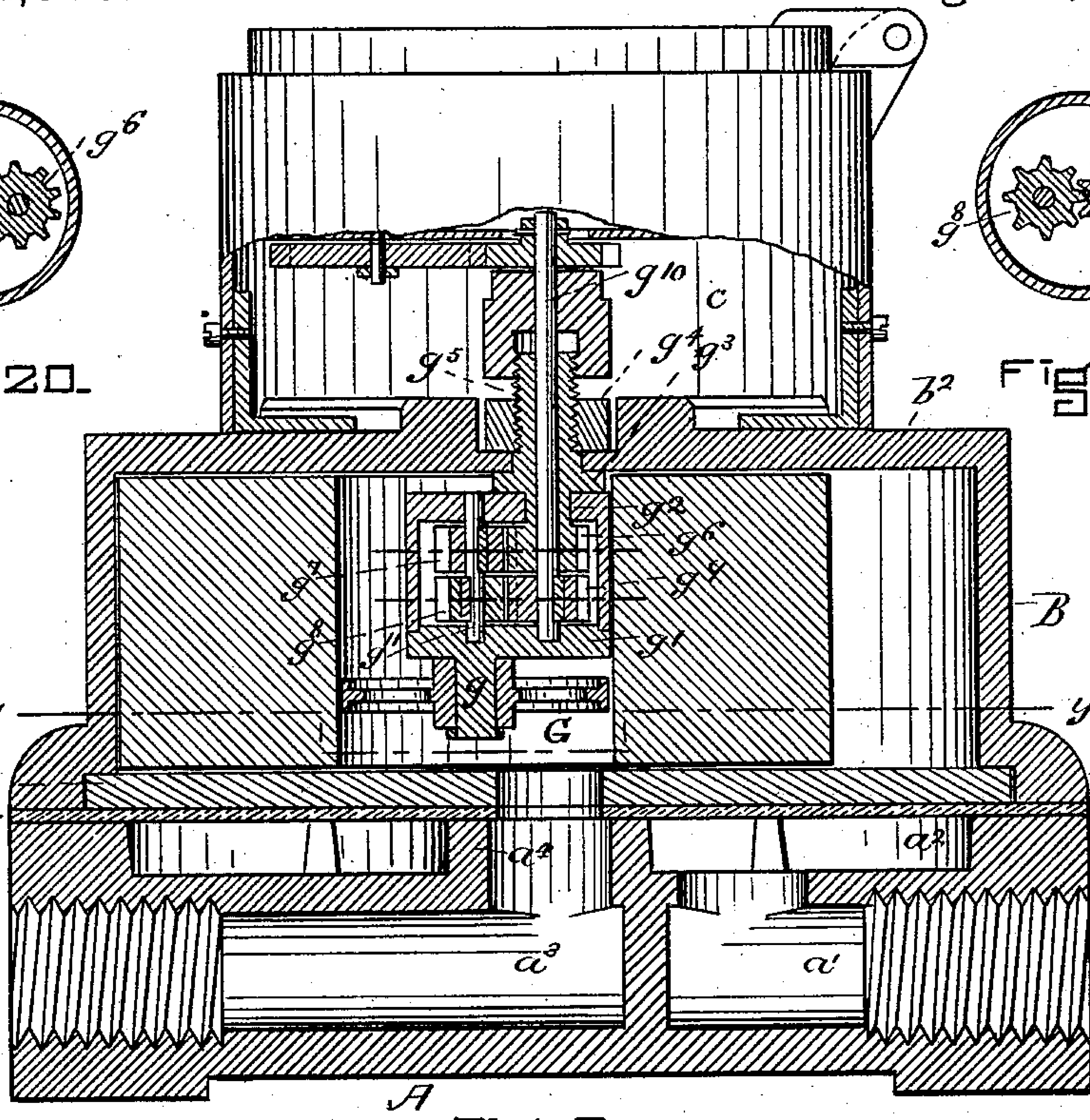

Fig. 3.

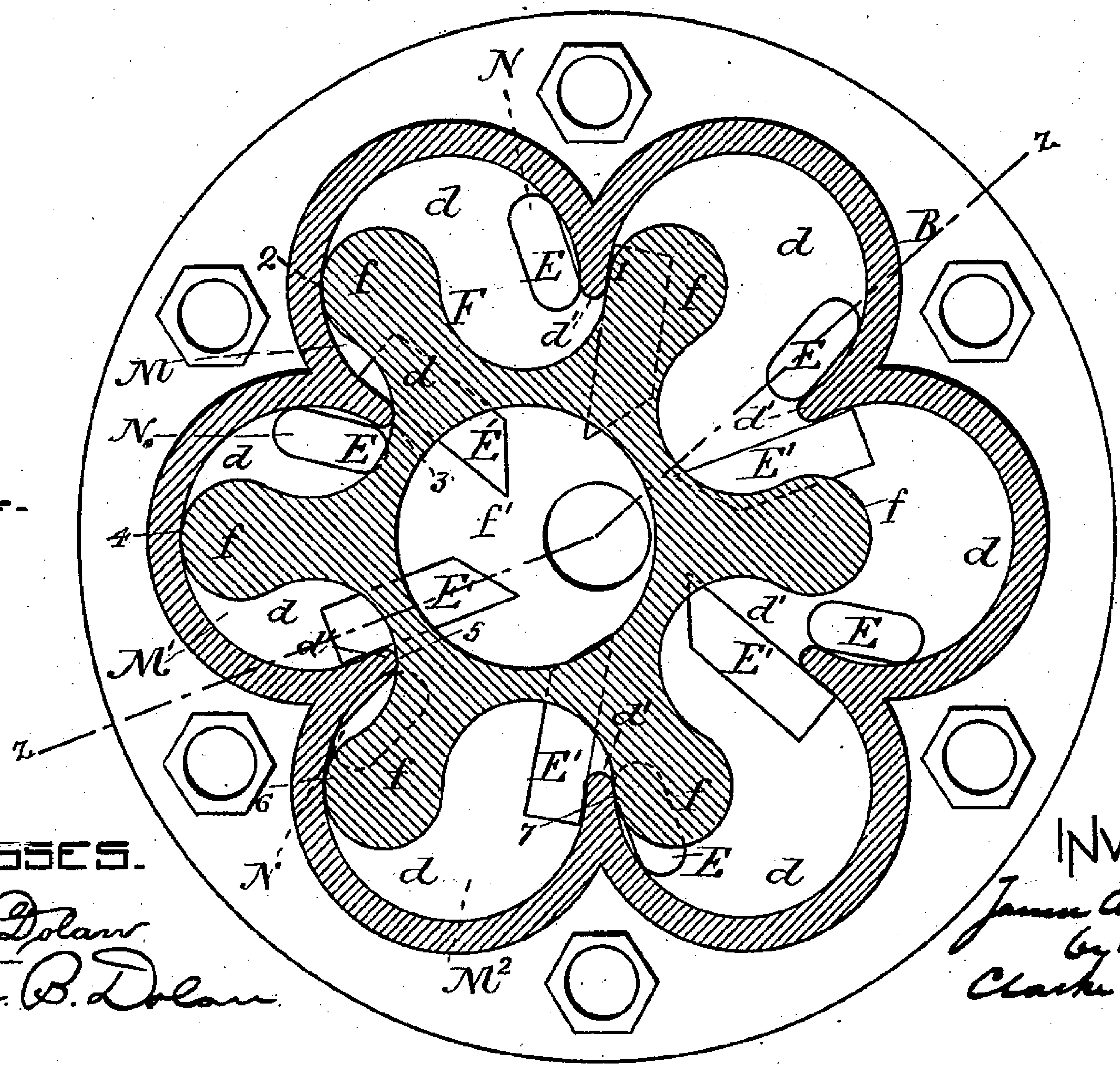

Fig. 4.

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J. M. Dolan

Fred. B. Dolan

INVENTOR.

James A. Tilden
by his attys
Clarke & Raymond.

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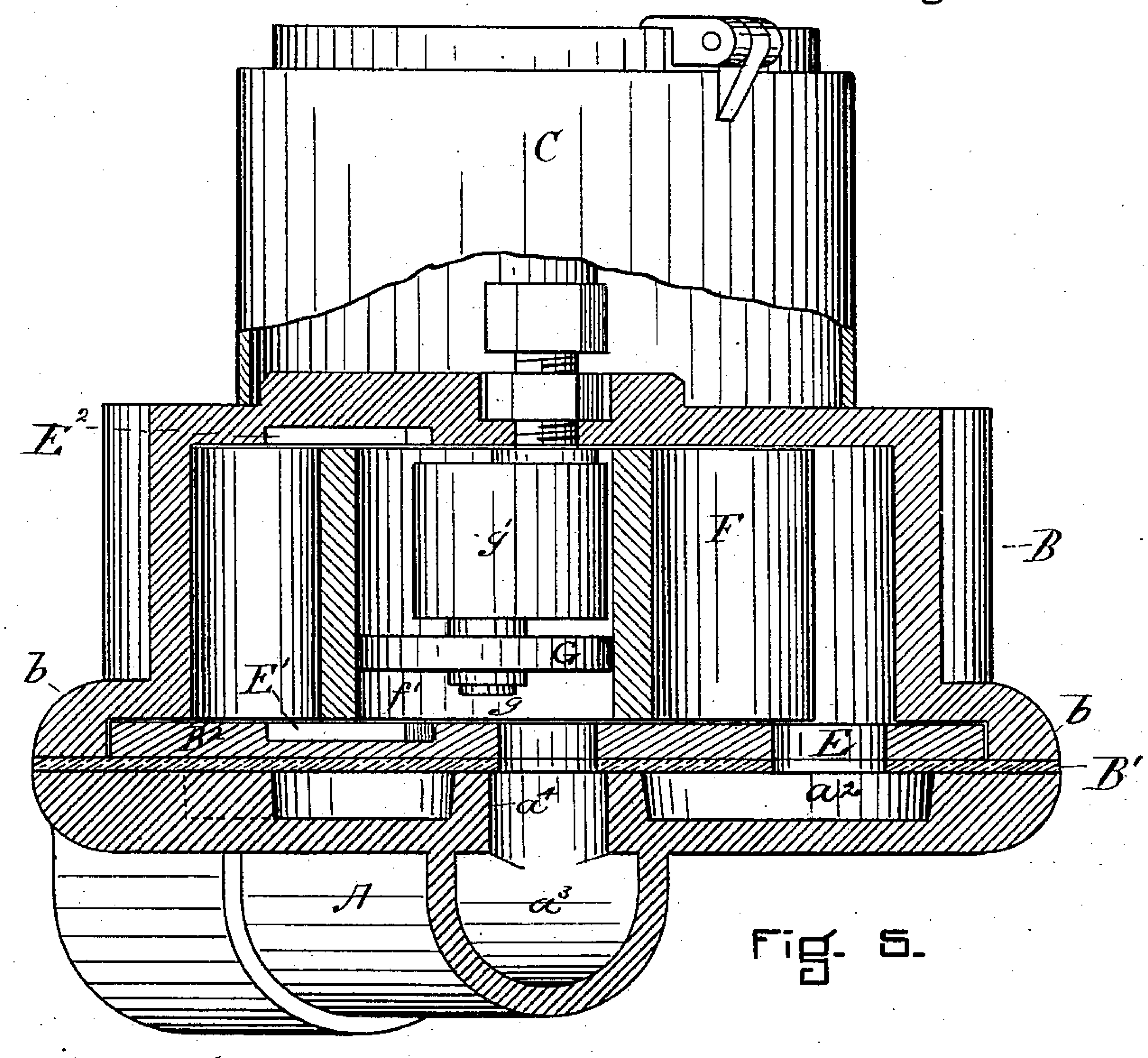

Fig. 5.

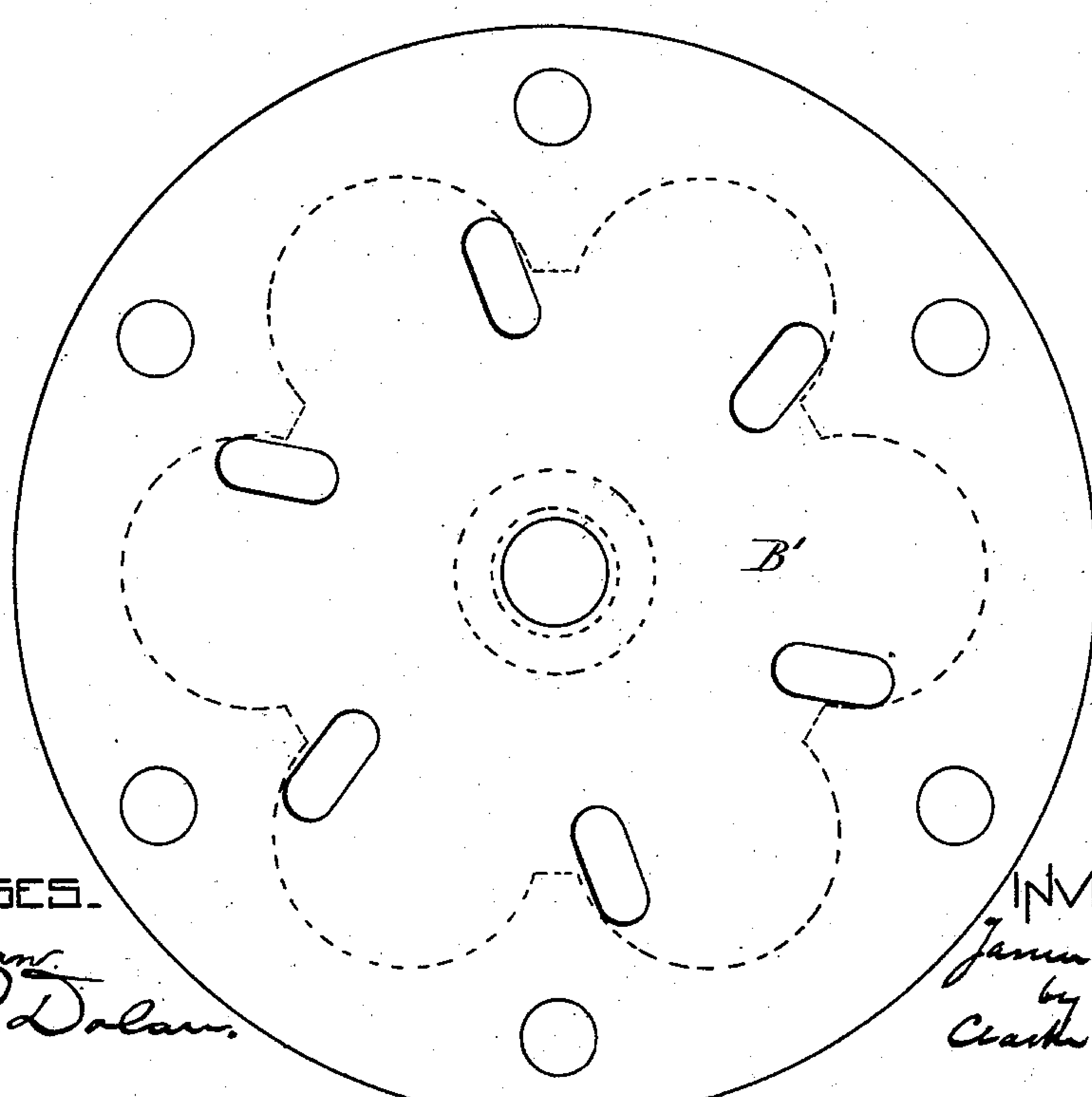

Fig. 6.

WITNESSES.

J. M. Dolan.

Fred B. Dolan.

INVENTOR.

James A. Tilden
by his attys
Clarke & Raymond.

N. PETERS. Photo-Lithographer. Washington, D. C.

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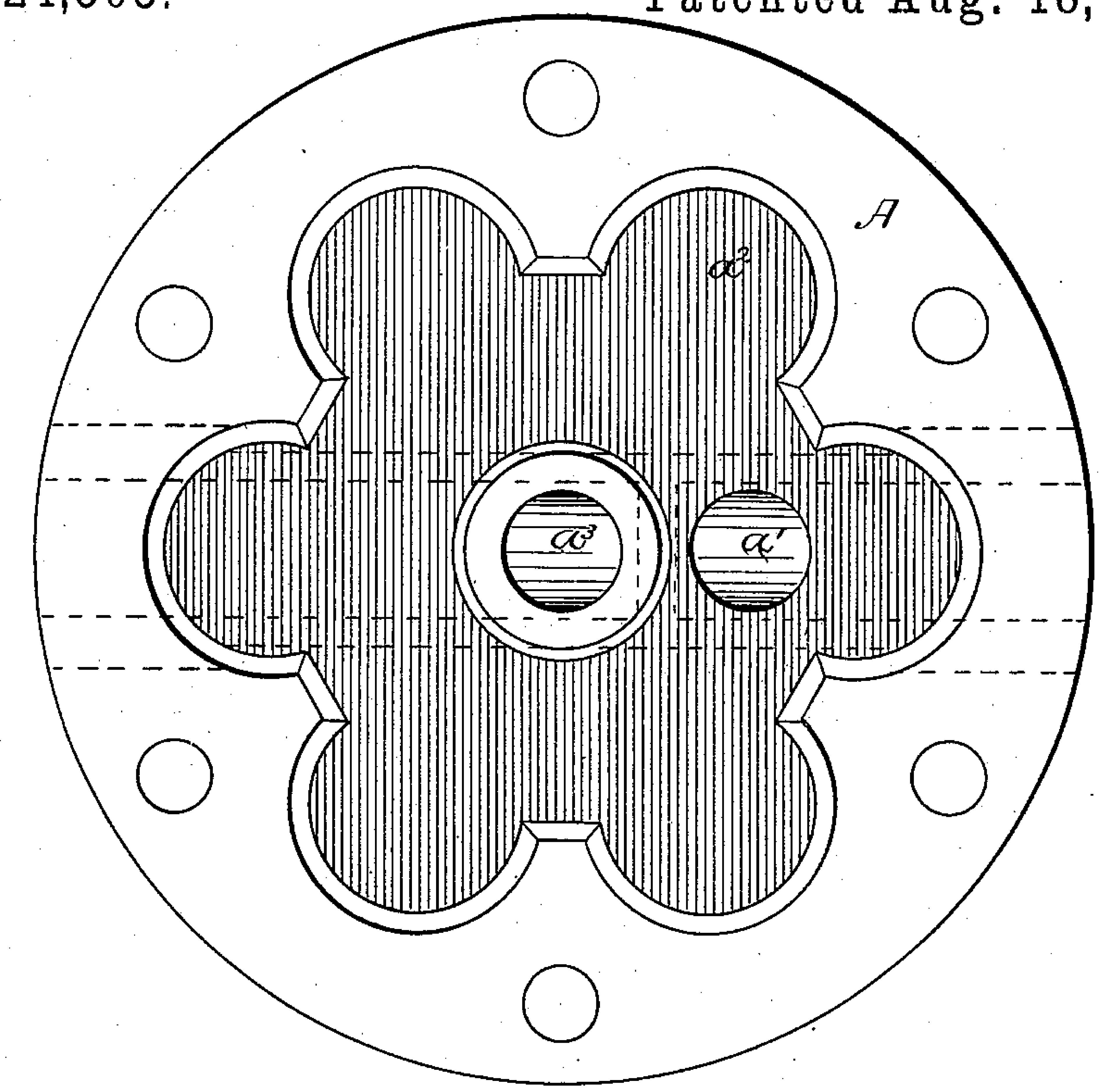

Fig-7-

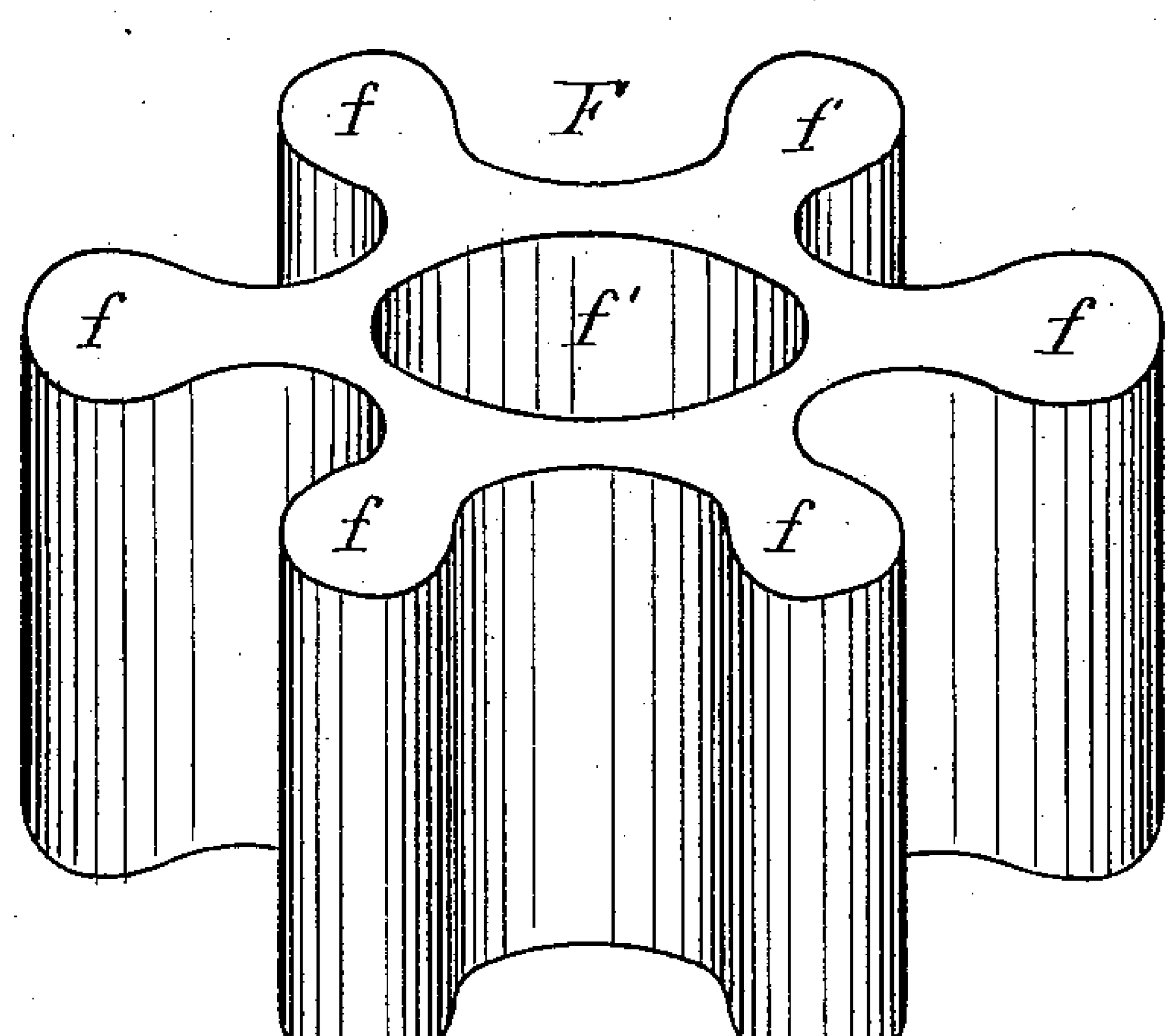

Fig-8-

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J. M. Dolan.

Fred. B. Dolan.

INVENTOR.

James A. Tilden
by his attys
Clarke & Raymond.

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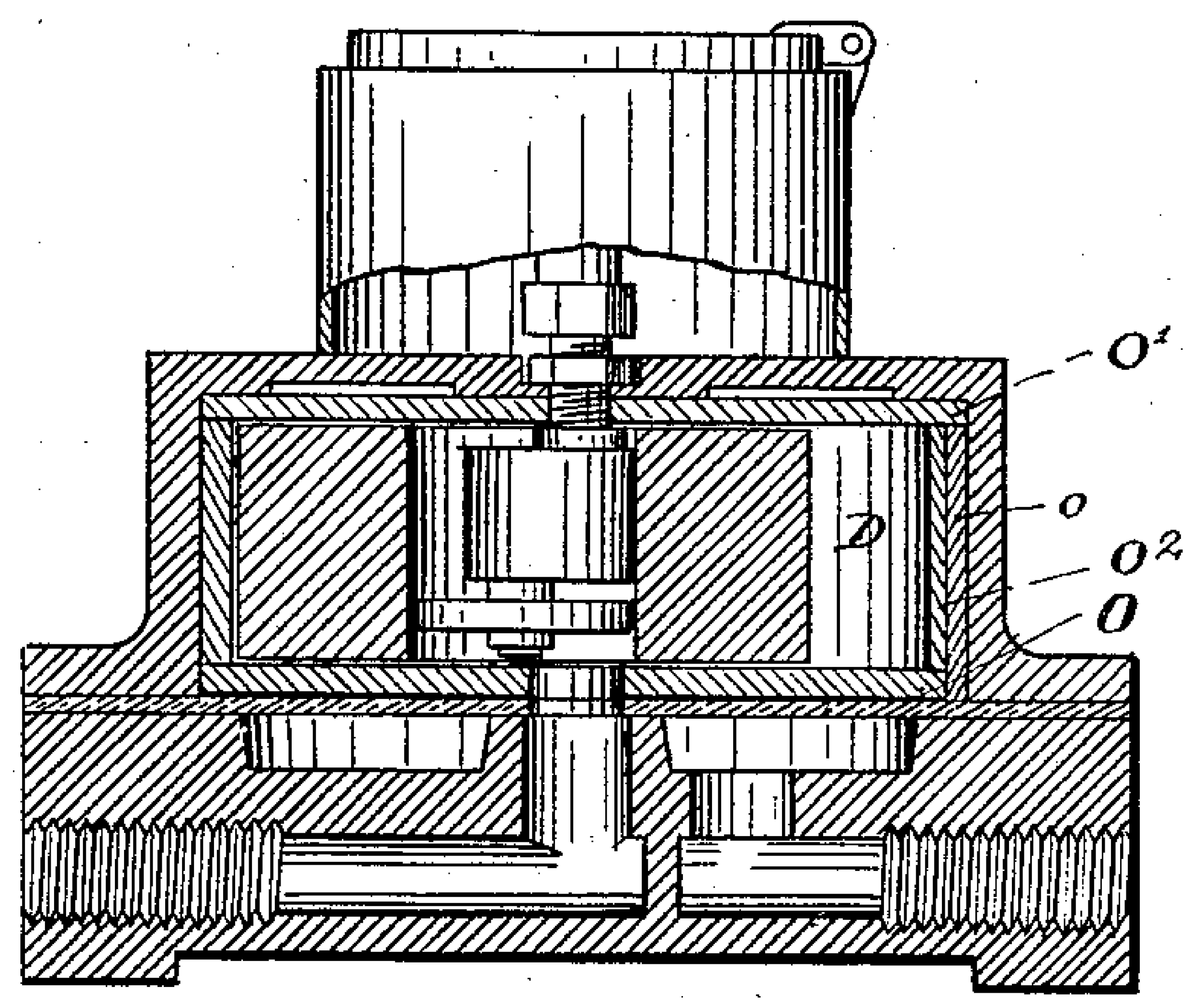

Fig. 9.

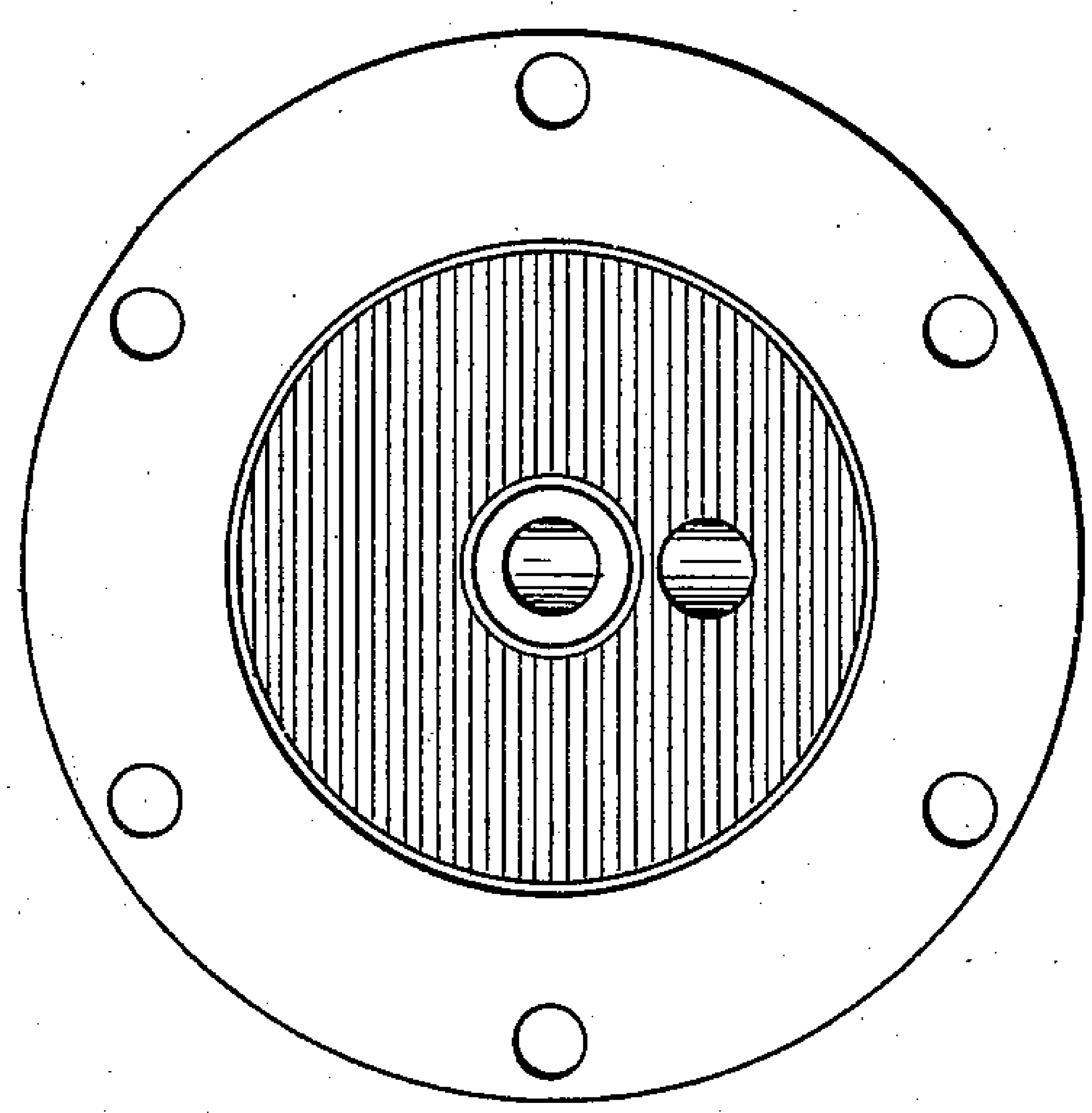

Fig. 10.

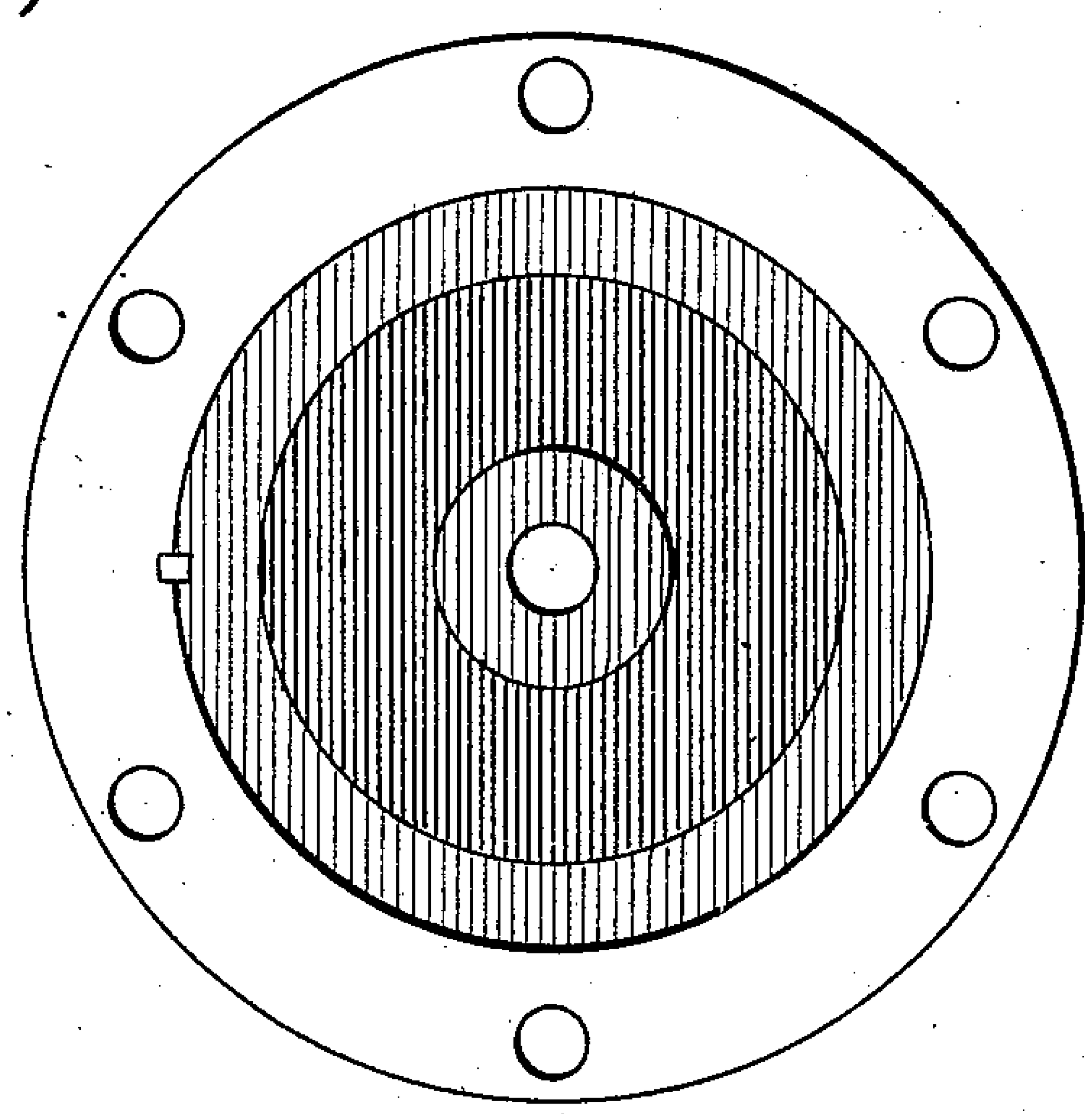

Fig. 11.

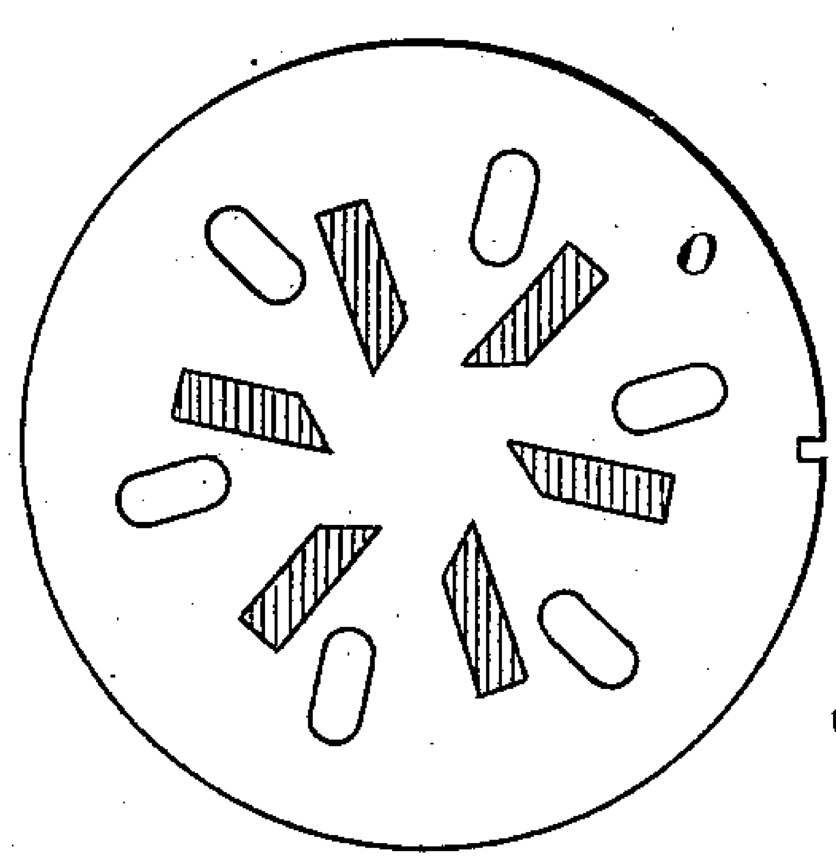

Fig. 12.

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J. M. Dolan

Fred. B. Dolan.

INVENTOR.

James A. Tilden

by his attys

Clarke & Raymond.

(Model.)

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J. A. TILDEN.

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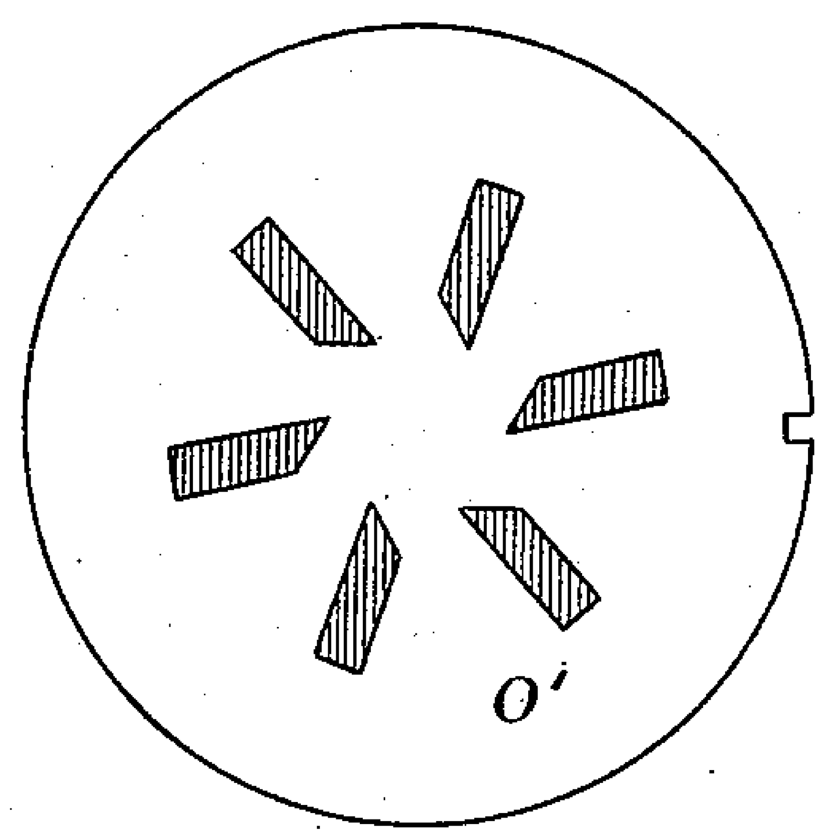

Fig. 13.

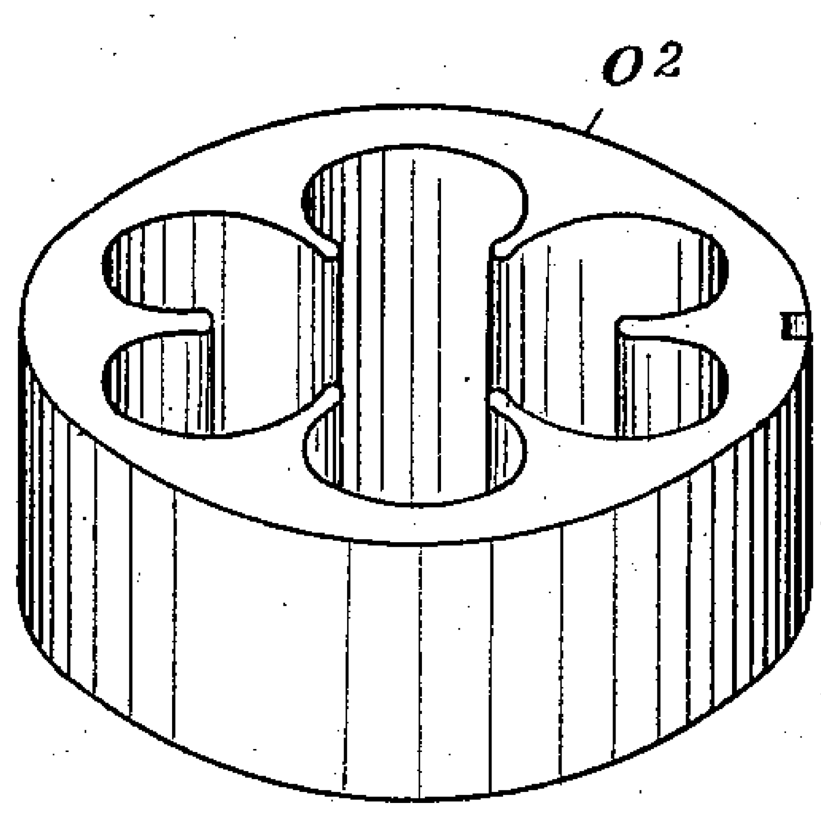

Fig. 14.

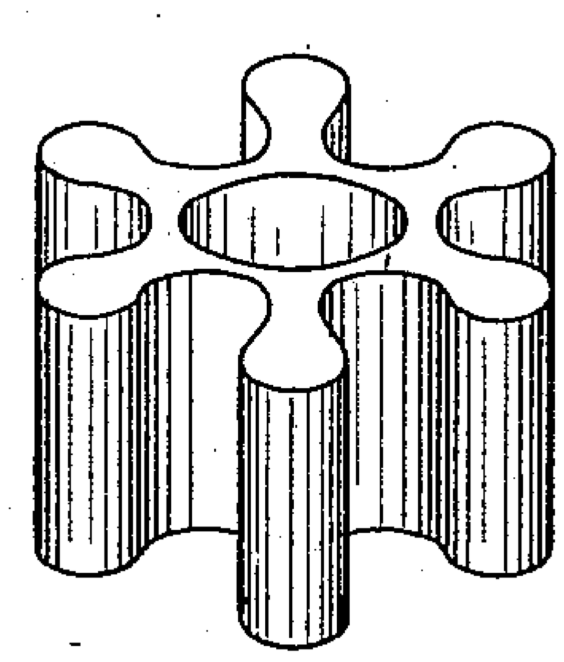

Fig. 15.

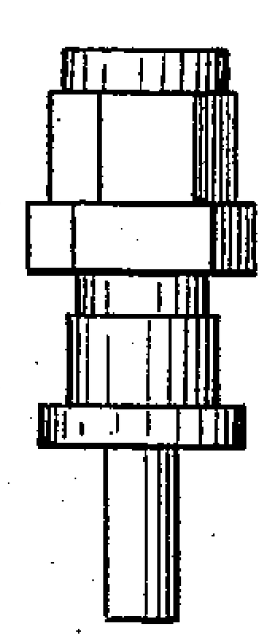

Fig. 22.

WITNESSES.

J. M. Dolan.

Fred. B. Dolan.

INVENTOR.

James A. Tilden

by his attys.

Clarke & Raymond.

(Model.)

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J. A. TILDEN.

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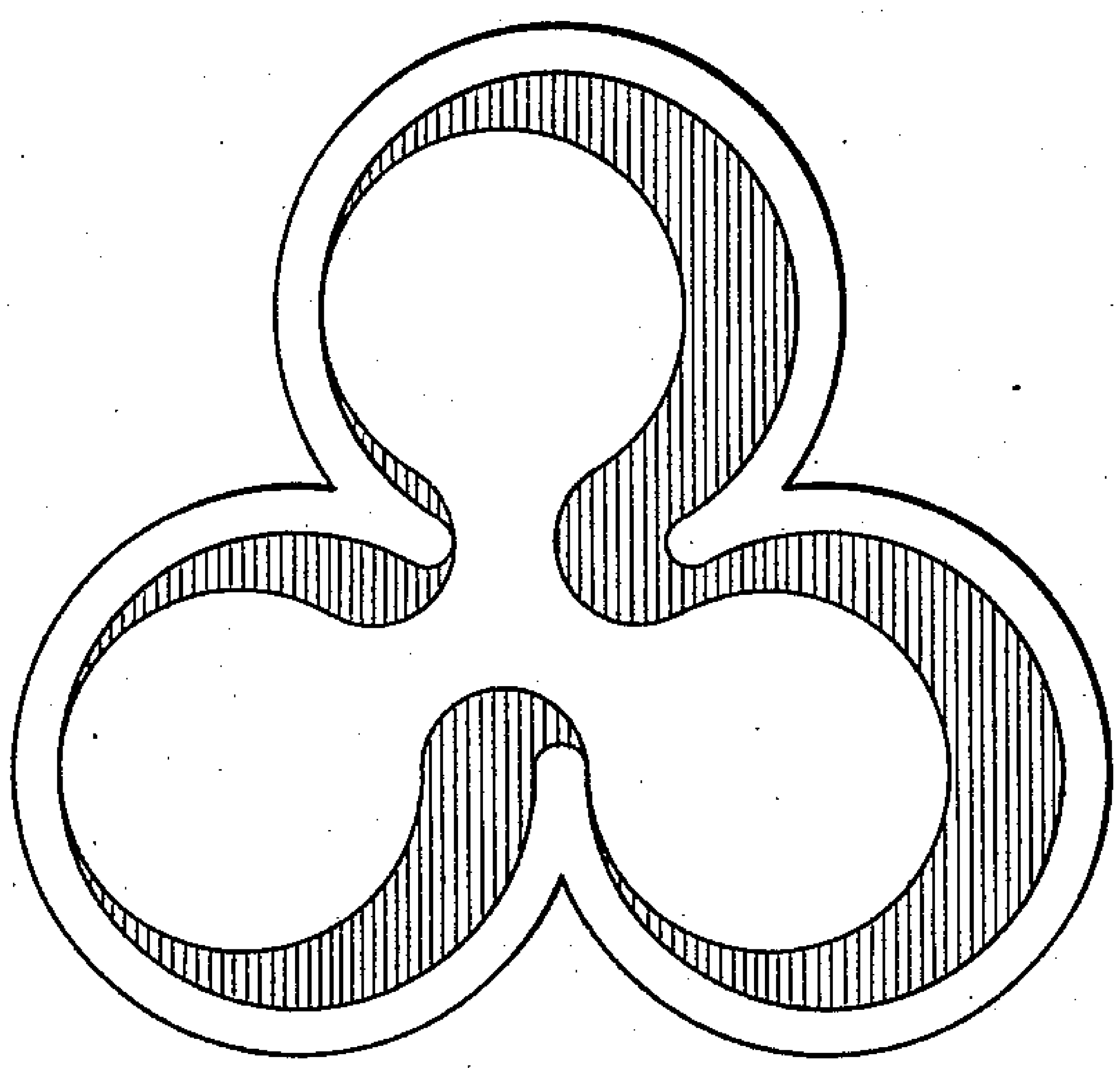

Fig. 16.

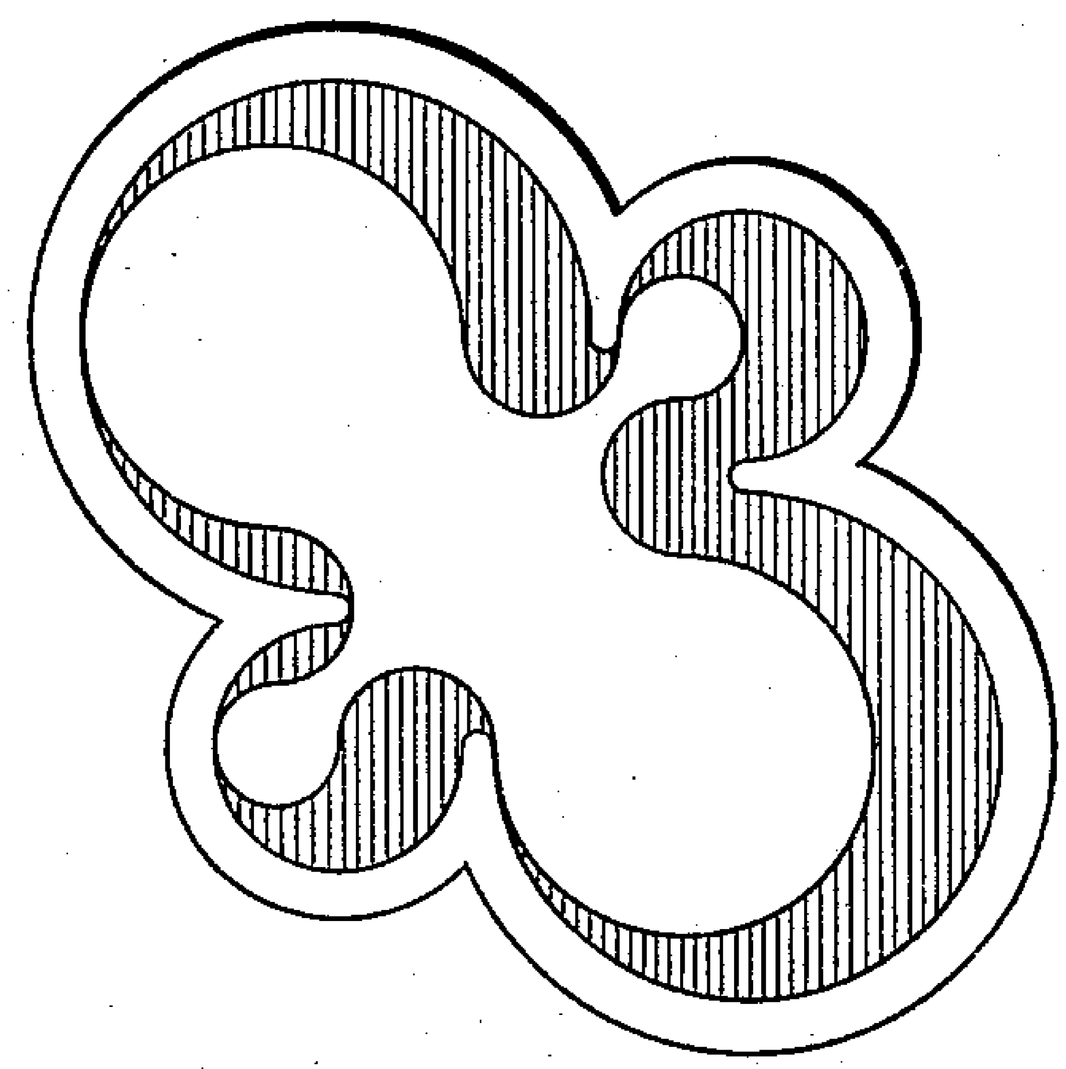

Fig. 17.

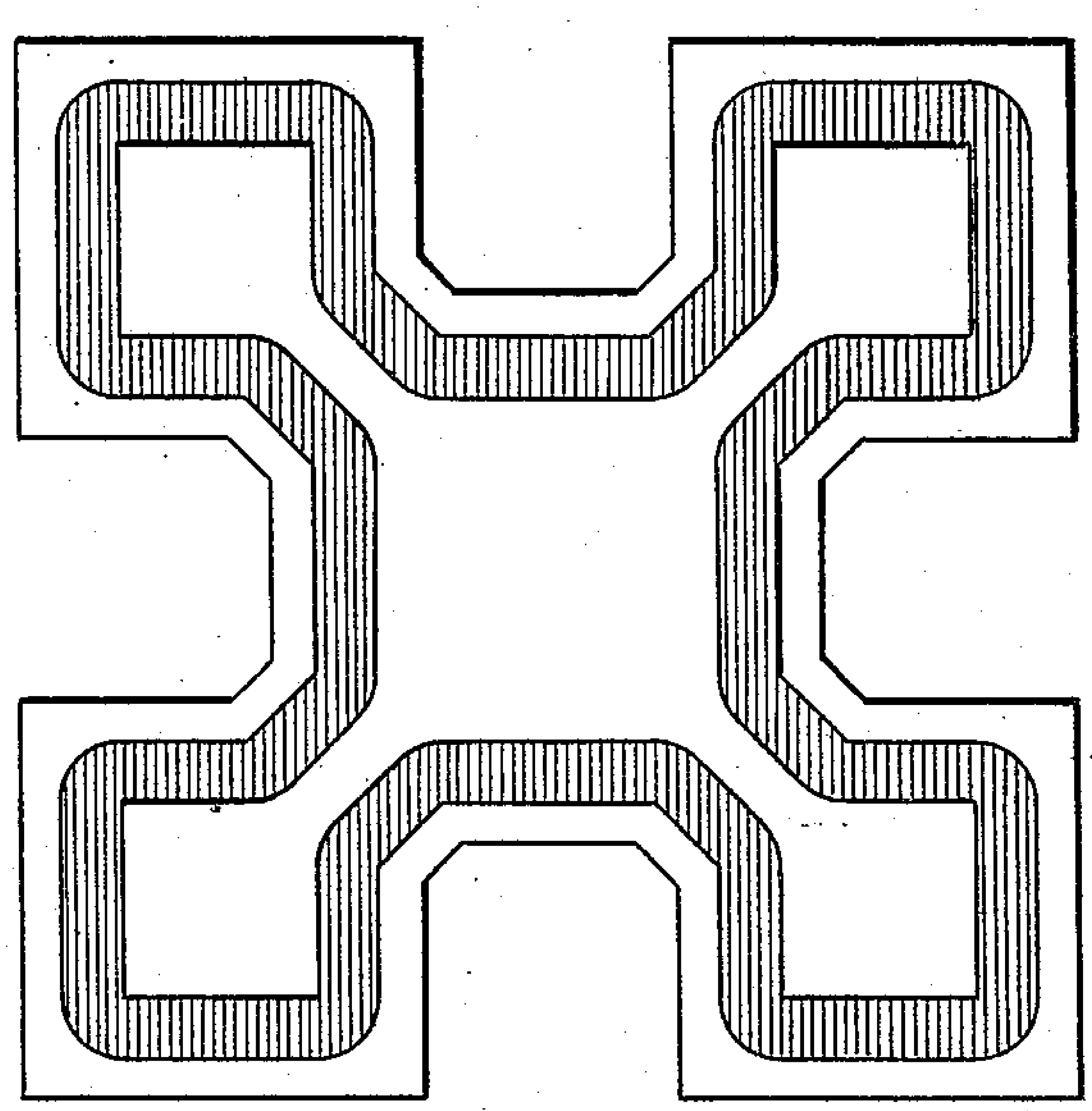

Fig. 18.

WITNESSES.

J. M. Dolan.

Fred. B. Dolan

INVENTOR.

James A. Tilden

by his attys

Clarke & Raymond.

(Model.)

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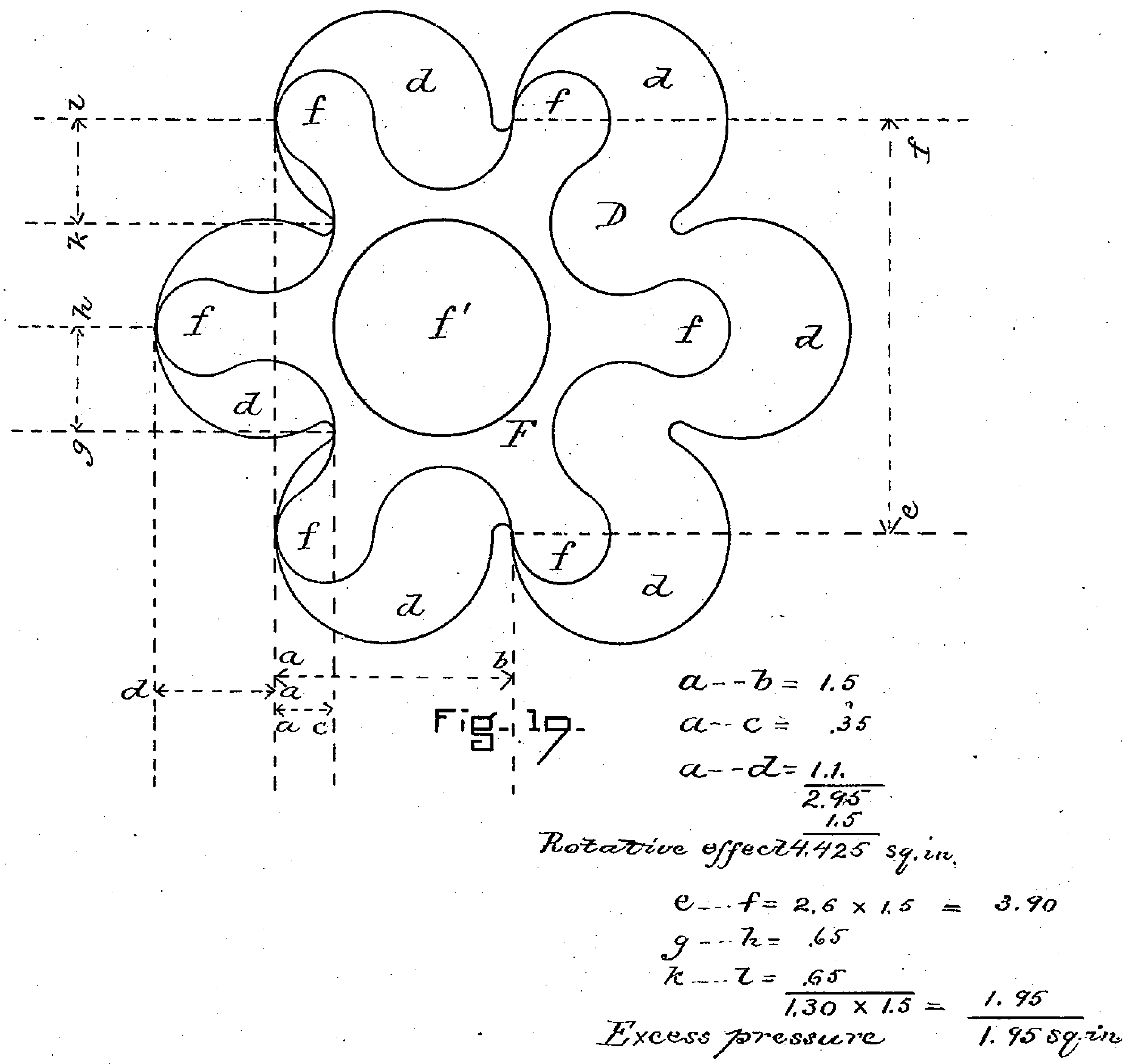

Fig. 17.

WITNESSES.

J. M. Dolan

Fred. B. Dolan

INVENTOR.

James A. Tilden
by his attys
Clarke & Raymond.

UNITED STATES PATENT OFFICE.

JAMES A. TILDEN, OF HYDE PARK, ASSIGNOR TO HERSEY BROTHERS, OF BOSTON, MASSACHUSETTS.

ROTARY FLUID-METER.

SPECIFICATION forming part of Letters Patent No. 324,503, dated August 18, 1885.

Application filed December 22, 1884. (Model.)

To all whom it may concern:

Be it known that I, JAMES A. TILDEN, of Hyde Park, in the county of Norfolk and State of Massachusetts, a citizen of the United States, have invented a new and useful Improvement in Fluid-Meters, of which the following is a full, clear, and exact description, reference being had to the accompanying drawings, forming a part of this specification in explaining its nature.

It is well known that a fluid-meter to be commercially successful must be capable of perfectly measuring or indicating the quantity of fluid which passes through it, regardless of the size of the stream, its speed, head, or any other condition, that it must not easily get out of repair, that its construction must be simple, and its manufacture inexpensive, and various meters have been made with some if not all of these conditions, but, so far as I am aware, there is not at present in the market any meter which combines all of these features with certain necessary wearing qualities to such an extent that it may be said to be a really commercially successful or practical meter; and while my invention may not be perfect in every respect, yet it has all the requisites of an efficient, desirable, and cheap meter.

The principle upon which the meter is constructed is so simple that but very few parts or pieces are necessary and very little machine-work required in fitting them, and these can be placed in such very small compass that the weight of metal necessary for the casing is very small.

The invention comprises, broadly speaking, a chamber having inlet and exhaust ports, and a piston for opening and closing the exhaust-ports. The meter can hardly be called a "rotary" meter, because the piston does not rotate, and yet it is quite unlike in appearance any of the ordinary reciprocating-piston meters; but it combines, it may be said, portions of both systems in substantially this manner. The measuring-chamber of the meter is divided or separated upon its outer edge into measuring spaces or recesses, all of which open into the central portion of the chamber, but which may or may not be of uniform size and shape. Each of these spaces has its individual inlet and exhaust ports. The part which I call the "piston" has a radially-extending portion or lobe, which enters each measuring space or recess and does not at any time leave it, and has a movement therein that causes it to be brought into contact with one side of each recess near the mouth and to advance along the side continuously until it reaches the other side of the recess, when it returns across the mouth of the recess or space to its original position. This movement of each lobe in each space or recess alternately exposes and closes the exhaust-ports, thereby preventing the flow of liquid from the chamber only after it has entered what may be termed the "measuring" and "discharging" spaces or recesses. The sides of the chamber and the sides of the piston should be parallel when the piston is centrally located in the chamber.

To understand the working of the device, it must be borne in mind that the liquid has free access to the chamber—that is, its inlet-ports are never entirely closed—that because of the shape of the wall of the chamber and of the piston, the piston is kept in contact with the wall of the chamber at a number of what I call "contact" points or lines, which form in the measuring and discharging passages spaces or recesses. The number of lines of contact depend, of course, upon the number of spaces or recesses. This separation or division of the chamber is necessary, because a full head is maintained in the larger part of the chamber, and it is of course necessary to divide the spaces or recesses or portions thereof which are successively emptied from those which are being successively filled by liquid under pressure. This division is accomplished by contact of the piston with the wall of the chamber. The lobes in connection with the portions of the wall which constitute or form the spaces or recesses also act to separate the exhaust-ports from the inlet-ports, so that each space or recess that is discharging is separated from the portion of the space that is filling by two contact-lines, one between the outer surface of the lobe and the wall of the recess and the other between the surface of the inward projection of the wall and the surface of the piston between the lobes. These lines of contact continually advance until the water has been expelled from each space or recess. While, however, this discharge from each space or recess is going on by the movement of the lobe, the space or recess is filling behind the lobe. Of course the number of spaces or recesses which are discharging simultaneously depend upon the entire number of spaces or recesses which the chamber contains, and there may be several recesses or spaces discharging and receiving at the same time. This advancing movement of the lobe in each space or recess does not continue beyond its individual space, but upon reaching the end of that space or recess it returns across the mouth or entrance of its recess or space to its original position, while the piston as a whole, without revolving, moves on a circular path.

In the drawings, Figure 1 represents a side elevation of the machine. Fig. 2 is a plan view of a portion of the meter above the line $x\ x$ of Fig. 1, inverted, showing the piston and upper series of exhaust-ports. Fig. 3 is a view, principally in vertical central section, showing, especially, the mechanism for connecting the piston with the registering-train. Fig. 4 is a section upon the line $y\ y$ of Fig. 3, also showing the lower series of exhaust-ports and the inlet-ports. Fig. 5 is a view, principally in vertical section, upon the lines $z\ z$ of Fig. 4, showing, especially, the relation of the exhaust-ports, meter-walls, and spaces or recesses when discharging. Fig. 6 is a plan view of the packing-piece between the base and main sections of the meter. Fig. 7 is a plan view of the base-section, showing the receiving-chamber and the inlet and outlet passages. Fig. 8 is a perspective view of the piston. Figs. 9 to 15, inclusive, illustrate special details of a modified form of construction. Figs. 16, 17, and 18 are diagrams showing that changes in the form and size of the chambers, spaces, and pistons do not vary the principle of the construction. Fig. 19 is a diagram showing by calculation the differences in pressure which cause the action of the meter. Figs. 20 and 21 are sections of the reducing-gears hereinafter described, and Fig. 22 is a view of the sleeve forming the support of the drum carrying the gears.

Preferably, the casing of the meter comprises three principal parts or sections—first, the base-section A; second, the body or main section B, and, third, the shell C, forming the chamber c, containing the registering mechanism.

The base-section is made somewhat larger in circumference than the main section, and the two parts are fastened together by bolts a, which pass through the flange b of the main section. The base-section has the inlet-passage a', which opens into the distributing-chamber a^2 and the outlet-passage a^3. The distributing-chamber a^2 occupies almost the entire upper portion of the base, and its object is to provide means for the ready distribution of fluid simultaneously through the various inlet-ports to the main chamber D.

Between the sections A B is a packing-ring, B′, which is shaped as shown in Fig. 6, and is provided with holes for the bolt-holes, the inlet-ports, and outlet-passage. Above this packing-ring is a metal plate, B^2, which may be called a "port-plate." It rests upon the packing-ring B′, and is held or fastened in place upon it and the upper surface of section A, surrounding the chamber a^2 and the central projection, a^4, by the bolts a, the plate being within the main section B and its edge projecting into a recess formed in the under edge thereof. This port-plate has the holes E, which form the inlet-ports to the chamber D and connect the distributing-chamber a^2 therewith. These ports E are arranged, preferably, to open into each space or recess d of the chamber D at one side thereof. The port-plate also has a central hole, which forms a portion of the outlet a^3 and the escape or exhaust ports E′, which are recesses formed in the upper surface of the plate, and arranged to extend from one side of each recess or space d inward upon converging lines. The chamber D has the measuring recesses or spaces d arranged about its outer edge, which open into the central portion, and the projections or portions of the wall of the chamber which form spaces or recesses I have lettered d'. The piston F preferably is made of hard vulcanized india-rubber, gutta-percha, or other equivalent material, and has the wings or lobes f, which extend radially therefrom, and the central hole, f'.

For the best working of the device it is desirable, but not essential, that the surface of the piston, when the same is centrally located in the chamber D, shall be parallel with the surface of the chamber, so that as the surface of the chamber is made up of alternating recesses and projections, so the surface of the pistons is made up of alternating lobes and recesses. The central hole, f', of the piston forms a part of the exhaust or outlet passage, and is large enough to always permit the escape of fluid therefrom into the outlet a^3, regardless of the position of the piston.

In addition to the lower set of exhaust-ports, E′, I have formed in the under surface of the upper plate, b^2, which forms the top of the main section B, another set of exhaust-ports, E^2. (Shown in Fig. 2.) They are of the same shape and connect the same parts of the spaces or recesses with the opening f' as the lower exhaust-ports, E′. There is also arranged in the hole f' a perforated disk, G, (see Figs. 2 and 3,) by which motion is communicated to the shaft which operates the train of gears comprising the registering mechanism. This disk carries at its center a stud, g, which projects downward from the drum g', which is pivoted at g^2 to the screw-sleeve g^3, which passes through the hole in the plate b^2, and is locked thereto by the nut g^4, which screws upon the thread g^5, and the movement of the piston causes the drum to be revolved upon the sleeve—that is, the drum and stud form substantially a crank. It is necessary, however, as the chamber is of small capacity and as the motion of the piston is rapid, to reduce the motion of the piston very considerably, and it is desirable to do so in as simple a manner and with as few parts as possible, in order that the construction may be cheap and as little weight of metal used as possible; and I employ for this purpose a train of four gears, one of which, g^6, is stationary, being secured to the end of the sleeve g^3. The gears g^7 g^8 are attached to the drum by the shaft or pinion g^9, to which they are keyed, and the gear g^7 meshes with the gear g^6. The gear g^8 is arranged to mesh with the fourth gear, g^9, which is keyed or fastened to the spindle g^{10}, which communicates motion to the registering-train. As the drum revolves about the sleeve g^2, it is obvious that if the gear g^7 has more or less teeth than the gear g^6 it will be caused to move each revolution of the drum a certain portion of a revolution depending upon the difference in the number of teeth between the two gears. It is also obvious that if the gears g^8 g^9 have the same number of teeth as the gear g^7, a movement of rotation will be communicated to the shafts or spindle g^{10}. If it is desired to still further reduce or change the rate of the rotation of the shaft g^{10}, then the gear g^8 may have more or less teeth than the gear g^7, as the case may be, as also may the gear g^9; and in the drawings I have represented the gear g^6 as provided with ten teeth, the gear g^7 with nine teeth, the gear g^8 with eight teeth, the gear g^9 with nine teeth, so that upon every complete revolution of the drum the shaft g^{10} is moved one eighty-first of a revolution, and it therefore requires eighty revolutions of the drum to make one complete revolution of the shaft, the spindle or shaft g^{10} being used, of course, to operate any registering mechanism.

It will be seen by this construction of gearing that the drum g', carrying the gears g^7 g^8, revolves from left to right, and that the gear-wheels g^7 g^8, being carried by the drum, are caused by the meshing of the gear g^7 with the stationary gear g^6 to turn from right to left, and that the meshing of the gear g^8, as it is turned upon its revolution about the gear g^9, causes the gear g^9 to be moved, as above specified, one eighty-first of a revolution for each revolution of the drum and the gears g^7 g^8 about it.

In operation the liquid passes into the distribution-chamber a^2 and through the inlet-ports E into the chamber D, moving the piston toward one side of the chamber and causing the formation of measuring or discharge spaces by the contact of the various portions of the piston with the chamber-wall. This position of the piston is well shown in Fig. 4, where there have been formed six divisions of the three spaces or recesses d by the contacting of the piston at the points 1, 2, 3, 4, 5, 6, and 7, and of these three recesses or spaces, two—namely, the small spaces marked M and the space M′—are connected by the discharge-ports E′ E² with the escape-passage, while the space M² is about to be; but the fluid, upon being admitted to the chamber under pressure, not only immediately moves the piston to the position shown in Fig. 4, which is one of any number of positions which it might cause it to assume, and from such position it causes it to advance or move, so that the lobes which are in contact with the wall of the chamber, are caused to continue that contact until they have expelled all the fluid which is in the discharge spaces or recesses before them, when each lobe in succession will leave the surface and return upon an arc of a circle to a position where it again comes in contact with the surface of the wall of the chamber on the opposite side from that which it left, and again advances and expels the fluid from its recess or space.

It will be seen that each recess or space becomes in succession a discharge space or recess, and that as soon as the piston has moved sufficiently to uncover the inner end of its escape-ports it begins to discharge through such ports into the escape-passages b^3 a^3, and that while a portion of each space or recess is discharging another portion is also receiving the liquid under pressure through the ports E.

To illustrate why with the arrangement of the inlet and exhaust-ports described the piston is compelled to make the motion that it does, I have shown in Fig. 19 by diagrams the differences in pressure upon both sides of the piston and the extent of the surface which is subjected to the direct pressure of the entering fluid.

It is obvious that the chamber D, excepting the spaces which are discharging, is filled with fluid under pressure, and that the pressure for moving the pistons is that which enters each space or recess which is being discharged, and behind the respective discharging lobe. For instance, referring to Fig. 4, the piston is receiving motion from the fluid which enters the spaces through the ports marked N N N, but from no other. It is not necessary that the main chamber and piston be shaped as represented in Fig. 4, for I have ascertained that the piston may have any number of lobes and recesses, from three upward, and that they may be of any size and of different sizes for the same piston, the only difference to be observed being that the piston and chamber-wall must be so shaped as to provide the contact-lines in the surface of the piston or chamber-wall, whereby the formation of measuring-chambers is effected.

In Fig. 16 I have illustrated a piston having three lobes in a chamber having three measuring and discharge spaces or recesses. In Fig. 17 I have shown a piston with two large lobes and two small ones, and a chamber with corresponding recesses or spaces. In Fig. 18 I have represented the piston as having square lobes, and the chamber with spaces which substantially follow the shape of the lobes, the only variation being that they are rounded at the corners.

It will be obvious from what I have stated that the meter is very simple in construction, that it has but very few parts, which require but little machine-work and are easily fitted and put together, and it is also apparent that a substantially-perfect registration of the liquid which passes through the meter is obtained, as it all is obliged to pass into the measuring-spaces, which are successively emptied. It will be seen, further, that this measuring of the liquid takes place very rapidly, and with comparatively very little friction of the wearing parts, and that the construction of the piston and chamber is such that sediment cannot interfere with the proper working of the invention, and that wear, up to a certain extent, improves the efficiency of the meter in that it causes the contacting surfaces of the piston and chamber to fit themselves as they wear.

To still further cheapen the manufacture I show in Figs. 9 to 15, inclusive, a construction which enables me to use, instead of the comparatively expensive casing of composition, an iron casing. This I accomplish by making the base-section entirely of iron, employing two composition port-plates, O O′, the plate O being like that described, and the plate O′ having simply the exhaust-passages E^2. The piston is made of hard rubber, gutta-percha, or other like non-corrosive material, and the wall O^2 (see Fig. 14) of the chamber D is formed of a ring or sleeve of gutta-percha, hard india-rubber, or even of composition, which is fitted into the iron shell or casing of the main section. This non-corrosive movable wall of the chamber is fastened to the casing by means of a key, *o*, which enters a groove in the ring and a corresponding one in the inner surface of the iron shell, or in any other suitable way. A view in perspective of the movable wall is shown in Fig. 14.

It will be seen that by this construction not only can an iron shell be employed, but that the principal wearing parts—namely, the port-plates, the piston, and the wall of the chamber—may be easily removed and others substituted therefor. The port-plates are also held in place by suitable keys or in any other desirable way, and it will be observed that they extend upon the two end surfaces of the removable wall. (See Fig. 9.)

Of course the invention can be utilized as a pump or motor, if desired.

It will be observed that by making the mechanism for reducing the movement of the piston in compact form, I am enabled to place it in the measuring-chamber and within the hole formed in the piston, thereby economizing space.

As the gears are inclosed in a drum or casing, no sediment can reach them to disturb their easy action.

While the invention as shown in the drawings represents a piston which, while not rotating moves in a circular path, yet by changing the forms of the piston-lobes and the shape of the walls of the chamber the piston may be made to take a square, rectangular, elliptical, or any other shape, the conditions governing these various movements depending entirely upon the shape of the surface of the piston, the surface of the wall of the chamber, and the relation which they bear to each other; but while these different movements may be given to the piston the principle of its action is not changed, as the lobe or portion of the piston which penetrates the measuring-space will have a continuous movement in said space, whether its path be circular, square, rectangular, elliptical, or of any other shape.

It will be seen that the contacting points or lines of the piston or valve are, in the operation of dividing the chamber into measuring-spaces or recesses and discharging the same, always upon the one side of the piston, and that these contacting points are brought successively into operation, not by the rotation of the piston or valve, but by their successive reverse movements, so that the piston or valve, while appearing more like a rotating piston or valve, is in principle more like a reciprocating piston or valve, in that each of its lobes or projections is caused to enter a measuring space or recess, advance therein, empty it, and return to its original position to again advance in the said space or recess and empty. In making this movement the contact between each lobe and the wall is not maintained during the reverse movement of each lobe or projection.

It will further be seen that by this construction the contacting points always being upon one side of the piston, and the piston being held against the wall of the chamber by the water-pressure behind, or that not included within the contact-lines, it is very loosely fitted within the chamber, so loosely, indeed, that it is free to be moved back and forward therein the depth of a measuring space or chamber, and is dependent upon the water-pressure for maintaining the proper contact with the walls of the chamber and for its operation.

It will further be seen that from this principle of construction there can be very little friction between the running parts, and that sediment or foreign substances cannot interfere with the fine and regular working of the device.

It will also be noticed that the piston in other respects has more of the principle of a reciprocating piston than of a rotating piston, in that each lobe or projection operates as a separate or distinct piston or discharging device in connection with its respective space or recess, so that the recess or space being filled with liquid, the lobe enters it and presses the liquid therefrom through the exhaust-port. In other words, each lobe or projection does not act to displace the liquid from the spaces or recesses, but to discharge the liquid therefrom by an advancing movement from one end of the chamber or recess to the other.

It will be seen that the piston is made to fit the piston-chamber loosely, and that the necessary contact between its contacting-surfaces and the wall of the chamber is obtained and maintained by so arranging the contacting-points and the admission of pressure to the chamber that there shall always be a sufficient area of the piston exposed to the direct pressure to cause it to overcome all resistance and to keep it in contact with the wall of the chamber while it is being moved.

I have shown in Fig. 19 a diagram which illustrates this feature of construction, giving for the form of piston and piston-chamber therein shown, the area of the piston upon which the direct pressure is exerted, and the area upon which there is a resisting force; and it will seen from the calculations noted upon said drawing that there is always an excess of pressure to maintain the piston in operation in working position. The said diagram and calculations also show how the rotative effect is obtained.

In order that this result may be obtained it is not only necessary that the piston be loosely fitted, but that its surface should be substantially parallel with the surface of the piston chamber. It will also be seen that by forcing the piston against the wall of the chamber by excess of pressure from behind, instead of drawing it to the wall of the chamber by a crank or other rigid mechanical device, a substantially perfect contact must always ensue and continue, and that the piston is constantly fitted to the wall of the chamber as it wears, the very action of wearing tending to give it a better fit, while if a crank or rigid connection be employed there is no compensation for wear or opportunity for it.

Another advantage which arises from this form of construction and operation is that the meter is kept free from sediment, and the accidental lodging of foreign matter on the piston lobes or walls of the chamber cannot injure the meter or interfere with its practical working, as the lobe is pressed away by or rides over it, and it is then immediately washed off by the liquid.

It will also be observed that by making the wearing portions of the meter separate or detachable from the casing, as shown in Figs. 9 to 14, inclusive, the casing can be made of cast-iron, and the wearing parts of more expensive, durable, and non-corrosive material, thereby lessening the cost of construction, increasing the efficiency and life of the meter, and enabling repairs to be cheaply, economically, and readily made.

It will be observed that the reducing gearing and drum are contained in a recess within the piston, and that they are therefore within the piston-chamber, and that by so arranging them less space is required than where they are placed without the piston-chamber, as is generally the case.

Having thus fully described my invention, I claim and desire to secure by Letters Patent of the United States—

1. In water meters, pumps, or motors, a piston-chamber having the measuring spaces or recesses described, each of which has a separate inlet-port and a separate outlet-port directly connected therewith, as specified, in combination with a piston having a lobe or projection entering each of said spaces or recesses, and adapted to be brought in contact with the walls of the chamber by the excess of pressure from behind, whereby the lobes are given the successive movements in their respective spaces or recesses indicated, all as set forth.

2. In a water meter, pump, or motor, a chamber having measuring recesses or spaces opening therefrom, in combination with a piston having a separate lobe or projection entering each of said recesses or spaces, and adapted to be brought in contact with the walls thereof, and to be held in contact therewith during the movement of the piston by the direct pressure exerted upon the piston, as specified, all substantially as set forth.

3. In water meters, pumps, or motors, the combination of a piston-chamber having measuring spaces or recesses opening therefrom, each of which has an inlet-port and an outlet-port, with a piston having a lobe or projection entering each space or recess adapted to control the exhaust-port thereof and to maintain a contact with the wall of the space or recess, which contact is maintained by the excess of direct pressure in the piston-chamber, as described, all substantially as set forth.

4. In a water meter, motor, or pump, the piston-chamber having measuring recesses or spaces forming a part thereof, a piston, F, having a projection or lobe entering each of said spaces or recesses, which projections or lobes are adapted to be brought successively into contact with the walls of said spaces or recesses, and to be moved therein, and the contact maintained during the discharge of the liquid from each space or recess by the direct pressure in the piston-chamber, as specified, a register, and devices connecting the piston with the register, all substantially as and for the purposes set forth.

5. In a water meter, motor, or pump, the piston-chamber having measuring spaces or recesses forming a part thereof, a distributing-chamber having an inlet, a', the passages or inlet-ports E, connecting the distributing-chamber with the measuring spaces or recesses of the piston-chamber, a piston having a separate or distinct lobe or projection which enters each of said measuring spaces or recesses and is operated or moved and the contact maintained by the excess of pressure, as herein set forth, all substantially as and for the purposes described.

6. In a water meter, motor, or pump, the combination of the distributing-chamber a^2, its inlet a', the piston-chamber D, having

measuring recesses or spaces *d*, the uncontrolled ports or passages E, connecting the distributing-chamber a^2 with the recesses or spaces *d*, the outlet-ports E′, and escape-passages connected therewith, and the piston F, having the lobes or projections *f*, one for each of the measuring spaces or recesses *d*, and operated or moved therein to maintain contact during the discharge of the liquid from each space or recess by the direct pressure in the piston-chamber, as specified, all substantially as described.

7. In a water meter, motor, or pump, the independent or separate base-section containing the inlet-passage *a′*, the distributing-chamber a^2, and the outlet-passage a^3, with the independent or separate section B, containing the piston-chamber D, with the measuring recesses or spaces *d*, connected with the distributing-chamber and outlet-passage, as described, and the piston F, having a lobe or projection for each of said spaces or recesses, and the bolts for fastening the two sections of the meter together, all substantially as and for the purposes described.

8. The combination of the section A, having the distributing-chamber a^2, the section B, and the removable port-plate B^2, having the ports E.

9. In a meter, motor, or pump, the combination of the section A, having the distributing-chamber a^2, the section B, containing the measuring-chamber, the port-plate B^2, and the packing-ring B′.

10. In a water-meter as a means for communicating the motion of the piston to the register, the mechanism described, consisting of the stationary gear g^6, the revolving gears g^7 g^8, adapted to be revolved around the stationary gear by the piston, and the gear g^9 upon the connecting-spindle.

11. The combination of the piston F, the disk G, the drum or frame g^2, pivoted, as described, to be revolved, and the differential gears inclosed within said drum or case.

12. The combination, in a water-meter, of the piston-chamber D, the piston F, the reducing mechanism or gearing for transmitting the motion of the piston to the registering device contained in a recess in the piston, and the registering mechanism, all substantially as and for the purposes described.

13. In a water meter, motor, or pump, a piston-chamber having measuring spaces or recesses, and a loosely-fitted piston having lobes or projections extending into said spaces or recesses to form by contact with the walls thereof successive discharge-spaces, the said walls being shaped to provide the surface of the piston within the contacting lines of the discharge-spaces with less area than the remainder of the piston, subjected to the direct action of the pressure from behind, whereby the piston or valve may be loosely fitted in the piston-chamber, and by the excess of pressure caused by the difference in area is brought in contact with the walls of the measuring spaces or recesses, maintained in contact therewith, and rotated, all substantially as described.

JAMES A. TILDEN.

Witnesses:
F. F. RAYMOND, 2d,
FRED. B. DOLAN.