A. M. ALLEN.

REGULATING VALVE.

APPLICATION FILED JAN. 11, 1906.

958,206.

Patented May 17, 1910.

5 SHEETS—SHEET 1.

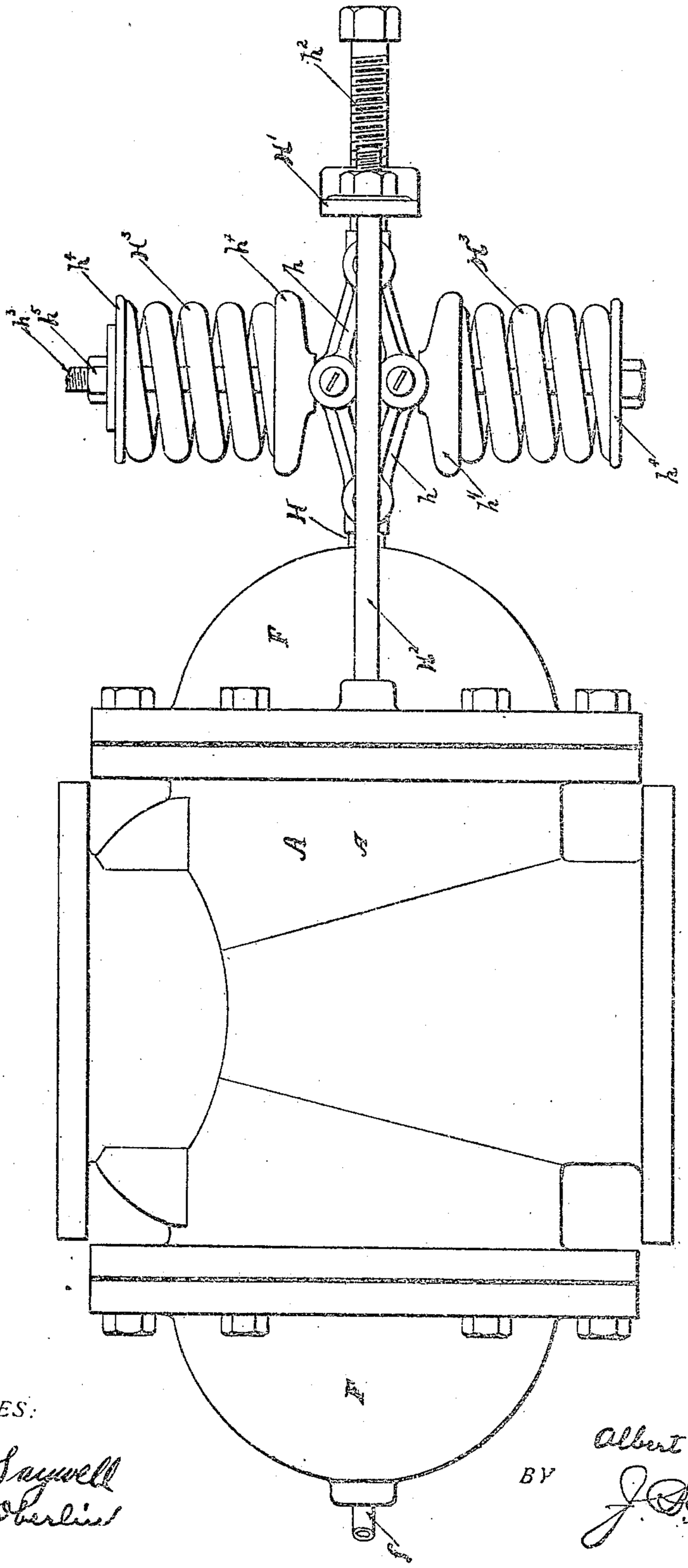

Fig. 1.

WITNESSES:

G. W. Saywell

Jno. F. Oberlin

INVENTOR.

Albert M. Allen

BY

J. D. Fay

ATTORNEY.

A. M. ALLEN.

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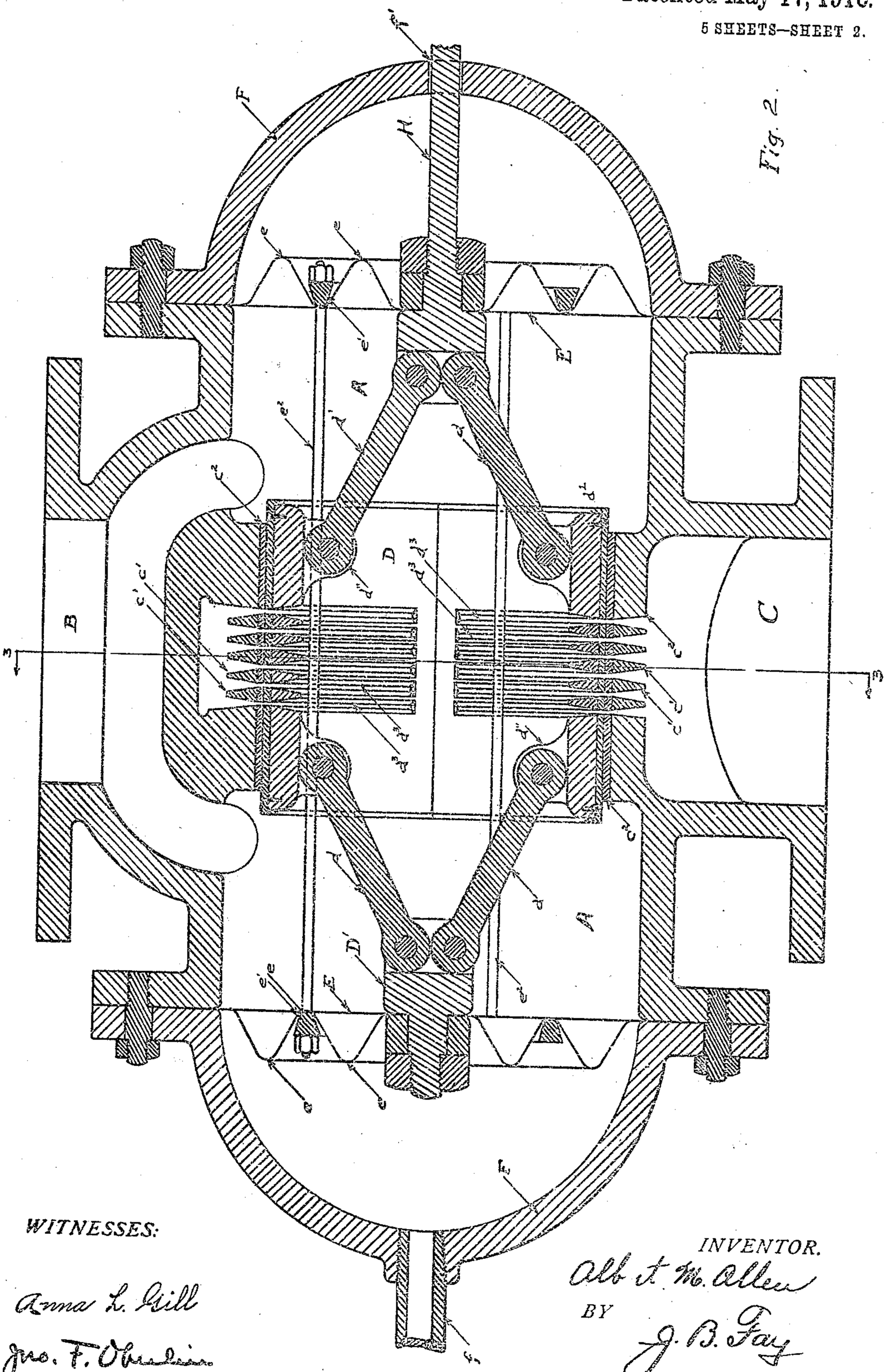
5 SHEETS—SHEET 2.

Fig. 2.



WITNESSES:

Anna L. Gill

Jno. F. Obenchain

INVENTOR.

Albert M. Allen

BY

J. B. Fay

ATTORNEY.

A. M. ALLEN.

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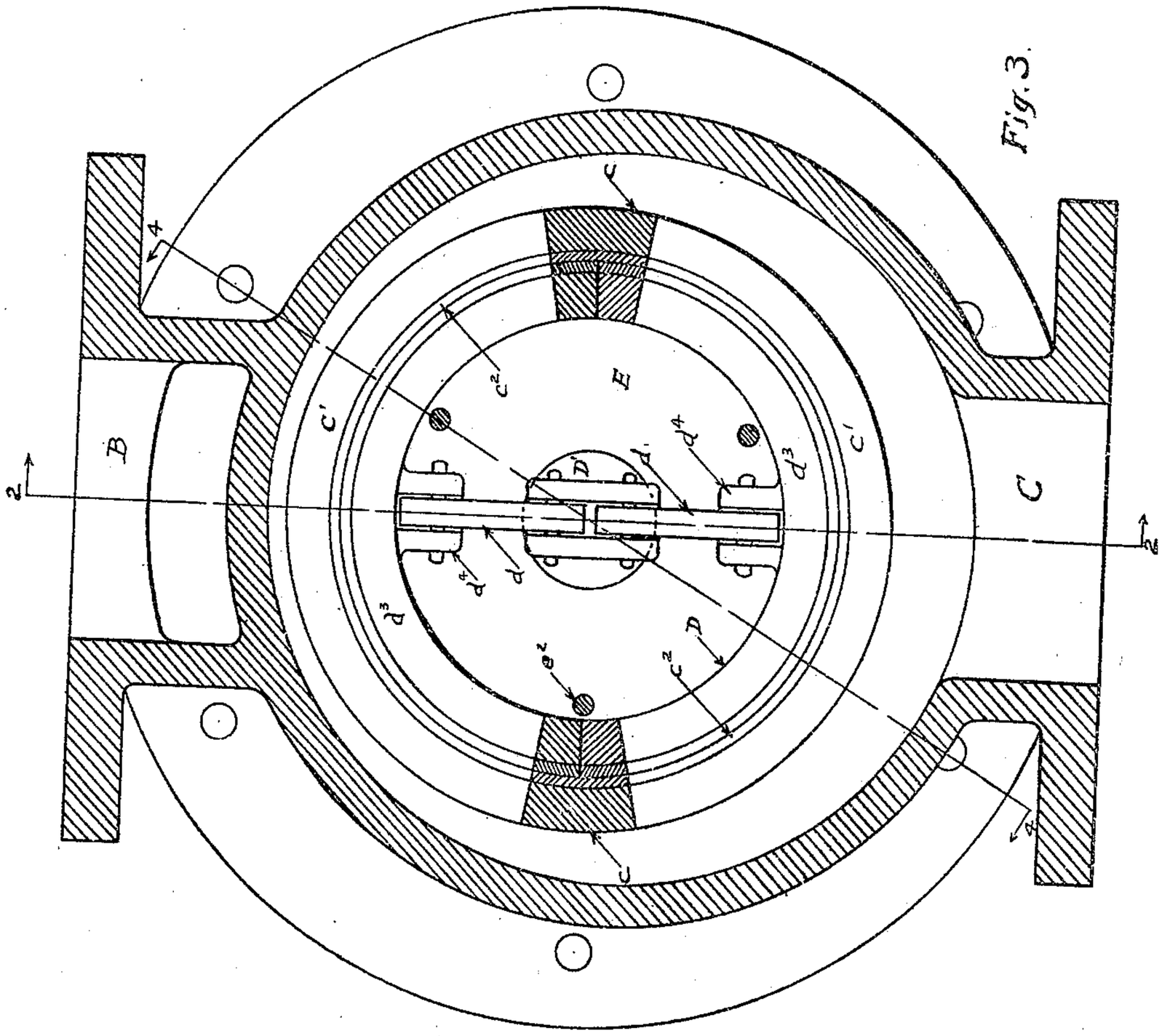

Fig. 3.

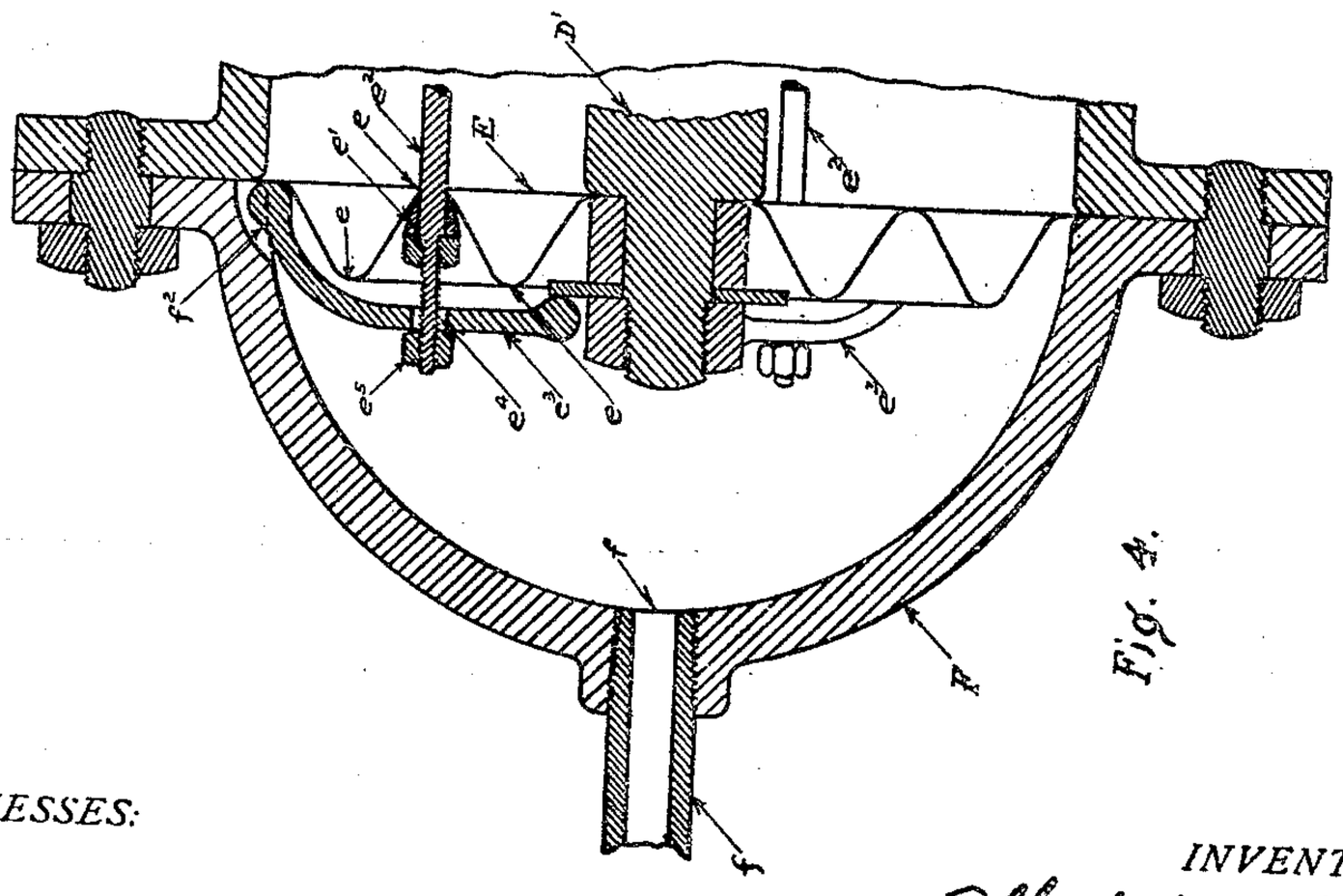

Fig. 4.

WITNESSES:

Anna L. Gill

Jno. F. Oberlin

INVENTOR.

Albert M. Allen

BY

J. B. Fay

ATTORNEY.

A. M. ALLEN.

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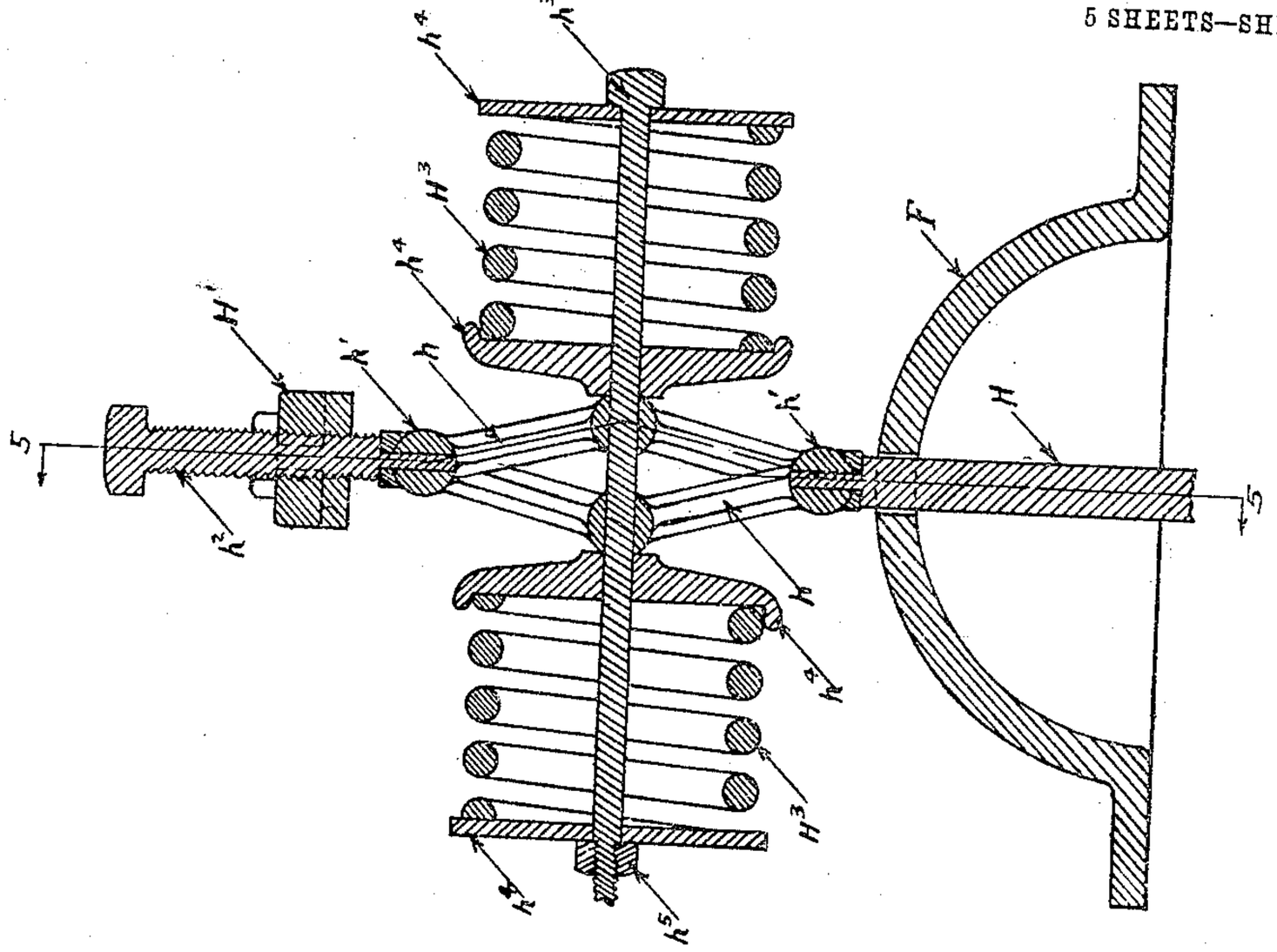

Fig. 6.

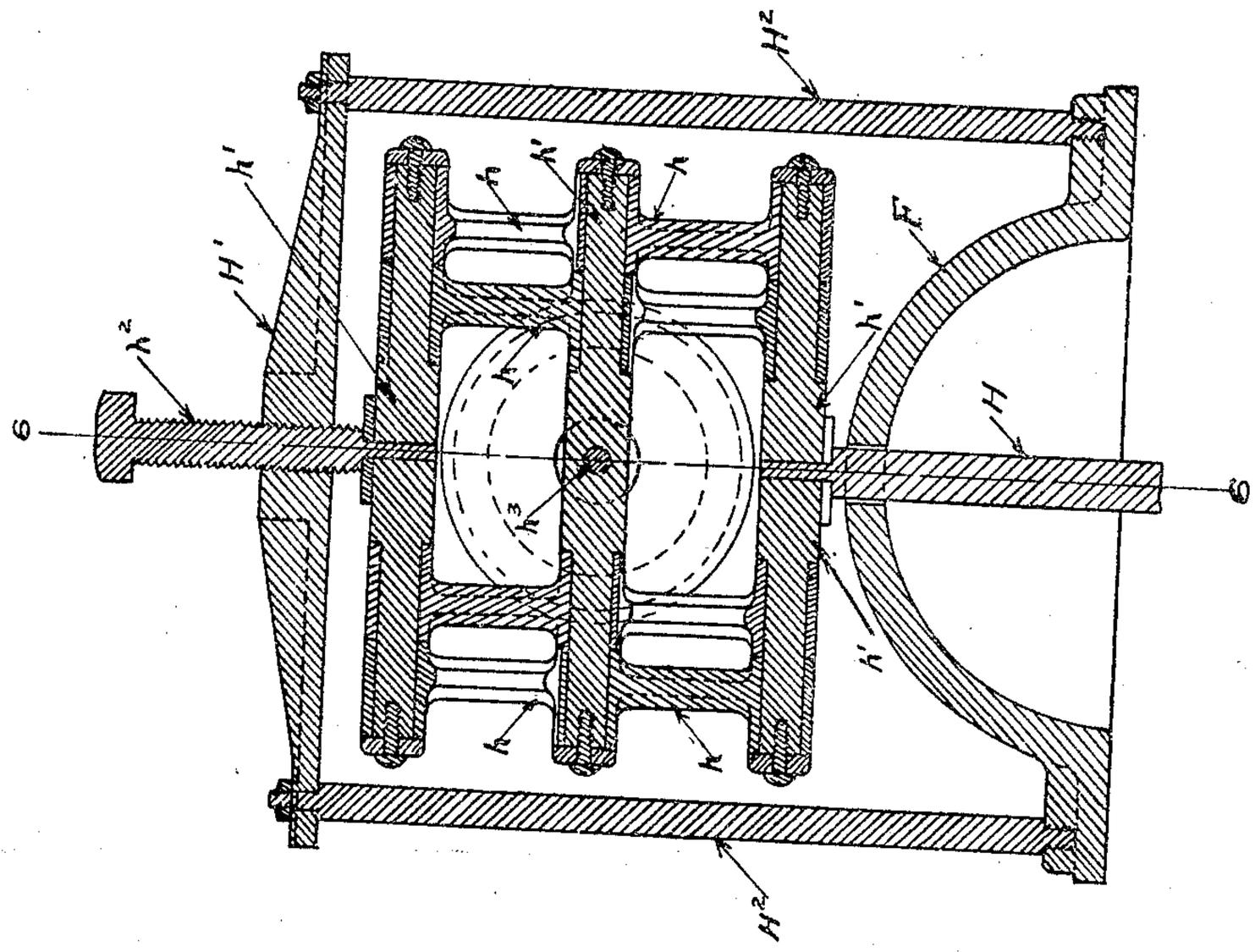

Fig. 5.

WITNESSES:

Anna L. Gill

Jno. F. O'Reilly

INVENTOR.

Albert M. Allen

BY

J. B. Fay

ATTORNEY.

A. M. ALLEN.

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5 SHEETS—SHEET 5.

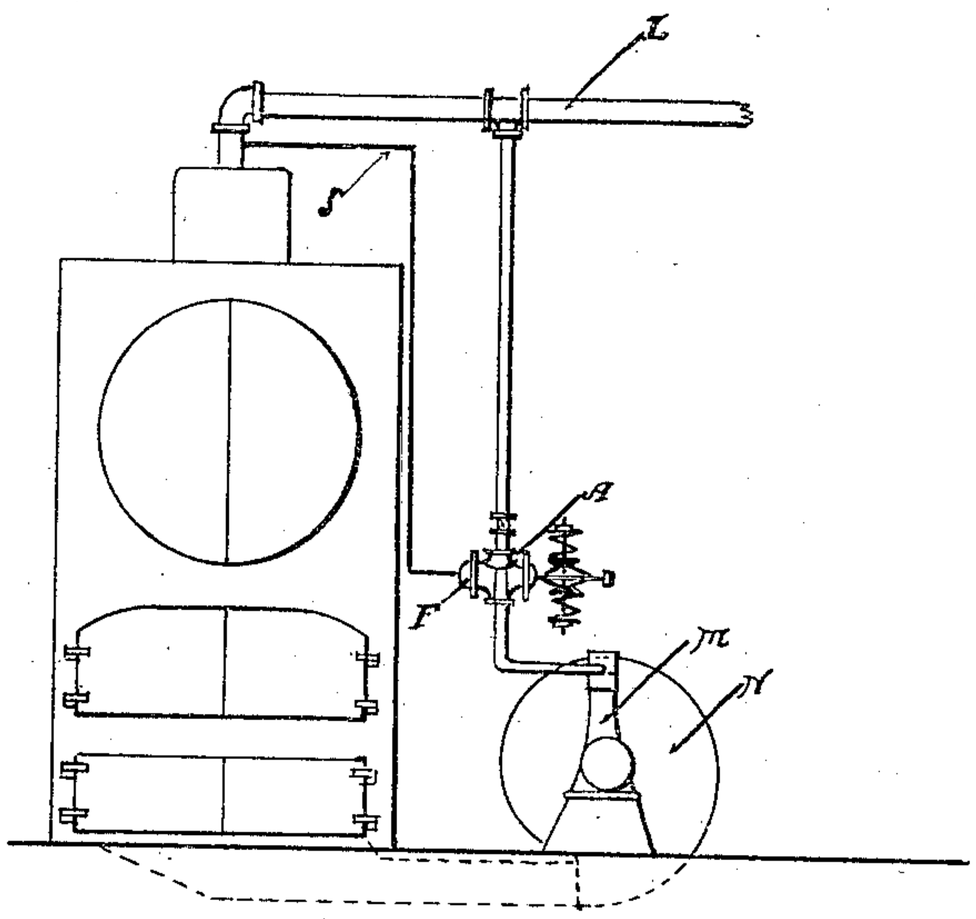

Fig. 8.

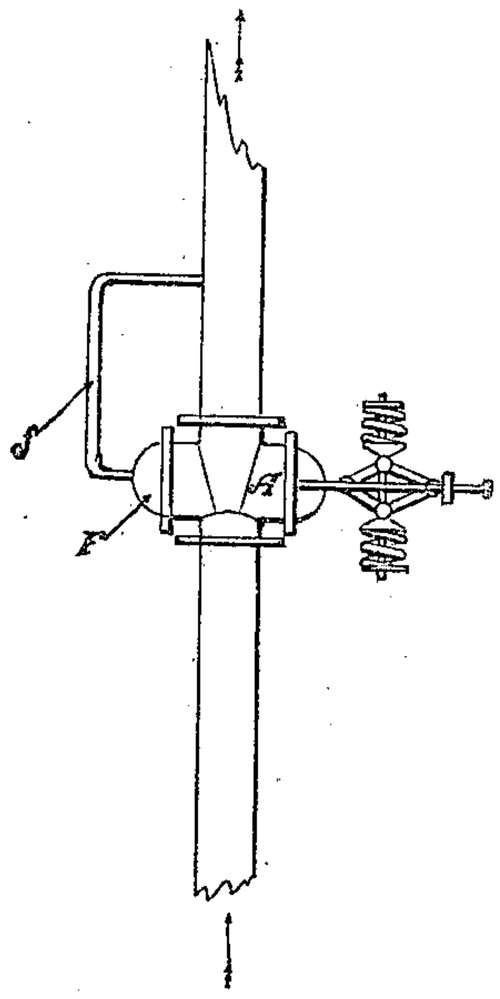

Fig. 7.

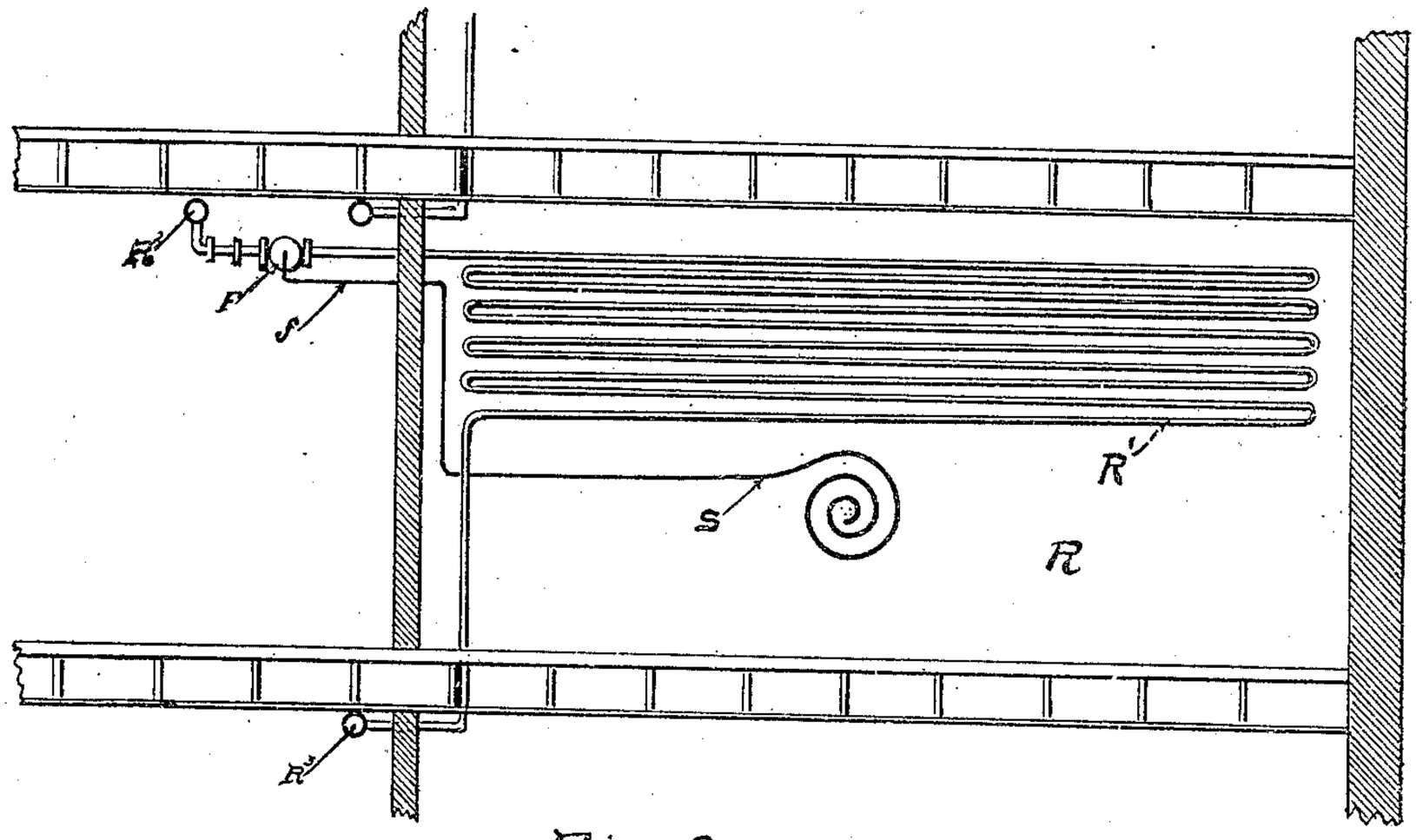

Fig. 9.

WITNESSES:

G. W. Saywell

Jno. F. Oberlin

INVENTOR.

Albert M. Allen

BY J. B. Fay

ATTORNEY.

UNITED STATES PATENT OFFICE.

ALBERT M. ALLEN, OF CLEVELAND, OHIO.

REGULATING-VALVE.

958,206. Specification of Letters Patent. Patented May 17, 1910.

Application filed January 11, 1906. Serial No. 295,594.

To all whom it may concern:

Be it known that I, ALBERT M. ALLEN, a citizen of the United States, resident of Cleveland, county of Cuyahoga, and State of Ohio, have invented a new and useful Improvement in Regulating-Valves, of which the following is a specification, the principle of the invention being herein explained and the best mode in which I have contemplated applying that principle, so as to distinguish it from other inventions.

My invention relates to regulating valves, and particularly to pressure-controlled regulating valves in which the medium, whose flow is being regulated, is passed between two diaphragms rigidly connected together and the effect of its pressure thereby nullified.

My invention has as its object the production of a valve of this type that will be more efficient and more generally adaptable than any heretofore devised, and, particularly, that shall be able to balance a high pressure and still operate promptly within narrow working limits.

To the accomplishment of the above and allied objects my invention comprises means hereinafter fully described and particularly set forth in the claims.

The annexed drawings and the following description set forth in detail certain mechanism embodying the invention, said disclosed means constituting but one of various mechanical forms in which the principle of the invention may be used.

In said annexed drawings: Figure 1 represents, in side elevation, a form of my improved regulating valve; Fig. 2 represents a vertical longitudinal cross-section of the same slightly enlarged and certain parts being omitted; Fig. 3 is a vertical transverse cross-section thereof taken on the line 3—3, Fig. 2; Fig. 4 is a longitudinal cross-section taken upon the plane passing through line 4—4, Fig. 3, of the left end of my valve as it appears in Fig. 2, certain modifications being shown; Fig. 5 is a horizontal longitudinal cross-section of the regulating spring, appearing on the right in the side elevation of the entire valve, Fig. 1; Fig. 6, is a vertical longitudinal cross-section of the same; while Figs. 7, 8, and 9 respectively represent different practical applications of my valve.

As is shown in the aforesaid figures, particularly in Figs. 1 and 2, my regulating valve comprises a main, or central, chamber A, through which the fluid, whose flow is being regulated, is designed to pass. Such fluid may freely enter chamber A through an inlet opening B, its escape therefrom, however, into outlet chamber C is controlled by means of slide-valves D of which there are two in the device as illustrated. The oposite ends of chamber A are closed by means of flexible diaphragms E, which are held tightly in place by means of inclosing caps F. Cap F at one end of the valve, the left in the figures, is designed to form another air-tight chamber in which the outer face of the corresponding diaphragm E may be exposed to the pressure of the controlling medium. The latter is designed to be admitted to such chamber through a duct *f* communicating therewith. Cap F at the other end of the valve is provided with a central aperture *f'* through which projects a rod H, rigidly connected at its inner end to the corresponding diaphragm E, and having an adjustable tension device secured to its outer end whereby its reciprocation may be regulated. This cap F, in addition to serving as supporting means for such tension device, is designed to prevent the escape of fluid from the valve in case the diaphragm inclosed thereby should break. At the same time the tension device is entirely without the valve casing and so readily accessible for adjustment and repair.

Having thus described in outline the structure of my valve as a whole, I shall now proceed to set forth in greater detail the structure of the several parts entering therein, and particularly that of the diaphragms E, the valve controlling the opening into outlet chamber C, and the adjustable tension device connected with rod H.

The object sought in the construction of the diaphragms E, which close the ends of chamber A, is to produce a diaphragm that shall be capable of withstanding a high pressure within such chamber while still remaining sufficiently flexible to respond to very slight changes in the pressure of the controlling medium in the chamber formed by cap F. Such diaphragms, as will appear from an inspection of Fig. 2, are of the usual circular form, having a number of concentric corrugations *e*, which are shown as being two in number. The centers of the two diaphragms are connected by what is in effect a rigid member, although composed

of a plurality of parts D′ and *d*, whereby the slide valves D are joined with said diaphragms. The construction and other function of parts *d* will be explained later. On the concave side of each inwardly turned corrugation *e* I place a ring or annular member *e′* having its inner face made so as to substantially conform with the shape of the diaphragm at the line of contact. The edges of such ring are rounded so that the side of a corrugation will be tangent at any point of contact with the ring, although such point of contact changes as the diaphragm is moved back and forth. The movement of the diaphragm relatively to a ring, in other words, may be described as a sort of folding and unfolding. Corresponding rings *e* of the respective diaphragms E, only one for each diaphragm is required in a valve of the size shown, are rigidly connected by means of stays or rods e^2, which pass through chamber A. These rods are preferably disposed as shown in Figs. 2 and 3, although their number may be varied as found desirable.

By the arrangement just described it is readily apparent that the diaphragms are supported at each alternate, or correspondingly turned, corrugation, so that they are subjected to no lateral, or bending, strains, being only in tension; furthermore they can be designed to resist any pressure without being made unduly heavy and stiff, since much thinner plates can be utilized in their construction. In order to secure any desired strength with the use of a minimum amount of material, I further have found it advisable to make the aforesaid corrugations so as to be approximately catenary in their transverse cross-section. The surface of the diaphragm is thus disposed most advantageously with a view to withstanding the strain of the fluid contained in chamber A and is subject to less flexure and consequent deterioration.

The means above described support, or fortify, the diaphragms against any pressure from within, *i. e.* that exerted by the fluid passing through the main chamber A of the valve. To similarly support them against the pressure of the fluid in the chamber in cap F, which in certain situations may be quite considerable, I provide the additional strengthening means shown in Fig. 4. The object of the device there shown is to limit to its proportionate amount the movement of each portion of the diaphragm intermediate of such diaphragm's center, to which the valve is attached, and its outer edge where it is secured to the valve body. Thus in any movement of the diaphragm, a corrugation *e* bearing the ring *e′* should obviously move only one-half the distance traversed by the center of the diaphragm when such corrugation *e* is midway between the center of the diaphragm and its outer edge. Where a thin diaphragm, however, is employed, as is highly desirable in view of the considerations previously mentioned, such intermediate portions of the diaphragm are apt to bulge inwardly or the diaphragm be otherwise injuriously distorted. The means referred to accordingly comprise a series of lever arms e^3 fulcrumed at their outer ends in recesses f^2 formed in the walls of cap F, and having their inner ends resting upon the nut by which the valve-stem D′ is secured to the center of the diaphragm or upon a washer *d′* held in place by such nut. Such arms are preferably equal in number to the rods e^2 and are respectively disposed adjacent to their ends to which latter they are secured as shown; that is, the ends of the rods themselves are simply extended far enough beyond the diaphragm to register in apertures e^4 in such arms, and receive a nut e^5 having its inner face rounded. This insures the free movement of the arms as the diaphragm is pressed inwardly by the fluid in chamber F, as does also the manner in which the ends of the arms are mounted. These, in each case, instead of being pinned, are merely rounded off and allowed to rest loosely in recess f^2 and upon washer *d′* respectively. Where it is desired to support, in the manner just described, more than one corrugation of the diaphragm, a separate series of arms e^3 may be employed for each corrugation, or one set of arms may be arranged to support them all. In the latter case the points of attachment of the several corrugations to any one arm should be so disposed as to allow to each point its proportional amount of movement only.

It will be observed, upon reference to Figs. 1, 2, and 3, that the outlet chamber C of the valve completely encircles chamber A. The wall or partition *c* between chamber A and chamber C is preferably of the cylindrical shape shown, and communication between the chambers is made through a series of parallel ports or slits *c′* in this partition, arranged transversely of the valve's length, there being two sets of such ports whose length in each case is somewhat less than half the circumference of the inner face of the partition *c*. Such partition *c* is faced with a removable bushing c^2 of suitable material forming a valve seat, and provided with a series of slits corresponding with ports *c′*. Fitted to such valve seat, which for the purposes of this description is assumed to be of cylindrical conformation, are two semicylindrical slide valves D each provided with a set of ports or slits d^3 adapted to register with ports *c′* in partition *c*. Such valves D being of comparatively thin metal are formed with flanges d^2 at each end for the sake of rendering them stronger. The number of valves D and corresponding sets

of port holes c' and d^3 may be varied as desired, since, when the valves D are in place, they are fitted sufficiently tightly together to form, in effect, a single valve.

Motion is communicated to the valves D from diaphragms E by means of a valve-stem comprising members D′ and d. Of these one member D′ is centrally secured to each of the diaphragms, while members d are toggle arms pivotally connected at their respective ends to a member D′ and to the valves D. Bearings for the pins by which such arms are pivoted to the valves are formed in members d^4 detachably secured to the valves as shown in Fig. 2. This construction is made necessary by the difficulty that would attend the drilling of such bearings in ears cast integral with the valve. It also facilitates the repair of the valve by permitting the easy renewal of the valve when it becomes worn. In fact, by simply renewing bushing c^2 and the valve members D the device is made as good as new. It readily follows from this construction that so far as reciprocatory movement of the valves D is concerned, members D′ and toggle arms d act as a continuous connecting rod or stem joining the two diaphragms and having the valves rigidly mounted thereon. By means of the toggle arms, however, I achieve a result of great importance, that of lessening the pressure of the fluid in chamber A; for, by a proper disposition of such toggle arms, it is evident that any desired part of the pressure referred to may be neutralized, and the valves thus left free to respond to a very slight external pressure upon the diaphragm exposed thereto. No measurable amount of play need be provided between the separate valves to thus relieve the valves from friction, and the angular positions of the arms d, of course, are calculated to nearly relieve such friction when the ports c' are entirely closed and the pressure upon the valve is the greatest. Accordingly, as soon as the valve is slightly open, it works entirely off or free from the seat. Another feature in the construction of my valve is also shown in aforesaid Fig. 2; namely, the disposition of the ports d^3, as also of ports c' in the partition c, whereby the spaces between the same are considerably wider than are the several ports. By this means, as the ports are made wider by the "cutting" action of the fluid passing through them, especially when such fluid is steam, it only requires a slight additional lateral shifting of the valve to effect a complete closure of the same in spite of the wear thus occasioned.

Regulation of the critical pressure point, by which I mean the degree of pressure required in the second chamber F to actuate the valve, as also regulation of the sensitiveness of the valve, is effected by means of the adjustable tension device connected with rod H, Figs. 1, 5, and 6. This device comprises a toggle joint made up, in the particular valve shown, of two sets of opposed toggle arms h, making eight in all, interposed between the outer end of rod H and a cross-bar H′ attached to two rods or bolts H^2 extending from one end of the valve casing. The toggle arms are preferably pivotally mounted on short spindles h' instead of being merely pinned together, since greater rigidity is thereby secured. The two spindles at the respective ends of the sets of toggle arms further provide convenient means for attaching the device to rod H on one side and the bar H′ on the other, such attachment in the latter case being made by means of a set screw h^2. By means of this set screw the normal position of the toggle joint may be varied from a longitudinally extended condition to a vertically extended position. Whatever this normal position of the joint, it is obvious that any outward movement of rod H, produced by the pressure of the fluid in second chamber F, will be communicated to toggle-arms h, the effect being to thrust outwardly those ends of such arms that are pivoted on the spindles h' intermediate of rod H and bar H′. Such outward thrust of the toggle arms is resisted by means of compression springs H^3, mounted upon a rod h^3 transversely disposed to the spindles h' and slidably mounted in said two intermediate spindles. Each of these springs is held between washers h^4, which may be drawn more or less closely together by means of a nut h^5 on rod h^3.

By means of the foregoing arrangement of toggle arms h and set screw h^2 it is evident, from the principle of the parallelogram of forces, that I am able to apply, without changing the strength of spring H^3, any desired resistance to initial movement on the part of diaphragms E and attached rod H. Moreover the increased leverage given as toggle arms h are expanded can be made to just about balance the increased resistance of the springs as they become compressed, and thus a practically uniform resistance is at all times afforded.

As has been stated, my improved valve is capable of numerous applications, several of which are shown in Figs. 7, 8, and 9. In the first of said figures its use as a simple reducing valve is illustrated, such as might be required of it in a steam heating plant where the pressure of the steam in the mains is too high for the radiators. The chamber formed by closed cap F is accordingly connected through duct f with the conduit on the farther side of the valve and by a proper adjustment of toggle arms h and springs H^2 the valve can be set to maintain any desired pressure in such conduit, as will be readily apparent. In Fig. 8, the valve is shown as applied to the regulation of a

blower for a forced-draft furnace. Steam from main L is admitted to engine M, which operates blower N, through the regulating valve as shown. Such valve is adapted to be actuated by the direct pressure of the steam in the main L, duct *f* connecting such main with closed chamber F of the valve. Thus, according as the pressure of the steam rises or falls, a smaller or larger amount of steam is permitted to enter the cylinder of engine M.

The adjustment of the valve in both of the preceding cases must, of course, be such as to allow an increase of pressure in second chamber F to more or less completely close the valve. In Fig. 9, however, a situation is represented where just the opposite actuation is required. In said figure, R represents a chamber in a refrigerator in which are disposed several coils R′ of pipe connected to be supplied with brine, liquefied ammonia, or similar refrigerating agent, from a supply pipe R^2, and to discharge the same into a return pipe R^3. The brine or ammonia is admitted into the coils R′ through one of my regulating valves connected as shown, such valve being operated by means of a fluid thermostat S. This thermostat comprises, in an approved form, a coil of pipe suitably connected with the proper chamber of the valve and containing a quantity of some fluid, as liquid ammonia, that is readily affected by changes in temperature, and that is capable of effecting directly the required movement of diaphragms E in the valve. This requires an excess of the fluid over the amount necessary to simply fill the thermostat when in vaporized condition, and also requires that as large an area as possible of such fluid be exposed to the controlling temperature. The adjustment of the valve, then, is such that, as the temperature in chamber R rises, the pressure of the fluid in the thermostat S upon the diaphragm of the valve will actuate the latter to admit an increased quantity of the refrigerating agent into coils R′; as the temperature thereupon falls this supply is gradually shut off, and if properly set the valve, it is clear, will maintain in this manner any desired temperature in the refrigerator. This last described example is an instance where a valve is required that will withstand a high pressure between the diaphragms and yet respond readily to slight changes in the pressure of the controlling medium; for the liquefied ammonia must necessarily be maintained under considerable pressure, while the range of variation in the pressure of the fluid in the thermostat is usually small. It has been fully set forth above how my improved valve is adapted to meet these conditions as well as the even more difficult ones where the controlling pressure is quite high, and the valve is nevertheless required to be sensitive to slight variations in such pressure. This high degree of adaptability I attain by the novel construction of the diaphragm E, and by the employment of the toggle arms *h* in connection with the regulating springs H^3 whereby a single pair of springs may be adjusted to balance any desired pressure. In addition to the above features, the construction of the slide valves D, whereby a large opening is secured by a relatively slight movement of the valves and means actuating the same, and whereby, also, any undesirable friction of the valves on their seats is practically eliminated, should be noted. Moreover, the wear due to the "cutting" of the fluid passing through the valve is automatically taken up, while, inasmuch as the valve by its shape is self-grinding, it always fits its seat closely.

Having thus described my invention in detail, that which I particularly point out and distinctly claim is:

1. In a pressure controlled regulating device, the combination with the valve, of actuating means therefor comprising two flexible diaphragms, one of said diaphragms being exposed to the controlling pressure, and a plurality of stays connecting corresponding points on said diaphragms.

2. In a pressure controlled regulating device, the combination with the valve, of actuating means therefor comprising two corrugated diaphragms, one of said diaphragms being exposed to the controlling pressure, and a plurality of stays connecting corresponding corrugations of said diaphragms.

3. In a pressure controlled regulating device, the combination with the valve, of actuating means therefor comprising two diaphragms having concentric corrugations, one of said diaphragms being exposed to the controlling pressure, annular members located in corresponding corrugations of said diaphragms, and stays connecting said annular members.

4. In a pressure controlled regulating device, the combination with the valve, of actuating means therefor comprising two corrugated diaphragms, one of said diaphragms being exposed to the controlling pressure, the corrugations of said diaphragms being substantially catenary in their transverse cross section, and a plurality of stays connecting corresponding corrugations of said diaphragms.

5. In a pressure controlled regulating device, the combination with the valve, of actuating means therefor comprising two diaphragms having concentric corrugations, one of said diaphragms being exposed to the controlling pressure, and such corrugations being substantially catenary in their transverse cross section, annular members located in corresponding inturned corrugations of

said diaphragms, and stays connecting said annular members.

6. In a pressure controlled regulating device, the combination with the valve, of actuating means therefor comprising a flexible diaphragm exposed to the controlling pressure and having its periphery secured, and a lever arm fulcrumed at such periphery and connected with said diaphragm substantially at the center of the same and at a point intermediate of its center and periphery.

7. In a pressure controlled regulating device, the combination with the valve, of actuating means therefor comprising a circular diaphragm exposed to the controlling pressure and secured about its circumference, said diaphragms having concentric corrugations, and a lever arm fulcrumed at the circumference of said diaphragm and connected with said diaphragm substantially at the center of the same and at a point intermediate of its center and circumference.

8. In a pressure controlled regulating device, the combination of a main chamber having an inlet opening; an outlet chamber; a port connecting said two chambers; a valve adapted to control said port; and valve-actuating means comprising two flexible diaphragms closing opposite ends of said main chamber one of said diaphragms having its outer face exposed to the controlling pressure, a plurality of stays connecting corresponding points on said diaphragms, and means operatively connecting said diaphragms with said valve.

9. In a pressure controlled regulating device, the combination of a main chamber having an inlet opening; an outlet chamber; a port connecting said two chambers; a valve adapted to control said port; and valve-actuating means comprising two corrugated diaphragms closing opposite ends of said main chamber one of said diaphragms having its outer face exposed to the controlling pressure, annular members located in corresponding corrugations of said diaphragms, stays connecting said annular members, and means operatively connecting said diaphragms with said valve.

10. In a regulating device, the combination of a main chamber having an inlet opening; an outlet chamber; a port connecting said two chambers; a valve adapted to control said port; and valve-actuating means comprising two corrugated diaphragms closing opposite ends of said main chamber, the corrugations of said diaphragms being substantially catenary in their transverse cross-section, a plurality of stays connecting corresponding corrugations of said diaphragms, and toggle arms operatively connecting said diaphragms with said valve.

11. In a regulating device, the combination of a main chamber having an inlet opening; an outlet chamber; a port connecting said two chambers; a valve adapted to control said port; and valve-actuating means comprising two flexible diaphragms closing opposite ends of said main chamber, a plurality of stays connecting corresponding points on said diaphragms, means operatively connecting said diaphragms with said valve, and a chamber inclosing the outer face of one of said diaphragms and adapted to receive a fluid under pressure, the diaphragm thus exposed being provided with a series of lever arms fulcrumed at its periphery and connected with said diaphragm substantially at the center of the same and at a point intermediate of its center and periphery.

12. In a regulating valve, valve-actuating means embodying a flexible diaphragm, a chamber inclosing one face of the same and adapted to receive a fluid under pressure, and means adapted to balance any pressure in such chamber, such means comprising an adjustably positioned support, a toggle-joint interposed between the other face of said diaphragm and said support and a resilient member adapted to control the motion of said toggle-joint.

13. In a regulating valve, valve-actuating means embodying two flexible diaphragms, means connecting the same whereby they move in unison, a chamber inclosing the outer face of one of said diaphragms and adapted to receive a fluid under pressure, and means adapted to balance any desired pressure in said chamber, such means comprising an adjustably positioned support, a toggle-joint interposed between said second diaphragm and such support; and a resilient member adapted to control the motion of said toggle-joint.

14. In a regulating device, the combination of a main chamber having an inlet opening; an outlet chamber; a port connecting said two chambers; a valve adapted to control said port; and valve-actuating means comprising two flexible diaphragms closing opposite ends of said main chamber and operatively connected with said valve, a chamber inclosing the outer face of one of said diaphragms and adapted to receive a fluid under pressure, and means adapted to balance any desired pressure in said chamber, such means including an adjustably-positioned support, a toggle-joint interposed between said second diaphragm and such support, and a spring adapted to control the motion of said toggle-joint.

Signed by me, this 5th day of January, 1906.

ALBERT M. ALLEN.

Attested by—
D. T. DAVIES,
JNO. F. OBERLIN.