No. 669,458. Patented Mar. 5, 1901.

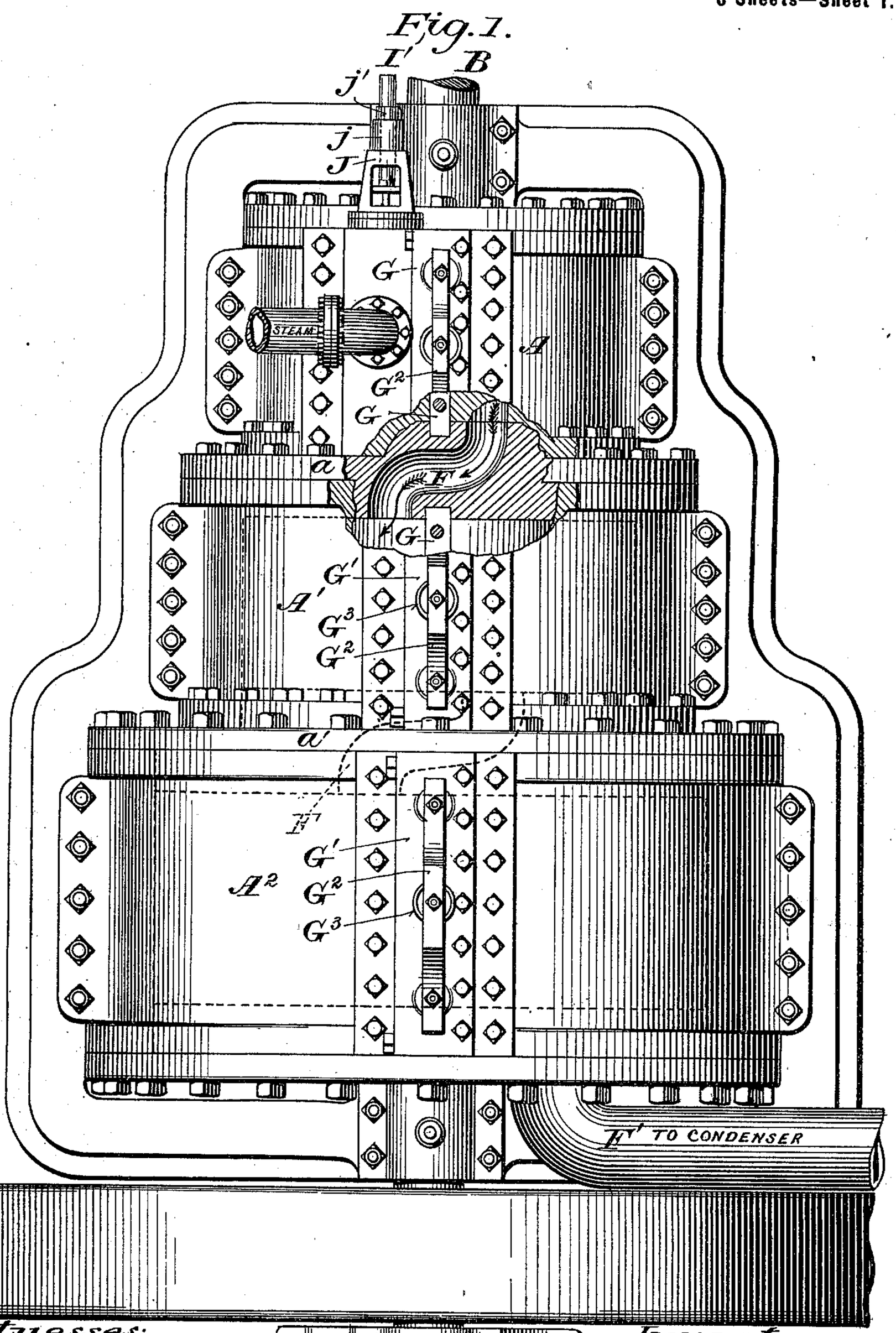
C. FISHER & H. F. KRUEGER.

STEAM ENGINE.

(Application filed July 13, 1900.)

(No Model.) 6 Sheets—Sheet 1.

Fig. 1.



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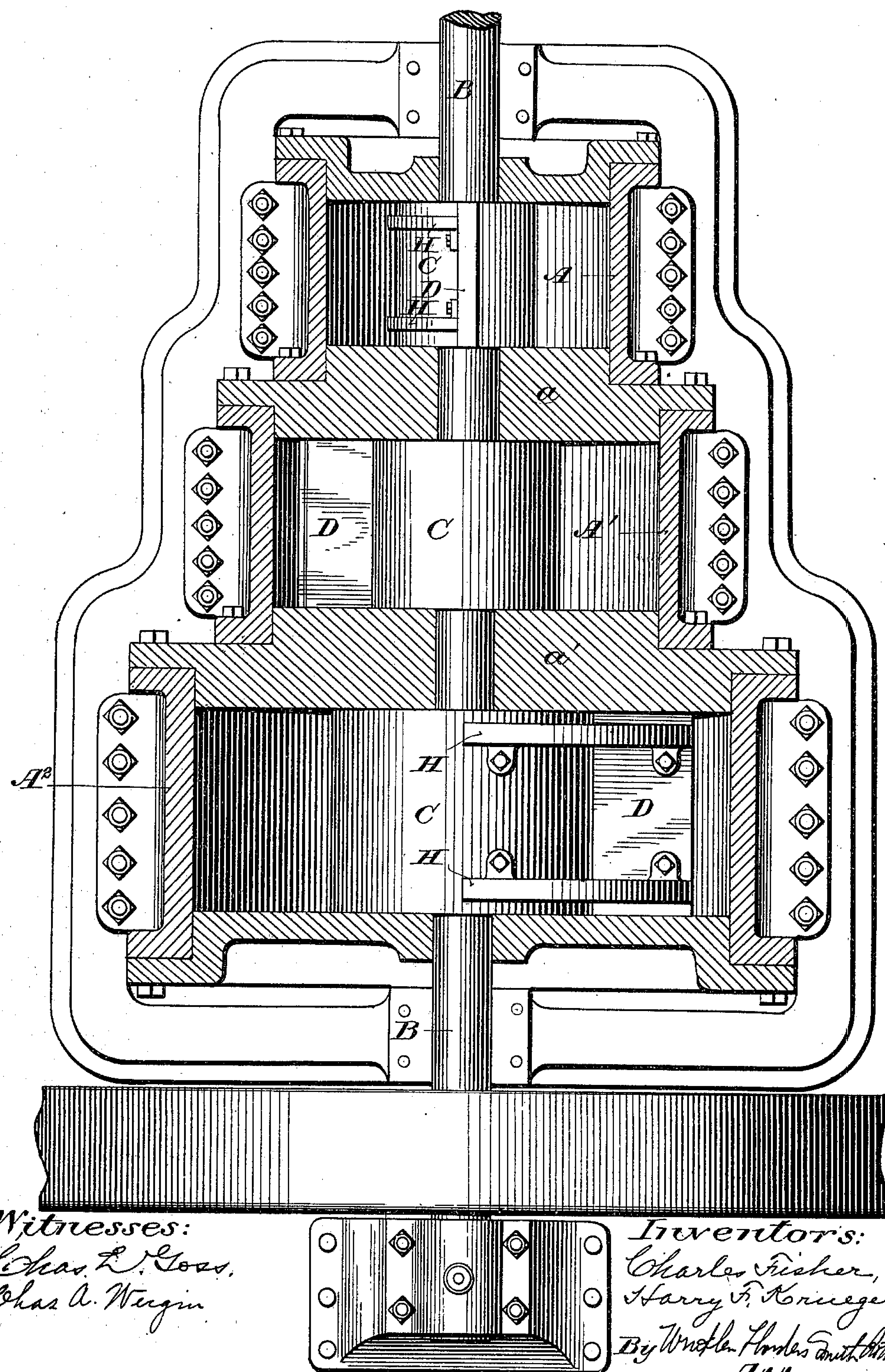
STEAM ENGINE.

(Application filed July 13, 1900.)

(No Model.)

6 Sheets—Sheet 2.

Fig. 2.



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THE NORRIS PETERS CO., PHOTO-LITHO., WASHINGTON, D. C.

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6 Sheets—Sheet 3.

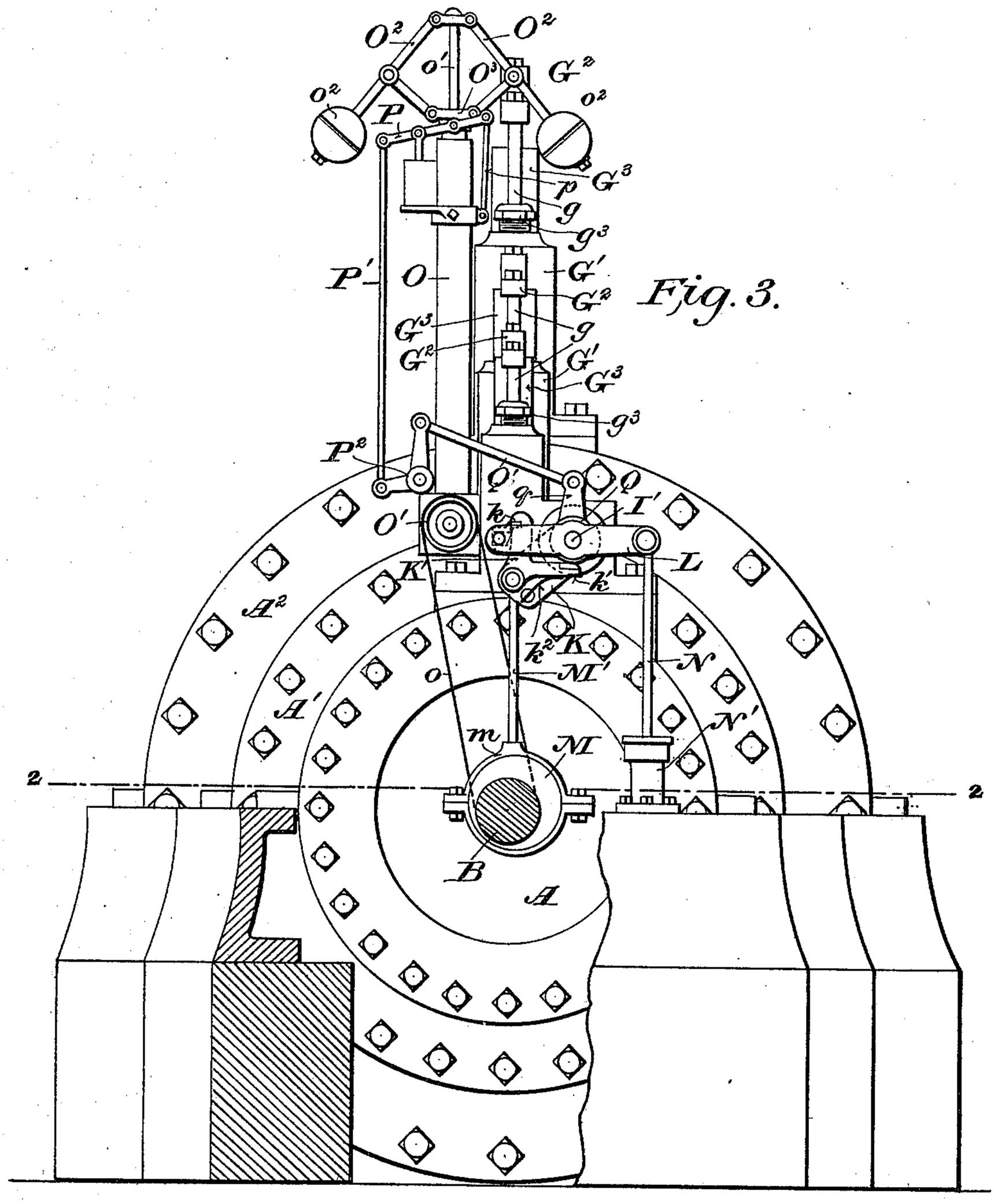

Fig. 3.

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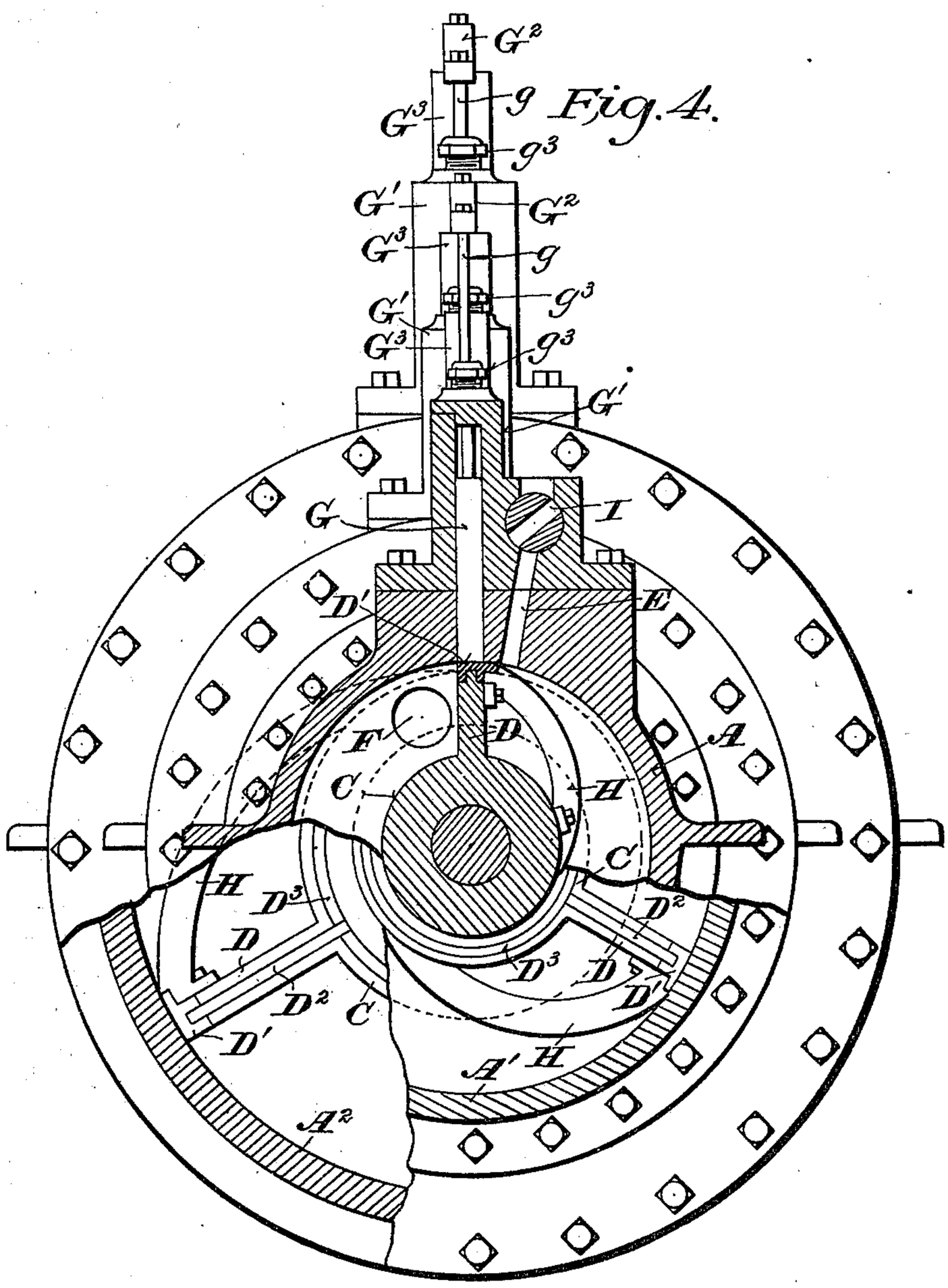
STEAM ENGINE.

(Application filed July 13, 1900.)

(No Model.) 6 Sheets—Sheet 4.

Fig. 4.



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No. 669,458. Patented Mar. 5, 1901.

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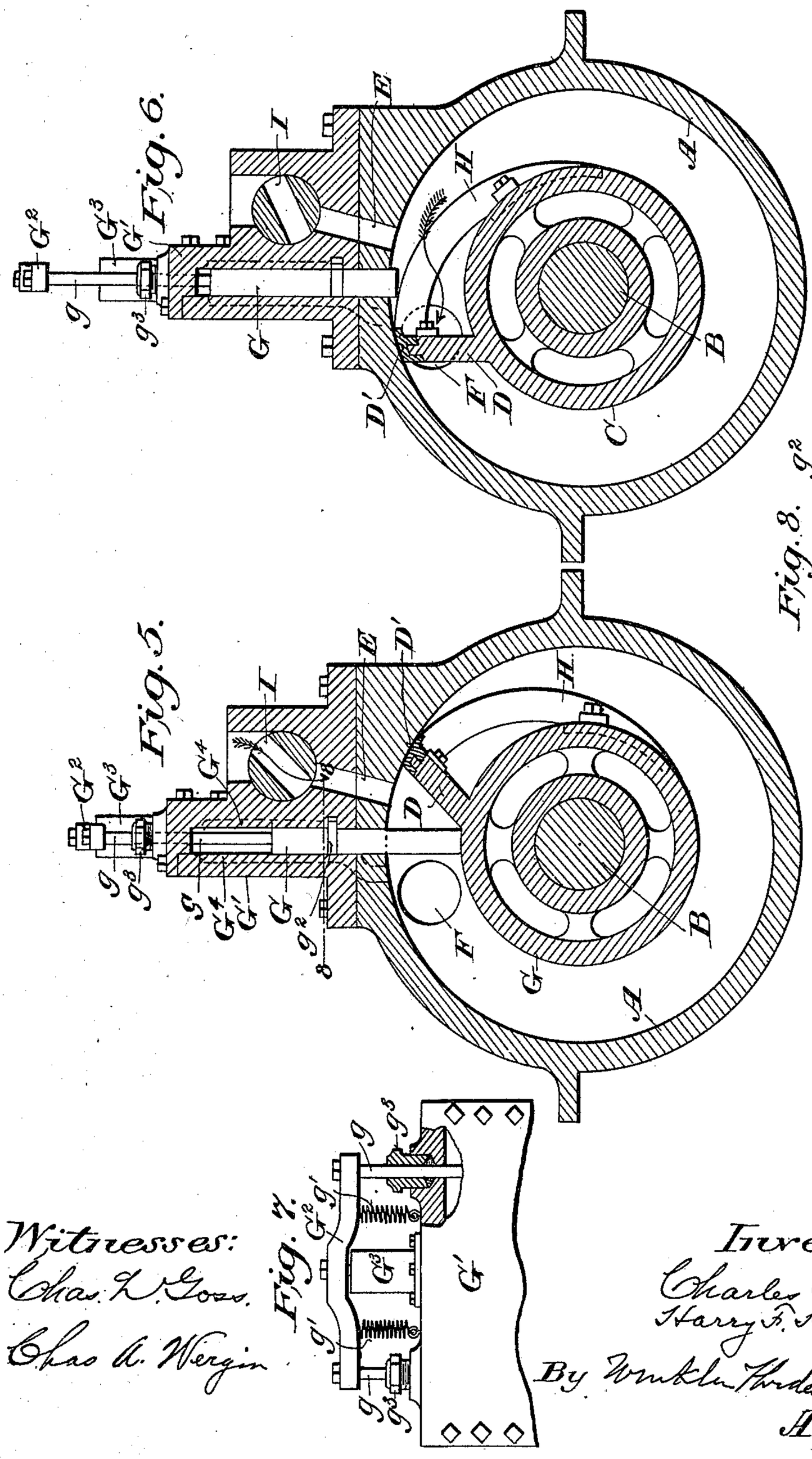
STEAM ENGINE.

(Application filed July 13, 1900.)

(No Model.)

6 Sheets—Sheet 5.



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STEAM ENGINE.

(Application filed July 13, 1900.)

(No Model.)

6 Sheets—Sheet 6.

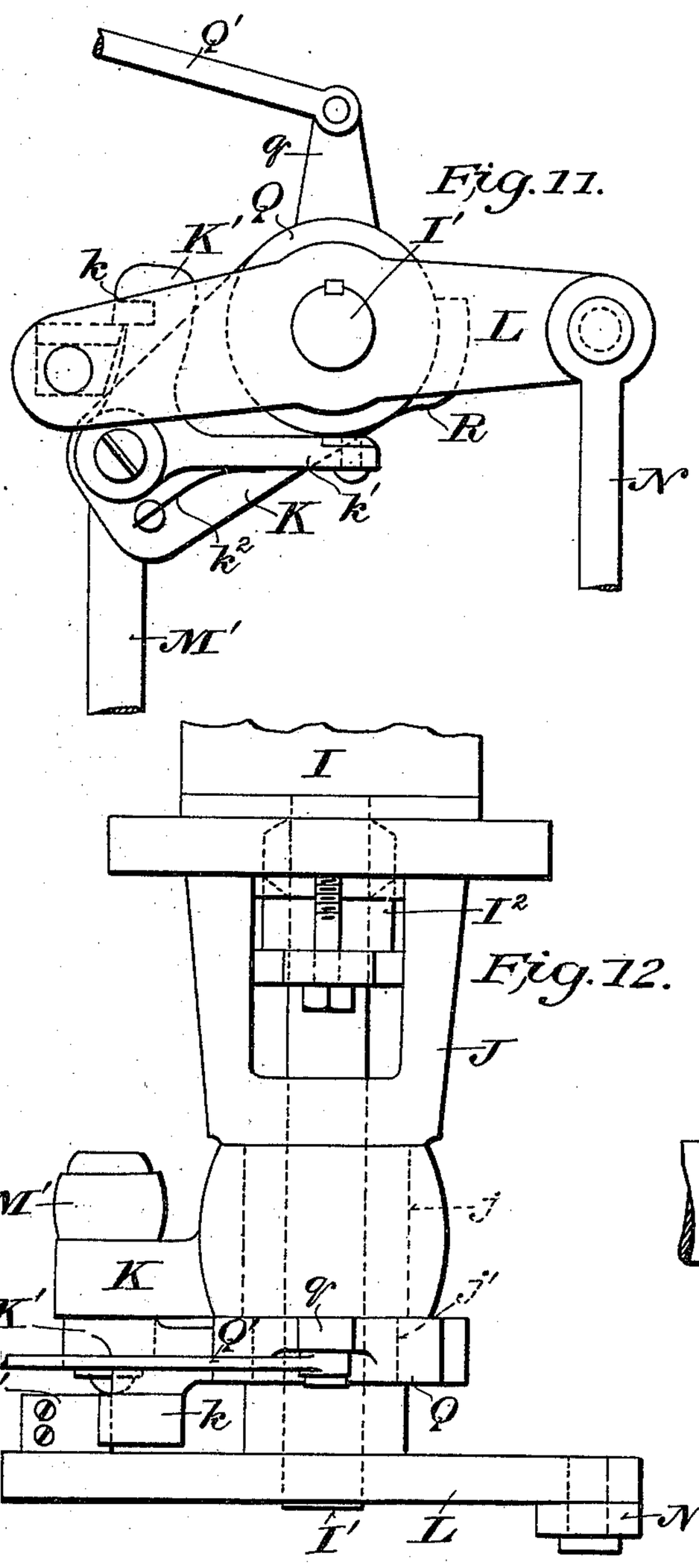

Fig. 11.

Fig. 12.

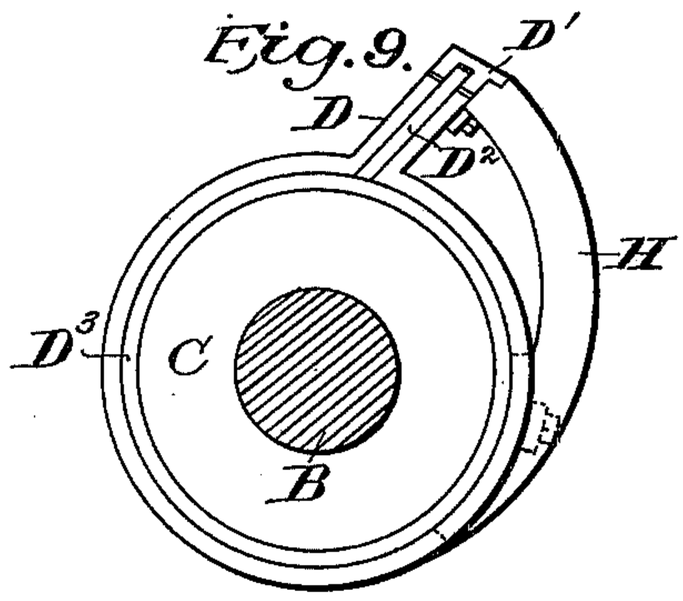

Fig. 9.

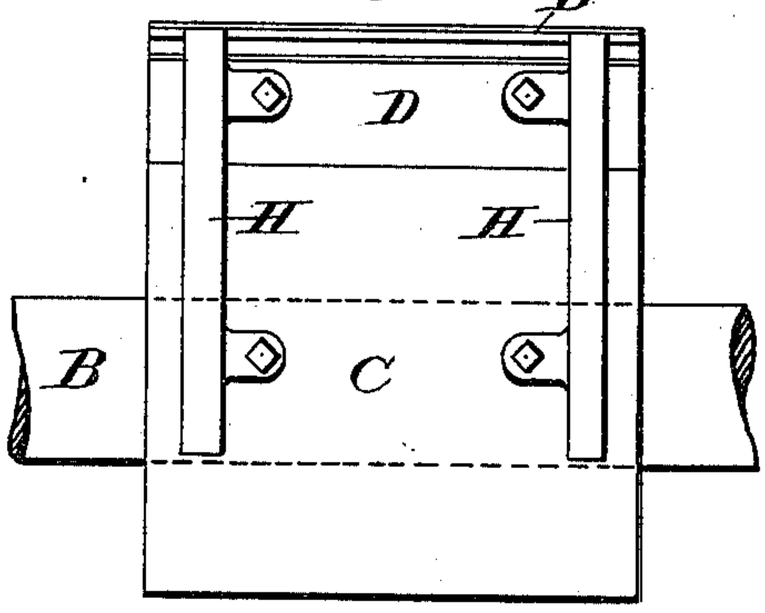

Fig. 10.

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UNITED STATES PATENT OFFICE.

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STEAM-ENGINE.

SPECIFICATION forming part of Letters Patent No. 669,458, dated March 5, 1901.

Application filed July 13, 1900. Serial No. 23,545. (No model.)

To all whom it may concern:

Be it known that we, CHARLES FISHER and HARRY F. KRUEGER, citizens of the United States, residing at Milwaukee, in the county of Milwaukee and State of Wisconsin, have invented certain new and useful Improvements in Steam-Engines, of which the following is a specification, reference being had to the accompanying drawings, forming a part thereof.

Our invention relates to new and useful improvements in the construction of steam-engines, and relates more particularly to that class of steam-engines commonly known as the "rotary" type; and our said invention consists in the matters hereinafter described, and pointed out in the appended claims.

One object of our invention is to provide an improved form of rotary engine which shall be at once of simple, strong, and durable construction and which shall by its peculiarity of construction be capable of economical use of steam and the development therefrom of the highest possible efficiency in horse-power from a given volume of steam under a given pressure.

A further object of our improvement is to enable us to construct engines of a rotary type that will be capable of perfect and accurate government and to apply thereto suitable automatic cut-off mechanism whereby the engines may be enabled to satisfactorily operate by the expansion of steam.

A further object of our invention is to enable us to construct rotary engines of compound character in which the steam may be repeatedly expanded from one cylinder to another and the full efficiency of the steam thus utilized, the steam being eventually discharged into a condenser, thereby obtaining the additional effective pressure derived from the vacuum thus formed.

The various features of our invention will be hereinafter fully described with reference to the accompanying drawings, in which—

Figure 1 is a plan view, partly in section, of a triple-expansion rotary engine constructed in accordance with our invention. Fig. 2 is a horizontal longitudinal sectional view of the same, taken on line 2 2 of Fig. 3. Fig. 3 is an end elevation of the same, showing parts broken away to better illustrate the construction. Fig. 4 is a broken transverse sectional view of the same. Fig. 5 is a detail transverse vertical sectional view illustrating the construction of one of the cylinders, together with the valve mechanism for controlling the admission of steam thereto. Fig. 6 is a similar view showing a changed position of the parts. Fig. 7 is a broken detail elevation of one portion of the device. Fig. 8 is a detail transverse sectional view taken on line 8 8 of Fig. 5. Fig. 9 is an end elevation of one of the rotary pistons. Fig. 10 is a side elevation of the same. Fig. 11 is an enlarged detail elevation showing the end of the valve-rod and the connected trip mechanism for automatically controlling the movements of the same by means of the governor. Fig. 12 is a plan view of the same.

In carrying out our invention we arrange one, two, three, or more cylinders or chambers upon the shaft in such a manner that revoluble pistons secured to said shaft may be caused to rotate within said cylinders or chambers, the pistons engaging in an operative manner with the inner surfaces of the cylinders or chambers, as will be presently described.

We will first describe our improvement with relation to a single cylinder only, it being of course understood that the piston mechanism shall be duplicated for each additional cylinder employed in case the device is constructed as a compound or multiple-expansion engine. The device illustrated in Figs. 5 and 6 shows more particularly the construction of a single cylinder and a revoluble piston therein and a rocking valve for governing the admission of steam to the cylinder.

Referring by letter to said drawings, A designates the cylinder, within which is revolubly supported a shaft B, extending lengthwise of the cylinder, and said shaft carrying a suitable hub or drum C, which latter is provided with a wing-piston D, extending outward and operatively engaging with the inner surface of the cylinder or casing. An inlet port or passage E is arranged to communicate with the interior of the cylinder or casing A at a suitable point, and an exhaust opening or port F also communicates with the

said cylinder at another point and is conveniently arranged near to the port or inlet E.

Between the inlet-port E and the exhaust-port F is conveniently placed a movable abutment or slide G, adapted to normally rest at its lower edge upon the surface of the hub or drum C, which carries the wing-piston D. This abutment G when in the position indicated in Fig. 5 serves to confine the steam which enters the casing between the wing-piston D and the abutment, but when raised from its seat upon the hub or drum C opens communication between the exhaust-port F and the inlet side of the cylinder or casing.

One or more suitable cams H H are provided upon the hub or drum and are arranged to engage with the lower edge of the abutment G at certain periods in the rotation of the hub or drum, so as to elevate said abutment and establish communication between the exhaust port or passage and the inlet side of the cylinder or casing.

A valve I is provided for governing the admission of steam to the inlet-port E, and this valve may be of any desired form, the particular style of valve shown in the drawings being the oscillating or rocking valve. It is of course essential that the valve shall be connected with a suitable actuating device—such, for instance, as an eccentric—by means of which its movements may be regulated so as to admit steam to the cylinder or casing when the wing-piston reaches a position such as is shown in Fig. 5 and to cut off steam before or by the time when the cams H H begin to lift the abutment G. Now supposing the parts to be in the positions indicated in Fig. 5, steam being admitted through the valve I and the port E to the cylinder, it is obvious that steam-pressure bearing directly upon the wing-piston D and reacting against the abutment G will serve to impart rotation to the wing-piston D, the hub or drum C, and the shaft B, actuated thereby. It also follows that when the piston, together with the drum and shaft, have revolved to such a point as to bring the cams H H into engagement with the lower edge of the abutment, so as to begin to lift the same from its seat upon the hub or drum, steam will begin to exhaust from the cylinder or casing through the passage F.

The cams H H may be made of any desired shape and proportions to insure a steady and gradual lifting of the abutment G and may be made to engage with said abutment at any desired point in the rotation of the shaft and the drum and are conveniently made to extend outward as far as the outer edge of the wing-piston, so that as the piston and the drum revolve the wing-piston will pass freely beneath the lower edge of the abutment.

The abutment G is suitably supported within a housing G′ and is freely movable vertically therein, and said abutment may either be arranged so as to be returned to its normal position by gravity or may be provided with actuating-rods g g, extending to the outside of the housing G′, normally drawn or pressed downwardly by means of suitable springs g' g', so as to assist in quickly returning the abutment to its normal position. The rods g g are conveniently connected together by a yoke or bar G^2, with which the springs g' g' are connected.

If desired, the wing D may be made as shown in Figs. 5, 6, and 9 of the drawings, in which said wing is inclined somewhat out of a radial position with respect to the hub or drum, or, as shown in Fig. 4, said wing may be made radial with respect to the said hub or drum. When the wing D is inclined out of a radial position, it will present an inclined surface for engagement with the lower edge of the abutment after the outer edge of the wing has passed from under said abutment, and the abutment bearing upon said inclined surface will descend more or less slowly and gradually as the wing and the drum revolve. When the wing is made radial, it will of course permit a relatively quicker return of the abutment to its normal position.

In order to insure a substantially noiseless operation of the abutment, we may provide any suitable means for cushioning the abutment upon its return movement, and for this purpose we find it convenient to provide a suitable dash-pot G^3 upon the housing, which engages with a piston carried by the yoke or bar G^2 in an obvious manner. It follows, therefore, that by this construction the movements of the abutment may be rendered practically noiseless, the return movement, while being assisted and facilitated by the weight of the abutment and also by the springs g' g', being partially arrested and cushioned by means of the dash-pot G^3.

Any suitable means may be provided for keeping the wing-piston tight within the cylinder, and for this purpose we find it convenient to provide upon the outer edge of the wing a suitable wearing-shoe or gib D′ for engagement with the inner surface of the cylinder or casing in the manner shown in the drawings.

As shown in Figs. 4 and 9, additional gibs D^2 D^2 may be provided for satisfactorily closing the space between the ends of the wing D and the hub or drum C and the cylinder-heads, so as to prevent leakage of steam past the ends of the wing or drum. Suitable means may also be provided for rendering the sliding abutment G steam-tight within the housing—such, for instance, as the gib g^2, let into a groove in the housing and bearing against the abutment in the manner shown.

The actuating-rods g g are conveniently carried up through stuffing-boxes g^3 g^3 upon the housing, which serve to maintain a steam-tight joint around said rods.

In order to insure ease of operation of the abutment, we prefer to chamber or recess the housing G′, as indicated at G^4, so as to admit steam from the exhaust side of the cylinder

to the interior of the housing, so as to nearly surround the abutment, and thereby "balance" the abutment.

When our improved engine is constructed as a multiple-expansion engine, a desired number of cylinders, as the cylinders A, A′, and A^2, are placed end to end upon the same shaft B, the cylinder A′ being larger than the cylinder A and the cylinder A^2 being larger than the cylinder A′, as is common in the construction of multiple-expansion engines. As shown more particularly in Fig. 2, one cylinder-head *a* may be used to close the adjacent ends of both of the cylinders A and A′, and a similar head *a′* may be used to close the adjacent ends of the cylinders A′ and A^2, thereby enabling the cylinders to be placed very close together and insuring a very compact form of construction. As is shown more particularly in Fig. 1 of the drawings, the exhaust port or passage F from one cylinder may readily be carried through the dividing-head and arranged to communicate with the next cylinder of the series, it being only necessary in order to accomplish the desired result to deflect said passage so as to communicate with the next cylinder upon the inlet side thereof, and to thus admit steam thereto between the wing-piston and the abutment when the latter is closed. It follows, therefore, that as the steam exhausts from the first cylinder it will enter directly into the second cylinder upon the inlet side of the abutment, so as to act against the wing-piston in the second cylinder, and the construction of the abutment G and the actuating-cams H H being the same in each cylinder it follows that when the steam exhausts from the second into the third cylinder it will similarly act upon the wing-piston in the third cylinder and finally exhaust from the last cylinder of the series. When desired, a pipe F′ may be arranged to communicate with the exhaust-port of the last cylinder of the series and to connect with a condenser in the ordinary manner, so as to produce a suction upon the exhaust side of the wing-piston in the last cylinder. In this manner our improved engine may be constructed as a multiple-expansion engine, being provided with the usual high-pressure, intermediate, and low-pressure cylinders, and, if desired, a greater number of cylinders than are shown in the drawings might be employed.

It will of course be understood that where a multiple-expansion engine is constructed in accordance with our invention the valve for governing the admission of steam will be provided only upon the first cylinder and that no regulating-valve need be applied to the inlet ports or passages of the intermediate or the low-pressure cylinders.

In constructing a triple-expansion engine according to our invention it is desirable that the wing-pistons in the several cylinders be so disposed about the shaft that they will successively reach the points of steam-inlet and the points of exhaust at different periods in the rotation of the shaft. We find it convenient in this construction to arrange the wing-pistons so as to stand substantially at angles of one hundred and twenty degrees with respect to each other, this arrangement producing successive exhausts of the three cylinders at equidistant periods in the rotation of the engine-shaft. It will be seen by reference to Figs. 2 and 4 of the drawings that when the parts are in the positions illustrated therein the wing-piston in the first or high-pressure cylinder has just passed the exhaust-port, the exhaust-port being now separated from the inlet side of the cylinder by the wing-piston, the abutment being raised to the uppermost limit of its movement, and that the high-pressure cylinder has been exhausting into the intermediate cylinder for the period of time during which the cams H H have held the abutment out of engagement with the hub or drum C and until the space between the inlet and the exhaust side of the high-pressure cylinder is closed by the wing-piston D. It will also be seen that the wing-piston in the intermediate cylinder has traveled one-third of the distance from the abutment, while the piston in the low-pressure cylinder has reached a position in which the cams H H are just ready to engage with and lift the abutment to permit the exhaust of steam from the low-pressure cylinder into the condenser. By thus arranging the pistons upon the shaft so as to take and exhaust steam at equidistant points in the rotation of the shaft the effective pressure will be applied to the piston of the high-pressure cylinder at the time when the low-pressure cylinder is exhausting and during the time in which the low-pressure cylinder is receiving steam from the intermediate cylinder, the effective pressure being applied to the piston in the intermediate cylinder during the period of the exhaust from the high-pressure cylinder and while steam received into the low-pressure cylinder during the preceding rotation of the shaft is expanding preparatory to its final exhaust from the low-pressure cylinder. It will furthermore be seen that the exhaust-passage of each cylinder being always open into the next cylinder the suction of the condenser when the abutment of the low-pressure cylinder is raised will act directly upon the wing-piston in the intermediate cylinder, this action continuing throughout one-third of the rotation of the shaft, and the suction of the condenser acting upon the wing-piston in the low-pressure cylinder during the remaining third of the rotation. It will furthermore be seen that when the abutment in the intermediate cylinder is raised, both of the abutments in the high-pressure and the low-pressure cylinders being closed, a direct communication is established between the high and the low pressure cylinders through the intermediate cylinder, thereby permitting a quick relief of the pressure from the high-pressure cylinder and equalizing the

pressure in the intermediate and low-pressure cylinders, this condition continuing during one-third of the rotation in which the abutment in the intermediate cylinder is raised. During the remaining part of the rotation of the shaft before the abutment in the high-pressure cylinder is raised the steam in front of the wing-piston in the high-pressure cylinder is free to pass into the intermediate cylinder. By thus arranging the wing-pistons upon the shaft a uniform, continuous, and steady operation of the shaft is insured, pressure being continuously applied to one or more of the pistons and pressure being always applied to two of the pistons while the other cylinder is exhausting.

By the described arrangement of the wing-pistons to travel around within the respective cylinders the pressure of the steam which is admitted to the cylinders is transmitted directly to the shaft, so as to produce the desired rotation thereof without the intervention of any reciprocating pistons, cross-heads, and connecting-rods, such as are commonly used in reciprocating engines. It will furthermore be observed that by the arrangement of the wing-pistons at substantially right angles to the shaft the pressure is applied substantially at right angles to the shaft in the most effective manner possible to produce rotation of the latter and that this pressure is continuous, causing a steady rotation of the shaft without any dead-points in said rotation.

Any suitable or desired means may be provided for automatically regulating the speed of the engine and automatically regulating the admission of steam to the cylinders according to the speed attained or the load carried by the engine, and to this end the actuating-stem I′ of the valve I may have an operative connection with any convenient form of governor mechanism—such, for instance, as that shown in Figs. 3, 11, and 12 of the drawings. The particular form of governor mechanism illustrated in said drawings is one form of the well-known "Corliss" type of governor, and in this particular form of construction we have shown a suitable bonnet extending outward from the end of the valve-chamber and forming a bearing in its outer end for the valve-stem I′. The valve-stem I′ is of course carried outward through a suitable gland or stuffing-box I^2, which prevents the escape of steam from the valve-chamber. The outer end of the bonnet J is turned down or reduced in diameter, so as to form a bearing *j* for a rock-arm K, carrying a trip-hook K′, and a valve-arm L is conveniently keyed to the outer end of the valve-stem I′, as shown, and is provided with a projecting ledge L′, adapted for engagement with the nose *k* of the trip-hook K′. An eccentric M is located upon the shaft B, and its strap *m* is connected by means of an eccentric-rod M′ with the rock-arm K, so that the rotation of the shaft B will cause the eccentric to actuate the eccentric-rod M′ to oscillate the rock-arm K upon its bearing on the outer end of the bonnet J, the trip-hook K′ engaging with the projection L′ upon the valve-arm, and thus serving to alternately depress the end of said arm and permit its return upward movement. The opposite end of the valve-arm L is conveniently connected with a rod N, carrying a piston, which engages within a dash-pot N′, the suction of the dash-pot serving to return the valve-arm, together with the valve, to its normal position. A governor O is actuated from the shaft B in a familiar manner by means of a belt *o*, passing over the governor-pulley O′, the governor-shaft *o*′, carrying the usual governor-arms O^2 O^2, having the weights or balls o^2 o^2 at their extremities, and said arms being linked to the usual collar O^3, which is caused to rise and fall by the movements of the governor-arms O^2 O^2 due to the centrifugal force developed by the rotation of the governor-shaft. A suitable yoke P has an operative connection with the collar O^3 and is connected by a link *p* with a stationary part of the governor-support, its other end being connected by means of a connecting-rod P′ with a bell-crank lever P^2. Upon the bearing *j*′ on the extremity of the bonnet J is located a trip-plate Q, having an operating-lever *q*, which is connected by a trip-rod Q′ with one arm of the bell-crank lever P^2. A cam R is arranged upon the trip-plate Q and is arranged to engage with an arm *k*′ upon the trip-hook arm K′, said arm *k*′ being normally pressed against the trip-plate by a spring k^2. It follows from this construction that as the speed of the engine increases and the governor-balls o^2 o^2 rise the rod P′ will actuate the bell-crank lever P^2, the connecting-rod Q′, and the trip-lever *q*, so as to adjust the trip-plate Q and move the cam R nearer to the free end of the arm *k*′, so that as the rock-arm K is turned downward by the eccentric-rod M′ the extremity of the arm *k*′ will ride up onto the surface of said cam and force the nose *k* of the trip-hook out of engagement with the ledge L′ upon the valve-arm. As soon as the valve-arm is freed by the hook the dash-pot, acting upon the piston-rod N, will serve to instantaneously return the valve-arm and the valve to their normal positions. It therefore follows from this construction that a further increase in speed of the engine would, through the governor mechanism, operate to adjust the trip-cam R into a position to sooner engage with the arm of the trip-hook and thus cut off steam from the cylinder at an earlier period in the rotation of the shaft. By this means the governor mechanism will automatically control and regulate the admission of steam, and when the load is light and the speed becomes excessive the steam is cut off at an early period in the rotation and the piston permitted to operate by the expansion of steam. On the other hand, when the load is heavy or in first starting the engine the trip-hook may remain in constant engage-

ment with the valve-arm or may be actuated at a later period in the rotation, in accordance with the speed at which the engine is running.

By our improved construction we are enabled not only to construct an engine by means of which steam-pressure is applied in the most direct and effective manner to the engine-shaft, but we are also enabled to construct engines which are capable of very close and accurate government or regulation and which will be very economical in the use of steam, developing a proportionately high efficiency in horse-power from the steam used. By our improvement, moreover, we are enabled to accomplish the desired regulation of the admission of steam to a plurality of cylinders by means of a single valve, whereas in the ordinary types of multiple-expansion engines one valve is provided for governing each inlet-port and each exhaust-port for each cylinder, thus making four valves to each cylinder, or twelve valves in all, for a triple-expansion engine. By the described arrangement of the wing-pistons to produce a continuous uninterrupted rotation of the hubs or drums and the shaft instead of the employment of the usual reciprocating pistons we are enabled to dispense with all mechanism between the high pressure and the intermediate, as well as between the intermediate and the low pressure, cylinders. Furthermore, by the described construction of the cylinders and the wing-pistons therein no special provision is necessary for draining or removing water of condensation from the cylinders, as is necessary in ordinary types of engines, it being of course understood that any water of condensation which accumulates in either one of the cylinders would be swept around to the exhaust port or passage by the wing-pistons and would pass freely from one cylinder to another and be ultimately discharged into the condenser.

In case one cam H is employed it may be constructed with a continuous bearing-surface to fit against the inner end of the abutment G, and thus prevent the passage of steam from the inlet-port E to the exhaust-port F between the hub C of the piston and said abutment. In this case steam would be released from the cylinder only when the wing-piston D passes and uncovers the exhaust-port F.

Various changes in minor details of construction and arrangement of parts may be made without departing from the spirit and intended scope of our invention.

Having thus described our invention, what we claim as new, and desire to secure by Letters Patent of the United States, is—

1. In a steam-engine the combination with a suitable cylinder having inlet and exhaust ports, of a shaft extending lengthwise of the cylinder, a wing-piston carried by the shaft and operatively engaged with the interior of the cylinder or casing, a movable abutment for normally preventing communication between the inlet and the exhaust ports, and suitable means carried by the shaft for engaging with said movable abutment to periodically elevate the same and permit steam to pass beneath the abutment to the exhaust-port, substantially as described.

2. In a steam-engine the combination with a suitable cylinder or casing having inlet and exhaust ports and a shaft extending lengthwise thereof and provided with a hub, of a wing-piston extending outward from said hub and having an operative engagement with the interior of the cylinder or casing, a movable abutment adapted to normally engage with said hub and to prevent communication between the inlet and the exhaust ports, and suitable cams carried by said hub for periodically elevating said abutment from the surface of the hub to permit the passage of steam from the inlet side of the cylinder or casing to the exhaust-port between the abutment and the hub, substantially as described.

3. In a steam-engine the combination with the cylinder having the inlet and exhaust ports, of the shaft carrying a hub, a wing-piston upon said hub fitting within said cylinder, a movable abutment between the inlet and exhaust ports for normally excluding steam from the exhaust-port, one or more suitable cams carried by the shaft and adapted to periodically engage with said abutment to elevate the same and permit steam to pass beneath it to the exhaust-port, and a valve operated from said shaft and adapted to be periodically opened at certain points in the rotation of the shaft to admit steam to the cylinder, substantially as described.

4. In a steam-engine the combination with the cylinder or casing provided with inlet and exhaust ports, of a shaft extending lengthwise therethrough, a wing-piston supported upon said shaft and operatively engaged within said cylinder or casing, a movable abutment adapted to normally prevent communication between the inlet and exhaust ports, suitable cams carried by the shaft and adapted to periodically engage with said abutment to elevate the same and permit the steam to pass from the inlet side of the cylinder to the exhaust-port beneath said abutment, and suitable means having operative engagement with said abutment for automatically returning the same to its normal position when released from engagement with said cams, substantially as described.

5. In a steam-engine the combination with the cylinder or casing provided with inlet and exhaust ports, of a shaft extending lengthwise therethrough and carrying a wing-piston operatively engaged with the interior of the cylinder or casing and provided upon its outer edge with an adjustable wearing-shoe, a movable abutment for normally preventing communication between the inlet side of the cylinder and the exhaust-port, and one or more cams carried by the shaft and extend-

ing outward as far as the outer edge of the wing-piston and adapted to periodically engage with the movable abutment to elevate the same and permit the exhaust of steam from the cylinder beneath the abutment, substantially as described.

6. In a steam-engine the combination with the cylinder having inlet and exhaust ports, the shaft, the drum carried thereby, the wing-piston upon the drum, the cams extending outward to the outer edge of the wing-piston, and the movable abutment for normally preventing communication between the inlet side of the cylinder and the exhaust-port, but adapted to be elevated periodically by said cams to permit steam to pass beneath it to the exhaust-port, of suitable means for automatically returning said abutment to its normal position, and suitable means for cushioning the return movement of said abutment, substantially as described.

7. In a steam-engine, the combination with the cylinder having inlet and exhaust ports, the shaft provided with the hub carrying a wing-piston having operative engagement within the cylinder or casing, the cams extending outward from said hub, and the valve for regulating the admission of steam to the inlet-port, of a movable abutment between the inlet and exhaust ports and adapted to normally rest upon said hub to prevent the passage of steam from the inlet side of the cylinder to the exhaust-port, and to be periodically elevated by the cams so as to permit steam to pass beneath it to the exhaust-port, one or more actuating-rods extending outward from said abutment, one or more springs operatively engaged with said actuating-rods to normally depress the abutment, and a suitable dash-pot for cushioning the return movement of the abutment, substantially as described.

8. The combination with the cylinder having inlet and exhaust ports, the shaft carrying the hub provided with a wing-piston fitted within the cylinder, and the cams extending outward to the outer edge of the wing-piston, of a suitably-chambered housing upon the cylinder, a sliding abutment operatively engaged within said chambered housing and adapted to normally rest upon the hub and to be periodically elevated by the cams to permit steam to pass beneath it to the exhaust-port, a suitable gib for maintaining a steam-tight joint or packing around said abutment, actuating-rods extending outward from the abutment through glands upon the housing and yoked together by a cross-bar, one or more springs operatively engaged with said cross-bar to normally depress the same, a dash-pot upon the housing, and a piston carried by said cross-bar for cushioning the return movement of the abutment, substantially as described.

9. A multiple-expansion steam-engine comprising a plurality of cylinders arranged in alinement and each having inlet and exhaust ports, a shaft extending through all of said cylinders and provided in each cylinder with a revoluble hub or drum carrying a wing-piston and one or more lifting-cams, a movable abutment adapted to normally extend into each cylinder and to rest upon the hub or drum therein, and to be periodically lifted by said cams to permit steam to pass between it and the drum to the exhaust-port, and a single controlling-valve for regulating the admission of steam to the first cylinder of the series, substantially as described.

10. In a multiple-expansion engine, a plurality of cylinders of successively-increasing capacities arranged end to end and in alinement, and each provided with inlet and exhaust ports, a shaft extending centrally through all of said cylinders and provided in each cylinder with a revoluble hub or drum carrying a wing-piston and one or more lifting-cams, a housing upon each cylinder, a sliding abutment within each of said housings adapted to normally rest upon the hub within the cylinder and to be periodically elevated by said cams to permit steam to pass between it and the drum to the exhaust-port, a single valve for governing the admission of steam to the inlet-port of the first or high-pressure cylinder, and suitable means actuated by the shaft for automatically regulating the movements of said valve, substantially as described.

11. In a multiple-expansion engine, a plurality of cylinders of successively-increasing capacities arranged end to end and in alinement, and each provided with inlet and exhaust ports, a shaft extending centrally through all of said cylinders and provided in each cylinder with a revoluble hub or drum carrying a wing-piston and one or more lifting-cams, a housing upon each cylinder, a sliding abutment within each of said housings adapted to normally rest upon the hub within the cylinder and to be periodically elevated by said cams to permit steam to pass between it and the drum to the exhaust-ports, a single valve for governing the admission of steam to the inlet-port of the first or high-pressure cylinder, the exhaust-port of the first cylinder communicating directly with the inlet-port of the intermediate cylinder, and the exhaust-port of the intermediate cylinder similarly communicating with the inlet-port of the low-pressure cylinder, and suitable means actuated by the shaft for automatically regulating the movements of said valve, substantially as described.

12. In a multiple-expansion engine, a plurality of cylinders of successively-increasing capacities arranged end to end and in alinement, and each provided with inlet and exhaust ports, a shaft extending centrally through all of said cylinders and provided in each cylinder with a revoluble hub or drum carrying a wing-piston and one or more lifting-cams, a housing upon each cylinder, a sliding abutment within each of said housings

and adapted to normally rest upon the hub within the cylinder and to be periodically elevated by said cams to permit steam to pass between it and the drum to the exhaust-port, a single valve for governing the admission of steam to the inlet-port of the first or high-pressure cylinder, the exhaust-port of the first cylinder communicating directly with the inlet-port of the intermediate cylinder, and the exhaust-port of the intermediate cylinder similarly communicating with the inlet-port of the low-pressure cylinder, and the exhaust-port of the low-pressure cylinder communicating with a condenser, and suitable means actuated by the shaft for automatically regulating the movements of said valve, substantially as described.

13. In a multiple-expansion engine, a plurality of cylinders of successively-increasing capacities arranged end to end and in alinement, and each provided with inlet and outlet ports, a shaft extending centrally through all of said cylinders and provided in each cylinder with a revoluble hub or drum carrying a wing-piston and one or more lifting-cams, a housing upon each cylinder, a sliding abutment within each of said housings adapted to normally rest upon the hub within the cylinder and to be periodically elevated by said cams to permit steam to pass between it and the drum to the exhaust-port, a single valve for governing the admission of steam to the inlet-port of the first or high-pressure cylinder, the exhaust-port of the first cylinder communicating directly with the inlet-port of the intermediate cylinder, and the exhaust-port of the intermediate cylinder similarly communicating with the inlet-port of the low-pressure cylinder, and suitable means actuated by the shaft for automatically regulating the movements of said valve, the wing-pistons in the several cylinders being so disposed upon the shaft as to pass the inlet-ports of the respective cylinders at successive periods of the rotation of the shaft, substantially as described.

14. In a steam-engine the combination with a suitable cylinder or casing having inlet and exhaust ports, a shaft extending lengthwise therethrough and provided with a hub carrying a wing-piston and one or more lifting-cams, of a suitable housing upon the cylinder or casing, a sliding abutment movable upon said housing and adapted to normally engage with said hub and adapted to be periodically elevated by said cams to permit steam to pass from the inlet side of the cylinder and between the abutment and the hub to the exhaust-port, said housing being suitably chambered and provided with one or more steam-ducts communicating with the cylinder for admitting steam to said housing so as to surround said abutment and equalize the pressure upon all sides thereof, substantially as described.

15. In a steam-engine the combination with a suitable cylinder or casing having inlet and exhaust ports and a shaft extending lengthwise therethrough and provided with a hub, of a wing-piston extending outward from said hub and having operative engagement with the interior of the cylinder or casing, a movable abutment adapted to normally engage with said hub and to prevent communication between the inlet and exhaust ports, and a suitable cam carried by said hub for periodically moving said abutment outward and permitting the wing-piston to pass it, substantially as and for the purposes set forth.

16. A multiple-expansion engine comprising a plurality of cylinders arranged in alinement and each having inlet and exhaust ports, a shaft extending through all of said cylinders and provided in each cylinder with a hub carrying a wing-piston and a cam, a movable abutment normally extending into each cylinder against the hub therein, and adapted to be periodically moved outward by the cam on the hub in said cylinder to allow the wing-piston to pass, and a single valve controlling the admission of steam to the first cylinder of the series, substantially as and for the purposes set forth.

In witness whereof we hereto affix our signatures in presence of two witnesses.

CHARLES FISHER.
HARRY F. KRUEGER.

Witnesses:
CHAS. L. GOSS,
CHARLES A. WERGIN.