No. 813,819. PATENTED FEB. 27, 1906.

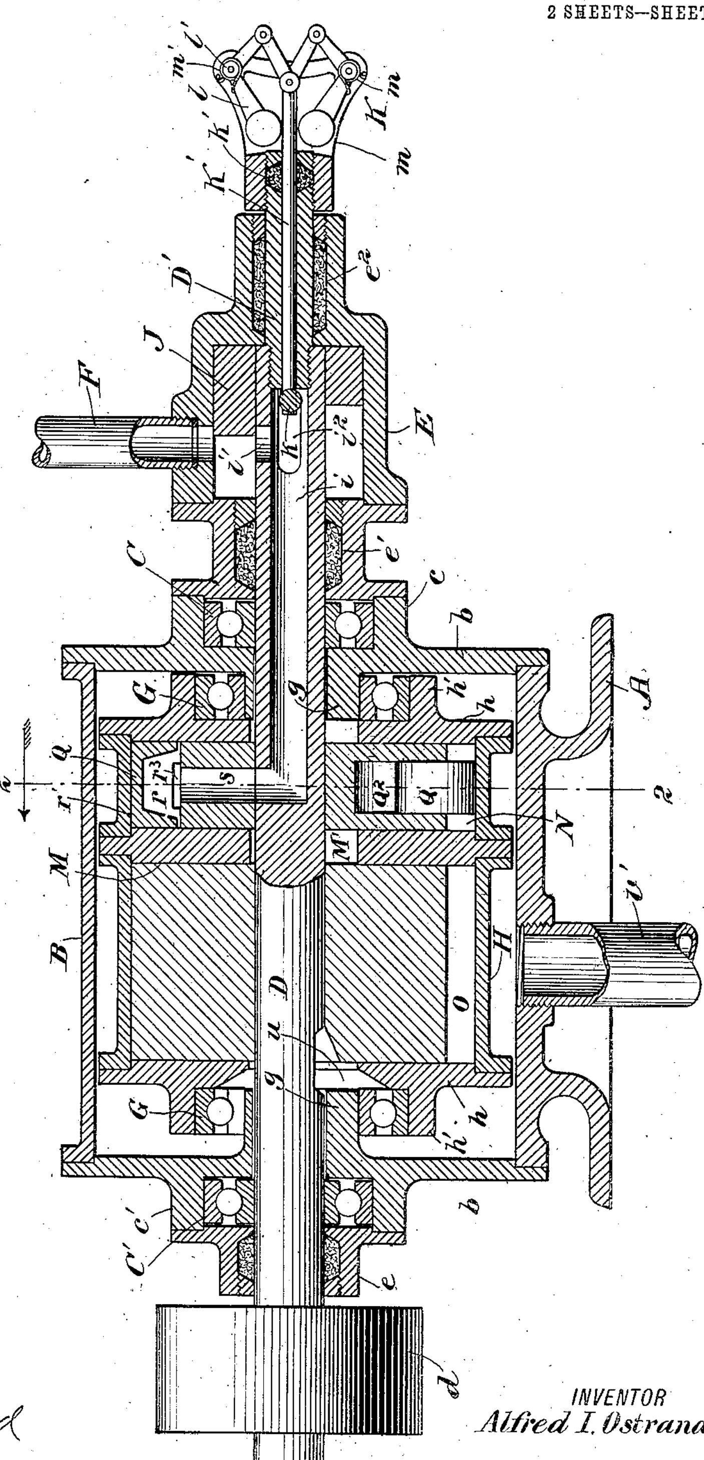
A. I. OSTRANDER.

MULTIPLE EXPANSION ROTARY ENGINE.

APPLICATION FILED MAY 27, 1905.

2 SHEETS—SHEET 1.

Fig. 1.



WITNESSES:

Robert Head

V. E. Nichols

INVENTOR

Alfred I. Ostrander,

BY

Griffin & Bernhard

ATTORNEYS

No. 813,819. PATENTED FEB. 27, 1906.

A. I. OSTRANDER.

MULTIPLE EXPANSION ROTARY ENGINE.

APPLICATION FILED MAY 27, 1905.

2 SHEETS—SHEET 2.

Fig. 3.

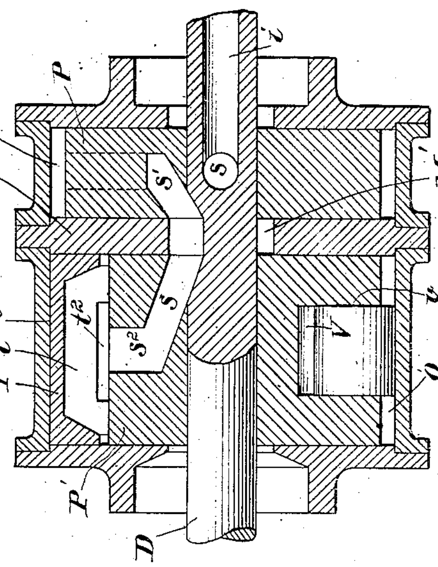


Fig. 4.

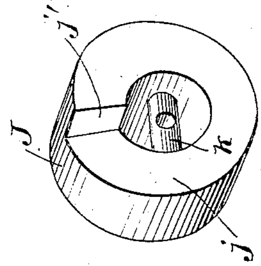
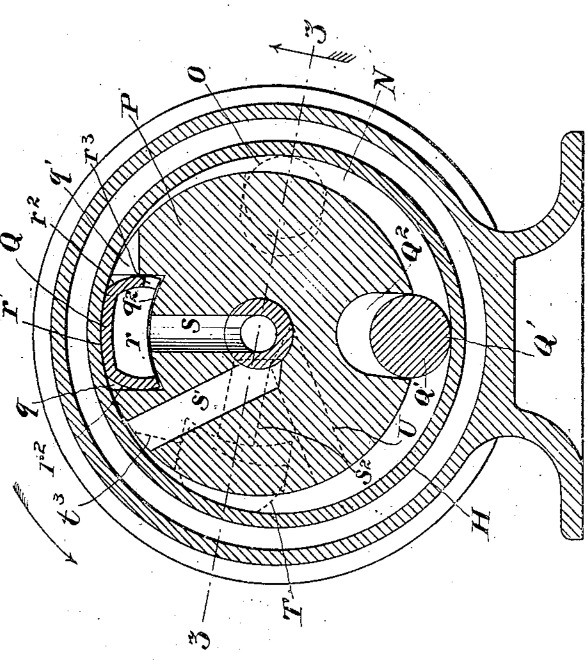


Fig. 2.



WITNESSES:

Robert Head

V. E. Nichols

INVENTOR

Alfred I. Ostrander.

BY

Griffin & Bernhard

ATTORNEYS

UNITED STATES PATENT OFFICE.

ALFRED I. OSTRANDER, OF YONKERS, NEW YORK.

MULTIPLE-EXPANSION ROTARY ENGINE.

No. 813,819. Specification of Letters Patent. Patented Feb. 27, 1906.

Application filed May 27, 1905. Serial No. 262,542.

To all whom it may concern:

Be it known that I, ALFRED I. OSTRANDER, a citizen of the United States, residing at Yonkers, in the county of Westchester and State of New York, have invented certain new and useful Improvements in Multiple-Expansion Rotary Engines, of which the following is a specification.

My invention relates to a rotary engine of that type wherein a revoluble member has eccentric relation to a cylindrical casing.

One part of this invention is a novel construction of the engine whereby a motive fluid, such as steam or air, is expanded for a number of times—say two, three, or more—as it passes successively through a corresponding number of pressure-chambers, said motive fluid being capable of multiple expansions in the engine and being utilized at successively lower pressures for the propulsion of the engine-shaft.

Another part of the engine is a novel construction of piston-shoe adapted for movement radially of the piston by centrifugal force and by the pressure of the motive fluid in order to maintain the necessary tight engagement with a working cylinder, said piston-shoe having in addition to the radial movement a rocking engagement with the piston-body and said shoe being adapted to be kept while in a working position in engagement with the cylinder and with the piston-body by pressure of the motive fluid.

Another part of the invention resides in a working cylinder adapted to rotate freely on its longitudinal axis and occupying a concentric relation to an inclosing casing, the revoluble engine-piston being eccentric to the working cylinder by which the piston is inclosed, whereby the friction and wear between the piston shoe or shoes and the working cylinder are minimized.

Another part of the invention is an automatic cut-off adapted to be actuated by a governor occupying an exceedingly compact relation to the engine-shaft and adapted to be operated under abnormal speed conditions for reducing the supply of motive fluid to the high-pressure chamber.

Other improvements and advantages will be hereinafter described and claimed.

Reference is to be had to the accompanying drawings, forming a part of this specification, wherein like characters of reference are used to indicate corresponding parts in all the figures.

Figure 1 is a longitudinal sectional elevation through a compound rotary engine constructed in accordance with my invention. Fig. 2 is a vertical cross-section taken in the plane of the dotted line 2 2 of Fig. 1 looking in the direction of the arrow. Fig. 3 is a sectional elevation taken in the plane of the dotted line 3 3 of Fig. 2 looking in the direction of the arrow. Fig. 4 is a detail perspective view of a cut-off for controlling the supply of steam to the high-pressure chamber.

A designates a suitable base which supports a cylindrical casing B, the ends or heads *b* of which casing are adapted to be secured removably in place by bolts or otherwise. Said heads *b* are provided with external bearing-seats *c c'*, which are eccentric to the axis of the cylinder, and these seats accommodate the journal-bearings C C' for the engine-shaft D. This shaft extends continuously through the engine, and it is mounted for free rotation in said shaft-bearings C C', the latter being herein shown in the form of roller, ball, or antifriction bearings, although it will be understood that any suitable kind of shaft-bearing may be employed. One head *b* is provided adjacent to the shaft-bearing C' with a stuffing-box *e*, through which passes one extremity of a shaft D, the latter being provided at said protruding end with a driving-pulley *d*. On the other head *b*, next to the shaft-bearing C, is another stuffing-box *e'*, and to this box is united a steam-chest E, the latter being provided at its distant end with a stuffing-box e^2. A feed-pipe F is united in a suitable way to the steam-chest E for the purpose of supplying the motive fluid under pressure to a hollow length or section of the engine-shaft D, as will presently appear.

The heads *b* of the stationary inclosing casing B are provided with internal hubs or sleeves *g g'*, the latter being concentric with the casing B and eccentric to the bearings C C'. These internal hubs *g* are adapted to support the bearings G G' for a revoluble working cylinder H, the heads *h* of which are provided with seats *h'*. Said seats extend externally from the cylinder-heads *h* toward the heads *b* of the stationary casing, and between the hubs *g* and the bearing-seats *h'* are the bearings G G' for the working cylinder H. Said bearings are shown as antifriction, ball, or roller bearings; but it is evident that the type of bearing for the working cylinder H may be modified or changed similarly to the bearings C C′ for the engine-shaft. The bearings G G′ are concentric with the longitudinal axis of the stationary inclosing casing B, thus making provision for supporting the working cylinder H in concentric relation to the inclosing casing; but, as heretofore stated, the shaft-bearings C C′ are eccentric both to the inclosing casing B and the working cylinder H, whereby the shaft D is mounted for free rotation within the casing B and the cylinder H and in eccentric relation to both of these parts. This shaft D extends loosely through the hubs g, so as to have the desired clearance with respect thereto; but the shaft is packed within the stuffing-boxes e e' e^2 in order to minimize the leakage of steam. The shaft D is hollow for a certain part of its length to provide an inlet-passage i, and in this shaft are the opening i' and the slot i^2, thus establishing communication between the hollow part i of the shaft and the chamber of the steam-chest E. The end of the shaft at the hollow part thereof terminates in the steam-chest E, and in this open end of the shaft is secured an extension D′, the latter being hollow and extending through the stuffing-box e^2.

On the hollow end of the shaft D is a slidable cut-off J, the latter fitting snugly within the steam-chest E and adapted to have a traversing endwise movement with respect to the inlet-port f^2 of said steam-chest. This cut-off is provided with a spiral working face j, which terminates in an abrupt shoulder or ledge j', as shown more clearly by Fig. 4. The cut-off is adapted to regulate the length of time during each revolution that the inlet-port f is in communication with the steam-supply of the boiler in order to reduce the volume of steam admitted to the chest E, the pressure in which is regulated or controlled by the action of the cut-off J. In the cut-off is secured a cross-pin k, which extends through the slots i^2 of the shaft, said pin having movement in said slots with the cut-off, and to this pin is attached an endwise-movable stem K′ of a centrifugal governor K. The stem K′ extends through the hollow extension D′ of the engine-shaft and through the stuffing-box k', which is attached to the protruding end of said extension D′. The centrifugal governor may be of the usual type or it may be of any preferred style; but, as herein shown, the governor consists of weighted levers l, fulcrumed at l' on a carrier or head m, the levers being held normally in closed relation by springs m' or their equivalents. It will be understood that my invention is not restricted to the use of any particular type of governor for actuating the cut-off J automatically; but in the present instance I have arranged the governor in coaxial relation to the engine-shaft and provided an exceedingly compact disposition of parts wherein the operating member between the cut-off and the governor proper is a slidable stem extending longitudinally through a part of the engine-shaft.

The working cylinder H is divided by an internal partition M into a high-pressure chamber N and a low-pressure chamber O, the last-mentioned chamber being of larger area than the high-pressure chamber N, because the partition M is situated at one side of the middle of said working cylinder. The partition M is secured in the cylinder so as to have steam-tight engagement therewith at the periphery of the cylinder; but this partition is provided with a single opening M′ for the shaft D to pass through the same. (See Figs. 1 and 3.)

The rotary eccentric piston of a compound engine constructed in accordance with my invention consists of two members P P′, which are made fast with the engine-shaft D and are arranged to work in the pressure-chambers N and O, respectively. Said members of the piston operate within the working cylinder H on the respective sides of the division or partition M, and said members P P′ are concentric with the shaft D, to which they are secured, whereby the piston members have the necessary eccentric relation to the working cylinder H, in order to have engagement at all times with said working cylinder on one side of the piston. The piston-member P is provided in its periphery with a pocket q and with a passage q', which opens into said pocket above the bottom thereof, said bottom of the pocket q^2 being curved on a radius concentric with the shaft D. In this pocket is arranged a piston-shoe Q, which is of chambered construction and is adapted to have tight engagement with the inner surface of the working cylinder H and a rocking engagement with the parallel side walls of the pocket q, said walls being parallel to a radial line through the center of the piston member P, as shown by Fig. 2. The piston-shoe Q extends the full length of the piston member P and the width of the high-pressure chamber N, and this piston-shoe is provided with a chamber r. The shoe is furthermore provided with an arcuate face r', adapted to have engagement with the inner surface of the working cylinder H, and the walls of the chambered piston-shoe are curved, as at r^2, for the purpose of permitting the piston-shoe to have a rocking engagement with the parallel walls of the pocket q, the radius of the walls r^2 being shorter than that of the wall or face r'. The steam or other motive fluid is supplied to the high-pressure chamber N by the passage i, which extends lengthwise of the engine-shaft D, and by a passage s, which extends radially through the piston member P, so as to open into the pocket q and into the chamber r of the piston-shoe Q, as clearly shown by Figs. 1 and 2.

It will be seen that the piston-shoe Q is exposed to the pressure of the motive fluid supplied through the passages i s, extending from the pressure-chest E to the pressure-chamber N, and when the engine is in service this piston-shoe Q is acted on by centrifugal force, so as to move it radially with respect to the piston member P. The combined energy of the centrifugal force and the pressure of the motive fluid on the piston-shoe keeps or maintains the arcuate face r' of said shoe normally in tight frictional contact with the inner surface of the working cylinder, and in the rotation of the shoe Q with the piston member P the shoe has a rocking movement with respect to the piston member, owing to the difference in diameters of the cylinder and the piston and the eccentric relation of the latter to the former. This radial movement of the piston-shoe relative to the piston is sufficient to close the port q' when the parts are in the position of Fig. 1; but as the parts assume the position shown by dotted lines in Fig. 2 for the other piston-shoe T, to be presently described, the shoe Q has a radial movement relative to the piston P, so as to open the ports q' r^3 for the motive fluid to pass into the chamber N back of the piston-shoe. It will be seen that the piston-shoe is kept in tight frictional contact with the working cylinder, although it has radial movement relative to the piston; but owing to the fact that the piston rotates on a different center from the axis of the cylinder I have found it advisable or necessary to construct the shoe Q in a way to have a slight rocking motion in and relative to the piston member, said rocking motion of the piston-shoe compensating for the difference in diameters of the piston and the cylinder and permitting the outer arcuate face r' of the shoe Q to remain in tight frictional engagement with the cylinder.

For the purpose of counterpoising the centrifugal action of the radially-movable piston-shoe on the working cylinder H, I provide a counterpoise Q'. (See Fig. 2.) The piston member P is provided with a pocket Q^2 at a point diametrically opposite to the pocket q, and in this pocket Q^2 is arranged the counterpoise Q', which is adapted to have radial movement freely in the pocket and to be maintained by centrifugal force in contact with the inner surface of the working cylinder H, said counterpoise having a traveling or rolling contact with said cylinder.

The working fluid is exhausted from the high-pressure chamber N through an exhaust-passage S. (See Fig. 3.) One branch s' of this exhaust-passage is formed radially and irregularly in the piston member P, so as to open through the periphery of said member at a proper distance from the pocket q, while the other end of said branch s' communicates with the opening M' of the division or partition M. The exhaust-passage S extends into the engine-shaft D, as shown by Fig. 3, and the remaining branch s^2 of this exhaust-passage extends irregularly and radially through the piston member P', as shown by dotted and full lines in Figs. 2 and 3, respectively. The branch s^2 of the passage S opens into another piston-shoe pocket t, the latter being provided in the periphery of the piston member P', as indicated by dotted lines in Fig. 2, the axis of the pocket t in the low-pressure section of the working cylinder being at an angle of less than ninety degrees, or thereabout, to the axis of the other pocket q in the piston member P of the high-pressure section of the cylinder. The pocket t in the piston member P' is similar in construction to the pocket q of the piston member P, and in this pocket t is the low-pressure piston-shoe T, the position of which is indicated by dotted lines in Fig. 2, and which is similar in construction to the piston-shoe Q. The shoe T extends the full length of the piston member P', and it has a peripheral arcuate face adapted for engagement with the inner face of the working cylinder H, said piston-shoe T being furthermore provided with curved side walls, which have rocking engagement with the parallel walls of the pocket t. The piston-shoe T is furthermore provided with a chamber t', having communication with the branch s^2 of the passage S in the rotary eccentric piston, and in one side of this piston-shoe T is a port t^2, adapted to communicate with the passage t^3 (indicated by dotted lines in Fig. 2) and similar to the passage q' of the piston member P. It will be seen that the motive fluid exhausted from the high-pressure chamber N is adapted to pass through the passage S and to be discharged into the chamber of the piston-shoe T, from whence it escapes through the ports t^2 t^3 into the low-pressure chamber O, so as to exert its pressure against the shoe T for the performance of useful work.

The motive fluid is exhausted from the low-pressure chamber O through an exhaust-passage U, one branch of which is indicated by dotted lines in Fig. 2, and which is shown as opening through the piston member P' adjacent to the pocket t for the shoe T, while the other branch of said exhaust-passage U cuts into the shaft D and opens, as at u, through one head h of the working cylinder H, so as to discharge the exhausted fluid through the bearings G' or through ports in head h around bearing G' into the casing B. From this casing the exhaust fluid makes its escape through the exhaust-pipe V', as shown by Fig. 1.

The section P' of the eccentric piston is provided with a pocket v at a diametrically opposite point to the piston-shoe pocket t, and in this pocket v is a counterpoise V, (see Fig. 3,) whereby the centrifugal action of the piston-shoe T on the working cylinder H is counteracted by the counterpoise V, the latter having a free movement in the pocket v, and also capable of rolling engagement with the inner surface of the working cylinder H, similar to the counterpoise in relation to the cylinder and the shoe Q.

The operation may be described as follows: Motive fluid under the required pressure is supplied by the pipe F through the port f^2 to the steam-chest E, and with the governor-controlled cut-off J in position assumed thereby under normal speed conditions the fluid passes at a regulated pressure through the chest E into the ports i' i^2 to the passage i. The fluid thence passes lengthwise of the shaft D to the supply-passage s in the piston member P and thence into the chamber r of the piston-shoe Q, which shoe in the position of Fig. 2 cuts off the passage of the fluid through the ports r^3 and q'. On the partial rotation of the piston and the shaft, so that the shoe Q will assume the position indicated by dotted lines for the shoe T in Fig. 2, said piston-shoe Q will be moved radially by the combined action of centrifugal force and pressure of the motive fluid, so as to keep the arcuate face of the shoe Q in tight frictional contact with the cylinder at all times. The shoe Q is thus made in its radial movement to open the ports r^3 and q', and fluid is admitted to the chamber N, in which it acts against the piston-shoe in a way to drive the piston in the direction of the arrow in Fig. 2. On the rotation of the piston the shoe has radial movement therein, and during each rotation said piston-shoe is slightly turned relative to the piston, so that its inner surface and one of its arcuate surfaces will be exposed to the pressure of the motive fluid, while two of the outer arcuate faces of the shoe have the required frictional and tangential engagement with the inner surface of the cylinder H and with one wall of the pocket q in the piston member P, respectively. The motive fluid is exhausted from the chamber N through the passage S, which extends through both piston members P P', and from this passage S the fluid acts against the low-pressure piston-shoe T, which is of larger area than the high-pressure shoe Q, and said shoe T is acted on by the fluid exhausted from the chamber N in a similar manner as the fluid acted originally on the shoe Q—that is to say, the shoe T is kept in tight frictional contact with the cylinder H by the centrifugal force and pressure of the motive fluid, and on the radial movement of the shoe relative to the piston the ports t^2 t^3 are opened at the proper time, thereby admitting the fluid back of the piston-shoe T and exerting pressure thereon in a direction required to drive the eccentric piston in the direction of the arrow. The two piston-shoes are acted on successively by the motive fluid, and the latter is finally exhausted through the passage u and the bearing G' or through independent ports in the head h around the bearing G' into the casing B, from whence the fluid makes its exit through the pipe V'. During the rotation of the piston and the shaft the cylinder H is free to turn on the supports provided therefor by the bearings G G', and thus the friction and wear due to the engagement between the piston-shoes and the working cylinder are reduced to a minimum, said piston-shoes having a comparatively small sliding movement on the inner surface of the working cylinder due to the eccentric arrangement of the shaft and the piston to said cylinder. The fluid is supplied at the required volume and under the necessary pressure through the port f^2 to the chest E, from whence the fluid passes through the ports i' i^2 into the shaft and thence to the pressure-chamber N; but in the event of the speed becoming abnormal the governor K acts to shift the stem K' and move the spiral end of the cut-off J across the inlet-port f^2 for a distance depending upon the speed, thereby reducing the admission of the volume of fluid to the chest E, and consequently the pressure and volume of steam supplied to the engine is regulated by the cut-off.

In the embodiment of the invention hereinbefore described the parts are constructed for operation so as to use the motive fluid at high and low pressures in a compound engine; but it is to be distinctly understood that the invention is not limited to a compound engine, because the principle of the invention can be made available in a multiple expansion-engine wherein the motive fluid is expanded a plurality of times. It is evident that a plurality of three or four pressure-chambers, a corresponding number of piston members and piston-shoes and their correlated parts may be used in the construction of a triple or quadruple expansion-engine of the rotary eccentric-piston type. Hence I desire to avail myself of the exclusive right to use my invention in the manner described.

Changes in the form, size, proportion, and minor details in construction may be made without departing from the spirit of the invention or sacrificing any of the advantages thereof, and I therefore reserve the right to make such alterations and modifications as fairly fall within the scope of my invention.

Having thus described my invention, what I claim, and desire to secure by Letters Patent, is—

1. In an engine, a cylinder, an eccentric piston, means for admitting fluid through said piston, and a hollow piston-shoe having arcuate faces in engagement with said piston.

2. In an engine, a rotary eccentric piston, and a radially-movable piston-shoe provided with curved bearing-surfaces which engage with, and are adapted to turn in, said piston.

3. In an engine, a cylinder, an eccentric revoluble piston carried by a shaft, a chambered piston-shoe having a radial and rocking movement relative to said piston, and means for supplying motive fluid to said piston-shoe.

4. In an engine, a cylinder, an eccentric piston therein, a passage for motive fluid in said piston, and a hollow shoe fitted in said piston for radial and rocking movement therein, said shoe being adapted to lie across said passage in the piston.

5. In an engine, a cylinder, an eccentric revoluble piston carried by a shaft, a chambered piston-shoe seated in the piston to have a radial movement and a rocking movement therein, said shoe in one position being adapted to cut off the passage of motive fluid back of the same, and means for supplying a motive fluid to the chambered shoe.

6. In an engine, a cylinder, an eccentric revoluble piston carried by a shaft, a piston-shoe, one face of which is of the same radius as the cylinder and having an arcuate face or faces of a different radius, whereby the shoe is adapted to have a radial movement and a rocking play relative to the piston, and means for supplying a motive fluid to the shoe.

7. In an engine, a cylinder, a rotary eccentric piston therein, said piston having a pocket or chamber in its periphery, a passage for motive fluid in communication with said pocket or chamber, and a hollow piston-shoe occupying said pocket or chamber and adapted to turn and to slide therein.

8. In an engine, a cylinder, an eccentric revoluble piston carried by a shaft, a chambered piston-shoe having a plurality of arcuate faces and a port in one of said faces, said port being adapted to register with a port in the piston, and means for supplying motive fluid to the shoe.

9. In an engine, a piston, a piston-shoe seated in said piston on one side thereof, and a counterpoise carried by the piston on the other side.

10. In an engine, a cylinder, a piston, a piston-shoe seated in said piston on one side thereof, and a counterpoise seated in the piston on the other side, the shoe and the counterpoise being held in contact with a cylinder under centrifugal energy and movable relative to said piston.

11. In an engine, a cylinder, a piston, a piston-shoe seated in said piston on one side thereof, and a counterpoise seated in the piston on the other side, said counterpoise having traveling contact with a cylinder and arranged to permit passage of fluid within the same.

12. In an engine, a piston having pockets at opposite points, a piston-shoe in one of said pockets, and an annular counterpoise movable freely in the other pocket.

13. In an engine, a working cylinder divided into piston-chambers, a piston having members adapted to operate in said chambers, passages in the members of the piston for supplying motive fluid directly to one of the chambers and for exhausting the motive fluid into other piston-chambers, and a plurality of piston-shoes seated on the respective members of the piston for operation in the piston-chambers, each piston-shoe being arranged across one of said passages in a piston member.

14. In an engine, a working cylinder divided into piston-chambers, a piston having members adapted to operate in said chambers, passages in the members of the piston for supplying motive fluid directly to one of the chambers and for exhausting the motive fluid into other piston-chambers, and a plurality of chambered piston-shoes, one of said shoes being in one of said piston-chambers and each shoe extending across one of said passages; one of the passages and the complemental shoe in one piston member being in a different plane lengthwise of the piston from another passage and the shoe in the next piston-chamber.

15. In an engine, a working cylinder divided into piston-chambers, a piston having members adapted to operate in said chambers, passages in the piston, one of said passages opening into a high-pressure chamber, another passage extending between the adjacent chambers, and each of said passages being free and unobstructed in the body of the piston, and a plurality of piston-shoes seated in the members of the piston, each of said shoes being across the outlet of one passage where the latter discharges into one of the piston-chambers.

16. In an engine, a plurality of pressure-chambers, a piston-shaft, a plurality of piston members on said shaft and adapted to operate in the respective chambers, unobstructed fluid-passages in the body of the piston members whereby communication is established between the chambers and with a source of supply, and a plurality of hollow shoes seated on the respective piston members and each arranged across one of said passages, a single shoe being in each of the pressure-chambers.

17. In an engine, a plurality of pressure-chambers, a piston having members adapted to operate in said chambers, fluid-passages in the piston members, and a plurality of piston-shoes seated in the respective piston members and each disposed across the outlet end of one of the passages, each piston-shoe engaging with one piston member for axial and slidable movement relative thereto.

18. In an engine, a plurality of pressure-chambers, a single shaft, a piston having members adapted to operate in the chambers, a plurality of piston-shoes on the respective members of the piston, each shoe being ca-

pable of a radial movement and a rocking movement, means for supplying motive fluid to one shoe, and a passage in the piston leading from one chamber to the other piston-shoe.

19. In an engine, a plurality of pressure-chambers, a single shaft, a piston having members adapted to operate in the chambers, a plurality of piston-shoes seated on the piston members and arranged in different radial positions relative to each other, a plurality of counterpoises seated in the piston members opposite to the piston-shoes therein, and means for supplying a motive fluid to the chambers through said shoes.

20. In an engine, a piston-shaft, a pressure-chest, a live inlet to said pressure-chest, a cut-off adapted to rotate with the piston-shaft and to slide across the live inlet to the pressure-chest, and a governor operatively connected to the cut-off for giving the slidable movement thereto.

21. In an engine, a piston-shaft, a pressure-chest, a live inlet to said chest, a cut-off having a spiral operating-face, said cut-off being revoluble with the shaft and also adapted to slide thereon for moving the spiral face across the live inlet, and a governor operatively connected with the cut-off for imparting the sliding movement thereto.

22. In an engine, a cylinder, a piston rotating on an axis different from that of the cylinder, and a piston-shoe seated on said piston, said shoe having a plurality of arcuate faces, one of which is normally in engagement with the cylinder, other arcuate faces of said shoe being in engagement with the piston to have rocking play relative to the piston.

23. In an engine, a cylinder, a rotary piston, a fluid-passage therein, and a piston-shoe seated in the piston across the outlet from the passage thereof, said shoe having a plurality of arcuate faces, one of which is adapted for engagement with the cylinder and the other faces engaging with the piston to enable the shoe to turn axially therein.

24. In an engine, a piston-shaft having means for the admission of a motive fluid, a pressure-chest, a cut-off slidable relative to an inlet-port to said pressure-chest, for regulating the area of said port, a governor on the piston-shaft, and a stem slidable in the piston-shaft and connecting the governor with said cut-off.

25. In a engine, a piston-shaft having a longitudinal passage and an inlet-port, a pressure-chest, a cut-off revoluble with said shaft, and slidable relative to an inlet-port of said chest, a governor in coaxial relation to the piston-shaft and carried thereby, and a stem slidable in the piston-shaft and operatively connecting the cut-off with said governor.

26. In an engine, a casing provided at its ends with a set of externally-located bearings, a piston-shaft journaled in said bearings, bearing-sleeves rigid with the casing and located internally thereof, a revoluble cylinder provided at its ends with hollow journals which surround the bearing-sleeves, bearings engaging with the hollow journals and the bearing-sleeves, and a piston on the shaft.

27. In an engine, a piston having a pocket and a fluid-passage, and a piston-shoe seated in said pocket of the piston for axial movement relative thereto and disposed across the passage, said shoe being of greater width that the depth of the pocket.

In testimony whereof I have signed my name to this specification in the presence of two subscribing witnesses.

ALFRED I. OSTRANDER.

Witnesses:
H. I. BERNHARD,
JAS. H. GRIFFIN.