March 28, 1950 A. SIMONS 2,501,856

PRIME MOVER APPARATUS

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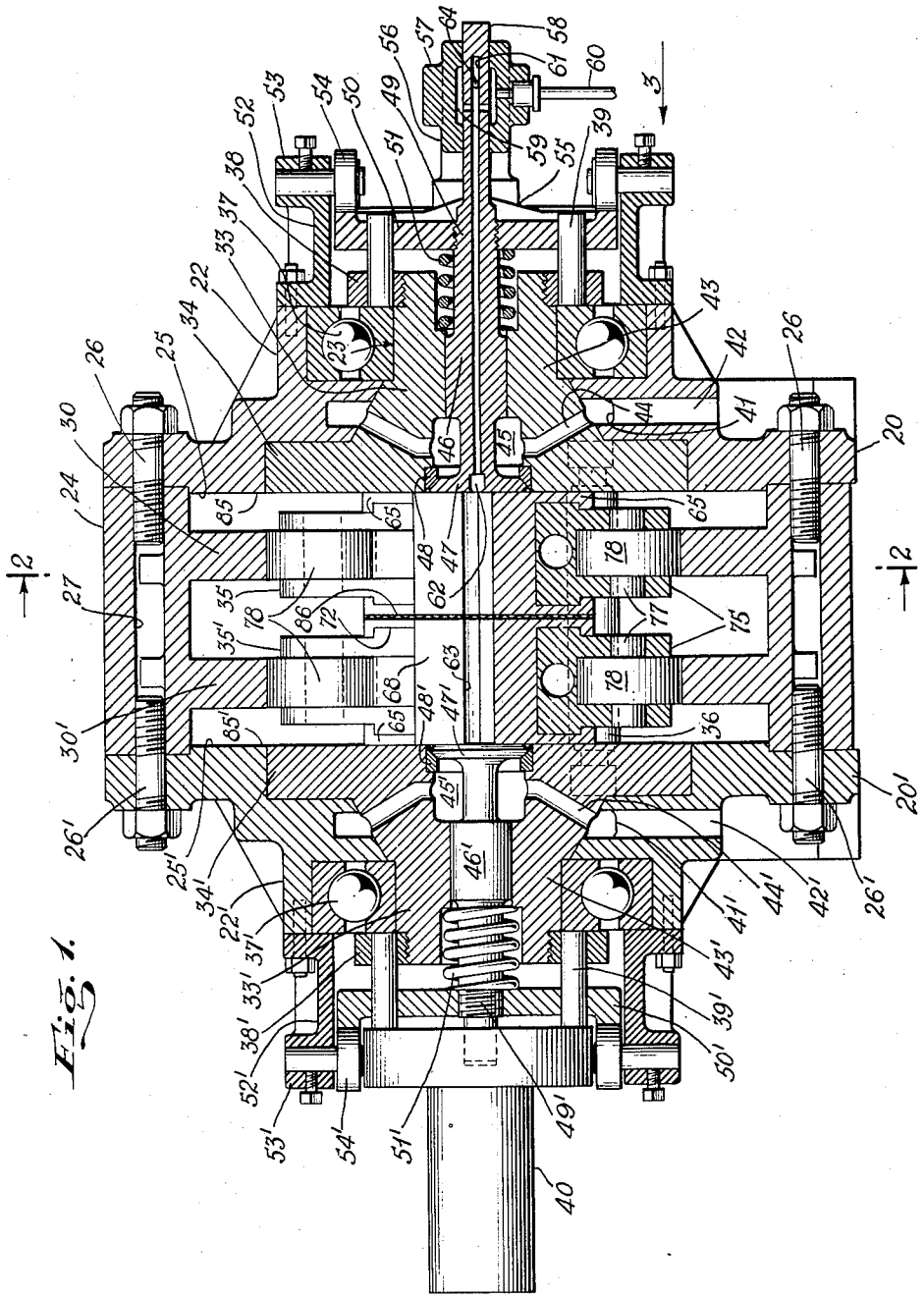


Fig. 1.

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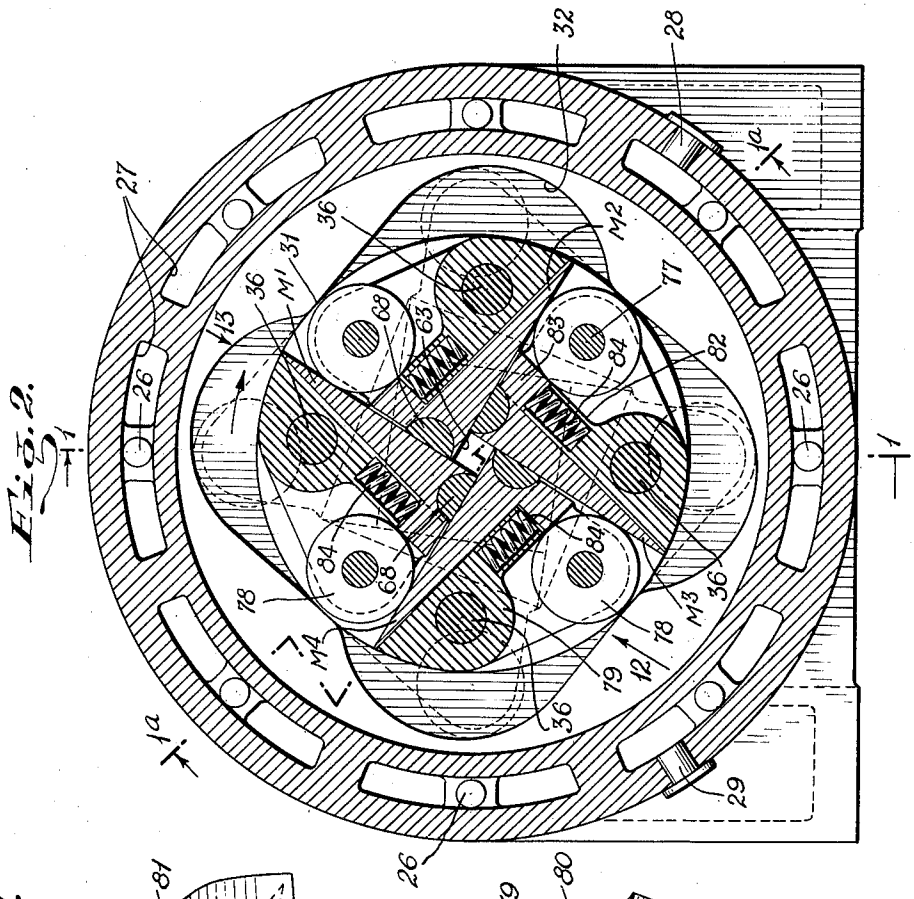


Fig. 2.

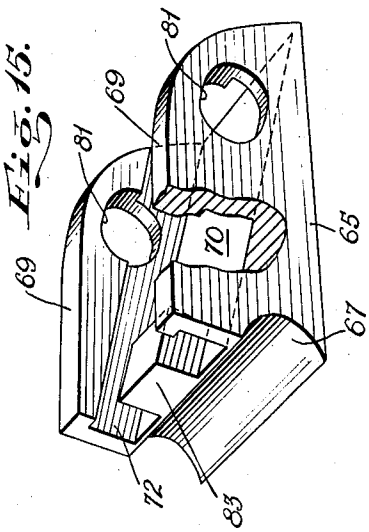


Fig. 15.

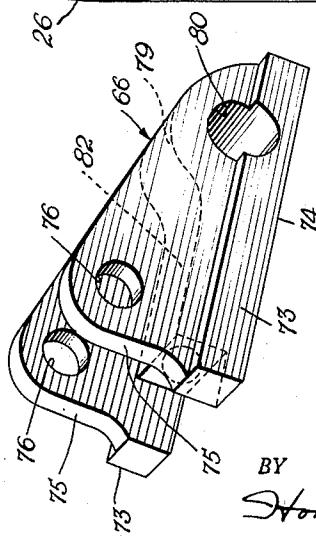


Fig. 16.

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Fig. 4.

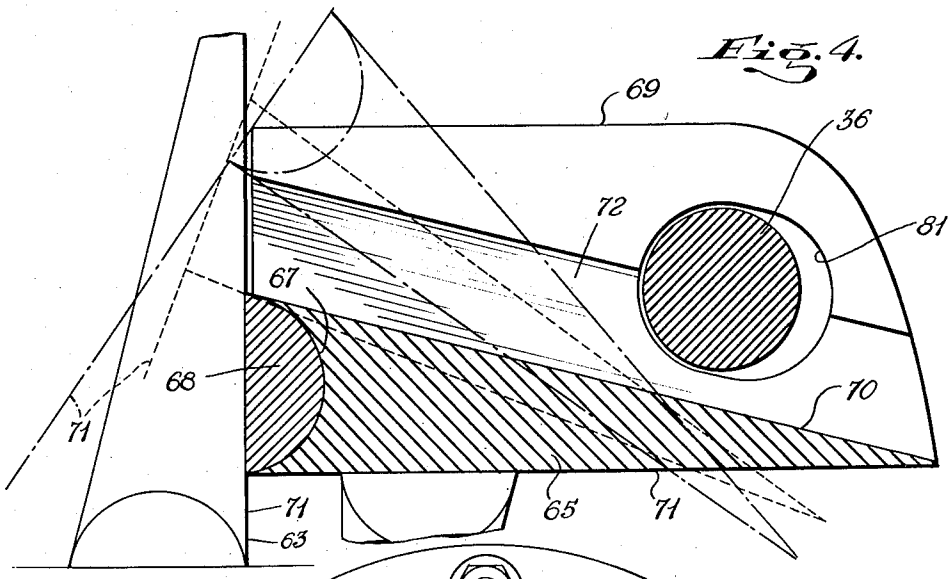
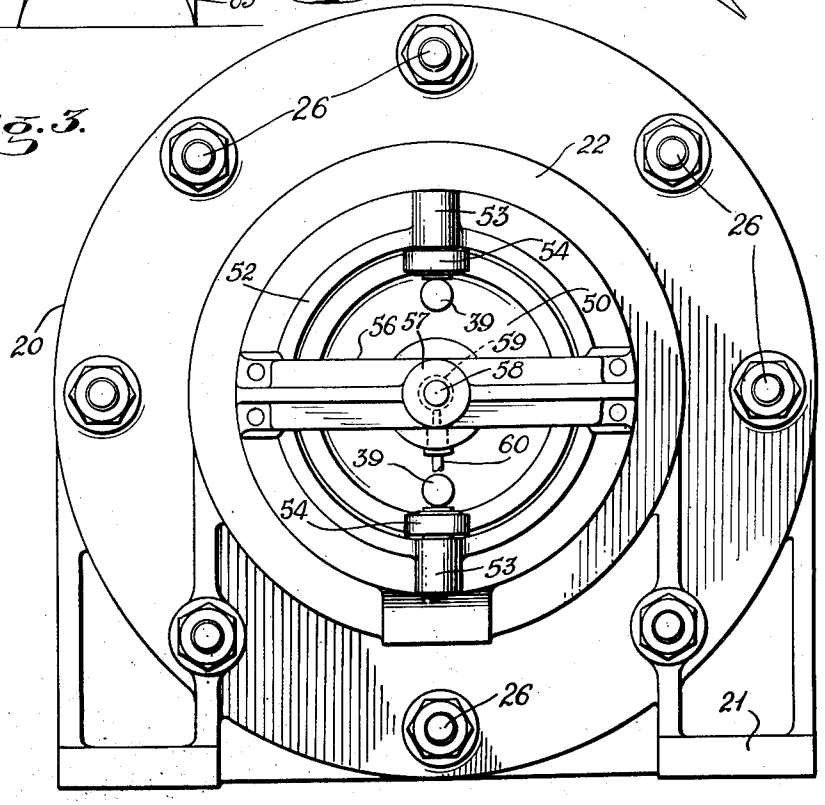


Fig. 3.



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Fig. 6.

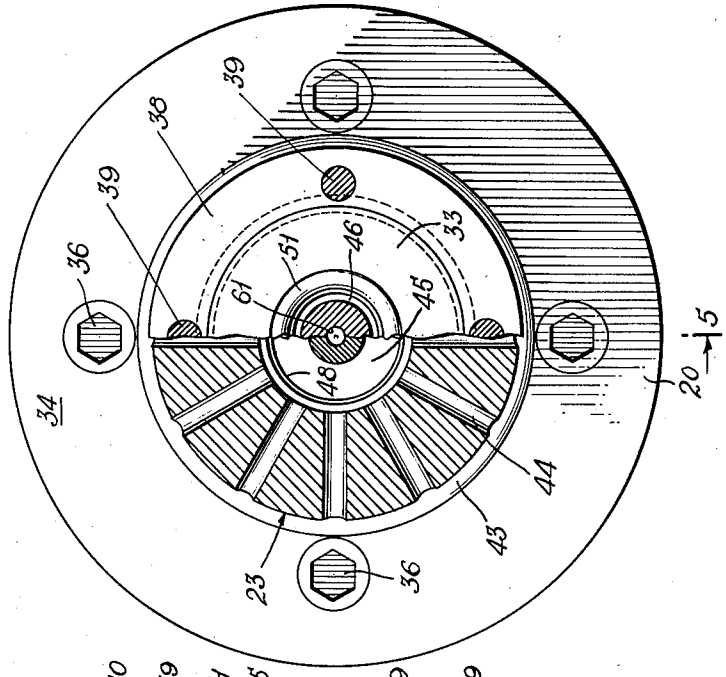
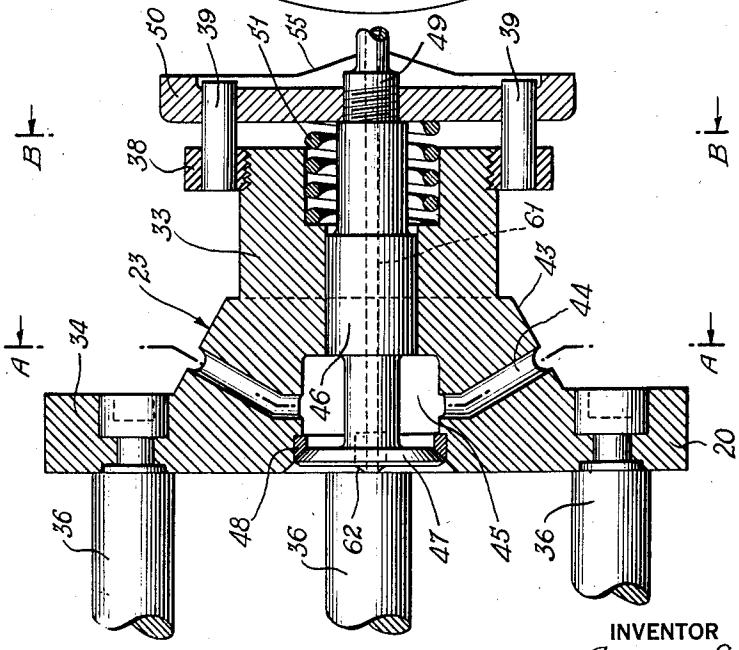


Fig. 5.

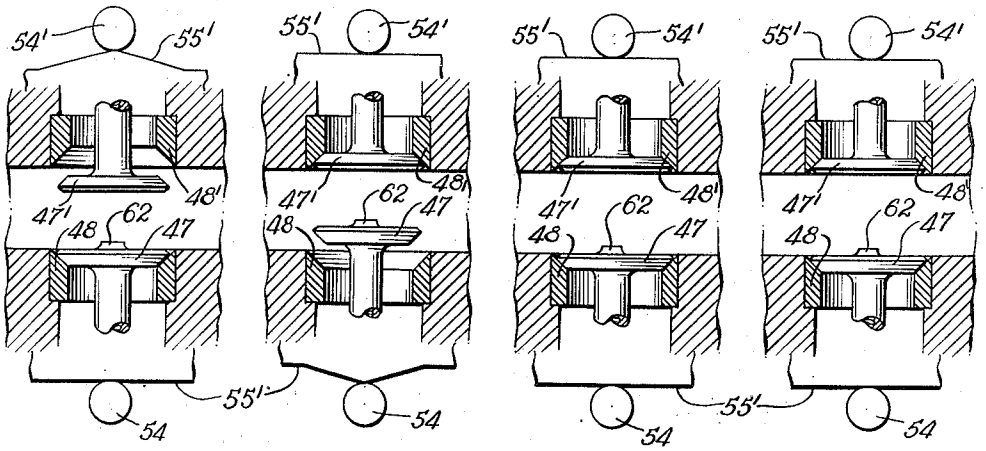


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EXHAUST Fig. 7.

INTAKE Fig. 8.

COMPRESSION Fig. 9.

DECOMPRESSION Fig. 10.

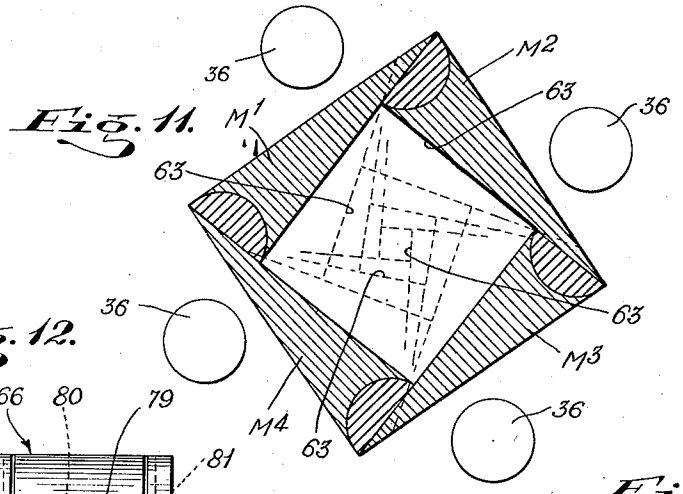
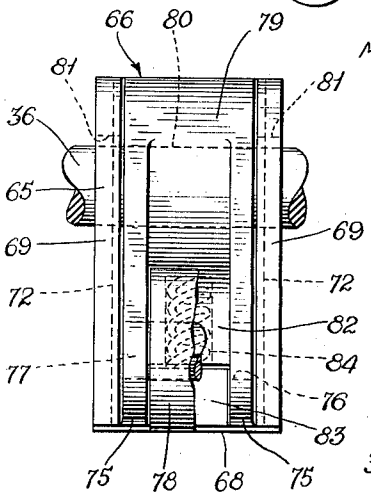


Fig. 11.

Fig. 12.



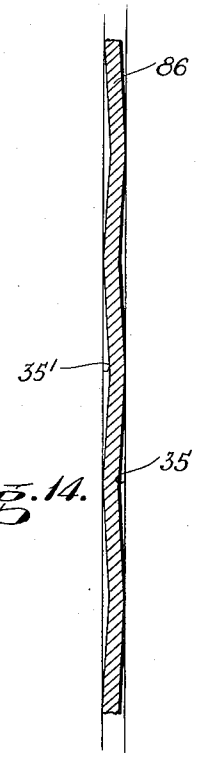
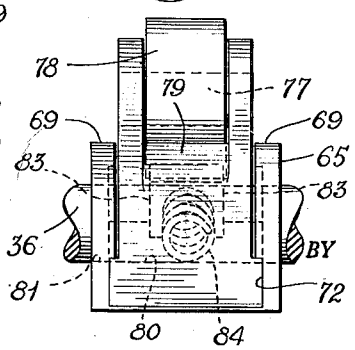


Fig. 14.

Fig. 13.



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Patented Mar. 28, 1950 2,501,856

UNITED STATES PATENT OFFICE

2,501,856

PRIME MOVER APPARATUS

Aaron Simons, Newburgh, N. Y.

Application February 4, 1947, Serial No. 726,265

16 Claims. (Cl. 123—8)

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This invention relates to apparatus generally termed "prime mover apparatus," and more specifically regarded as an engine or motor. More particularly, the invention deals with an apparatus employing one or more cylinder units, each unit comprising a plurality of circumferentially spaced elements or members movable radially with respect to the axis of the apparatus, and slidable one with respect to the other in increasing and decreasing the area of a cylinder or chamber formed therebetween. Still more particularly, the invention deals with apparatus of the character described wherein each element or member comprises relatively movable parts, one part swinging about a fixed axis, and means comprising a cam controlling swinging movement of said part. The novel features of the invention will be best understood from the following description when taken together with the accompanying drawings, in which certain embodiments of the invention are disclosed, and in which the separate parts are designated by suitable reference characters in each of the views, and in which:

Fig. 1 is an irregular longitudinal section taken primarily on the line 1—1 of Fig. 2 with the section of the center rotor mechanism substantially on the line 1^a—1^a of Fig. 2, and with parts shown in elevation.

Fig. 2 is a section approximately on the line 2—2 of Fig. 1, with parts of the construction shown in elevation.

Fig. 3 is an end view looking in the direction of the arrow 3 of Fig. 1.

Fig. 4 is an enlarged diagrammatic view illustrating the movement of one of the elments or members of the apparatus, showing the same in different positions, and indicating relative movement of the separate parts of the element or member.

Fig. 5 is an enlarged sectional view similar to Fig. 1 showing only a part of the construction, and with the section substantially on the line 5—5 of Fig. 6.

Fig. 6 is a sectional view on the line A—A and B—B of Fig. 5.

Figs. 7 to 10 inclusive are diagrammatic views illustrating the relationship of the valves in the exhaust, intake, compression and decompression stroke cycles of the apparatus.

Fig. 11 is a sectional view diagrammatically illustrating the control elements or members of the apparatus in an open position, and indicating in a successive series of lines, movement of said elements and members into the closed position, as shown for example, in Fig. 2 of the drawing.

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Fig. 12 is a face view of one of the elements or members detached, looking in the direction of the arrow 12 of Fig. 2.

Fig. 13 is a view similar to Fig. 12, looking in the direction of the arrow 13 of Fig. 2.

Fig. 14 is a sectional detailed view, on an enlarged scale, of one of a number of sealing discs which I employ between the members or elements of successive units of the apparatus.

Fig. 15 is a perspective view of one part of an element or member detached; and

Fig. 16 is a perspective view of a companion part or element detached.

The invention deals with apparatus, which for purposes of the present description, will be termed an engine wherein one or more chamber forming units are employed. Each unit has a plurality of members or elements, four of which are employed in the present construction, which are actuated one with respect to the other in forming therebetween a chamber which is increased and decreased in area in successive stroke cycles of the engine. In this operation of the members or elements, the same collectively form a chamber, which in cross section, is rectangular in form. In other words, the surface of one member forming one wall of the chamber is disposed at right angles to the corresponding surface of another member forming another wall of said chamber, and the latter wall is perpendicular to the first wall.

Considering this from another standpoint, when the cross sectional dimensions of the chamber is at its minimum, the exposed surface of each member is at its shortest length, and these surfaces increase in length as the cross sectional area of the resulting chamber increases, thus one member slides over the surface of an adjacent member in the inward and outward radial movement of said members. It will also appear from a consideration of Fig. 2 of the drawing that each member or element is composed of relatively movable parts, the parts having tapered engaging surfaces which aids in moving said parts one with respect to the other, one part swinging about a fixed axis and the other part carrying an antifriction roller operating upon a cam surface of the engine in controlling radial movement of said member in each cycle of operation thereof. Other features of the apparatus will appear from the following detailed description.

In Figs. 1 and 3 of the drawing, the engine as shown, comprises two substantially similar casting portions 20—20', which are generally in the

form of discs having foot-ends 21, as seen in Fig. 3, for mounting upon a suitable support. Extending outwardly from each casing are bearing portions 22—22' within which the rotor generally identified by the reference character 23, is mounted. Arranged between the casing plates or discs 20—20', is an annular casing portion 24 which spaces inner surfaces 25—25' of the discs 20, 20' one from the other, and the parts are joined by circumferentially spaced bolts, as seen at 26—26'. The casing 24 is preferably water-jacketed, as seen at 27, suitable means being provided, as for example, at 28 and 29, note Fig. 2, for the circulation of water therethrough.

On the inner surface of the casing 24 is arranged two cam surfaces 30—30', both of which are of the same contour, and have four compartively long straight surfaces 31 extending into intermediate curved surfaces 32 for purposes later described. The rotor 23 comprises two similar tubular members 33—33', having inner enlarged disc ends 34—34' to which two similar chamber forming units 35—35' are keyed by four pins 36, equally spaced circumferentially of the disc ends 34—34'.

Between the bearing portions 22—22' and the members 33—33', are suitable anti-friction bearings 37—37' which provide free rotation of the rotary unit. The outer ends of the members 33—33' are externally threaded to receive rings 38—38' which carry a plurality of outwardly extending coupling pins 39—39', the pins 39' being preferably longer than the pins 39 and adapted to extend into a shaft coupling 40 for the output of the drive of the rotor.

Each casing 20—20' has similarly formed annular passages 41—41' having suitable communicating ports 42—42', the port 42 constituting an intake, and the port 42' the exhaust. The annular passages 41—41' encircle the conical portions 43—43' of the members 33—33', and these conical portions have circumferentially spaced passages 44—44', placing the passages 41—41' in communication with inner chambers 45—45', note in this connection Fig. 6 of the drawing.

Slidably mounted in each member 33—33' is a control valve 46—46', the head 47—47' of each seats upon a suitable ring 48—48', forming the valve seat. Secured to an externally threaded reduced end portion 49—49' of the valve 46—46' is a cam disc 50—50', and a spring 51—51' operates upon said disc and seats in the member 33—33' in normally supporting the valve in seated position. Secured to the outer bearing ends 22—22' of the casings 20—20' are housings 52—52' supporting at upper and lower outer portions thereof, in bearings 53—53', rollers 54—54' which operate upon the surface 55—55' of the cam disc 50—50' in controlling opening and closing movement of the valves 46—46'.

The housing 52 differs from the housing 52' in having a cross strap 56 secured thereto, carrying a central bearing 57 for an extended end 58 on the valve 46 and in this respect, as well as a few others, later described, the valve 46 differs from the valve 46'. The bearing 57 has an annular fuel distributing chamber 59 surrounding the stem 58 and to which oil or other fuel is supplied by a supply pipe 60. The valve 46 including the stem 58 has a long bore or passage 61 opening through the head end 47 and in said end is arranged a discharge nozzle 62 for discharging fuel under pressure into the chamber 63, formed between the units 35—35', as later described. The valve stem 58 has a

series of passages 64 placing the chamber 59 in communication with the bore or passage 61.

It will be understood that the discharge of fuel into the chamber 63 is under pressure and will be timed with the operation of the engine so as to be injected into said chamber substantially at the time that the compression stroke has been completed. In Diesel type of engines, the high compression of air or gases within the cylinder or chamber 63 will be sufficient to ignite and charge the fuel.

At this time, it may be well to note for the most part, each half of the engine is substantially of the same construction, being modified only to the end necessary to distinguish the intake end from the exhaust end. In this way, an engine may be very economically constructed. In the same sense, the units 35—35' are of identical construction, and in this way, engines may be constructed having any number of units 35—35', depending upon the capacity of the motor desired, the only difference being that the casing 24 will be modified to suit the number of units employed. In small motors, or motors of low horse-power, a single unit would be sufficient. However, to illustrate one adaptation of my invention, I have shown a double unit engine.

Considering now Figs. 2, 12, 13, 15 and 16, it will appear that each unit 35—35' comprises a series of four cylinder or chamber forming members or elements, each of which is of the same construction, and therefore, the brief description of one will apply to all. However, for purposes of description of operation, the members in Fig. 2 of the drawing will be identified as M^1—M^2—M^3— and M^4. Each member is composed of two primary parts 65 and 66, the part 65 having on one surface thereof a semi-circular transverse channel 67 for the reception of a semi-circular bearing or sealing strip or shoe 68, note Figs. 4 and 15. The part 65 is more or less of channel cross sectional form, and has raised side walls 69 and a tapered bottom wall 70, forming between the same and the outer flat operating surface 71, a substantially wedge-like cross sectional contour, as clearly appearing in Fig. 4. Inner surfaces of the walls 69 have longitudinal grooves 72 paralleling the surface 70 for slidable engagement of outwardly extending parts 73 on the part 66. The lower surface 74 of the part 66 is tapered to correspond to the tapered surface 70 so that the part 66 is free to move longitudinally with respect to the part 65. The part 66 is also of U-shaped or channel cross sectional form as defined by spaced walls 75. The walls 75 have at their free ends alined apertures 76 for the reception of a pin 77 upon which a roller 78 is mounted, the roller being arranged between the walls 75, as will be clearly seen at the lower portion of Fig. 1 of the drawing.

The rear portion of the part 66 is solid and somewhat rounded in cross sectional form, as seen at 79, and has a transverse aperture 80 in which the bolts or rods 36 snugly fit, but sufficient to provide free swinging movement of the part 66. The bolts or rods 36 also pass through elliptical apertures 81 in the walls 69 of the part 65, the apertures 81 being elliptical and sufficiently large to provide for free movement of the part 65 with respect to the part 66.

Extending forwardly from the solid portion 79 is a tubular portion 82, the forward end of which is spaced with respect to a raised stop wall 83 centrally of the channel of the part 65. Bearing on the wall 83 and extending into the tube 82 is

a heavy coil spring 84 which normally tends to separate the parts, or in other words, to support the shoe 68 upon the surface 71 of a companion member or element, affecting and maintaining a seal between the same.

Considering Fig. 2 of the drawing, the shoe 68 of the member M^2 bears upon the surface 71 of the member M^1. The shoe of M^3 bears upon the surface of M^2. The shoe of M^4 bears upon the surface of M^3, and the shoe of M^1 bears upon the surface of M^4. At all times, the surfaces 71 are maintained at right angles or perpendicular to each other. That is to say, the surface 71 of M^1 is perpendicular to the corresponding surface of M^4, the surface of M^2 perpendicular to M^1, the surface of M^3 perpendicular to M^2, and the surface of M^4 perpendicular to M^3. Thus the surfaces 71 of the four combined members defines the walls of a chamber which, in cross sectional contour, is square or rectangular. The surfaces 71, in question, extend the full width of each member, or in other words, each unit 35—35', and from the inner cylinder surface 85 to the surface 85'. The surfaces 85—85' are defined partially by the casings 20—20' and partially by the members 33—33' including the flange portions 34—34' thereof. Between adjacent units 35—35' and arranged upon each member or element M^1—M^2—M^3 and M^4, or outer surfaces of the parts 65 thereof, are thin and preferably corrugated sealing or packing sheets or strips 86, the cross-section of part of one of which is shown on an enlarged scale in Fig. 14 of the drawing.

The purpose of these sealing strips or sheets is to compensate for expansion and contraction of the units in the operation of the engine, and to affect a substantial seal between the separate members of each unit. These sheets or strips may be secured by welding, not shown, to one of the side walls 69 of the part 65 of one of the units.

Considering now the diagrammatic layouts of Figs. 7 to 10 inclusive, here is indicated the relative position of the intake and exhaust valves of the rotor in the four stages of engine operation. That is to say, exhaust, intake, compression, decompression of fire. The cams 50—50' or the surfaces 55—55' thereof are so arranged, that the exhaust valve is open at the exhaust stroke and the intake valve opened at the intake stroke, whereas in the other two strokes of the cycle, both valves are maintained closed.

From a standpoint of operation, as the members M^1 to M^4 move from the innermost position of Fig. 2 outwardly, to the fully opened position which is diagrammatically illustrated in Fig. 11, air may be drawn into the chamber 63 with the valve 47 in the open position in the intake stroke of the engine, whereupon the valve will be closed and inward or closing movement of the members M^1 to M^4 compression will take place in the chamber 63 and substantially at the end of the compression stroke fuel oil will be injected under pressure into the chamber 63 and ignited, in which operation the members M^1 to M^4 are forced outwardly in the fire or decompression stroke, which is the power stroke of the engine, contributing in this respect, drive to the rotor, as will be apparent. Then, the members M^1 to M^4 again move inwardly in the exhaust stroke, during which time, the exhaust valve 47' is open, and the burned or spent gases are discharged from the cylinder or chamber 63.

The above, completes one cycle of operation, and this cycle is performed twice in each complete revolution of the rotor in the engine casing.

In the aforesaid inward and outward movements of the members M^1 to M^4, the rotor is rotating in the casing and the parts 65—66 of each member swing about the axis of the pins 36 with the rollers 78 travelling over the cam surfaces 31—32 in the manner partially indicated in dot and dash lines in Fig. 2 of the drawing.

In the outward swinging or radial movement of each of the members M^1 to M^4 there is a slight sliding movement of the parts 65—66 of each member one with respect to the other in keeping or maintaining the shoes 68 in firm engagement with the surfaces 71 of adjacent members, the springs 84 being sufficiently strong to at all times maintain this contact, notwithstanding the pressure of the gases within the chamber 63. By constructing the parts 65 and 66 of the wedge type construction shown, the parts 65 are more freely movable than would be the case if the wedge construction was not employed.

It will be understood that the cross sectional area of the chamber 63 in the fully closed position of the members M^1 to M^4 can be regulated to suit any desired pressures to be obtained, and consistent with the size of the engine.

In the above radial operation of the members or movement inwardly and outwardly with respect to the axis of the rotor, an axial combustion and other chamber is formed in the engine, varying in capacity to the extent of movement of said members. As the area of the chamber 63 increases, the members slide one over the surface of the other to increase the length of the surfaces 71, as will clearly appear from a consideration of Fig. 2 and the diagrammatic illustration of Fig. 11, in which several cross sectional sizes of the chamber 63 are shown, in indicating the stages from the minimum opening to the maximum opening. At all times, the surface 71 of one member or the part 65 thereof is maintained perpendicular to the corresponding surface of an adjacent member.

In the specification, the term member or elements has been used in describing the separate relatively movable devices of each unit. They function in a sense as drivers similar to the pistons of an engine in transmitting power to the drive shaft of the engine. On the other hand they form and control, to a major degree and aside from the end walls of the casing, the walls of the cylinder or chamber.

From the standpoint of the general term internal combustion engine, here applicant has produced what is in fact, a true internal combustion engine where combustion takes place axially with respect to the rotor or drive shaft driven by the engine and wherein the driving medium is in the form of one or more units, each employing a series of circumferentially and radially moving members or elements.

Aside from the end walls defining the surfaces 85—85' and the valves 47—47' arranged therein, the chamber 63 may be said to be formed by the driving members or the surfaces 71 thereof. This arrangement or mode of operation in a prime mover, is distinctly contrasting to the average type of engine, motor or compressor wherein the driver or actuated member or element only forms a part of the wall structure of the chamber throughout the different positions of the complete cycle of operation.

With my improved prime mover, the power of the explosion or other force is transmitted directly to the surface of the drivers and the sur-

face area of the drivers is lengthened or increased as the power force becomes spent, thereby producing a highly more efficient operation than would be possible with other types of engine design. Furthermore, the gases of an explosion or firing, as the case may be, are permitted to expand radially with respect to the axis of the driving shaft and the engine has the benefit of the normal centrifugal force to assist in operation of the drivers, particularly in the power strokes, and in this connection, will dispense with the use of fly-wheels or similar balance wheels which are otherwise required.

For purposes of this description, all of the fixed parts of the apparatus may be generally termed a casing, with the rotor mounted for rotation therein.

The chamber structure of the prime mover herein disclosed, and which for purposes of description has been termed a "cylinder," is formed by a plurality of members having walls or surfaces, each of which is flat. These walls or surfaces are movable toward and from the axis of said chamber, with one member moving along the surface of an adjacent member. In this operation of the members, the exposed area of the flat surfaces or walls are decreased and increased in said inward and outward movements of the members with respect to the axis. With my improved method, in the inward movement of said members toward the axis as above stated, the pressure of the gases within the chamber formed by said walls is increased, but the load on the walls or surfaces is decreased. In other words, the pressure of the gases is increased in square proportion to the degree of decreasing the volume. In the aforesaid operations of the members toward and from said axis, the surface of each wall is decreased or increased in proportion of the square root to the degree of increase or decrease of the pressure in the chamber.

Having fully described my invention, what I claim as new and desire to secure by Letters Patent is:

1. In apparatus of the character described employing a casing, a rotor rotatably mounted in the casing, a drive coupling at one end of the rotor, said rotor having within the casing a plurality of circumferentially spaced members constituting a drive unit, said members having flat surfaces collectively forming boundary walls of a chamber centrally of said casing in all positions of said members, one member being movable over the flat surface of an adjacent member in enlarging and contracting said chamber, means maintaining members in engagement with each other in relative movement thereof, and means controlling relative movement of said members in enlarging and contracting said chamber.

2. In apparatus of the character described employing a casing, a rotor rotatably mounted in the casing, a drive coupling at one end of the rotor, said rotor having within the casing a plurality of circumferentially spaced members constituting a drive unit, said members having flat surfaces collectively forming boundary walls of a chamber centrally of said casing in all positions of said members, one member being movable over the flat surface of an adjacent member in enlarging and contracting said chamber, means maintaining members in engagement with each other in relative movement thereof, means controlling relative movement of said members in enlarging and contracting said chamber, said last named means comprising cam surfaces circumferentially enveloping said members, and said members having rollers operating upon said cam surfaces.

3. In apparatus of the character described employing a casing, a rotor rotatably mounted in the casing, a drive coupling at one end of the rotor, said rotor having within the casing a plurality of circumferentially spaced members constituting a drive unit, said members having flat surfaces collectively forming boundary walls of a chamber centrally of said casing in all positions of said members, one member being movable over the flat surface of an adjacent member in enlarging and contracting said chamber, means maintaining members in engagement with each other in relative movement thereof, means controlling relative movement of said members in enlarging and contracting said chamber, said last named means comprising cam surfaces circumferentially enveloping said members, said members having rollers operating upon said cam surfaces, and bearing shoes between adjacent abutting surfaces of said members.

4. In apparatus of the class described employing a cylindrical casing, means comprising radially moving and relatively sliding members in said casing, forming centrally of the casing and longitudinally with respect to the axis thereof a chamber, the cross sectional area of said chamber being increased and decreased by outward and inward radial movement of said members, surfaces of said members defining the walls of said chamber, in all positions of said members, being flat, and means on the casing controlling movement of said members by a power medium in the chamber thereof.

5. In apparatus of the class described employing a cylindrical casing, means comprising radially moving and relatively sliding members in said casing, forming centrally of the casing and longitudinally with respect to the axis thereof a chamber, the cross sectional area of said chamber being increased and decreased by outward and inward radial movement of said members, surfaces of said members defining the walls of said chamber, in all positions of said members, being flat, means on the casing controlling movement of said members by a power medium in the chamber thereof, valves at end portions of said chamber controlling intake and exhaust with respect thereto, and means on said casing controlling actuation of said valves.

6. In apparatus of the class described employing a cylindrical casing, means comprising radially moving and relatively sliding members in said casing, forming centrally of the casing and longitudinally with respect to the axis thereof a chamber, the cross sectional area of said chamber being increased and decreased by outward and inward radial movement of said members, surfaces of said members defining the walls of said chamber, in all positions of said members, being flat, means on the casing controlling movement of said members by a power medium in the chamber thereof, valves at end portions of said chamber controlling intake and exhaust with respect thereto, means on said casing controlling actuation of said valves, and means for introducing a fuel into the chamber through one of said valves.

7. An engine of the class described, comprising a casing consisting of similar casing ends and an intermediate cylindrical casing, a rotor rotatably mounted in said casing, said rotor including two drive units within the cylindrical portion of said

casing, each unit comprising a plurality of radially swinging members having flat surfaces, each member comprising relatively movable parts, one part being a swinging part and the other part slidably in the first part, means in the cylindrical casing controlling radial movement of said members, and means maintaining the members of each unit in constant engagement with the flat surfaces of adjacent units in forming between the flat surfaces of said members of each unit, in the radial movement of said members, a chamber increasing and decreasing in cross sectional area.

8. An engine of the class described, comprising a casing consisting of similar casing ends and an intermediate cylindrical casing, a rotor rotatably mounted in said casing, said rotor including two drive units within the cylindrical portion of said casing, each unit comprising a plurality of radially swinging members having flat surfaces, each member comprising relatively movable parts, one part being a swinging part and the other part slidably in the first part, means in the cylindrical casing controlling radial movement of said members, means maintaining the sliding part of the members of each unit in constant engagement with the flat surfaces of adjacent units in forming between the flat surfaces of said members of each unit, in the radial movement of said members, a chamber increasing and decreasing in cross sectional area, and means including valves in said rotor controlling intake and exhaust of said chamber.

9. An engine of the class described, comprising a casing consisting of similar casing ends and an intermediate cylindrical casing, a rotor rotatably mounted in said casing, said rotor including two drive units within the cylindrical portion of said casing, each unit comprising a plurality of radially swinging members having flat surfaces, each member comprising relatively movable parts, one part being a swinging part and the other part slidably in the first part, means in the cylindrical casing controlling radial movement of said members, means maintaining the sliding part of the members of each unit in constant engagement with the flat surfaces of adjacent units in forming between the flat surfaces of said members of each unit, in the radial movement of said members, a chamber increasing and decreasing in cross sectional area, means including valves in said rotor controlling intake and exhaust of said chamber, and means for introducing fuel to the chamber through one of said valves.

10. An engine of the class described comprising a casing defined by a cylindrical portion and two similar end plate portions, said end plate portions having outwardly extending bearings, a rotor having tubular ends rotatably mounted in the bearings of said end plate portions of said casing, a pair of drive units within the cylindrical portion of the casing and intermediate said end plates, each unit comprising a series of radially swinging members, means joining the tubular portions of the driver forming pivots around which said members swing, means in the cylindrical portion of the casing controlling swinging radial movement of said members, each member including a sliding part, and the sliding part of each member having an inner flat surface disposed perpendicular to a corresponding inner flat surface of the sliding part of another member in the several positions of the members one with respect to the other in defining walls of a chamber between said members increasing and decreasing in cross sectional area in the outward and inward swinging movement of said members.

11. An engine of the class described comprising a casing defined by a cylindrical portion and two similar end plate portions, said end plate portions having outwardly extending bearings, a rotor having tubular ends rotatably mounted in the bearings of said end plate portions of said casing, a pair of drive units within the cylindrical portion of the casing and intermediate said end plates, each unit comprising a series of radially swinging members, means joining the tubular portions of the driver forming pivots around which said members swing, means in the cylindrical portion of the casing controlling swinging radial movement of said members, each member including a sliding part, the sliding part of each member having an inner flat surface disposed perpendicular to a corresponding inner flat surface of the sliding part of another member in the several positions of the members one with respect to the other in defining walls of a chamber between said members increasing and decreasing in cross sectional area in the outward and inward swinging movement of said members, valves mounted in the tubular ends of said rotor, tensional means normally seating said valves, said valves controlling intake and exhaust parts for communication with ends of said chamber, and means for intermittently opening and closing the valves in each cycle of operation of the engine.

12. An engine of the class described comprising a casing defined by a cylindrical portion and two similar end plate portions, said end plate portions having outwardly extending bearings, a rotor having tubular ends rotatably mounted in the bearings of said end plate portions of said casing, a pair of drive units within the cylindrical portion of the casing and intermediate said end plates, each unit comprising a series of radially swinging members, means joining the tubular portions of the driver forming pivots around which said members swing, means in the cylindrical portion of the casing controlling swinging radial movement of said members, each member including a sliding part, the sliding part of each member having an inner flat surface disposed perpendicular to a corresponding inner flat surface of the sliding part of another member in the several positions of the members one with respect to the other in defining walls of a chamber between said members increasing and decreasing in cross sectional area in the outward and inward swinging movement of said members, valves mounted in the tubular ends of said rotor, tensional means normally seating said valves, said valves controlling intake and exhaust parts for communication with ends of said chamber, means for intermittently opening and closing the valves in each cycle of operation of the engine, and means for admitting fuel to said chamber through one of said valves.

13. In apparatus of the class described employing an operating unit, said unit comprising a plurality of circumferentially spaced members mounted to move radially with respect to the axis of said circumferential arrangement of the members, each of said members having flat chamber forming surfaces of predetermined width, the width of said surfaces defining the axial length of the chamber to be formed, means supporting and maintaining one member upon said surface of an adjacent member in all of the members constituting said unit, and means for moving said adjacent members relatively to each other in increasing and decreasing the length of said flat

surfaces and the corresponding increased and decreased cross sectional area of the chamber therebetween.

14. In apparatus of the class described employing an operating unit, said unit comprising a plurality of circumferentially spaced members mounted to move radially with respect to the axis of said circumferential arrangement of the members, each of said members having flat chamber forming surfaces of predetermined width, the width of said surfaces defining the axial length of the chamber to be formed, means supporting and maintaining one member upon said surface of an adjacent member in all of the members constituting said unit, means for moving said adjacent members relatively to each other in increasing and decreasing the length of said flat surfaces and the corresponding increased and decreased cross sectional area of the chamber therebetween, and means for introducing a power generating medium into said chamber.

15. In apparatus of the class described, a rotor, means comprising radially movable elements on the rotor forming axially and longitudinally of the axis of the rotor a substantially sealed chamber increasing and decreasing with respect to cross sectional area in outward and inward radial movement of said elements, means controlling radial movement of said elements, each element having a surface defining part of the wall structure of said chamber, and the surface of one

element being disposed at right angles to the surface of an adjacent element.

16. In apparatus of the class described, a plurality of circumferentially arranged intercooperating elements, said elements being relatively movable between spaced walls, said elements and walls defining a substantially sealed chamber in the apparatus, said elements having flat surfaces defining, in all positions of said elements, the walls of said chamber, means controlling relative movement of said elements, and each element being slidable over the flat surface of an adjacent element in increasing and decreasing the exposed area of the flat surfaces of the elements and said spaced walls in increasing and decreasing the volume of said chamber.

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The following references are of record in the file of this patent:

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