April 28, 1959 R. A. HEISING 2,883,974

INTERNAL COMBUSTION ENGINES

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FIG. 1

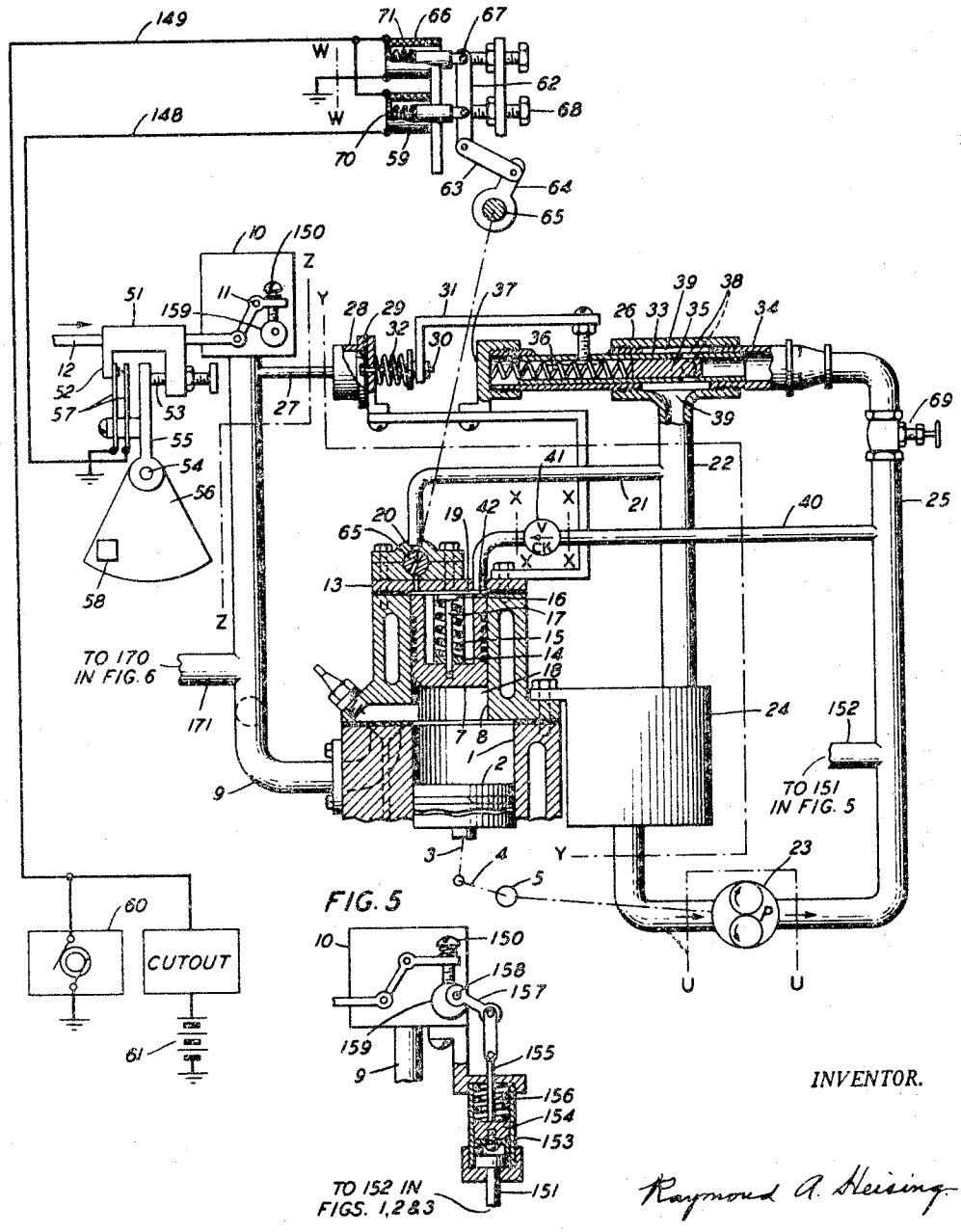


FIG. 5




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FIG. 2

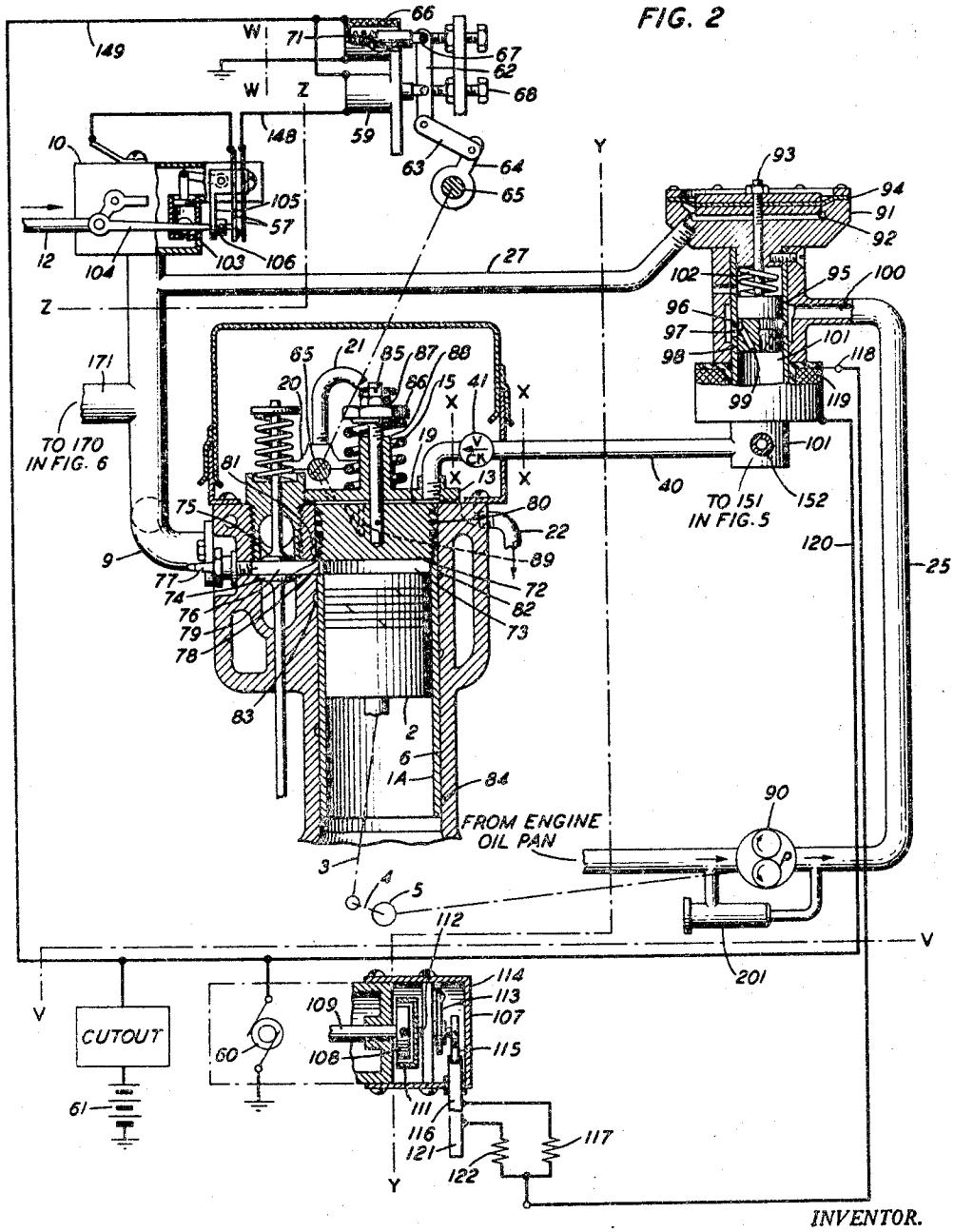


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FIG. 3

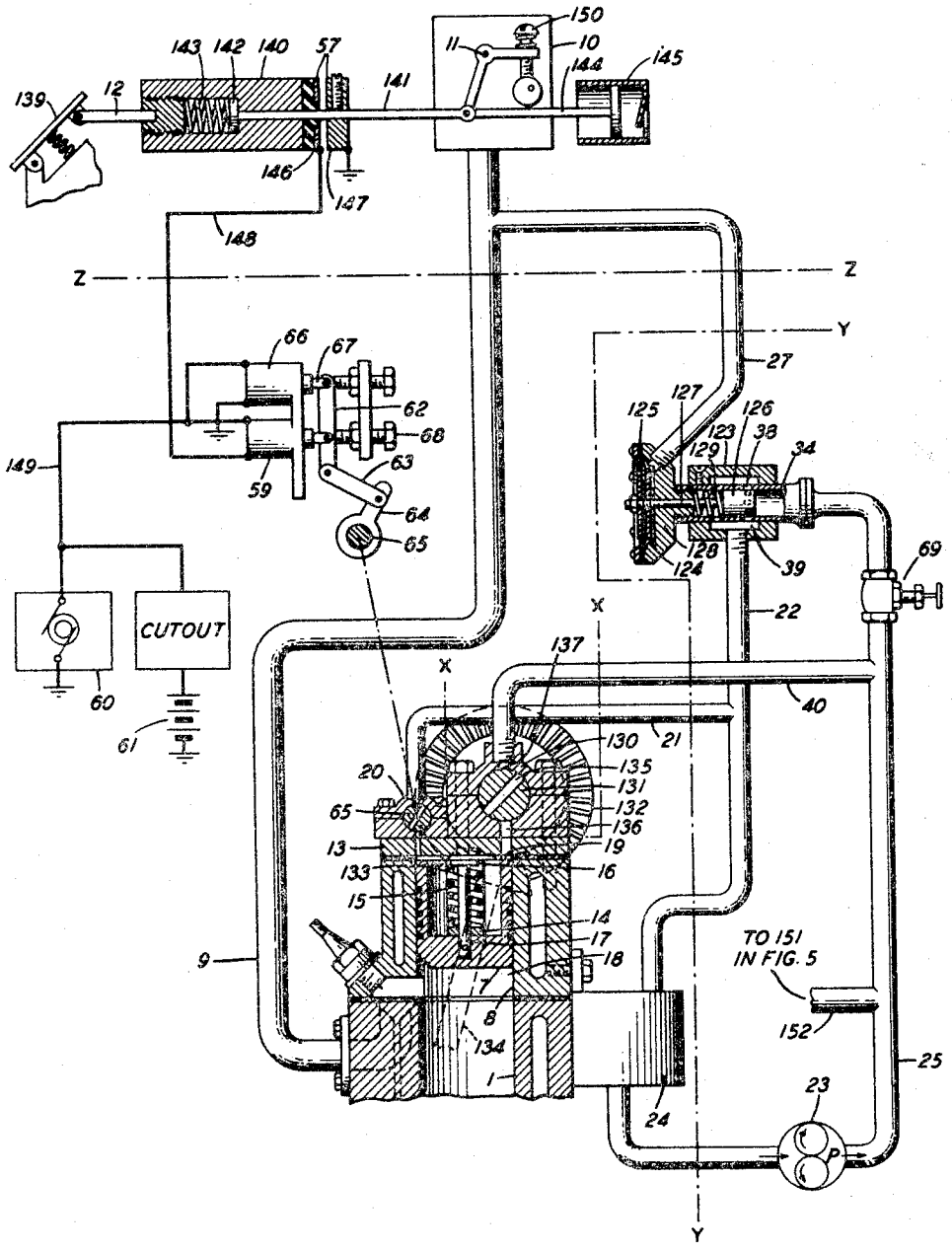


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FIG. 4

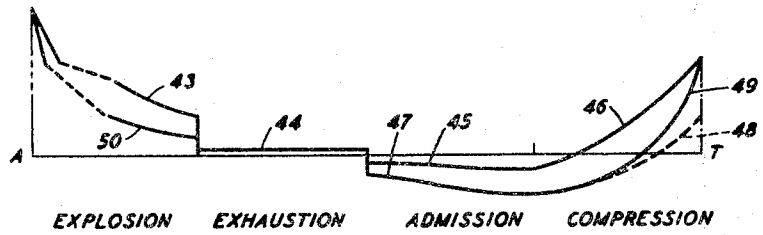


FIG. 8

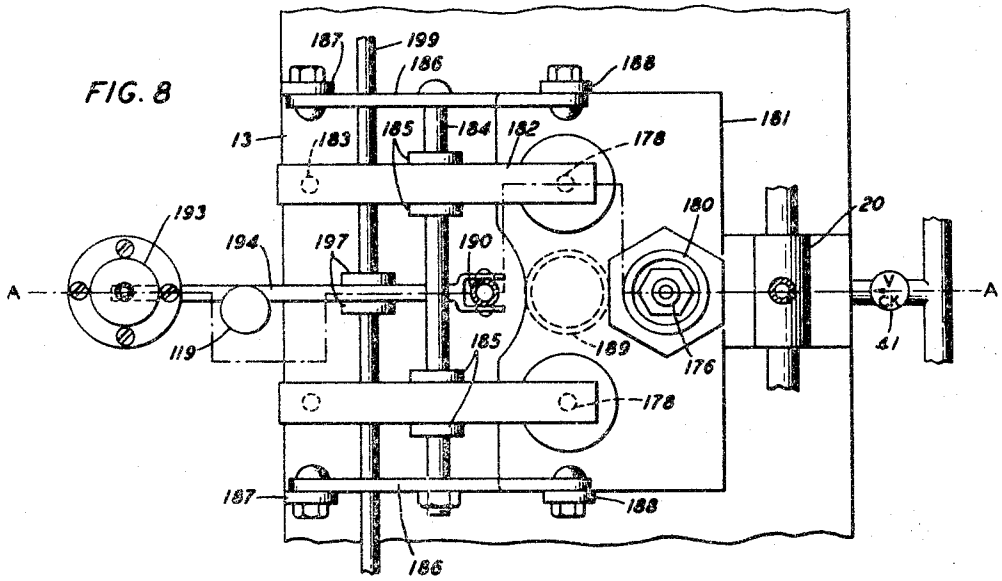


FIG. 6

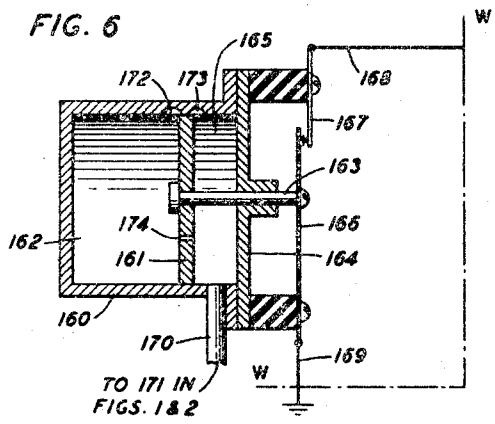


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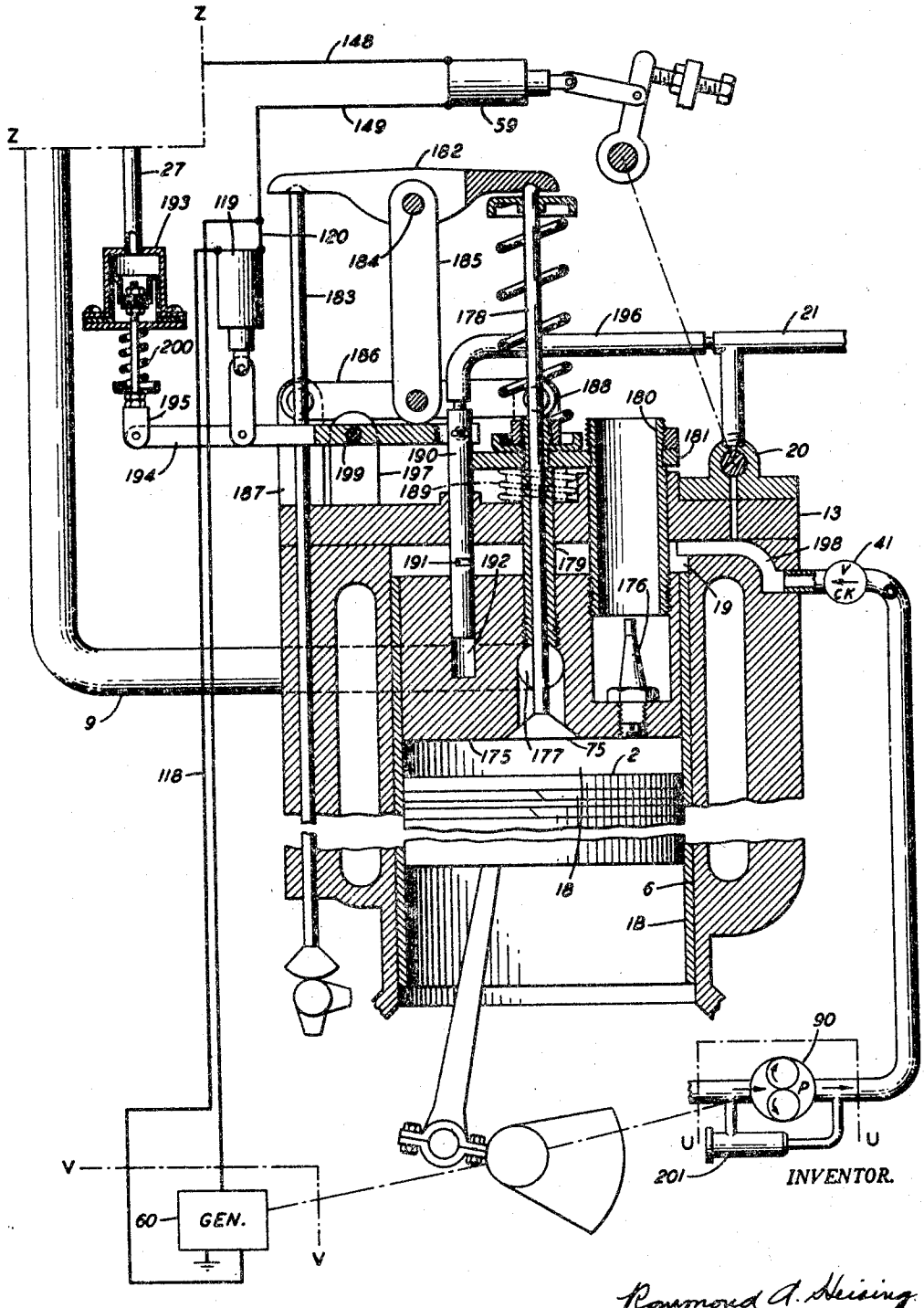
FIG. 7



United States Patent Office 2,883,974 Patented Apr. 28, 1959



2,883,974

# INTERNAL COMBUSTION ENGINES

Raymond A. Heising, Summit, N.J.

Application December 2, 1955, Serial No. 550,641

26 Claims. (Cl. 123—48)

This application is a continuation-in-part of my application Serial No. 208,037 filed January 26, 1951, which is now abandoned.

This invention relates to internal combustion engines.

The object of the invention is to improve the efficiency of internal combustion engines of the type in which the speed or power or both are varied, such as automobile engines.

An object of the invention is to increase the efficiency by varying the compression ratio of the engine while it is in operation.

A further object is to vary the compression ratio approximately inversely as the amount of explosive mixture drawn into the cylinder or cylinders.

Another object is to vary the compression ratio with speed, making it higher at higher speeds.

A still further object is to return the compression ratio quickly to a lower value upon the opening of the throttle, and to effect the return in a manner that will avoid excessive pressures within the cylinder.

Still further objects are to return the compression ratio to a minimum upon the engine stopping, to provide thoroughly sealed movable walls for the compression chamber, to provide means whereby the pressure in the compression chamber assists in the sealing, to provide improvements in the method of supporting the movable walls to stand the high internal pressure of explosion, to provide improved ways to manipulate the movable walls of the compression chamber, to provide new and improved ways to adjust the compression chamber to the optimum size, and other objects that will be described.

I have observed that the efficiency of an internal combustion engine of the automobile type can be improved markedly at powers below full power if the compression ratio is increased so that the temperature and pressure of the compressed mixture is raised as near to a suitable maximum at all partial powers as it is at full power.

It has long been known that an automobile requires only a small fraction of the power capacity of the engine to drive it on an average road at average speeds, and I have observed that the vacuum in the intake manifold at such times is such that the gas pressure therein is between one-half and one-third atmospheric pressure. At such small pressures, a full cylinder charge approximates only one-half to one-third a cylinder charge at full power for a given speed, and such small charges are susceptible to a much greater relative compression than are full charges without causing self ignition. To bring about the higher compression at lower power requires that the engine be so constructed that the compression ratio can be changed while the engine is in operation, that it be changed quickly when more power is required, and that it be done with a minimum of attention. Various individuals have devised variable compression engines in the past, but I find them unsuited for these purposes for various reasons. The method of varying the compression chamber usually involved a movable piston,



and suitable sealing to prevent the escape of gases of compression and combustion was absent. The system for handling the tremendous reactive force of explosion amounting to several tons was inadequate. The compression chamber size could not be changed rapidly upon a demand for more power. Means to determine the variations in compression to apply at different times or under different conditions have been absent. I have invented an engine in which these problems are adequately taken care of which is new and novel and in which a marked increase in efficiency is obtained over present day engines burning commercial gasoline.

For a clearer understanding of the nature of this invention and the additional advantages, features, and objects thereof, reference is made to the following description taken in connection with the accompanying drawings, in which like reference characters represent like or similar parts and in which:

Fig. 1 shows a form of the invention;

Fig. 2 shows a preferred form of the invention;

Fig. 3 shows another form of the invention;

Fig. 4 is a diagram to explain certain operative features of the various forms of the invention;

Fig. 5 shows an attachment for the forms in Figs. 1, 2 and 3 to improve idling;

Fig. 6 is an attachment for Figs. 1 and 2 for reducing the compression ratio slowly with a slow rise in intake manifold pressure; and

Figs. 7 and 8 show another form of the invention.

In Fig. 1, a cylinder of an internal combustion engine is represented at 1. In it slides the customary piston 2 connected by a connecting rod 3 to the crank 4 of the engine and the shaft 5. The cylinder is provided with a movable cylinder head 7 that slides inside cylinder 8 which takes the place of the usual cylinder head on internal combustion engines. The cylinder 1 is provided with the usual intake and exhaust valves. The intake valve, when it opens, connects cylinder 1 with intake manifold 9, which herein is called the manifold whether the engine is a single or multiple cylinder engine. Manifold 9 connects with carburetor 10 containing the usual throttle valve attached to shaft 11 operated by the movement of throttle rod 12 also called throttle member. Cylinder 8 is closed at its upper end by a plate 13 to which is fastened a U-shaped yoke 14 supporting spring 15 which in turn bears against the head 16 of rod 17 that is fastened to the movable wall element 7. Spring 15 is under compression at all times exerting a force tending to enlarge the compression chamber 18 between wall 7 and piston 2 when the latter is at its uppermost position. Movable wall element 7 is of a shape similar to engine pistons and it may contain rings or other sealing means to prevent ingress or egress of liquids or gases to or from the compression chamber 18. Between wall element 7 and plate 13 is an enclosed space 19 adapted to be filled with a liquid and sealed against egress of any of the liquid during operation of the engine at constant speed and power. By forcing a liquid into enclosed space 19, wall 7 may be moved against the compression of spring 15 and reduce the size of compression chamber 18. An egress valve 20 is provided that may be of the "rocking" or slightly rotating type which connects with the enclosed space 19 behind movable wall 7. When this valve is opened, spring 15 together with any gas pressures in the compression chamber 18 and cylinder 1 will force the liquid out, and into return lines 21 and 22.

In this invention, the movable wall 7 is positioned by means of a liquid being supplied to the enclosed space 19 at a pressure in the supply lines determined and controlled by the vacuum in intake manifold 9 in relation to the stiffness of spring 15. A liquid pump 23 which may be of the gear variety draws liquid from a storage

chamber 24 and discharges it into pipe 25. If the liquid is oil such as lubricating oil, the storage chamber may be the oil chamber or oil pan holding lubricating oil for the engine. Pump 23 is driven by the engine and will supply liquid at a rate substantially proportional to the speed of the engine. The pressure of the liquid in pipe 25 is regulated by regulator 26, which regulator is controlled by the vacuum in manifold 9 by virtue of pipe 27 connecting the regulator 26 to manifold 9. Pipe 27 connects to vacuum register 28 closed by flexible member 29 which in turn is fastened to rod 30. Rod 30 is fastened to and moves yoke 31 against the force of compression of spring 32. Yoke 31 moves hollow cylinder 33 inside cylinder 34 which is part of the frame of pressure regulator 26. Inside cylinder 33 is piston 35 resting against spring 36 which bears in turn against the end 37. Supply pipe 25 is connected to cylinder 34 so as to allow the liquid from pump 23 to exert pressure against piston 35. As the liquid pressure in pipe 25 and cylinder 34 rises, piston 35 is moved against the compression of spring 36 until the piston uncovers holes 38 in the walls of cylinder 33 which then permit the liquid to escape into passageway 39 from which the liquid is conducted by pipe 22 back to reservoir 24. When the vacuum in manifold 9 increases, spring 32 is compressed further, cylinder 33 with holes 38 is moved to the left, and the liquid pressure in pipe 25 rises until piston 35 again uncovers holes 38 because pump 23 supplies liquid at a rate proportional to speed with no regulation of the pressure. Thus, the pressure of the liquid in pipe 25 varies in a predetermined manner with the vacuum in the intake manifold.

A pipe 40 connected to pipe 25 conducts the liquid under pressure to check valve 41, thence to opening 42 to the enclosed space 19 behind the movable wall. It is to be understood that the synchronous rotating valve 130 of Fig. 3 may be used instead of check valve 41, if desired.

The operation of the invention so far as described is as follows: Pump 23 driven by the engine delivers liquid to pipe 25. The pressure rises in pipe 25 until an escape route is provided. The engine while operating with light load produces a partial vacuum in the intake manifold which acting on diaphragm 29 pulls sleeve 33 to the left, hiding openings 38 behind piston 35. As the pressure in pipe 25 rises piston 35 moves to the left and uncovers part of the holes 38. The pressure in pipe 25 will therefore be maintained in a predetermined relation to the vacuum in the intake manifold 9. The liquid in pipe 25 will pass through pipe 40 and check valve 41 at moments when there is no explosion pressure or high compression pressure in the compression chamber. The liquid will force movable wall 7 downward against the compression of spring 15, and the wall 7 will reach a stable position when the average force in the compression chamber during exhaust, admission, and part of the compression stroke with the force from spring 15 balances the pressure exerted in closed chamber 19 by the liquid. This position will, by design of spring 15 and pressure regulator 26 be in a predetermined relation to the manifold gas pressure to secure substantially the same maximum compression pressure at partial loads as at full engine load.

Fig. 4 indicates the pressure history during two complete revolutions of an engine shaft. 43 represents the pressure in the cylinder during a full load explosion stroke of the engine. At the end of the stroke, the exhaust valve opens and the pressure curve 44 shows very low pressure during exhaust stroke. At the end of the exhaust stroke, the exhaust valve closes, and the intake valve opens. During the admission stroke, enough of a vacuum forms in the cylinder to draw in some of the mixture, giving vacuum curve 45, and then during the compression stroke with both valves closed, the pressure rises as shown by curve 46. If the throttle valve in carburetor 10 should be closed partially during the admission stroke, a curve such as 47 with considerable vacuum shows the pressure within the compression chamber. If the movable wall 7 has not been moved the compression pressure will follow dotted curve 48 to a relatively low value. If however, the pressure of liquid in pipe 25 has increased due to the increased manifold vacuum mentioned, liquid will have been forced through check valve 41 during exhaustion and admission strokes and have moved wall 7 downward against the compression of spring 15 so as to reduce the compression chamber size, and the pressure during compression will then follow curve 49 and it may reach the same peak value as results with full power cylinder charges. During the explosion stroke following, curve 50 shows the fall in pressure giving increased efficiency over what would have resulted without reducing compression chamber size.

If now the throttle should be opened to secure more power, the intake manifold vacuum will fall, larger amounts of explosive mixture will be drawn into the cylinder, and excessive compression pressures will result unless the compression chamber is enlarged in anticipation of the fall in manifold vacuum. Applicant's invention accomplishes this desirable result. The throttle valve in carburetor 10 is actuated by throttle rod 12. Fastened to the throttle rod 12 is frame 51, carrying lug 52 and adjusting screw 53. Separately supported, and movably suspended on shaft 54, is element 55 carrying at one end sheet conductor 56, preferably of copper or brass, and two springs 57, one of which is insulated. The spring 57 are adapted to make contact at the upper end by means of slight pressure. A magnet 58 is positioned close to element 56 such that the magnetic field is perpendicular to 56 and passes through it. Adjusting screw 53 is adjusted so that springs 57 almost, but do not touch each other. Element 55, 56 should preferably have the center of gravity close to shaft 54 but below it. One of springs 57 is grounded. The other is connected to solenoid 59 by lead 148, and solenoid 59 in turn is connected to generator 60 or battery 61, or both, by lead 149. Upon movement of throttle rod to the right to open the throttle, the damping effect of magnet 58 on element 56 holds 55, 56 still until springs 57 touch each other and exert pressure to rotate 55 on shaft 54. When springs 57 touch each other, solenoid 59 is energized and its armature through linkage 62, 63 pulls on crank 64 which rotates the rocking part 65 of valve 20, thereby placing the passageway through 65 inside valve 20 in line with the egress passageway for liquid from chamber 19. Pressure from spring 15, and any explosion or compression pressures in cylinder 1, will expel liquid and move the movable wall 7 upward. The mechanism for enlarging the compression chamber is thus put in operative condition before the throttle valve has moved appreciably and before the gas pressure in the intake manifold can rise. At the same time, the opening of egress valve 20 disables the means for reducing the compression chamber size because liquid leaves enclosed space 19 through valve 20 faster than it can enter through check valve 41.

When throttle rod 12 ceases to move in the direction that opens the throttle valve, the springs 57 in contact with lug 52 will exert enough pressure to rotate element 55, 56 far enough to touch stop 53, and the contact between springs 57 will be broken. Energization of solenoid 59 will cease, and spring 70 will push the armature of solenoid 59 and lever 62 back against stop 68, moving link 63 and closing egress valve 20. This action removes the disability from the means for increasing the compression ratio described above and said means can then increase the compression ratio under control of the vacuum in the intake manifold that develops after the opening of the throttle, and cause the compression ratio to reach the corresponding predetermined value. Con-

tacts 57 will energize solenoid 59 and open egress valve 20 only while throttle rod is in motion in such a direction as to open the throttle. This will be for a period of time of an engine cycle or more so that the pressures within the cylinder 1 during explosion may move the movable wall quickly, and move it further than it is expected to stand for operation with the manifold vacuum resulting from the throttle movement.

If throttle rod 12 is moved in such a direction as to close the throttle, element 55, 56 is pushed by screw stop 53 and springs 57 do not touch each other.

When the engine is stopped provision is made to enlarge the compression chamber to a maximum to make starting the engine easy. For this purpose solenoid 66 is connected between generator and ground and its armature 67 is attached to the upper end of lever 67. With the engine stopped, neither solenoid is energized. Spring 70 pushes lever 62 against stop 68, and spring 71 pushes armature 67 and lever 62 outward so that using stop 68 as a fulcrum, valve 20 is opened slightly, and spring 15 can expel liquid in enclosed chamber 19 and enlarge the compression chamber to a maximum. When the engine is started, the generator builds up its voltage at a certain speed and solenoid 66 operates compressing spring 71 and again using stop 68 as a fulcrum, it rotates crank 64, closing valve 20, and the compression control means begins to operate. When solenoid 59 is operated by movement of throttle rod 12, it operates lever 62 with armature 67 as a fulcrum and pulls on crank 64 opening valve 20.

The description of the operation of egress valve 20, and solenoids 59 and 66 is applicable to Figs. 2 and 3, except for the location of the springs 57 making contact for energizing solenoid 59. The description of the operation of egress valve 20 and solenoid 59 is also applicable to Fig. 7.

In the liquid supply line to pressure regulator 26 may be inserted a valve 69. By regulating the passageway through this valve, the compression ratio of the engine can be increased with increasing speed. That is, if the engine is running at a speed corresponding to 50 miles an hour for the car, and with a given intake manifold vacuum, the compression ratio can be increased above that which is determined by the intake manifold vacuum. The pressure required to push a liquid through a given opening goes up much faster than the amount of liquid to pass. It may increase as the square of the amount, or even faster. Thus by regulating an orifice at valve 69 for the liquid from pump 23 to pass through, noticeable pressure to get the liquid therethrough will develop at a car speed of, say 50 miles an hour, that is, it will be found that the pressure in pipe 25 below valve 69 will be higher than above it. Since the pressure will be regulated above valve 69, there will result increased compression ratio with increase in engine speed in the speed range where the pressure differential across valve 69 is appreciable.

The same result can be secured by suitably restricting the size of openings 38 in regulator 26. However, the adjustable feature is lost, and there is no control of the effect which will change with change in viscosity of the liquid.

It is to be understood that in a multicylinder engine a single pump 23 driven by the engine, supply pipe 25, regulator 26, and vacuum register 28 suffice for all the cylinders, but that an individual check valve 41 and pipe 40 connect to each cylinder. Similarly, a single solenoid 59 and actuating apparatus function for all cylinders in line, if not for all in an engine, and serve to operate a single shaft 65 forming the movable part of the several valves 20 individual to each of the cylinders in a line.

The system for varying the size of the compression chamber 18 in an engine disclosed herein is a great improvement over any previous system using a movable piston in that the piston 7 is thoroughly sealed against the escape of gases from compression chamber 18. The oil in closed space 19 above piston 7 is under pressure from the gases of compression or explosion and therefore no difference in pressure occurs between compression chamber 18 and pressure space 19 except that produced by spring 15. Without a difference in pressure, the gases will not pass piston 7. The oil or other non-compressible liquid that can be used in pressure space 19 also permits of transfer of the reactive pressure of explosion directly to the cylinder block without the intervention of any levers, rods, or other moving parts. In addition, the oil provides a simple means for moving piston 7.

In this type of design, there are parts of the engine cycle when the oil pressure above piston 7 is greater than the pressure below. To minimize leakage of oil past piston 7, it is desirable that piston rings be used on piston 7 and that the inside of cylinder 8 within which piston 7 slides be polished. Plastic rings may be used as piston 7 will not get much hotter than the walls of cylinder 8 within which it slides when it is constructed with thick walls that permit of readily carrying away the heat. At the temperatures that the walls and the oil attain, there are plastics available that will stand the temperature and the oil without damage.

It is to be understood that the use of the words "oil" and "liquid" mean any suitable liquid having the properties necessary or described, and may mean the regular lubricating oil for the engine, special lubricating oil, glycerine, shock absorber liquid, or other oil-like liquid.

Fig. 2 shows the preferred form of the invention. Piston 2 slides in a sleeve cylinder 1A which is movable along its axis in a cylindrical bed in engine block cylinder 6. The sleeve cylinder 1A is closed at the end remote from the crankshaft by a cylinder head 72 which forms the movable wall of the compression chamber 73. The intake and exhaust valves 74 and 75 may be located in the engine block in a customary manner, either side by side, or opposite each other. They are shown in the latter position in Fig. 2. The space between the valves 74 and 75 is marked 76 and serves as the room into which each valve in turn moves upon opening. The space 76 also becomes part of the compression chamber, and is made a minimum in size. The spark plug 77 is preferably located in one wall of space 76 contiguous to the valves 74 and 75 as shown. The entire compression chamber consists of the space 76 and the space 73 between the engine piston 2 at its uppermost position and the cylinder head 72, plus the opening 78 in the wall of the sleeve cylinder 1A which provides communication between spaces 73 and 76. The opening 78 needs to be higher than the height of space 76 at its maximum so as to provide good communication for the flow of gases when the compression chamber 76 plus 73 plus 78 is a maximum and full charges are drawn into cylinder 1A, and it must provide reasonably good communication for the flow of gases when the compression chamber 73 is a minimum and only partial charges are drawn into cylinder 1A. This is facilitated by beveling off the edge of cylinder head 72 at point 79 and the bevel is continued through the sleeve.

The cylinder head 72 is provided with rings 80 to minimize the escape of oil from the pressure space 19 above. There need be only enough to suitably seal the pressure space 19 and to allow enough oil to seep past to provide the necessary oil to lubricate the surface between sleeve 1A and its bed in engine block 6. To prevent the oil seeping into the communicating opening 78, a groove may be cut in the outer side of the sleeve 1A around the opening 78, or around the inner side of the cylinder bed 6 at the same point so as to carry away from opening 78 whatever oil seeps down in that region. Such a groove appears in Fig. 2 at 81, 82, 83. If desired, a groove may start at 81, and run around the inside of the cylinder bed 6 to 82, then to 83, and it may continue spiraling down further such as

to 84 to spread the oil more uniformly around the outside of cylinder 1A.

The size of the compression chamber 76 plus 73 plus 78 is varied by injecting oil into the pressure space 19 between the cylinder head 72 and plate 13 bolted to the cylinder block, or letting it escape, through valve 20. The oil should preferably always be under pressure. Cylinder head 72 is fastened to pin 85 in any suitable manner, and pin 85 extends through plate 13 and has on its upper end a head, or preferably a large diameter nut 86 and a castellated nut 87, threaded in the usual manner. The pair can be adjusted as necessary and then locked and pinned. At the point pin 85 passes through plate 13, a stuffing box may be used to seal the pressure space 19 against oil leakage. A satisfactory seal however is produced by using a cylindrical sleeve 88 having a hole through it that allows pin 85 to fit reasonably snugly, yet slide easily. Some oil leakage will occur, but it will not be enough to interfere with efficient operation of the device. The cylindrical sleeve 88 can be fastened to plate 13 by threading into a hole or be constructed integral with 13. Spring 15 placed around sleeve 88 and between nut 86 and plate 13 serves to pull cylinder head 72 and cylinder 1A upward when oil is released from pressure space 19. It also serves to determine the position cylinder head 72 takes with respect to the engine piston 2 according to the oil pressure in space 19 due to oil coming in through valve 41 from supply line 40. Cylinder 1A may be kept from rotating by any suitable means such as pin 89 extending down from plate 13 into a hole in head 72.

Motor driven valve 130 of Fig. 3 may be used to admit oil to pressure space 19 if desired, but a simpler valve is shown. Check valve 41 is provided instead as it will automatically let oil enter the pressure space 19 when the oil pressure in pipe 40 is higher than the pressure in pressure space 19, and it will prevent oil from moving in the reverse direction during compression and explosion periods.

It is to be noted that spring 15 and pin 85 perform the same functions here as do spring 15 and pin 17 in Fig. 1, where they are under plate 13 and inside the pressure chamber 19. Either design may be used either place.

In Fig. 2, it is shown how oil under controlled pressure can be obtained from the regular engine oiling system supplied by oil pump 90 driven by the engine. Since the engine oiling pump 90 is designed to provide oil at a reasonably constant pressure, a pressure reducing control valve 91 under control of the manifold 9 gas pressure is provided. Pipe 27 connects intake manifold 9 with the suction chamber 92 whereupon rod 93 may be moved by virtue of its connection to flexible diaphragm 94 which forms one side of chamber 92. Rod 93 moves piston 95 downward under the influence of a vacuum so that the lower part of piston 95 below the groove 96 cut therein may uncover holes 97 in the cylinder 98 and allow oil in the surrounding space to enter groove 96 and pass through holes 99 in the piston that lead from groove 96 to the face of piston 95. The lower end of piston 95 is shown partly cut away to make the path of one of the holes visible. The oil from the engine oiling system enters at 100 and passes through holes 97, through groove 96, and the holes 99 to the face of the piston where it may now accumulate under pressure in cylinder 101 and pass into supply pipe 40 for distribution to all the enclosed spaces 19 in all cylinders of the engine. When the gas pressure in chamber 92 is atmospheric, the position of piston 95 is such as to partly uncover holes 97 by the part of piston 95 below the groove 96. The pressure in cylinder 101 will rise to that value which corresponds to minimum compression ratio at which time the pressure on the face of the piston 95 will compress spring 102 enough so piston 95 will cover the holes 97 and halt the pressure rise. When a vacuum develops in intake manifold 9, the vacuum in space 92 causes diaphragm 94 to push rod 93 downward and the lower part of piston 95 will uncover holes 97 until the oil pressure in cylinder 101 rises to a pressure designed to correspond to the said vacuum, at which time it will push piston 95 back far enough to cover holes 97 again. The said oil pressure will then send oil through pipe 40 and check valve 41 during exhaust and admission strokes and push cylinder head 72 and sleeve cylinder 1A down until the pressure on cylinder head 72 from the oil is balanced by the compression of spring 15.

In Fig. 2, a gasoline or other dashpot or equivalent device may be provided instead of the magnetic damping 56—58 of Fig. 1 in connection with controlling contacts 57 that operate release valve 20. The dashpot 103 is shown as built into carburetor 10, but can be separate, and use other liquid as desired. When the throttle is opened to give more power, throttle opening rod 12 is pushed in direction of the arrow, and rod 104 connected thereto slides through a hole in arm 105 and closes contacts 57 energizing solenoid 59 which opens valve 20 as described before. Arm 105 is connected to dashpot 103 in any suitable manner as are springs 57. The dashpot 103 has a loose fitting piston so its movement downward is permitted but resisted, thereby keeping contacts 57 closed during movement, and a ball check valve at the bottom over a large opening allows easy ingress of oil so the piston can rise with little resistance. A collar 106 is fastened to rod 104 to pull back on arm 105 when the throttle is closed, and the adjustment of the collar 106 determines the sensitiveness of the contacts to slight throttle movements.

At higher than average speeds, the compression ratio may be increased still further for a given sized explosive charge drawn into cylinder 1A. At still higher speeds, there tends to be smaller charges drawn into each cylinder 1A during the admission stroke for a given gas pressure in the intake manifold 9 than at low speeds. Provision is therefore made to secure improved efficiency under both these conditions by increasing the compression ratio faster than inversely as the manifold gas mixture pressure at higher than average speeds. 107 is an attachment for the generator 60 for accomplishing this improvement utilizing a register or indicator of speed to control the increased compression desired. 108 is a magnet fastened to the end of the shaft 109 of the generator 60 driven by the engine that supplies electric power for lights and battery charging. It is rotated inside a metal cup 111 fastened to one end of shaft 112. A spiral spring 113 is connected between the shaft 112 and metal frame 114 to exert an opposing force to the magnetic drag on cup 111. On the end of shaft 112 is a dog 115 adapted to strike spring 116 when the generator rotation is such as to correspond to a car speed of, say, 50 miles an hour, and the contact completes a circuit to ground through resistance 117 terminal 118, solenoid 119, wire 120, battery 61 (or generator 60), to ground and to frame 114 and dog 115 which will energize solenoid 119 which in turn will attract piston 95 of magnetic material and exert a force aiding the suction force in chamber 92 and result in permitting more oil to pass through openings 97 into pipe 101 and increase the pressure in cylinder 101 thereby increasing the compression ratio beyond the value determined by the intake manifold vacuum. When still higher speeds result, dog 115 pushes spring 116 against spring 121 which is located behind spring 116 and insulated from it. Resistance 122 is then placed in parallel with resistance 117 and more current will pass through solenoid 119 and still further increase the compression ratio.

In Fig. 3 is shown another modification of my invention. In cylinder 1 moves the engine power piston 2 (shown in Fig. 1) which drives the engine, and which

in turn drives liquid pump 23. The compression chamber 18 has a movable wall 7, the face of a piston that slides in cylinder 8. Cylinder 8 is closed at the top by plate 13 providing between it and movable wall piston 7 an enclosed space 19 adapted to be filled with liquid and sealed against egress of any of the liquid during the explosion cycle while the engine is running at constant speed and power. The movable wall 7 piston is supported by rod 17 with head 16, spring 15 and yoke 14 as described in connection with Fig. 1. Liquid from a reservoir 24, which can be the engine oil pan, is pumped by pump 23 into pipe 25 at a rate substantially proportional to the engine speed since pump 23 contains no pressure regulator. The liquid may pass into connecting pipe 34, which is a cylinder, of pressure regulator 123.

Pressure regulator 123 is simpler in design than regulators 26 and 91 of Figs. 1 and 2, respectively. Pipe 27 connects intake manifold 9 with the vacuum chamber 124, which chamber has a flexible daiphragm 125 of rubber or other suitable material as one side, and which diaphragm is arranged to actuate piston 126 by means of rod 127 which is attached to the diaphragm and to the piston. Rod 127 slides through a close fitting hole in the supporting frame 128. The fit need not be air tight, but should be close fitting enough to not let in air enough to upset the mixture under the highest vacuum conditions. Piston 126 slides in cylinder 34 which is supported from the frame of the regulator 123 and has threads or other arrangement at the other end to permit of attachment to oil line 25. Escape openings 38 are provided in cylinder 34 so that when the oil pressure on the face of piston 126 is sufficient to overcome the vacuum suction on diaphragm 125 and spring 129 resistance, the oil can escape and return to the oil reservoir through opening 39 connected to return pipe 22. Spring 129 is designed to establish the oil pressure desired when that engine is operated with the minimum vacuum in intake manifold 9. The increased oil pressure with higher vacuum is determined by the force exerted by the liquid on piston 126 necessary to balance the vacuum suction on diaphragm 125 due to its connection with intake manifold 9. Pressure regulator 123 will thus regulate the liquid pressure in supply line 25 in accordance with the vacuum in the intake manifold.

Pipe 40 connected to pipe 25 conveys the liquid to a rotating valve 130 having a rotating element 131 carrying a gear wheel 132 on an external extension, said gear meshing with gear 133, shown dotted, fastened to and turned by shaft 134 which in turn is driven by the engine. Valve element 131 rotates at one quarter the engine main crankshaft rate. Valve element 131 contains a passageway 135 positioned such as to line up with opening 136 to enclosed space 19 and opening 137 to supply pipe 40 about the center of the admission stroke of the piston in cylinder 1. Its size is such as to open before the admission stroke begins, and close after the compression stroke starts. Rotating valve 130 thus serves to admit liquid to the enclosed space behind movable wall 7 when the compression ratio is to be increased, and to allow liquid to return to pipe 40 if the intake manifold vacuum falls and the egress valve 20 is not operated. Alternatively, the passageway 135 may be made with such a size and position as to begin to open just after the exhaust valve opens, and close just after the compression stroke starts, or to provide a passageway for other periods of duration.

Egress valve 20 with oscillating valve element 65 is operated by crank 64, link 63, lever 62 and solenoids 59 and 66 by contacts 57 as described in connection with Fig. 1. Egress valve 20 discharges the liquid into pipe 21 which in turn delivers it to pipe 22 for return to reservoir 24.

Contacts 57 are differently arranged than in either Fig. 1 or 2. Throttle rod 12 is moved when foot throttle 139 is depressed. Throttle rod 12 is firmly attached to element 140. Rod 141 slides easily in element 140 and carries a head 142 against which bears spring 143 which in turn bears against an inside wall of element 140. Rod 141 not only moves the throttle on shaft 11 in carburetor 10, but moves a connection 144 which actuates dashpot 145 or an equivalent device. Dashpot 145 may be of any suitable design, and is arranged to provide resistance opposing the opening of the carburetor throttle when rod 12 is pushed to the right, but will provide little or no impedance to the movement in the reverse direction to close the throttle. One of contacts 57 is metal plate 146 carried by element 140 but insulated therefrom and from rod 141. The other contact of the pair 57 is metal element 147 firmly attached to rod 141 and grounded in any suitable manner. The grounding means can be connected to the engine or frame. When pedal 139 is pressed to speed up the engine or deliver more power, rod 12 and element 140 are moved to the right but dashpot 145 prevents rod 141 from moving and opening the throttle until contact 146 strikes 147 making electrical and mechanical contact. The foot pressure will then open the throttle against the resistance of dashpot 145. When contacts 146 and 147 touch each other, the circuit from the generator 60 or battery 61 is completed through wires 148 and 149 to solenoid 59 and egress valve 20 is opened as described in connection with Fig. 1. When pedal 139 stops moving, spring 143 pressing against head 142 moves rod 141 enough further to separate contacts 146 and 147, it being understood that dashpot 145 produces resistance against rapid movements but very little against slow movements. Solenoid 59 then releases, and egress valve 20 closes permitting the mechanism for increasing the compression ratio to again function.

With this form of the invention, the means for reducing the compression ratio are made operative before the throttle moves at times the pedal is depressed for increasing the engine power or speed and are kept in operative condition so long as the foot pedal 139, and throttle rod 12 are in motion in such a direction as to increase the manifold gas pressure.

In an engine equipped with my invention, the efficiency is so much increased that with an idling throttle adjustment common for fixed compression, the engine may idle at excessive speed when the compression ratio is increased. Since the engine starts easier with minimum compression it may be preferable to provide an initial idling adjustment suitable for the minimum compression condition. Idling adjusting screw 150 on carburetor 10 is so adjusted. If the generator 60 does not "build up" at idling speed, idling with minimum compression ratio proceeds. If the generator does build up, solenoid 66 is energized through connection 149 and egress valve 20 is closed placing the mechanism in operation to increase the compression ratio. When the compression ratio is increased, the idling speed will increase. In Fig. 5 is shown an arrangement for controlling the excessive speed. Pipe 151 connects to pipe 152 in Figs. 1, 2 and 3, and carries the liquid at the pressure in pipe 25 in Figs. 1 and 3 or cylinder 101 in Fig. 2, to a cylinder 153 in Fig. 5 where it exerts pressure on piston 154, moving rod 155 against the force from spring 156 and turning crank 157 on shaft 158 which carries cam 159 against which bears adjusting screw 150 for controlling idling. When the liquid pressure rises in pipes 25 or 101 to increase the compression ratio, cam 159 is rotated in such a direction that screw 150 is lowered, thereby closing further the throttle valve in carburetor 10, and the engine idling speed is reduced.

Fig. 6 shows an attachment for Figs. 1 and 2 to reduce the compression ratio of the engine when the engine slows down slowly with an increase in load, and the throttle is not moved. 160 is a cylinder closed at one end, with piston 161 near the other end and adapted to move therein. A chamber 162 of sufficient size to partake of the operation described below exists between piston 161 and

the closed end thereof. The piston is connected to a piston rod 163 which in turn passes through plate 164 which closes the other end of the cylinder 160 forming a small chamber 165 between plate 164 and piston 161. Piston rod 163 is fastened to spring 166 which is designed and adapted to move piston 161 back or forth about a position of equilibrium whenever the piston is displaced therefrom. Spring 166 makes contact with spring 167 when the piston is in the position of equilibrium, but the contact is broken if the piston moves to the left. Wires 168 and 169 connecting to springs 167 and 166 are to be inserted in series in the circuit at point W—W in Figs. 1 and 2, between solenoid 66 and ground. Chamber 165 connects to intake manifold 9 by means of pipe 170 connecting to pipe 171 in Figs. 1 and 2. On the inside of cylinder 160 are two depressions, that may be circular or other convenient shape, whose edges almost, but do not quite touch, under the rim of piston 161 when the latter is in its position of equilibrium.

The operation is as follows. When the engine slows up under an increased load and the throttle is not moved, the gas pressure in the intake manifold rises slowly. Pipe 170—171 connecting chamber 165 with the intake manifold 9 allows the increased gas pressure to act upon piston 161 pushing it to the left. The piston pulls rod 163 and spring 166 so that the contact between springs 166 and 167 is broken. Since the two springs are in the circuit with generator 60 and solenoid 66, the solenoid is released, and valve 20 is opened a small amount. Explosion pressures in engine compression chamber 18 or 73 and pressure from spring 15 will slowly force out liquid from closed space 19 and enlarge the compression chamber thereby avoiding excessive compression pressures. After the gas pressure in the intake manifold 9 and chamber 165 ceases to rise, the gas in chamber 162 will leak around the piston slowly, or pass through orifice 174 in piston 161 equalizing the pressures on both sides of the piston and spring 166 returns the piston to the equilibrium position and also makes contact with spring 167 which again energizes solenoid 66 to close egress valve 20.

When large changes in pressure occur in chamber 165 due to the operation of the throttle valve, the piston 161 will move to one side or the other of its equilibrium position enough so that bypass depression 172 or 173 will straddle the piston and provide a path for the passage of gas quickly between chambers 162 and 165. The device shown in Fig. 6 together with solenoid 66 and valve 20 therefore provides a means for reducing the compression ratio slowly when the gas pressure in the intake manifold rises slowly.

In Figs. 7 and 8 is shown another form of the invention. Fig. 8 is a top view of one cylinder and Fig. 7 is a side view of the same cylinder at A—A in Fig. 8. A sliding cylinder 1B in which the power piston 2 moves, is slidably positioned inside cylinder 6 which is part of the engine cylinder block. Cylinder 1B is closed at its upper end by movable wall 175 to which it is firmly fastened in any suitable manner. Cylinder 1B contains no side openings so that the compression chamber 18 is entirely enclosed by cylinder 1B, piston 2 and movable wall 175. With this arrangement problems connected with leakage of gases or liquids past the movable wall are avoided. Exhaust valve 74 and intake valve 75 are located in the movable wall 175. Spark plug 176 may also be placed in the movable wall. Intake and exhaust passageways 177 run from their respective valves to the outer cylindrical side of the movable wall, and slidably connect with passageways in the engine block to the intake manifold 9 and the exhaust pipe (not shown) respectively. Valve rods 178 pass through guides 179, the guides being firmly attached to the movable wall 175. The valve guides 179 pass through plate 13 by means of any suitable stuffing box. Plate 13 closes the upper end of cylinder 6 to which it is firmly attached thereby producing an enclosed chamber 19 between it and the movable wall 175 adapted to be filled with liquid. A tubular well 180 may extend through plate 13 by means of a stuffing box and be attached to the movable wall so as to provide a well in which the spark plug 176 can be reachably placed.

A platform 181 may be attached to the valve guides 179 and spark plug tube 180 in any suitable manner so as to move up and down as wall 175 and cylinder 1B move up and down. The valves are actuated by rockers 182 which in turn are actuated by valve rods 183 from the cam shaft. Rockers 182 are pivoted on shaft 184 which in turn is supported by links 185 from levers 186. Levers 186 are rotatably supported at one end by stanchions 187 attached to the plate 13, and at the other end by stanchions 188 attached to the platform 181 whereby the movable wall 175 and valves 74, 75 may be raised and lowered and such movement will raise and lower the pivoting shaft 184 the correct amount so as to cause the valves to correctly operate at all positions within the movable range of the assembly 175, 179, 180, 181.

Positioned under platform 181 between it and plate 13 may be a spring 189 of any convenient shape, so as to exert an upward force tending to move the platform upward and enlarge the compression chamber.

The compression chamber 18 is reduced in size by means of liquid from pump 90, which may be the regular engine oil pump. The liquid enters inclosed space 19 through check valve 41 and passageway 198. The movable wall is positioned as follows. Pipe 190 containing one or more holes 191 in its side passes through plate 13 by means of a suitable stuffing box and into a close fitting hole 192 in the movable wall. Pipe 190 at its upper end is attached to vacuum register 193 in any suitable manner such as by lever 194 pivoted on stanchions 197 from plate 13, and connection 195. Vacuum register 193 is connected by pipe 27 to the intake manifold 9. With no vacuum in the intake manifold, the spring 200 on the vacuum register 193 lifts pipe 190 until holes 191 are just under the lower surface of plate 13. All liquid entering enclosed space 19 from pump 90 passes directly out holes 191, pipe 190 and flexible pipe 196 to return pipe 21. When a vacuum develops in the intake manifold 9, the diaphragm in the vacuum register 193 compresses the attached spring 200 a predetermined amount, and pipe 190 moves downward a predetermined amount placing holes 191 at the position of the upper surface of movable wall 175 that has been determined to produce a compression ratio to correspond with the intake manifold vacuum. The liquid entering enclosed space 19 will then depress the movable wall until the escape holes 191 are partially uncovered by the upper surface of the movable wall. The wall will now remain at such a position that the amount of liquid entering enclosed space 19 equals that passing out through holes 191. The wall will move up and down slightly during the explosion and admission strokes, respectively, but the movement can be made as small as desired by enlarging and shaping holes 191.

If the gas pressure in the intake manifold should rise slowly as from an increase in engine load and drop in speed, the vacuum register spring 200 will withdraw pipe 190 sufficiently to readjust the compression ratio.

Lever 194 is fastened firmly to shaft 199 and shaft 199 extends to other cylinders in the case of a multicylinder engine so that vacuum register 193 can operate pipes 190 for all cylinders simultaneously.

To provide for a rapid increase in size of the compression chamber when the throttle rod is moved to get more power or speed, egress valve 20 is provided as mentioned and described in connection with Figs. 1, 2 and 3. The valve 20 is actuated by solenoid 59 from contacts associated with the carburetors mentioned, and the operation is as described with respect to the other figures.

The carburetor, intake manifold connection, and oper-

ating mechanism for solenoid 59 may be provided by utilizing such parts above lines Z—Z from one of Figs. 1, 2 or 3 and connecting in Fig. 7 at Z—Z.

The generator 60 in Fig. 7 below the lines V—V may be the generator 60 in Fig. 2 below the lines V—V, including the elements 107 to 117, inclusive, and 121 and 122. A solenoid 119 is provided in Fig. 7 such that when it is energized it assists the suction in the intake manifold to increase the compression ratio by lowering pipe 190. As described in connection with Fig. 2, a sufficient increase in engine speed will cause dog 115 to connect first with spring 116 and then with spring 121 making connections through resistances 117 and 122 and wires 118 and 120 to energize solenoid 119 and cause the compression ratio to be increased as a result of speed above that which is determined by the intake manifold vacuum alone.

If desired, liquid pump 23 of Fig. 1, described above as a pump without a pressure regulator, may be substituted in Fig. 7 at U—U for liquid pump 90, described above as the customary engine lubricating oil pump containing a pressure regulator 201. With pump 23 delivering liquid proportionally to engine speed, the compression ratio may be caused to be increased at a faster rate than with pump 90. In addition, the faster rate of liquid delivery with increased speed of the engine will cause the movable wall to uncover a greater amount of holes 191 at higher engine speeds, thus causing the compression ratio to increase with increased engine speed above the amount determined by the intake manifold vacuum. With this substitution elements 107 to 114 and 117, 122, and 119 in Fig. 7 may be dispensed with.

The engine driven rotating valve 137 in Fig. 3 at lines X—X may be substituted for the check valve 41 at X—X in Figs. 1 and 2, or the check valve 41 at X—X in Fig. 1 or 2 may be substituted for the rotating valve 137 at X—X in Fig. 3.

The pressure regulator 26 and pump 23 in Fig. 1 at Y—Y, the pressure regulator 91 and pump 90 at Y—Y in Fig. 2, and the pressure regulator 123 and pump 23 at Y—Y in Fig. 3 may be interchanged or substituted among the three figures.

The carburetor 10 and resistance 56, 58 carrying contracts 57 in Fig. 1 at Z—Z, the carburetor 10 and dashpot 103 with contacts 57 in Fig. 2 at Z—Z, and the carburetor 10 dashpot 145 and element 140 carrying contacts 57 in Fig. 3 at Z—Z may be interchanged or substituted among the three figures.

It is to be understood that the various subcombinations for performing specific functions may be used in any of the systems disclosed to which they are adaptable.

Although this invention has been described and illustrated in relation to specific arrangements, it is to be understood that it is capable of application in other organizations and is therefore not to be limited to the particular embodiments disclosed.

What is claimed is:

1. A variable compression internal combustion engine including an intake manifold, means comprising a throttle for varying the intake manifold gas pressure, a throttle member for controlling said throttle, means activated by a falling intake manifold gas pressure to increase the compression ratio of said engine, means for disabling said second-named means and for decreasing said compression ratio, and actuating means for said last-named means connected between said last-named means and said throttle member operable before said throttle moves appreciably while said throttle member is moving in a direction to raise said intake manifold gas pressure.

2. A variable compression internal combustion engine, comprising an intake manifold, a throttle, a throttle member for controlling said throttle, and means to adjust the compression ratio of said engine to a predetermined value in relation to the gas pressure in said intake manifold of said engine in response to a throttle movement that causes a rise in said pressure, said means comprising, in combination, means to reduce said compression ratio beyond said predetermined value under control of said throttle member before said throttle moves appreciably, additional means for increasing said compression ratio to said predetermined value under control of said gas pressure in said intake manifold and means controlled by said means for reducing the compression ratio for rendering inoperative said additional means for increasing the compression ratio while said means for reducing the compression ratio is operating.

3. A variable compression ratio internal combustion engine in which the compression ratio is varied as a result of a change in the gas pressure in the intake manifold, a throttle for controlling said gas pressure, a throttle member for actuating said throttle, means for reducing the compression ratio comprising a valve, and connecting means connecting said throttle member, said throttle and said valve for actuating said valve before appreciably actuating said throttle to prevent excessive rise in compression pressure upon opening the throttle, said connecting means comprising instrumentalities for operating said throttle independently of said compression ratio at all times.

4. A variable compression ratio internal combustion engine according to claim 3 in which the means connecting said throttle, said throttle member and said valve includes elastic and damping means adapted to actuate said valve only while said throttle member is in motion.

5. A variable compression ratio internal combustion engine according to claim 3 in which the means connecting said throttle, said throttle member and said valve include an elastic member adapted to be strained before either said throttle or said valve is actuated, and a dashpot means connected to said throttle for opposing motion of said throttle until said connecting means to said valve begins to actuate said valve.

6. A variable compression ratio internal combustion engine according to claim 3 which includes a compression chamber having a movable wall, an enclosed space behind said movable wall adapted to be filled with liquid, and an egress passageway from said enclosed space containing said valve.

7. A variable compression ratio internal combustion engine according to claim 6 which includes a hollow cylinder in which the power piston slides, said cylinder being slidably positioned in the engine and having firmly attached thereto said movable wall so as to close one end of the cylinder.

8. A variable compression ratio internal combustion engine according to claim 7 which includes intake and exhaust valves, said valves being located in said movable wall.

9. A variable speed internal combustion engine operable over a substantial speed range comprising an electromagnetic generator of a force driven by said engine and generating a force due solely to speed of said engine which varies in a predetermined manner with variations of speed of said engine, and a second force generating means operated by power from said engine for increasing the compression ratio of said engine, control means for said second force generating means actuated by gas pressure in the intake manifold, and additional control means for said second force generating means actuated by said first generating force means for increasing the compression ratio of said engine with increase in speed of said engine beyond the value determined by the gas pressure in the intake manifold.

10. A variable speed variable compression ratio internal combustion engine including means for supplying a liquid under variable pressure for varying said compression ratio, a carburetor for said engine, an idling adjustment on said carburetor, and pressure responsive means connecting said idling adjustment with said means for supplying a liquid under variable pressure, for varying said idling adjustment in a direction to reduce the engine speed when the compression ratio is increased.

11. An internal combustion engine having a variable compression chamber with a movable wall, an enclosed space behind said movable wall adapted to be filled with liquid, means for supplying liquid under pressure, and means comprising a valve driven by said engine for providing a two-way passageway for said liquid between said enclosed space and said means for supplying liquid under pressure solely during exhaust, admission and compression strokes of the engine.

12. In an internal combustion engine, a variable compression chamber having a movable wall, an enclosed space behind said movable wall adapted to be filled with liquid, a pump driven by said engine for supply liquid for said enclosed space, a passageway for conveying said liquid from said pump to said enclosed space, a pressure regulator for regulating the pressure of the liquid in a predetermined relation to the intake manifold gas pressure, a second passageway for said liquid running from said first passageway to said pressure regulator, a restricted opening in said second passageway across which an increasing pressure develops due to the passing to the pressure regulator of an increasing volume of liquid with increasing speed of said engine.

13. An internal combustion engine comprising a combustion chamber having a movable wall, an intake manifold connected with said combustion chamber, a carburetor having a throttle connected with said intake manifold, a liquid pump driven by said engine, an enclosed liquid pressure space behind said movable wall, a passageway for conducting liquid supplied by said pump to said enclosed pressure space, a pressure regulator connected with said pump, said intake manifold and said passageway for regulating the liquid pressure in said passageway in accordance with the vacuum in said intake manifold, a valve connected between said passageway and said enclosed pressure space for admitting said liquid into said enclosed pressure space and for preventing compression and explosion pressures from influencing the liquid pressure in said passageway, a spring connected with said movable wall for exerting pressure on said liquid in said enclosed pressure space, a second valve connected with said enclosed liquid pressure space behind said movable wall for opening an egress passageway for said liquid in said enclosed space, and a solenoid controlled by said throttle and connected to said second valve.

14. An internal combustion engine comprising means including an intake manifold to supply an explosive gas mixture at variable pressure to said engine, a variable compression chamber for said gas mixture comprising a movable wall, a spring adapted to exert a force on said movable wall in such a direction as to enlarge said compression chamber and of a predetermined magnitude with respect to the position of said movable wall, an enclosed space behind said movable wall adapted to be filled with liquid and sealed against egress of any of said liquid during the explosion cycle of said engine while operating at substantially constant speed and power, a supply connection to said enclosed space adapted to be filled with liquid at a pressure force controlled by and in a predetermined relation to said gas pressure in said intake manifold, and means to position said movable wall at a position determined by said spring force and said liquid pressure force comprising means to open a passageway between said supply connection and said enclosed space.

15. An internal combustion engine having a variable compression chamber comprising a movable wall, an enclosed space behind said movable wall adapted to hold liquid, a throttle adapted to control the speed of said engine, means for moving said movable wall and enlarging said compression chamber quickly comprising valve means adapted to open a low impedance egress passageway for said liquid in said enclosed space, a connection between said throttle and said valve means, and a source of velocity produced force included in said connection between said throttle and said valve means for actuating said valve means and opening said egress passageway only while said throttle is in motion in such a direction as to increase the power of said engine.

16. An internal combustion engine comprising an intake manifold, a movable cylinder having a power piston therein, a compression chamber having a movable wall, said wall being firmly attached to and closing one end of said movable cylinder in which said power piston slides, an enclosed space behind said movable wall adapted to be filled with liquid, a liquid pump connected to said enclosed space for supplying liquid thereto, a valve connected between said liquid pump and said enclosed space behind said movable wall, said valve constituting means adapted to provide a passageway for said liquid between said pump and said enclosed space, regulating means connected to said intake manifold and to said pump for controlling the pressure of the liquid supplied by said pump in accordance with the varying vacuum in said intake manifold, a spring connected to said movable wall, said spring constituting means adapted to exert a pressure on said liquid in said enclosed space and adapted to cooperate with the controlled pressure of said liquid supplied by said pump to said enclosed space for positioning said movable wall in a predetermined relation to the gas pressure in said intake manifold, a second connection to said enclosed space behind said movable wall, said connection including a second valve constituting means adapted to provide an egress passageway for said liquid in said enclosed space for disabling said means cooperating to position said movable wall in a predetermined relation to the gas pressure in said intake manifold and for enabling said spring to enlarge said compression chamber, a throttle member adapted to control the gas pressure in said intake manifold, and a connection between said throttle member and said second valve constituting means adapted to open said second valve for enlarging said compression chamber while said throttle member moves in a direction to increase said gas pressure in said intake manifold.

17. A variable compression internal combustion engine comprising a carburetor for said engine, a throttle member connected to said carburetor, an intake manifold connected to said carburetor for supplying an explosive gas mixture to said engine at variable pressure, a cylinder connected to said intake manifold and having a power piston therein, a variable compression chamber in said cylinder and having a movable wall member, said wall member being attached to and closing one end of said cylinder in which said power piston slides, an enclosed space behind said movable wall member adapted to be filled with liquid and sealed against egress of any of said liquid during the explosion cycle of said engine while operating at constant speed and power with constant gas pressure in said intake manifold, a source of a force comprising a liquid pump driven by said engine and adapted to supply said liquid under pressure to said enclosed space, means to regulate said force comprising a pressure regulator connected to said liquid pump and to said intake manifold and constructed and arranged to regulate said pressure of said liquid in a predetermined relation to said gas pressure in said intake manifold, means to admit said liquid into said enclosed space behind said movable wall comprising a connection between said pump and said enclosed space including valve means adapted to admit said liquid into said enclosed space only during periods of relatively low pressure in said compression chamber, means to enlarge said compression chamber comprising a spring adapted to exert a force on said movable wall in such a direction as to apply pressure on said liquid in said enclosed space, said last-mentioned means being adapted to cooperate with said regulated pressure of said liquid supplied by said pump to said enclosed space by exerting a force on said movable wall for positioning said movable wall in a predetermined relation to said gas pressure in said intake manifold, a passageway of substantially low impedance

for the egress of said liquid in said enclosed space comprising a connection between said enclosed space and a region of relatively low pressure, means to control the egress of said liquid from said enclosed space comprising a second valve means adapted to close said egress passageway, means driven by said engine for generating a second force continuously while the speed of said engine is higher than a predetermined value, means to prevent said compression chamber from being enlarged under the influence of said spring comprising connecting means between said generator of said second force and said second valve means for closing said second valve means by said second force, means to enlarge said compression chamber quickly upon a demand for more power from said engine comprising a connection between said second valve means and said throttle member for opening said second valve when said throttle member is moved in a direction to increase the power of said engine, means to actuate said connection between said second valve means and said throttle member only while said throttle member is moving comprising a source of a force generated by the velocity of movement of said throttle member inserted in said connection between said second valve means and said throttle member, means driven by said engine for generating a third force, said force varying in a predetermined manner with variation in speed of said engine, means to increase said pressure of said liquid supplied by said liquid pump with increase in said speed of said engine comprising a connecton between said generator of said third force and said pressure regulator, an idling adjustment on said carburetor, means responsive to said pressure of said liquid supplied by said liquid pump for varying said idling adjustment for keeping the speed of said engine substantially constant with change in compression ratio of said engine produced by change in size of said compression chamber.

18. A variable compression ratio internal combustion engine comprising a movable wall, an enclosed space behind said movable wall adapted to be filled with liquid, means for moving said wall and increasing the compression ratio under control of the intake manifold gas pressure, a throttle rod for controlling said gas pressure, means for moving said wall and reducing the compression ratio under control of the intake manifold gas pressure, and additional means for reducing the compression ratio quickly comprising an egress valve for liquid in said enclosed space connected to said enclosed space, and a connection between said egress valve and said throttle rod adapted to open said valve when said throttle rod moves in such a direction as to increase said intake manifold gas pressure.

19. A variable compression ratio internal combustion engine comprising a movable wall, an enclosed space behind said movable wall adapted to be filled with liquid, means for moving said wall and increasing the compression ratio under control of the intake manifold gas pressure, a throttle rod for controlling said gas pressure, and means for reducing the compression ratio comprising an egress valve for said liquid in said enclosed space connected to said enclosed space, and a connection between said egress valve and said throttle rod adapted to open said valve only while said throttle rod is in motion in such a direction as to increase said intake manifold gas pressure.

20. A variable compression ratio internal combustion engine comprising a movable wall, an enclosed space behind said movable wall adapted to be filled with liquid, a pump driven by said engine for supplying liquid at a rate proportional to the speed of said engine, a connection for conveying liquid from said pump to said enclosed space, means under control of the intake manifold gas pressure for controlling the flow of said liquid to position said movable wall in a predetermined relation to said gas pressure, and a restricted opening in the path of flow of at least a part of said liquid whereby the pressure developed across said restricted opening by the flow of liquid therethrough will be applied to said movable wall and will move said movable wall an additional amount beyond said predetermined relation position.

21. A variable speed variable compression ratio internal combustion engine comprising a liquid pump driven by said engine for supplying liquid at a rate proportional to the engine speed, a liquid pressure regulator controlled by the gas pressure in the intake manifold for regulating the liquid pressure at its intake side in a predetermined relation to said gas pressure, a connection for liquid between the output side of said pump and said regulator intake side, a variable compression chamber in said engine having a movable wall, an enclosed space behind said movable wall adapted to be filled with liquid, a second connection for the liquid running from said enclosed space to the output side of said pump, a restricted passageway in said first connection positioned so that the liquid to said pressure regulator passes therethrough, said restricted passageway being so proportioned that at the higher speeds of the engine speed range a pressure differential will appear across said passageway that increases with speed of said engine.

22. An internal combustion engine having a variable compression chamber comprising a movable wall, an enclosed space behind said movable wall adapted to hold liquid, a throttle adapted to control the speed of said engine, a throttle rod, means for moving said movable wall and enlarging said compression chamber quickly comprising valve means adapted to open a low impedance egress passageway for said liquid in said enclosed space, actuating means connecting said throttle, said throttle rod and said valve means adapted to actuate said valve means and open said egress passageway only while said throttle rod is in motion in such a direction as to increase the power of said engine and before appreciably actuating said throttle, said actuating means comprising instrumentalities for operating said throttle independently of said compression ratio at all times.

23. An internal combustion engine according to claim 22 which includes a hollow cylinder in which the power piston slides, said cylinder being slidably positioned in the engine and having firmly attached thereto said movable wall so as to close one end of the cylinder.

24. An internal combustion engine according to claim 23 which includes intake and exhaust valves located in said movable wall, valve rod means driven by said engine for actuating said intake and exhaust valves, rocker arms adapted to actuate said intake and exhaust valves by movement of said valve rods, and means connecting said rocker arms and said movable wall for moving the fulcrum of said rocker arms up and down with movement of the movable wall to maintain an operative adjustment between said intake and exhaust valves and said valve rods.

25. An internal combustion engine according to claim 22 which includes means for adjusting the compression ratio comprising a movable discharge passageway for said liquid in said enclosed space, means actuated by said movable wall to increase the size of said passageway as said movable wall moves in a direction to increase the compression ratio, and means connecting said movable discharge passageway with the intake manifold adapted to position said discharge passageway so as to position said movable wall and adjust the compression ratio in predetermined relation to the gas pressure in said intake manifold.

26. A variable compression ratio internal combustion engine comprising an expandable chamber adapted to hold liquid and change the size of the compression space, a valve connected to said chamber for controlling the exit of liquid from said chamber, a throttle, a throttle rod, yieldable connecting means connecting said throttle rod, said valve and said throttle adapted to open said valve and said throttle by a single movement in one direction of said throttle rod, means to delay the opening

of said throttle until after said valve is opened upon the movement of said throttle rod in said one direction, and means subsequently operative to close said valve independent of motion of said throttle rod and independent of the position of said throttle.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