C. F. HOPEWELL.

CONVERTIBLE TWO TO FOUR CYCLE GAS ENGINE.

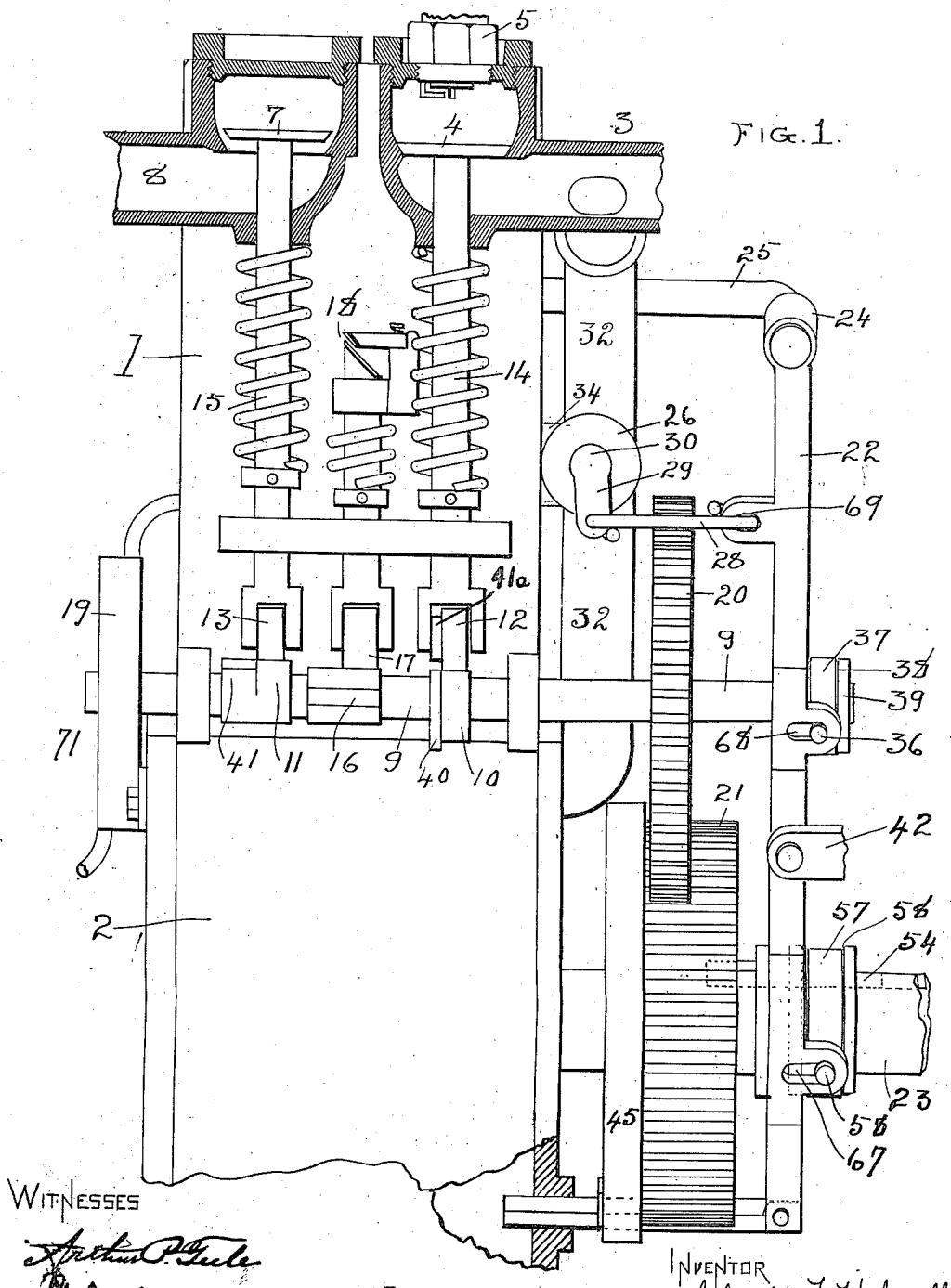
APPLICATION FILED MAY 13, 1904.

991,063.

Patented May 2, 1911.

4 SHEETS—SHEET 1.

FIG. 1.



WITNESSES

Arthur P. Seale

Philip Mansfield

BY HIS ATTORNEY

INVENTOR

Charles F. Hopewell

Myron Francis Hill

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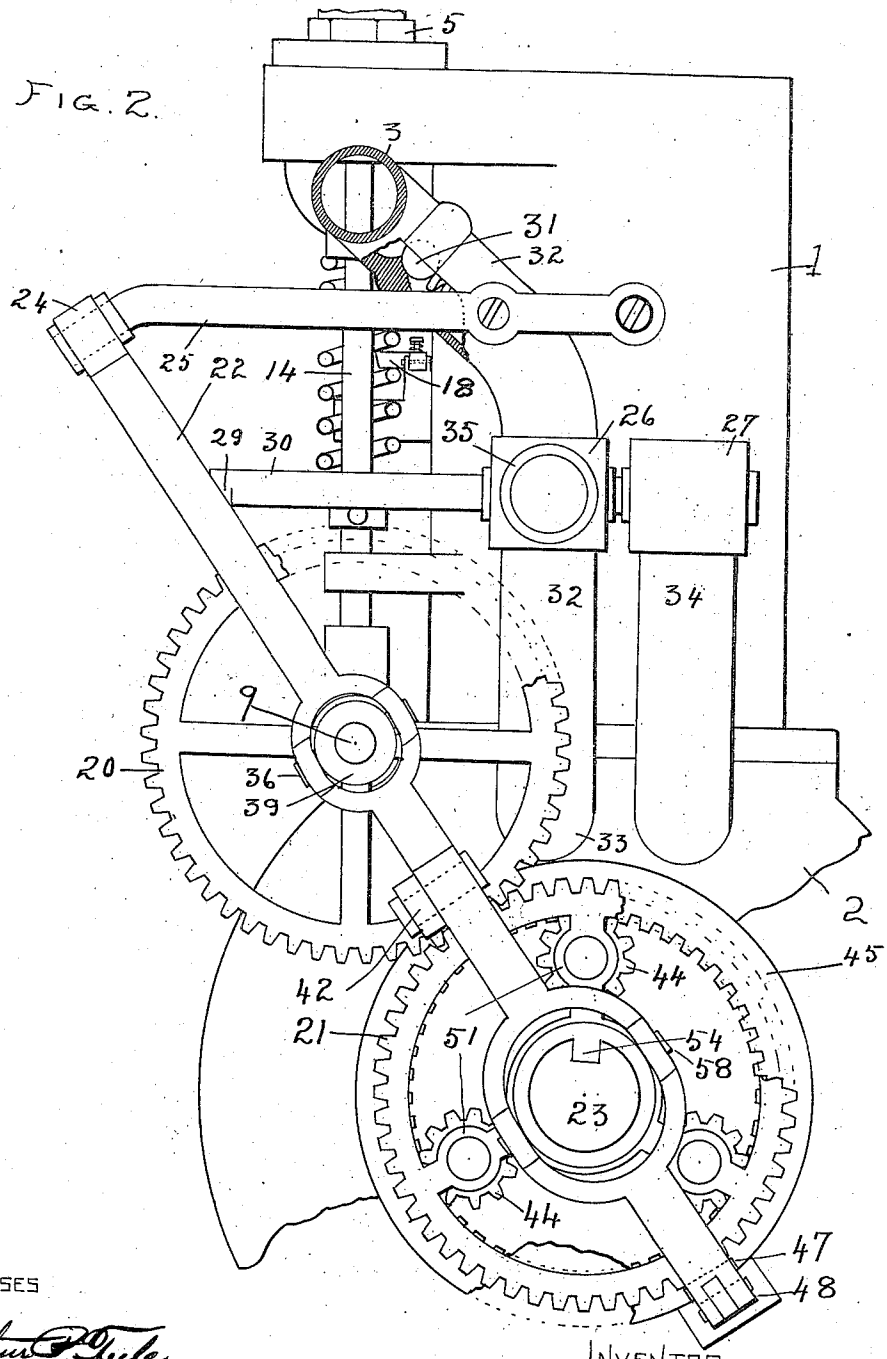
4 SHEETS—SHEET 2.

FIG. 2.



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Arthur P. Dale

Philip Mansfield

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BY HIS ATTORNEY

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4 SHEETS—SHEET 3.

FIG. 3.

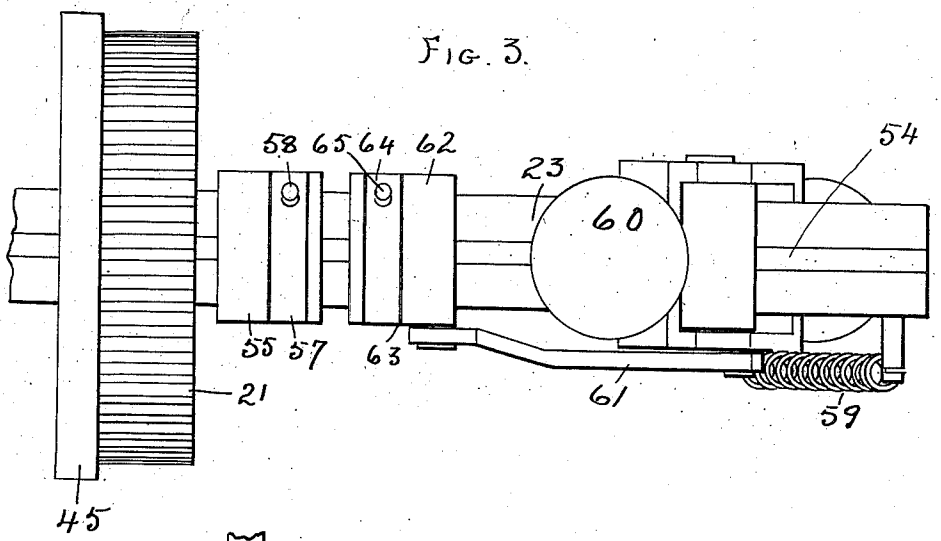
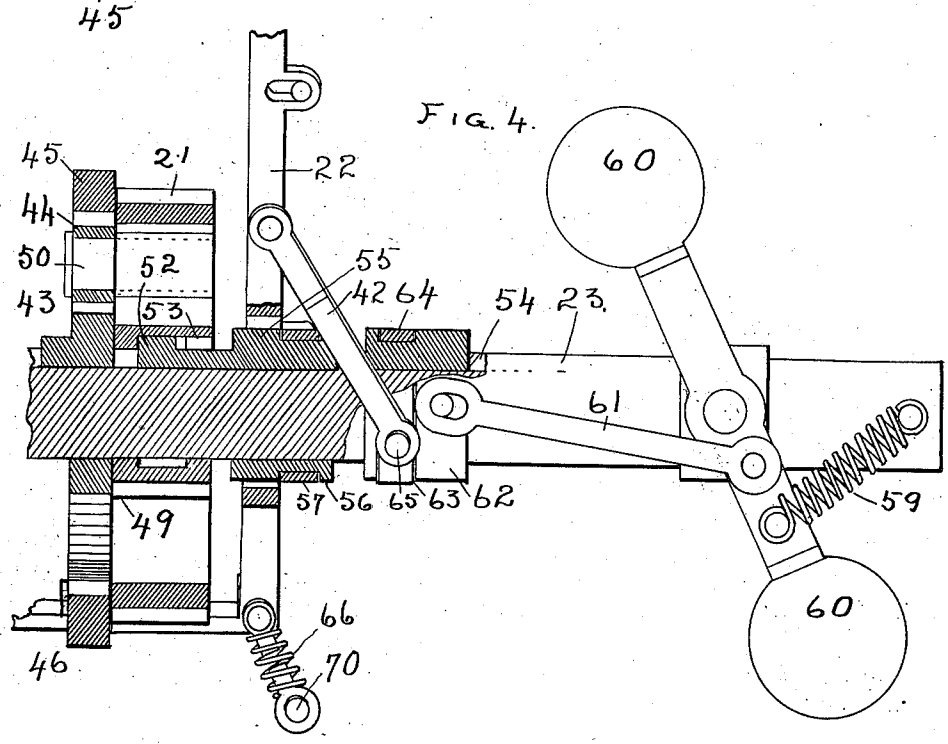


FIG. 4.



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Philip Mansfield

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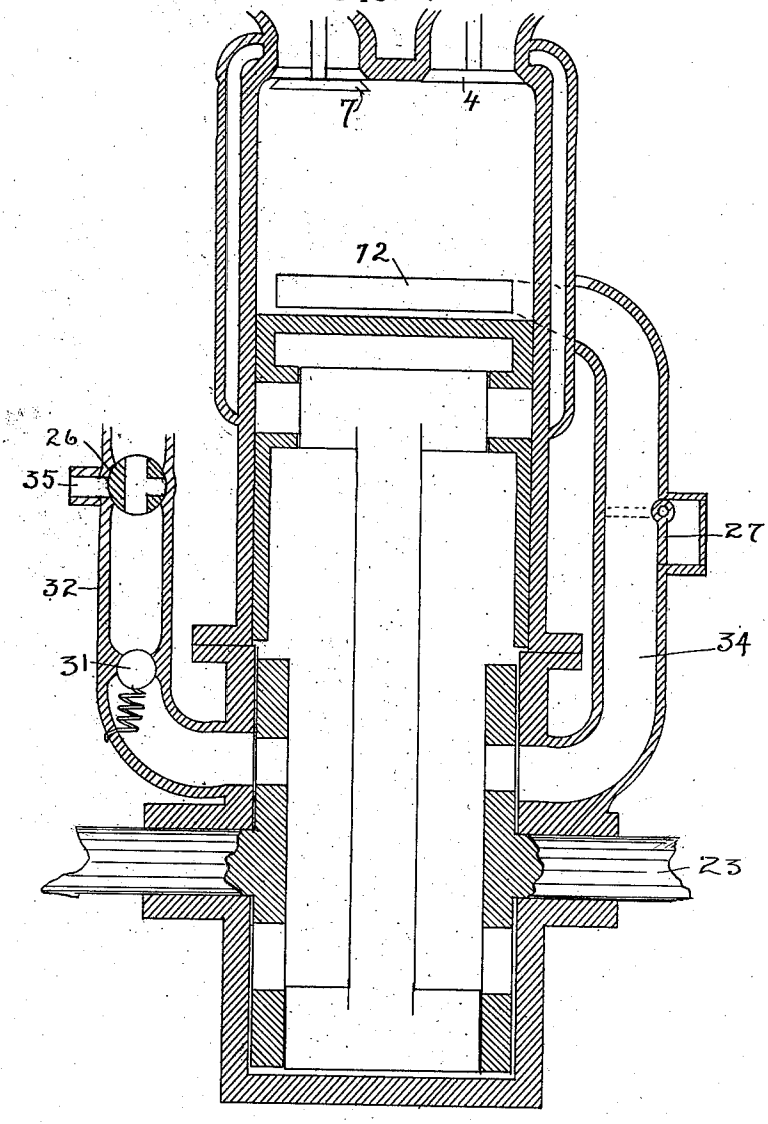
4 SHEETS—SHEET 4.

FIG. 5.



WITNESSES

Arthur P. Steele

Philip Mansfield

INVENTOR

Charles F. Hopewell

BY HIS ATTORNEY

Myron Francis Hill

UNITED STATES PATENT OFFICE

CHARLES F. HOPEWELL, OF CAMBRIDGE, MASSACHUSETTS.

CONVERTIBLE TWO TO FOUR CYCLE GAS-ENGINE.

991,063. Specification of Letters Patent. Patented May 2, 1911.

Application filed May 13, 1904. Serial No. 207,746.

To all whom it may concern:

Be it known that I, CHARLES F. HOPEWELL, of Cambridge, in the county of Middlesex and State of Massachusetts, have invented certain new and useful Improvements in Convertible Two to Four Cycle Gas-Engines, of which the following is a specification.

This invention seeks to combine in a single hydrocarbon explosion engine the phases of both the two cycle and the four cycle types. It seeks further to make these two sets of phases interchangeable. The phases may be changed either by hand or by automatic means. It is generally understood that a four cycle engine is the more economical in the use of fuel than the two cycle engine, while the two cycle in turn is capable of developing greater power weight for weight than the four cycle type. My invention seeks to combine both these advantages in one engine. The alteration of the phases from the two cycle sequence to the four cycle sequence may be accomplished by manual means such as the throw of a lever by hand, or it may be accomplished automatically by a governor which acts when the engine slows down due to the imposition of a greater load upon it. In power station for illustration, when overloaded, the greater load imposed upon the engine causes it to slow down. This automatically converts the four cycle engine into a two cycle engine. When running on the usual load the engine speeds up again and this causes the engine to be automatically switched over to the four cycle type.

In the accompanying drawings forming a part of this specification, in which similar letters of reference refer to similar parts in the different figures: Figure 1 is a front elevation with parts in section; Fig. 2 is a side elevation; Fig. 3 is a plan view of the governor with connecting levers omitted; Fig. 4 is a part sectional view of the governor; Fig. 5 is a diagram of the gas passages and valves, the features of actual construction being omitted to avoid confusion.

The usual type of four cycle engine is used for illustrating my invention, there being the usual puppet valves, cam shaft, and gear drive between the main shaft and the cam shaft. In order to conveniently change the speed of the cam shaft a planetary type of gear has been found effective. By means of this gear the speed of the cam shaft may be altered from the four cycle speed which calls for one revolution of the cam shaft for every two revolutions of the main shaft, to the two cycle speed which calls for a revolution of the cam shaft for each revolution of the main shaft. At the same time the valves must be switched to accommodate the explosion at every down stroke of the piston. In order to accomplish this the puppet inlet valve has to be thrown out of action, the exhaust valve has to be closed at an earlier stage of the up stroke of the piston, the sparking arrangements must be speeded for twice as many ignitions, and separate inlet passages and valves have to be opened. These changes are secured by sliding the cam shaft, and by opening separate inlet valves. All these functions I accomplish by the throw of a single lever.

In Fig. 1 is shown the cylinder 1, the crank case 2, the inlet pipe 3, the inlet puppet valve 4, the spark plug 5, the exhaust valve 7 and the exhaust pipe 8. The inlet and exhaust valves 4 and 7 are both mechanically actuated by the cam shaft 9 having cams 10 and 11 which as they revolve lift the rollers 12 and 13 mounted upon the valve stems 14 and 15. The cam 16 lifts the roller 17 and closes the pair of contacts 18 once during each revolution of the cam shaft. This commutator causes the spark plug to ignite the mixture at the proper moment.

Upon the cam shaft 9 is mounted the driving member of a water pump 19 which causes the water in the water jacket to circulate. This pump 19 always works at the speed of the cam shaft.

The cam shaft is driven by a gear wheel 20 fixed to the shaft. This gear wheel 20 meshes with the gear wheel 21 which revolves at two different speeds as compared with the driving shaft of the engine. In the position of parts shown in the drawings the wheel 21 revolves once while the driving shaft revolves twice. This rate of speed secures the four cycle sequence of phases. By shifting the main switching lever 22 the gear wheel 21 runs at the same speed as the driving shaft 23 of the engine.

The engine is adapted as described to be switched from the two cycle sequence of phases to the four cycle sequence of phases and vice versa. The main switching lever 22 performs this function. This lever is

pivoted at 24 upon a fixed arm 25 mounted upon the cylinder casting 1. This main switching lever is connected to the valves 26 and 27 through the link 28 and the arm 29 secured to the stem 30. When the lever is switched for the purpose of using the four cycle sequence, the valve 26 closes the passage from the inlet 3 to the crank case through the pipe 32; and opens a passage from the crank case through the same pipe 32 to the air inlet 35; and the valve 27 closes the passage through the pipe 34 from the crank case to the cylinder.

When the switching lever is thrown to the opposite position the valves 26 and 27 are opened and the engine is in condition to employ its two cycle sequence of phases. In this condition, the mixture enters through the inlet pipe 3, and passes through the open valve 26, through the pipe 32, the check valve 31 and the crank case where it is compressed by the piston; then it passes up through the pipe 34, and the valve 27 into the cylinder. The main switching lever 22 is also connected to the cam shaft 9 through the pins 36 fixed to the free ring 37 mounted in the groove 38 in the spool 39 fixed to the cam shaft. When the lever 22 is switched to the right in Fig. 1 it pulls the cam shaft to the right substituting a new set of cams under the valve stems. This shaft should be switched at the proper moment to get the best results, and the parts are shown in the switching position. The shoulder 40 on the cam 10 is cut away so that it may pass to the right under the roller 12. While working in the position shown the shoulder passes under the reduced portion 41ª, of the roller 12 and at any other position than the one shown the shoulder 40 would abut against the side of the roller 12 preventing the cam shaft from being switched. This shoulder acts as a locking device to prevent the arm 22 from being switched at any time except the particular moment selected. When the cam shaft does switch to the right the cam 10 passes out from beneath the roller 12 and no longer lifts the valve stem. The inlet valve is therefore kept closed for it is useless when the engine is working as a two cycle engine. When the cam shaft slides to the right, a new cam 41 is brought under the roller 13 of the exhaust valve stem 15 which opens the exhaust valve during a portion only of the up stroke of the piston. This cam 41 opens the exhaust valve while the piston uncovers the port from the pipe 34 and valve 27. The cam 16 is double length so that it actuates the circuit closer once during each revolution of the cam shaft as during four cycle operation. When the cam shaft slides to the right, the gear wheel 20 slides also on the gear wheel 21 and remains in mesh with it.

A lever 42 may be used to switch the main lever 22. This lever or link 42 may be operated by hand or by a governor as shown hereafter. The next connection of the main switching lever 22 is to the keys operating the speed changing gears. The form which seems particularly effective is the planetary gear shown in Figs. 1, 2 and 3. The planetary gear has a driving member a pinion 43 shown in Fig. 4, which meshes with pinions 44, shown in Figs. 2 and 4, which in turn mesh with the internal gear 45. When acting as a four cycle engine as shown, this internal gear 45 is held stationary by the key 46 in the slot 47. The key 46 is slidably mounted in the hole 48 in the crank case to assist in bracing the key to do its work. The driving pinion 43 then causes the pinions 44 to rotate and travel around the inside of the gear 45 and carry the sleeve 49. The pinions 44 are mounted on journals 50 which are fixed in the arms 51 of the sleeve 49. This sleeve freely rotates upon the shaft 23 in the position shown and has fixed to it the external gear 21 which drives the gear 20 on the cam shaft.

When the main switching lever switches the engine to the two cycle sequence of phases the external gear 21 must rotate at the same speed of the engine shaft, and this result is secured by locking the sleeve 49 to the shaft 23 and releasing the internal gear 45 which now becomes an idler. The sleeve 49 is locked to the shaft by the key 52 sliding into the slot 53. In this position of parts the planetary gear revolves as a unit with the shaft and the gear 21 drives the cam shaft at twice the previous speed.

The key 52 is carried in a slot 54 and is fixed to the spool 55. This spool has a groove 56 in which is a ring 57 freely mounted but carrying pins 58 pivoted in the main switching lever 22 which is thus connected to the key 52 to operate it to lock and unlock the sleeve from the shaft 23.

In Figs. 3 and 4 are shown a governor adapted to perform the switching function when the engine changes its speed due to a variation of the load. In the overloaded power station before cited, the engine slows down allowing the spring 59 to pull the governor balls 60 in toward the shaft. As the balls move toward the shaft the link 61 pulls the spool 62 in Figs. 3 and 4 to the right, and the spool carries the ring 64 mounted in the groove 63 with it. This ring 64 has pivots 65 mounted in the link 42 and causes the link to throw the main switching lever 22 to the right which switches the cams, valves and gears so tha tthe engine runs with the two cycle sequence of phases.

It is essential that the switching arm 22 act quickly so that there will be no chance for keys or cams to get half way and bind. A spring 66 is used preferable to cause the arm to switch instantly when the right con-

ditions exist. The main lever 22 has extended slots 67, 68 and 69 for the pivots 58, 36 and the link 28 to work in thus allowing a considerable movement of the switching lever without disturbing the valves, cams or gears. The switching arm is allowed to pass over the center of the stationary pivot 70 before it actuates the pivots 58, 36 or the link 28. When once over the center of the pivot 70 these pivots and link are thrown so as to switch the gears, valves and cams from one sequence of phases to the other very quickly. This force is supplied by the compressed spring 66 which thus acts in both directions.

It will be noticed that the circulating pump 19 drives water at double the speed when the engine works with the two cycle sequence as when the engine works with the four cycle sequence. This gives an additional cooling effect when the explosions are doubled in comparison to the speed of the engine shaft. The cam shaft 9 is slidably mounted in the driving member of the circulating pump by means of the key way 71.

The moment for switching the engine from one sequence of phases to the other is preferably just after ignition, for at that moment no valves are in operation, and the next stroke of the engine, the exhaust stroke may work either on the four cycle phase or the two cycle phase. An interlocking device, the notched disk 40 on the cam shaft 9, performs the office of preventing switching except when the notch permits the roller to pass.

The set of valves hereafter termed the four cycle set comprises the valves 4 and 7. The two cycle set includes the puppet valve 7 with the cylinder valve 72, the inlet valves 31 and 26, and the transfer valve 27. These valves of course may be varied in construction and position so long as the two cycle and the four cycle phases are preserved. It is of course possible to have entirely different sets of valves for the two sequences, but simplicity of parts induces me to make the exhaust valve 7 a member of both sets.

The compression space for the two cycle sequence of phases, is in this case the crank case. It is clear that the compression chamber might be entirely separate, and the convertibility of the engine secured. The plunger in the compression space in this engine is the piston. It might be entirely separate from the piston, but simplicity of construction demands the present form as preferable. This convertible principle may be applied to a multiple cylinder engine, a rotary engine, a single or compound engine, or a single or double acting cylinder engine, or any other type of engine.

The lever that converts the engine may be of any type desired, or it may be any mechanical equivalent, operated directly or indirectly.

Many changes may be made in the details of the engine and the application of the ideas without departing from my invention. If the rollers upon the valve stem should slide with relation to the cam shaft, such a movement would be equally effective in switching the cams. Many other mechanical movements may accomplish the same purpose.

What I claim is:—

1. In an explosion engine, in combination, a piston, a cylinder, and puppet inlet and exhaust valves for the four cycle sequence, valves for the two cycle sequence, a shaft, two sets of cams one for the two cycle sequence, one for the four cycle sequence, means to switch said sets of cams alternately into action consisting in a sliding cam shaft, and a variable gear adapted to alter the speed of said cam shaft to suit the alternate cycles.

2. In an explosion engine, in combination, a piston, a cylinder, and puppet inlet and exhaust valves for the four cycle sequence, valves for the two cycle sequence, a shaft, two sets of cams, one for the two cycle sequence and one for the four cycle sequence, means to switch said sets of cams alternately into action consisting in a sliding cam shaft, a variable gear adapted to alter the speed of said cam shaft to suit the alternate cycles, and a lever adapted to switch said cam shaft and change the speed of said variable gear to coöperate therewith.

3. In an explosion engine, in combination, a shaft, piston, cylinder, valves and electric ignition devices, two sets of cams, one for a two cycle sequence, and one for a four cycle sequence, means for switching said sets into action alternately consisting in a sliding cam shaft, and a variable gear to vary the speed of said cam shaft alternately for said sequences.

4. In an explosion engine, in combination, a shaft, piston, cylinder, valves and electric ignition devices, two sets of cams, one for a two cycle sequence, one for a four cycle sequence, means for switching said sets into action alternately, consisting in a sliding cam shaft, a variable gear to vary the speed of said cam shaft alternately for said sequences, and a lever to shift said cam shaft, and change the variable gear for said alternate sequences.

5. In an explosion engine, in combination, a shaft, piston, cylinder, valves, spark plug and ignition circuits, two sets of cams, one for a two cycle sequence, and one for a four cycle sequence, means for switching said sets into action alternately consisting in a sliding cam shaft, and a variable gear to vary the speed of said cam shaft alternately for said sequence.

6. In an explosion engine, in combination, a shaft, piston, cylinder, valves, spark plug, and ignition circuits, two sets of cams one for a two cycle sequence, one for a four cycle sequence, means for switching said sets into action alternately consisting in a sliding cam shaft, a variable gear to vary the speed of said cam shaft alternately for said sequences, and a lever to shift said cam shaft and change the variable gear to said alternate sequences.

7. In an explosion engine, in combination, a shaft, piston, cylinder, inlet and exhaust valves, a two cycle compression device, valves therefor, ignition circuits, two cycle and four cycle cams for said circuits and valves, a variable speed gear and a lever to shift said cams and gear to a two cycle sequence or to a four cycle sequence.

8. In an explosion engine, in combination, four cycle cylinder inlet and exhaust valves, an auxiliary two cycle compression device, valves therefor, two cycle cylinder valves, means to switch said four cycle valves and said two cycle valves into action alternately consisting in two sets of cams, a sliding cam shaft, and a variable gear adapted to vary the speed of said cam shaft.

9. In an explosion engine, in combination, four cycle cylinder inlet and exhaust valves, an auxiliary two cycle compression device, valves therefor, two cycle cylinder valves, means to switch said four cycle valves and said two cycle valves into action alternately consisting in two sets of cams, a sliding cam shaft; a variable gear adapted to vary the speed of said cam shaft, and a lever to shift said cams and variable gear.

10. In an explosion engine, in combination, a shaft, four cycle cylinder valves, a two cycle auxiliary compression space a piston working in said compression space connected to said shaft, inlet and transfer connections for said compression space and the explosion chamber of said engine, two cycle valves, and means to shift said four cycle valves or said two cycle valves alternately into action, consisting in a sliding cam shaft, and a variable gear to vary the speed of said cam shaft.

11. In an explosion engine, in combination, a shaft, four cycle cylinder valves, a two cycle cylinder compression space, a piston working in said compression space connected to said shaft, inlet and transfer connections for said compression space, and for the explosion chamber of said engine, two cycle valves; means to shift said four cycle valves or said two cycle valves alternately into action, consisting in a sliding cam shaft, a variable gear to vary the speed of said cam shaft, and a lever to operate the same.

12. In an explosion engine, in combination, a shaft, four cycle cylinder valves, a two cycle cylinder compression space within the crank case, a piston working in said compression space connected to said shaft, inlet and transfer connections for said compression space and the explosion chamber of said engine, two cycle valves, means to shift said four cycle valves or said two cycle valves alternately into action consisting in a sliding cam shaft, a variable gear to vary the speed of said cam shaft, and a lever to operate the same.

13. In an explosion engine, in combination, a set of four cycle valves, a two cycle auxiliary compression device, a set of two cycle valves, electric ignition circuits and devices for each cycle, and means to switch said valves and circuits from one cycle to the other consisting in two sets of cams, a sliding cam shaft, a variable gear and a lever to operate said cams, shaft and gear.

14. In an explosion engine, in combination, a set of four cycle valves, a set of two cycle valves, a cam shaft operating said sets alternately, a water pump for cooling said engine, means for shifting from one cycle to the other thereby varying the delivery of said water pump and its cooling effect.

15. In an explosion engine, in combination, a set of four cycle valves, a set of two cycle valves, a cam shaft operating said sets alternately, a water pump for cooling said engine operated by said cam shaft, a variable speed gear therefor, means for shifting from one cycle to the other thereby varying the delivery of said water pump and its cooling effect.

16. In an explosion engine, in combination, a set of four cycle valves and parts, a set of two cycle valves and parts, a variable speed gear therefor, a cooling device, means for varying the relative cooling effect of said cooling device in switching from four cycle sequence to two cycle sequence.

17. In an explosion engine, in combination, a variable speed gear therefor, a set of four cycle valves and parts, a set of two cycle valves and parts, a cooling device, means for varying the relative cooling effect of said cooling device when switching from four cycle sequence to two cycle sequence.

18. In an explosion engine, in combination, a set of four cycle valves and parts, a set of two cycle valves and parts, a water cooling device, means for varying the relative cooling effect of said cooling device in switching from the four cycle sequence to the two cycle sequence.

19. In an explosion engine, in combination, a set of four cycle valves and parts, a set of two cycle valves and parts, a water cooling pump, means for varying the relative cooling effect of said pump in switching from four cycle sequence to two cycle sequence.

20. In an explosion engine, in combination, a set of four cycle valves, a set of two

cycle valves, a cam shaft operating said sets alternately, a water pump for cooling said engine operated by said cam shaft, means for shifting said cam shaft from one cycle to the other thereby varying the delivery of said water pump and its cooling effect, and a variable speed gear adapted to vary the speed of said cam shaft.

21. In an explosion engine, in combination, a cam shaft, a water pump for cooling said engine operated by said cam shaft, means for shifting said cam shaft from one cycle to the other thereby varying the delivery of said water pump and its cooling effect, said means consisting in a variable gear adapted to vary the speed of said cam shaft.

22. In an explosion engine in combination, two sets of valves, a two cycle set and a four cycle set, electric ignition circuits, means for operating said circuits and valves for the two or the four cycle sequence consisting in a cam shaft, water cooling devices operated by said cam shaft, and a variable gear to vary the speed of said cam shaft and associated devices for the alternate sequences.

23. In an explosion engine, in combination, two sets of valves, a two cycle set and a four cycle set, electric ignition circuits, means for operating said circuits and valves for the two or the four cycle sequence consisting in a cam shaft, water cooling devices operated by said cam shaft, and a variable gear to vary the speed of said cam shaft and associated devices for the alternate sequences.

24. In an explosion engine in combination, a set of two cycle parts, cams therefor, a set of four cycle parts, cams therefor, a cam shaft carrying said cams provided with a variable gear adapted to vary the speed of said cam shaft, means to shift said cams and variable gear consisting in an automatic governor.

25. In an explosion engine, in combination, a piston, a cylinder, puppet inlet and exhaust valves for the four cycle sequence valves for the two cycle sequence, a shaft, two sets of cams, one for the two cycle sequence, one for the four cycle sequence, means to switch said sets of cams alternately into action consisting in a sliding cam shaft, and a variable gear adapted to alter the speed of said cam shaft to suit the alternate cycles both operated by an automatic governor actuated by variations in speed.

26. In an explosion engine, in combination, a piston, a cylinder, puppet inlet and exhaust valves for the four cycle sequence valves for the two cycle sequence, a shaft, and two sets of cams one for the two cycle sequence and one for the four cycle sequence, means to switch said sets of cams alternately into action consisting in a sliding cam shaft, a variable gear adapted to alter the speed of said cam shaft to suit the alternate cycles, and a lever adapted to switch said cam shaft and change the speed of said variable gear to coöperate therewith both operated by an automatic governor actuated by variations in speed.

27. In a convertible two to four cycle explosion engine, in combination, a variable speed shaft for the two sequences and a planetary gear, means for switching it from a half speed to a full speed and back again.

28. In a convertible two to four cycle explosion engine, in combination, a variable speed cam shaft, a planetary gear, and a sliding key for said planetary gear to change the speed of said cam shaft.

29. In an explosion engine, in combination, a piston, cylinder, four cycle valves and parts, a two cycle auxiliary compression space, two cycle valves and parts, electric ignition devices and circuits for each cycle, a cooling device and means for varying its cooling effect relative to each cycle, and means for switching said apparatus from one cycle to the other.

30. In an internal combustion engine, having two cycle valves and other means for scavenging and compressing a fresh combustible gas during each instroke and igniting and expanding during each out stroke; and having four cycle valves and other means for compressing a combustible gas during every alternate instroke, igniting and expanding during the succeeding out strokes, exhausting and admitting fresh gas during the next in and out strokes respectively; means for operating said valves, means to shift out of operation said two cycle valves and shift into operation said four cycle valves, and vice versa.

31. In an internal combustion engine, having two cycle valves and other means for scavenging and compressing a fresh combustible gas during each instroke and igniting and expanding during each out stroke; and having four cycle valves and other means for compressing a combustible gas during every alternate instroke, igniting and expanding during the succeeding out strokes, exhausting and admitting fresh gas during the next in and out strokes respectively; means for operating said valves, a cam shaft, cams for said two cycle valves, cams for said four cycle valves, and means to shift said cams alternately into action, consisting in a sliding cam shaft.

32. In an internal combustion engine, having two cycle valves and other means for scavenging and compressing a fresh combustible gas during each instroke and igniting and expanding during each out stroke; and having four cycle valves and other means for compressing a combustible gas during every alternate instroke, igniting and expanding during the succeeding out strokes.

exhausting and admitting fresh gas during the next in and out strokes respectively; means for operating said valves, a cam shaft, cams for said two cycle valves, cams for said four cycle valves, and means to shift said cams alternately into action consisting in a sliding cam shaft.

33. In an internal combustion engine, having two cycle valves and other means for scavenging and compressing a fresh combustible gas during each instroke and igniting and expanding during each out stroke; and having four cycle valves and other means for compressing a combustible gas during every alternate instroke, igniting and expanding during the succeeding out strokes, exhausting and admitting fresh gas during the next in and out strokes respectively; means for operating said valves, igniting devices and circuits coöperating with said two cycle means and said four cycle means, and means to switch said igniting devices and circuits from two cycle operation to four cycle operation.

34. In an internal combustion engine, having two cycle valves and other means for scavenging and compressing a fresh combustible gas during each instroke and igniting and expanding during each out stroke; and having four cycle valves and other means for compressing a combustible gas during every alternate instroke, igniting and expanding during the succeeding out strokes, exhausting and admitting fresh gas during the next in and out strokes respectively, means for operating said valves, igniting devices and circuits coöperating with said two cycle means and said four cycle means, and means to switch said igniting devices and circuits from two cycle operation to four cycle operation consisting in cams adapted to be alternately shifted into action.

35. In an internal combustion engine, having two cycle valves and other means for scavenging and compressing a fresh combustible gas during each instroke and igniting and expanding during each out stroke; and having four cycle valves and other means for compressing a combustible gas during every alternate instroke, igniting and expanding during the succeeding out strokes, exhausting and admitting fresh gas during the next in and out strokes respectively, means for operating said valves, igniting devices and circuits coöperating with said two cycle means and said four cycle means, and means to switch said igniting devices and circuits from two cycle operation to four cycle operation consisting in cams adapted to be alternately shifted into action by a sliding cam shaft.

36. In an internal combustion engine, having two cycle valves and other means for scavenging and compressing a fresh combustible gas during each instroke and igniting and expanding during each out stroke; and having four cycle valves and other means for compressing a combustible gas during every alternate instroke, igniting and expanding during the succeeding out strokes, exhausting and admitting fresh gas during the next in and out strokes respectively; means for operating said valves, means to shift out of operation said two cycle valves and shift into operation said four cycle valves, igniting devices and circuits coöperating with said two cycle means and said four cycle means, and means to switch said igniting devices and circuits from two cycle operation to four cycle operation.

37. In an internal combustion engine, having two cycle valves and other means for scavenging and compressing a fresh combustible gas during each instroke and igniting and expanding during each out stroke; and having four cycle valves and other means for compressing a combustible gas during every alternate instroke, igniting and expanding during the succeeding out strokes, exhausting and admitting fresh gas during the next in and out strokes respectively; means for operating said valves, means to shift out of operation said two cycle valves and shift into operation said four cycle valves, igniting devices and circuits coöperating with said two cycle means and said four cycle means, and means to switch said igniting devices and circuits from two cycle operation to four cycle operation consisting in cams adapted to be alternately shifted into action.

38. In an internal combustion engine, having two cycle valves and other means for scavenging and compressing a fresh combustible gas during each instroke and igniting and expanding during each out stroke; and having four cycle valves and other means for compressing a combustible gas during every alternate instroke, igniting and expanding during the succeeding out strokes, exhausting and admitting fresh gas during the next in and out strokes respectively; means for operating said valves, means to shift out of operation said two cycle valves and shift into operation said four cycle valves, igniting devices and circuits coöperating with said two cycle means and said four cycle means, and means to switch said igniting devices and circuits from two cycle operation to four cycle operation consisting in cams adapted to be alternately shifted into action by a sliding cam shaft.

39. In an internal combustion engine, having two cycle valves and other means for scavenging and compressing a fresh combustible gas during each instroke and igniting and expanding during each out stroke; and having four cycle valves and other means for compressing a combustible gas during every

alternate instroke, igniting and expanding during the succeeding out strokes, exhausting and admitting fresh gas during the next in and out strokes respectively; means for operating said valves, means to shift out of operation said two cycle valves and shift into operation said four cycle valves, igniting devices and circuits coöperating with said two cycle means and said four cycle means, and means to switch said igniting devices and circuits from two cycle operation to four cycle operation consisting in cams adapted to be alternately shifted into action by a sliding cam shaft and by a variable gear.

40. In an internal combustion engine, having two cycle valves and other means for scavenging and compressing a fresh combustible gas during each instroke and igniting and expanding during each out stroke; and having four cycle valves and other means for compressing a combustible gas during every alternate instroke, igniting and expanding during the succeeding out strokes, exhausting and admitting fresh gas during the next in and out strokes respectively; means for operating said valves, means to shift out of operation said two cycle valves and shift into operation said four cycle valves, shifted by an automatic governor under variations of speed.

41. In an internal combustion engine, having two cycle valves and other means for scavenging and compressing a fresh combustible gas during each instroke and igniting and expanding during each out stroke; and having four cycle valves and other means for compressing a combustible gas during every alternate instroke, igniting and expanding during the succeeding out strokes, exhausting and admitting fresh gas during the next in and out strokes respectively; means for operating said valves, means to shift out of operation said two cycle valves and shift into operation said four cycle valves, consisting in cams adapted to be alternately shifted into action, shifted by an automatic governor under variations of speed.

42. In an internal combustion engine, having two cycle valves and other means for scavenging and compressing a fresh combustible gas during each instroke and igniting and expanding during each out stroke; and having four cycle valves and other means for compressing a combustible gas during every alternate instroke, igniting and expanding during the succeeding out strokes, exhausting and admitting fresh gas during the next in and out strokes respectively; means for operating said valves, means to shift out of operation said two cycle valves and shift into operation said four cycle valves, consisting in cams adapted to be alternately shifted into action by a variable gear shifted by an automatic governor under variations of speed.

43. In an internal combustion engine, having two cycle valves and other means for scavenging and compressing a fresh combustible gas during each instroke and igniting and expanding during each out stroke; and having four cycle valves and other means for compressing a combustible gas during every alternate instroke, igniting and expanding during the succeeding out strokes, exhausting and admitting fresh gas during the next in and out strokes respectively; means for operating said valves, means to shift out of operation said two cycle valves and shift into operation said four cycle valves, a locking device to prevent shifting, and means to unlock said locking device at the proper moment for conversion.

44. In an internal combustion engine, having two cycle valves and other means for scavenging and compressing a fresh combustible gas during each instroke and igniting and expanding during each out stroke; and having four cycle valves and other means for compressing a combustible gas during every alternate instroke, igniting and expanding during the succeeding out strokes, exhausting and admitting fresh gas during the next in and out strokes respectively, means for operating said valves, means to shift out of operation said two cycle valves and shift into operation said four cycle valves, a variable gear, a cooling device, and means coöperating with said speed gear to operate said cooling device at different speeds for either cycle.

45. In an internal combustion engine, having two cycle valves and other means for scavenging and compressing a fresh combustible gas during each instroke and igniting and expanding during each out stroke; and having four cycle valves and other means for compressing a combustible gas during every alternate instroke, igniting and expanding during the succeeding out strokes, exhausting and admitting fresh gas during the next in and out strokes respectively; means for operating said valves, means to shift out of operation said two cycle valves and shift into operation said four cycle valves, igniting devices and circuits coöperating with said two cycle means and said four cycle means, and means to switch said igniting devices and circuits from two cycle operation to four cycle operation, a cooling device, and means to operate said cooling device at different speeds for either cycle.

46. In an internal combustion engine, having two cycle valves and other means for scavenging and compressing a fresh combustible gas during each instroke and igniting and expanding during each out stroke; and having four cycle valves and other means for compressing a combustible gas during every alternate instroke, igniting

and expanding during the succeeding out strokes, exhausting and admitting fresh gas during the next in and out strokes respectively; means for operating said valves, means to shift out of operation said two cycle valves and shift into operation said four cycle valves, igniting devices and circuits coöperating with said two cycle means and said four cycle means, and means to switch said igniting devices and circuits from two cycle operation to four cycle operation, a variable gear, a cooling device, and means coöperating with said speed gear to operate said cooling device at different speeds for either cycle.

47. In an internal combustion engine, in combination, a set of four cycle valves, a two cycle auxiliary compression space, a set of two cycle valves, alternate ignition devices and circuits for the two cycles, a water cooling device and combined means for changing its cooling effect and shifting said valves from the four cycle to the two cycle method of operation.

48. In an internal combustion engine, in combination, a set of four cycle valves, a two cycle auxiliary compression space, a set of two cycle valves, electric ignition devices and circuits for each cycle, a water cooling device, combined means for changing its cooling effect and shifting said valves from the four cycle to the two cycle method of operation including a variable speed gear.

49. In an internal combustion engine, in combination, a set of four cycle valves, a two cycle auxiliary compression space, a set of two cycle valves, electric ignition devices and circuits for each cycle, a water cooling device, combined means for changing its cooling effect and shifting said valves from the four cycle to the two cycle method of operation, including a variable gear and a lever to vary the speed of the cooling device through said gear.

In testimony whereof I have affixed my signature, in presence of two witnesses.

CHARLES F. HOPEWELL.

Witnesses:

MYRON FRANCIS HILL,

A. P. TEELE.