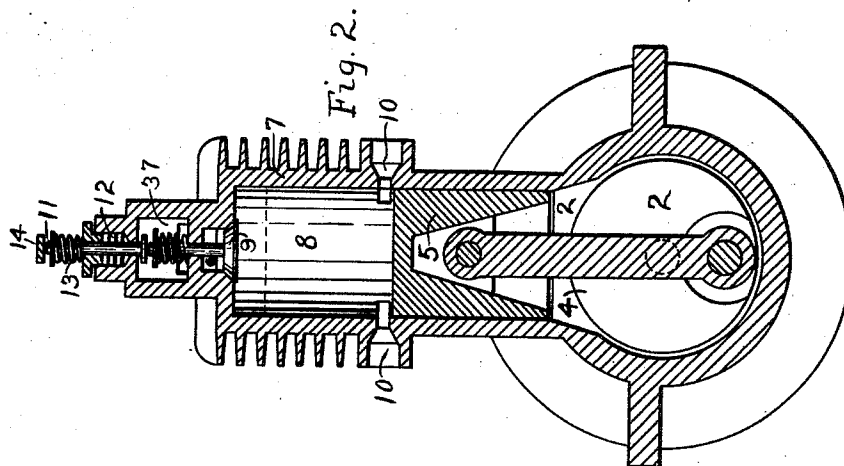
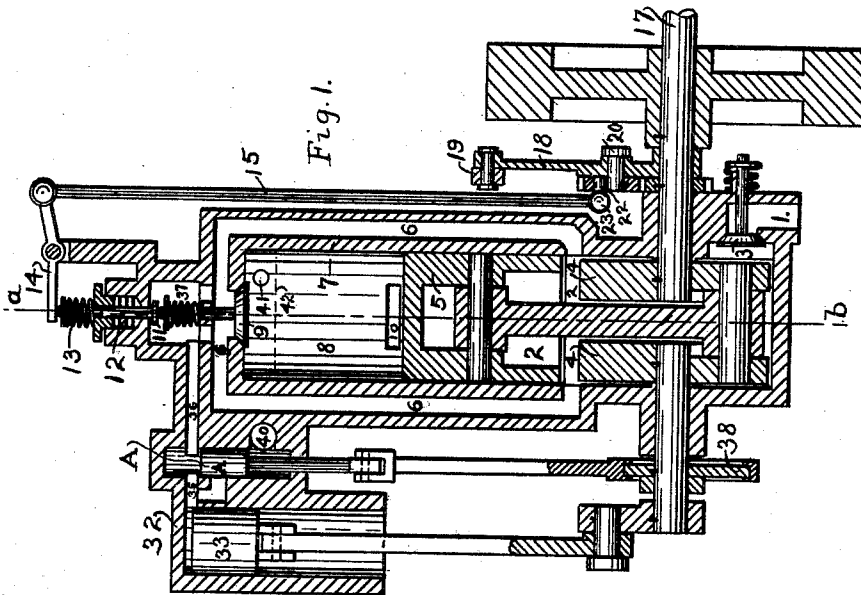


H. H. WIXON.
EXPLOSIVE ENGINE.
APPLICATION FILED NOV. 13, 1906.

1,006,037.

Patented Oct. 17, 1911.

2 SHEETS—SHEET 1.



WITNESSES:

Henry Wehlan
Charles Schenck

INVENTOR.

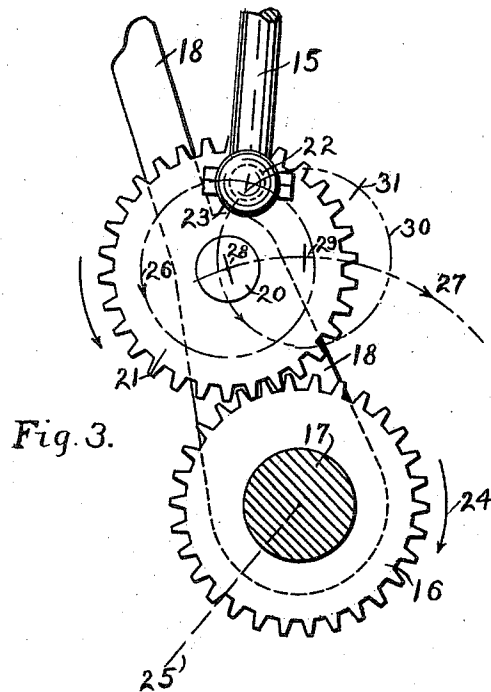
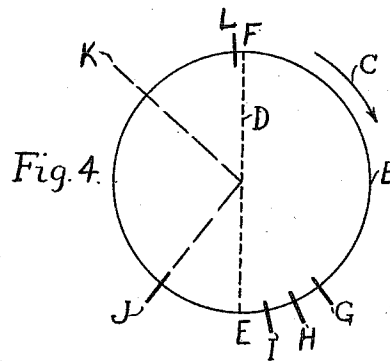
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2 SHEETS—SHEET 2.



WITNESSES:

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EXPLOSIVE-ENGINE.

1,006,037.

Specification of Letters Patent.

Patented Oct. 17, 1911.

Application filed November 13, 1906. Serial No. 343,217.

To all whom it may concern:

Be it known that I, HOWARD H. WIXON, a citizen of the United States, and resident of Chicago, in the county of Cook and State of Illinois, have invented certain new and useful Improvements in Explosive-Engines, of which the following description, with accompanying drawings, is declared to be such a full, clear, and exact description as will enable others skilled in the art to which it appertains to make and use the same.

My invention relates to internal combustion engines and particularly to those engines in which the combustible is burned explosively on what is commonly called the two-stroke cycle.

The chief object of my invention is to provide an efficient engine of the two stroke cycle type of high power, light weight, and simple design, the speed and power of which can be perfectly controlled within wide limits, and which is especially adapted to be used in automobiles, airships, flying machines and like service in either single or multiple cylinder forms, though the invention is not in any way limited to such use or application, as some of the features thereof can be used with advantage in many engines of the two stroke cycle type ordinarily used for other purposes and which may have separate supply pump and explosion chambers as distinguished from engines using crank case compression.

At the present state of the art in automobile construction, four-stroke cycle engines are almost entirely used, though they only give one power impulse in four strokes of the engine piston, and therefore it is advisable to use a large number of cylinders (four, six or eight cylinders to an engine) to counteract the irregularity of power impulse, thus resulting in an engine which is unnecessarily heavy, complicated, expensive, and bulky; whereas engines which work on the two-stroke cycle, giving one power stroke in two strokes of the engine piston and being of comparatively simple, inexpensive and compact mechanical construction, are used to only a very small extent in automobiles because of the inherent defects in the operating cycle and construction of such engines. My invention seeks to provide a two-stroke cycle engine which overcomes these defects, which are hereinafter more par-

ticularly pointed out. In the present state of the art the contrast in the use of two-stroke cycle and four-stroke cycle engines in their application to airship and flying machine construction is so marked that the application of a two-stroke cycle engine to an airship or flying-machine is practically unheard of, as four-stroke cycle engines, having usually eight cylinders, are practically the only engines capable of fulfilling the extreme conditions required for such use. The defects of the two-stroke cycle engine for such service are sought to be overcome in my invention, and as what is required in the application of the internal combustion engine for such use forms a concise, concrete, and exact example, the requirements and application of such an engine to airship or flying machine use is hereinafter referred to, it being obvious that the advantages of my invention for such use will also be advantageous in automobile or other use.

In the following specification I set forth the preferred form of my invention, the new features and scope thereof being particularly specified and pointed out in the appended claims.

In the drawings: Figure 1 is a longitudinal section of my new engine; Fig. 2 is a side section along the line *a-b* of Fig. 1; Fig. 3 is an enlarged detail of the speed or power controlling mechanism, and Fig. 4 is a diagram representation of the cycle of operations.

No attempt is made to show details of construction which are not features of the invention.

The same reference numerals or letters indicate the same parts in the different figures.

The improved result obtained in my engine is obtained partly by an improved operating cycle and partly by the features of construction hereinafter more fully pointed out. The operating cycle of my two-stroke cycle engine gives better results than that of the present largely used four-stroke cycle engines. This it does largely because it wipes out or displaces the entire quantity of burned gas during each cycle, and partly because it furnishes an explosive gas mixture of exactly the right proportion and quantity to be burned explosively in the en-

gine cylinder with the most rapid and forcible combustion. This improved engine cycle can be utilized in widely different forms of engine construction.

5 Considering the application of an explosive engine to drive a flying-machine, for instance, it is evident that the first two essential requirements for such use are that the engine shall be of the utmost compact-
 10 ness and that it shall be designed so that it can be constructed of extremely light weight without sacrificing the necessary strength of the parts. At present the best engines coming within these primary limita-
 15 tions are what may be termed "automobile-type" engines as distinguished from stationary engines, and practically all successful engines of this type for this use have been operated on the four-stroke cycle.
 20 In my invention I employ the general features of automobile type engines for the above reasons, and, as the two-stroke cycle gives twice as many power impulses per revolution as the four-stroke cycle, I utilize the broad
 25 two-stroke cycle of operations in my engine. While there are "automobile-type" two-stroke cycle engines, as said before, they have not come into general use, even with the advantage of double the number of
 30 power impulses and the advantages of mechanical construction hereinbefore mentioned, such engines having been chiefly used in such automobiles, motor-boats, etc. where only a relatively inferior quality of
 35 service is required. My invention seeks to reverse these conditions and provide an engine which overcomes the defects of the present automobile type of two-stroke cycle engine, these defects being hereinafter more
 40 particularly pointed out. I overcome these objections to present two-cycle engines chiefly by the use of elements which in themselves are old in the art but which produce new and superior results in my inven-
 45 tion, as hereinafter more particularly described. Briefly stated, this above referred to automobile-type of two cycle engine usually consists, as far as I am familiar with engines generally used, of a crank case
 50 chamber, into which the explosive gas mixture is drawn and slightly compressed, passages and ports by which this mixture is transferred to the explosion cylinder or chamber when said ports are uncovered by
 55 the engine piston which is common to both of these chambers, and exhaust ports in the cylinder by which the burned gas is exhausted after each explosion or working stroke; the speed and power of such an engine usually being varied by throttling the
 60 supply of mixture to the crank case together with variable timing of ignition. The first great difficulty with this particular type of engine, as above described, is that it cannot be controlled; that is, that neither the

speed nor power of such an engine can be economically regulated, except within very narrow limits, for which the engine must be especially proportioned. This is due to the fact that in such engines as above de-
 70 scribed a full cylinder of gas mixture is always compressed on each compression stroke of the engine piston, regardless of the speed or load on the engine, the regula-
 75 tion being obtained by admitting less explosive gas to the cylinder (explosion chamber) which thereby retains more burned gas (from the previous explosion). With this method, on reduced speed or load, a point is very quickly reached where the fresh
 80 explosive gas mixture is so diluted or weakened by the burned gas which remains in the engine cylinder that the resulting gas mixture will not explode or ignite at all, much less form an efficient explosive combination.
 85 Hence it is easily seen why the actual application of this particular type of engine is so limited. Moreover this particular type of engine, as above described, under its best condition of full load, still retains such a
 90 large proportion of burned gas in the cylinder that the power resulting from the explosion thereof is fully forty or fifty per cent. less than if there were no burned gas mixed with it, as is the case in my invention.
 95 The retention of burned gas which mixes with the explosive gas prior to ignition has a far greater weakening effect on the explosive power value of the resulting combination than its quantity would indicate, and
 100 in my invention I avoid its effects entirely by entirely exhausting the burned gas from the explosion chamber automatically. It is evident that the method of regulation or means adapted to control the speed will not
 105 alter this condition in the present largely used automobile-type engine. This refers to the usual method of throttle and ignition regulation or control. To overcome this lack of control of this type of engine, I employ in
 110 my invention what will herein be termed the rejection method of control, or regulation, which is not new in the art in its application to this type of engine, though it has not been commercially applied to any extent, as
 115 far as I am aware. This method of control employs a variable charge of explosive mixture in the explosion chamber without altering so much the proportions of the charge as would other methods of control if used
 120 in my engine, practically not altering the proportions at all, but only altering the quantity of the charge used. However, such engines as have this method of control, which method of control is the only one
 125 capable of efficient regulation within wide speed or power limits, also have other objectionable or limiting features which it is my object to avoid and which will now be more particularly pointed out.

For the sake of clearness, an automobile-type engine as above described having this rejection method of control will hereafter be referred to in this specification as a rejection control engine.

Referring to the drawings, my engine has a crank case or pump chamber 2, with an explosive mixture inlet 1, which is preferably provided with the automatic non-return valve 3, which is arranged to admit the explosive mixture to the crank case when there is a suction therein. The engine piston 5 is connected to the crank shaft 17 in the usual manner and operates in the cylinder 7, which has the exhaust ports 10 arranged therein, so that they will be opened by the piston 5 at the lower or inner end of its stroke, but closed by the piston at other parts of its stroke, the piston thereby being common to both the pump chamber 2 and explosion chamber 8. In these respects my engine is similar to previous rejection control engines in the operation of the engine, the explosive mixture being drawn into the pump chamber 2, compressed slightly by the piston 5, transferred to the explosion chamber 8 during the exhaust of burned gas therefrom, through the ports 10, and part of said explosive mixture being returned, when there is less than full load on the engine, from the explosion chamber 8 back to the pump chamber 2 on the compression stroke of the piston by means of suitable mechanism, as hereinafter more fully described.

In my invention I prefer to fill up the pump chamber 2 and connected spaces by the crank-shaft, counter-balance weights 4, piston 5, which may be made hollow, and connected parts, so that the compression obtained in this space is about ten or fifteen pounds, which enables the pump chamber to be more completely filled on suction therein and more nearly a full piston displacement quantity of gas to be pumped into the explosion chamber.

It is well known that the explosive mixture proportion cannot be varied very much with the hydro-carbons usually used to form the gas mixture in automobile and other engines for similar services. Particularly is this true of four cycle and two cycle engines using gasoline by means of carbureters, and more especially is this true of two cycle engines. When it is considered that the carbureting devices usually used to make the explosive gas mixture do not in themselves make a perfect mixture under different engine speeds, it will be readily seen that the result has been to make the operation of two cycle engines unreliable, which has been the general objection, as far as I am aware, to all forms of two cycle engines, which are compact and adapted for use in automobiles and similar service.

In my engine employing rejection control,

I avoid these objectionable features by passing the explosive charge around the cylinder, so as to admit the explosive charge at one end of the cylinder while the exhaust takes place at the opposite end of the cylinder, thus providing a direct path for the gases. For this purpose the transfer passages 6, 6 lead to the upper end of the cylinder 7 into the explosion or working chamber 8. These passages are preferably on opposite sides and come together in the upper end of the cylinder where the one-way automatic valve 9 is placed in control of this passage and is arranged to automatically admit a charge from the pump chamber into the explosion chamber and prevent its return when the pressure in the former is greater than in the latter, while there are preferably two exhaust ports on opposite sides of the cylinder and placed midway between the transfer passages. With this construction the explosive mixture is transferred around the cylinder 7, entering the explosion chamber 8 from its upper end during exhaust, and pushes the burned gas out of the exhaust ports in a direct path, both bodies of gas moving in the same direction in a practically straight path and therefore having very little or no tendency to mix together. In my invention as far as it has been described, it will be seen that when the explosive charge is transferred in this way, the explosive mixture will be in the upper or compression end of the cylinder, while such burned gas as would remain will be in the lower end of the cylinder and largely independent of and not mixed with the explosive mixture, and therefore having a much less weakening effect on the explosive power value of the explosive mixture than has heretofore been the case in such engines. Further the engine can be run at a much higher speed, and the explosive gas kept much purer, which gives it the property of quicker combustion, which in turn permits greater economy and still higher speed in my engine up to the point where "back-firing" takes place. This "back-firing" is overcome in my engine by means hereinafter described, so that my invention is capable of high speeds similar to that usually used in automobile-type four cycle engines, which speed has heretofore been impossible in all controllable two cycle engines of which I am aware. The valve 9 is also arranged to be mechanically opened to permit the return of part of the explosive mixture to the pump chamber under certain conditions by the pin 11 extending through the stuffing box 12, which is held normally out of contact with the stem of the valve 9 by the spring 13, the valve 9 being held open when the end of the lever 14 pushes the pin 11 downward. The object of this stuffing box arrangement is to take the friction of the packing in the

stuffing box off the valve 9, so that it will operate quickly and with very little resistance. The other end of the lever 14 is connected by a ball joint to the reach-rod 15, in its turn connected to the speed controlling mechanism.

It will be seen that when the valve 9 is held open to permit the return of part of the explosive mixture that part of the explosive mixture which is pure and cool is drawn off the top of the explosion chamber and returned to the pump chamber, thus keeping the explosive mixture of the correct and most efficient proportions in this pump chamber. It follows from these two advantages of correct mixture in the pump chamber, and unmixed charge in the explosion chamber, that my engine can be regulated in a far greater degree from higher speed down to low speed and power, and will keep cooler than will other prior engines of this type which have the necessary requirements of light and compact construction.

In the speed controlling mechanism, of which Fig. 3 is an enlarged view, the gear 16 is rigidly attached to the shaft 17. The arm 18, to which an extension rod may be attached at 19 (Fig. 1), is free to turn on the shaft and carries the pin 20 on which the gear 21 turns in mesh with the gear 16. The gear 21 carries the eccentric pin 22 which imparts motion to the reach rod 15 through the ball joint 23. The object of this mechanism is to open the valve 9 (through its connection) always at about the same point in the up or compression stroke of the piston 5 and allow the valve 9 to close at various points of the piston's upstroke, depending on the power load on the engine, except when the engine is fully loaded at which time the motion of the reach rod 15 is not communicated to and has no effect on the valve 9. In Fig. 3, this mechanism is shown set for a crankshaft rotation indicated by the arrow 24, the relative crank position is indicated by the dash line 25, and the lever arm 18 is shown in nearly the full engine load position. The path of the eccentric pin 22 is then as indicated by the circle 26. At the point shown this pin 22 is just about to open the valve 9 through its connections, which will then be held open for a very short period of the revolution of the crankshaft 17. During the rest of the time the lever 14 is out of contact with the pin 11 and consequently the valve 9. For decreased load the lever 18 is moved in the direction of the arrow 27 around the shaft 17. This movement raises the circle 26 and also shifts the eccentric pin 22 (backward from the direction of the arrow on 26) so that the valve 9 is always opened at about the same point of the piston stroke regardless of the position of the

lever 18 (within the limits of its motion, indicated by the center 28 to the center 29). From the raising of this circle 26 it will be understood that the valve 9 is held open for a longer period of time, the no load position being indicated by the circle 30 where the point of opening of the valve 9 is then shifted to 31 with relation to the crank position 25.

In my invention as thus far described and in prior rejection control engines, the maximum speed possible is usually limited by the occurrence of "back-firing", which takes place at about 900 revolutions, for engines using gasoline for fuel, of the crankshaft, but is a little higher or lower in various engines, depending somewhat upon the mechanical construction and such features as affecting the rapidity of combustion of the explosive mixture, some of these features being hereinabove pointed out. It will be seen that such an engine capable of a maximum speed of 900 revolutions is broadly in no way superior to a four cycle engine of the kind now largely used and capable of a maximum speed of 1800 revolutions per minute, though the former, operating on the two stroke cycle, gives twice as many power impulses of equal force per revolution as the latter, as the power depends on the speed. This "back firing" is due to the time required for complete combustion of the explosive charge in the explosion chamber and on all things which affect the rapidity of this combustion. This is affected to the largest extent by the proportions of the explosive mixture, any variation from a perfect proportion of this mixture, either in the explosive mixture itself prior to its admission to the explosion chamber, or in this mixture when admitted to the explosion chamber if mixed with a quantity of burned gas which remains in the explosion chamber, will result in causing the combustion to be slower and thereby limit the maximum speed obtainable, but an excess of air does not reduce the power of the explosive mixture so much as a like quantity of burned gas. However, a point is reached in all prior rejection control engines, and in my engine as thus far described, beyond which further speed is impossible because of this back firing. Briefly this "back-firing" is as follows: On ignition of the explosive mixture in the explosion chamber, this chamber is filled with flame which continues as long as combustion takes place, requiring considerable time, and on high engine speeds the cylinder is filled with flame when the exhaust occurs, and the transfer of the explosive mixture is made to the explosion chamber. This explosive mixture entering the cylinder full of flame, is ignited and the fire carried back to the pump chamber, igniting the mixture therein, so that the engine will have to make several

revolutions before this is all pumped out the exhaust and the engine becomes operable again.

If it is sought to prevent firing into the crank-case by the use of wire gauze in the transfer passages, still the explosive charge entering the explosion chamber will be ignited and burn in this chamber before its proper time in the cycle where it will produce power, and this form of pre-ignition is included in the term "back-firing", as used in this specification.

It is my purpose to improve the cycle of operations of all forms of previous rejection control engines, by the addition of means whereby a non-combustible medium is inserted to form a barrier between the burning gas in the explosion chamber and the incoming explosive mixture to prevent back-firing during the transfer part of the cycle, which improvement makes higher speeds and more efficient operation possible. It is further my purpose to improve the cycle of operations of these engines by entirely displacing all of the products of combustion from the explosion chamber during each exhaust part of the cycle, which improvement gives higher efficiency of engine operation. I employ the same means to effect both of the above improvements, which will now be described.

First, the quantity of burned gas that would remain in the explosion chamber of my engine, as thus far described, will be pointed out, it being understood that this same condition exists in all prior constructions of rejection control engines. On the suction stroke of the engine piston, the pump chamber 2 is not entirely filled with explosive mixture, due to the slight resistance of the inlet valve 3 and passage. Then on compression in this pump chamber, the quantity of explosive mixture transferred to the explosion chamber will be slightly reduced by the resistance of the passages 6, 6 and valve 9, so that less than the full charge displaced in the crank case enters the explosion chamber. The charge entering the explosion chamber is further slightly reduced by the small back pressure from the exhaust, due to the muffler which is usually placed on the exhaust of such engines in the well known manner to reduce the noise of exhaust. In addition to these losses, the full displacement capacity of the pump chamber is less than the full capacity of the explosion chamber by the amount of the compression space in the explosion chamber above the dotted line 42. All these losses increase in proportion to the increase in speed at which it is desired to operate the engine, but are diminished in my engine as much as possible by the relatively high compression used in the crank-case, it being, however, undesirable to increase this compression over about fifteen pounds per square inch, as the pressure in the explosion

chamber falls to about that pressure before the exhaust port is opened when the engine is lightly loaded. From the effect of these losses, the explosion chamber 8 would be only about 70% filled with explosive mixture, the balance being hot burned gas remaining from the previous explosion. This burned gas dilutes and weakens the explosive value of the mixture, as said before, to a much greater extent than its quantity would indicate, besides keeping the working cylinder hotter and having a tendency to cause pre-ignition. I avoid or overcome these losses and objections by the addition of a pump 32, which may be arranged in any suitable manner to add a sufficient volume to the charge of the crank case pump chamber, as will entirely displace or exhaust the burned gas from the explosion chamber, thus providing for the first time a rejection control engine in which all of the products of combustion are completely exhausted during each cycle. In my invention I prefer to use this pump 32 exclusively as a pure air pump in such a way as to insert a pure air charge in between the explosive charge and the burning charge in the explosion chamber during the exhaust thereof and the transfer of the explosive charge to this explosion chamber, as pure air forms an absolute barrier between the two charges across which the flame cannot pass to cause back-firing, thus providing for the first time a rejection control engine in which the speed is not limited by this back-firing and which can, therefore, be run at such high speeds, which have heretofore been impossible in previous engines of this type. This air, being cool, enables the cylinder to be kept cooler, prevents loss of the explosive charge out of the exhaust ports, and such air as does mix with the explosive charge will add to the explosive power thereof, as this explosive charge can be previously so proportioned as to require such addition of air to make a perfect mixture.

The up stroke of the piston 33 takes place during the down stroke of the piston 5. On the up stroke of the piston 33 air is compressed through passage 35, filling passages 36—37—6—6—6. On the down stroke of the piston 33, the piston valve A (operated by the eccentric 38) closes the passage from 35 to 36 and opens the passage from 35 to 40 (the air inlet) admitting air to the cylinder of 32. The air may be introduced directly into the explosion chamber through a suitable valve instead of being introduced into the passages or compression space of the pump chamber as shown.

It will be seen that all the features combine to increase the speed, power and control obtainable in my engine, while at the same time increasing the efficiency of the cycle of operations and producing the necessary com-

compact and light weight engine construction. An igniter 41 of some suitable kind, preferably electrical, is provided in the compression space above the dotted line 42 it being
 5 assumed that other well known and necessary accessories are provided when it is desired to operate the engine.

The complete operation of my engine is as follows, considering therewith the diagram
 10 in Fig. 4, in which the circle B represents the crank circle in the direction of the arrow C and the dotted line D represents the stroke of the piston 5. On the up stroke of the piston 5 (E to F) the explosive mixture
 15 is drawn into the lower end of the cylinder and crank case spaces 2—2 through the inlet 1. At the same time air is drawn into the air pump 32. On the down stroke of the piston 5 (F to E) the explosive mixture
 20 is compressed in the pump chamber 2 as said before, to about 10 or 15 pounds. This pressure or compression is preferably higher in engines intended to run at high speeds than in engines intended to run at
 25 lower speeds. At the same time the air pump 32 delivers its charge of air into the passages 37—6—6—6. At the point G the exhaust begins from the explosion chamber 8 through the exhaust ports 10—10 and continues to the point J. At the point H the
 30 pressure in 8 is below that in compression spaces 2—2—6—6 and the excess pressure opens the valve 9 admitting first the air from spaces 6—6 to the point I and then the
 35 explosive mixture to the point J. The combined displacement capacity of the pump chamber 2 and the air pump 32 should be sufficient to entirely displace the burned charge from the explosion chamber 8. Now
 40 if there is a full load on the engine the entire explosive charge will be retained in the explosion chamber 8, compressed on the up stroke (E to F, hereinafter referred to as the compression stroke) of the piston to
 45 about 80 pounds (more or less depending on the nature of the explosive mixture as is well known) and exploded by the igniter at point L. If however, there is less than full
 50 load on the engine the valve 9 is opened at point J (by the lever of the speed controlling mechanism being shifted by hand or otherwise to the proper place) and allowed
 55 to close at a point between J and K so that part of the explosive charge in 8 is rejected or returned to the crank case chamber 2, say up to the point K (which is about the full range of control.) Then at K the valve 9 closes, cutting off further rejection, and
 60 the rest of the explosive charge is compressed to L where it is ignited. From the point L (on the down stroke) expansion takes place doing work down to the point G or exhaust. It will be understood that the
 65 suction and compression in the pump chamber takes place during the same time as the

compression and expansion in the explosion chamber so that the four operations are gone through in one revolution of the crankshaft as is usual in the ordinary form of the two-stroke cycle engine. It will also be understood that only such a quantity of explosive
 70 mixture is drawn into the crank case during each cycle as has been used on the previous cycle.

For a stationary engine an automatic governor is preferable to regulate the charge by substantially the same method as that shown. In some cases it may be desirable
 75 to combine a variable timing of the ignition with the charge rejection method of control herein shown.

I show the herein described speed controlling mechanism as being of simple and suitable construction but there are other mechanisms that will perform the same
 80 functions equally as well.

The means for returning a part of the explosive charge to the pump chamber may be separate from the means for admitting the transfer of the explosive charge to the
 90 explosion chamber.

The valves 3 and 9 may be in multiple and mechanically operated in large engines instead of single and automatic as shown.

It is evident that many of the features of
 95 construction, besides those herein suggested, can be widely varied without departure from the invention. I have further developed some of these features which are described and claimed in a separate application for Letters Patent which culminated in the Letters Patent No. 947,566 of Jan. 25, 1910.

The term "passage connecting the two chambers," in combination with a "valve,"
 105 as used in the following claims, does not include a port in the wall of the working cylinder, the end of which is uncovered and thereby opened by the working piston when the said piston is at or near the bottom or
 110 inner end of its stroke.

While I have herein shown and particularly described the preferred embodiment of my invention, I do not mean to limit myself to the precise construction and arrangement set forth, but
 115

Having thus described one form of carrying out my invention, what I claim as new and desire to secure by Letters Patent is:—

1. The combination of a cylinder forming
 120 an explosion chamber, a crank case forming a pump chamber and consisting of an extension of said cylinder, a passage extending from the crank case to the end of the cylinder farthest removed from said crank case,
 125 a valve controlling the opening of said passage into said cylinder and having a reciprocating spring controlled valve stem, a pivoted lever acting upon said valve stem and connected with a reciprocating rod, a
 130

crank to which said rod is connected, driving means for said crank, and a lever carrying said crank whereby the same can be shifted to vary the period of opening of said valve.

2. The combination of a cylinder having a piston and forming an explosion chamber at one end, a crank case forming a pump chamber at the other end, a passage between the crank case and the end of the cylinder farthest removed from the crank case, a valve controlling such passage, an air pump at one side of the cylinder, a passage between said air pump and the same end of the cylinder in which the aforesaid passage enters, and a valve controlling said air pump passage.

3. In an explosive engine, the combination of a main explosive gas mixture pump and an explosion chamber, a passage connecting the said pump and explosion chamber, a valve in said passage which controls the transfer of the explosive charge to the explosion chamber, an auxiliary air pump, means to deliver the charge of air from said air pump into the explosion chamber in addition to and ahead of the explosive charge, and means for returning more or less of the admitted explosive charge in the explosion chamber to the said main pump prior to ignition of the remaining charge left in the explosion chamber.

4. In an explosive engine, the combination of a crank case forming a pump chamber and provided with an explosive charge inlet, a cylinder forming an explosion chamber, a passage connecting the two chambers, a valve in said passage which controls the transfer of the explosive charge to the explosion chamber, an auxiliary air pump connected with the explosion chamber, and means controlling the passage of the charge of air from said air pump whereby said air will be admitted or delivered into the explosion chamber in addition to and ahead of the explosive charge.

5. In an explosive engine, the combination of a crank case forming a pump chamber and provided with an explosive charge inlet, a cylinder forming an explosion chamber, a passage connecting the two chambers, a valve in said passage which controls the transfer of the explosive charge to the explosion chamber, an auxiliary air pump which connects with said engine and delivers a charge of air into the said crank case chamber or passage forming part of said crank case chamber, where said air will enter the explosion chamber in addition to and ahead of the explosive charge.

6. In an explosive engine, the combination of a cylinder and piston therein, one end of said cylinder forming a pump chamber and the other end an explosion chamber, an explosive charge inlet for said pump

chamber, a passage connecting the two chambers, a valve in said passage adapted to control the transfer of the explosive charge to the explosion chamber, an auxiliary pump for supplying compressed air to the explosion chamber, and regulating means for effecting the return of more or less of the explosive charge from the explosion chamber to the said pump chamber prior to ignition to regulate the speed or power of the engine.

7. In an explosive engine, the combination of a cylinder and a piston therein, one end of the said cylinder forming a pump chamber and the other end an explosion chamber, an explosive charge inlet for said pump chamber, a passage connecting the two chambers, a valve in said passage which controls the transfer of the explosive charge from the pump chamber to the explosion chamber, means for introducing a charge of air into the explosion chamber in addition to the explosive charge, and regulating means for effecting the return of a part of the explosive charge from the explosion chamber to the pump chamber to regulate the speed or power of the engine.

8. In an explosive engine, the combination of a cylinder and piston therein, one end of said cylinder forming a pump chamber and the other end an explosion chamber, means for introducing the full charge of explosive gas from the pump chamber into the explosion chamber, means for introducing a charge of air into the explosion chamber in addition to the explosive charge, and regulating means including a valve for effecting the return of a portion of the admitted explosive charge in the explosion chamber to the said pump chamber prior to ignition of the remaining charge left in the explosion chamber.

9. In an explosive engine, the combination of a crank case forming a pump chamber and having therein a crank which is extended to occupy a substantially large part of the compression space in said crank case, an attached cylinder forming an explosion chamber at its outer end and having therein a working piston which is common to both chambers, and connected to the said crank, a passage directly connecting the two chambers, a normally closed valve which controls said passage and is adapted to open or be opened at the proper time to allow the transfer of the explosive charge to the explosion chamber, means for introducing a charge of air into the explosion chamber in addition to the said explosive charge, and regulating means for effecting the return of a portion of the explosive charge from the explosion chamber to the pump chamber prior to ignition.

10. In an explosive engine, the combination of a crank case forming a pump cham-

ber and having therein a crank which is extended to occupy a substantially large part of the compression space in said crank case, an attached cylinder forming an explosion chamber at its outer end and having therein 5 a working piston which is common to both chambers and connected to the said crank, a passage directly connecting the two chambers, a normally closed valve which controls 10 said passage and is adapted to open or be opened at the proper time to allow the transfer of the explosive charge to the explosion chamber, means for introducing a charge of air into the explosion chamber 15 in addition to the explosive charge, and means for also holding the said valve open during more or less of the compression stroke of the engine piston thereby permitting a part of the explosive charge to be 20 returned to the pump chamber prior to ignition.

11. In an explosive engine, the combination of a crank case forming a pump chamber, an attached cylinder forming an explosion chamber at its outer end and having 25 therein a working piston which is com-

mon to both chambers and connected to the engine crank within the crank case, means for introducing the full charge of explosive gas from the pump chamber into the explosion chamber, means for introducing a 30 charge of air into the explosion chamber in addition to the explosive charge, and regulating means for effecting the return of a portion of the admitted explosive charge in 35 the explosion chamber to the pump chamber prior to ignition of the remaining charge left in the explosion chamber.

12. In a two stroke cycle explosive combustion engine, the combination of a cylinder and piston therein, means to supply 40 said cylinder with an entire fresh charge during the exhaust part of the cycle, said means comprising two pumps, both of which deliver their charge into said cylinder during 45 said exhaust, and means for returning a portion of the charge in the cylinder back into one of said pumps.

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Witnesses:

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