C. G. SPRADO.

METHOD OF AND APPARATUS FOR MANIPULATING INTERNAL COMBUSTION ENGINES.

APPLICATION FILED OCT. 22, 1919.

1,399,900. Patented Dec. 13, 1921.

2 SHEETS—SHEET 1.

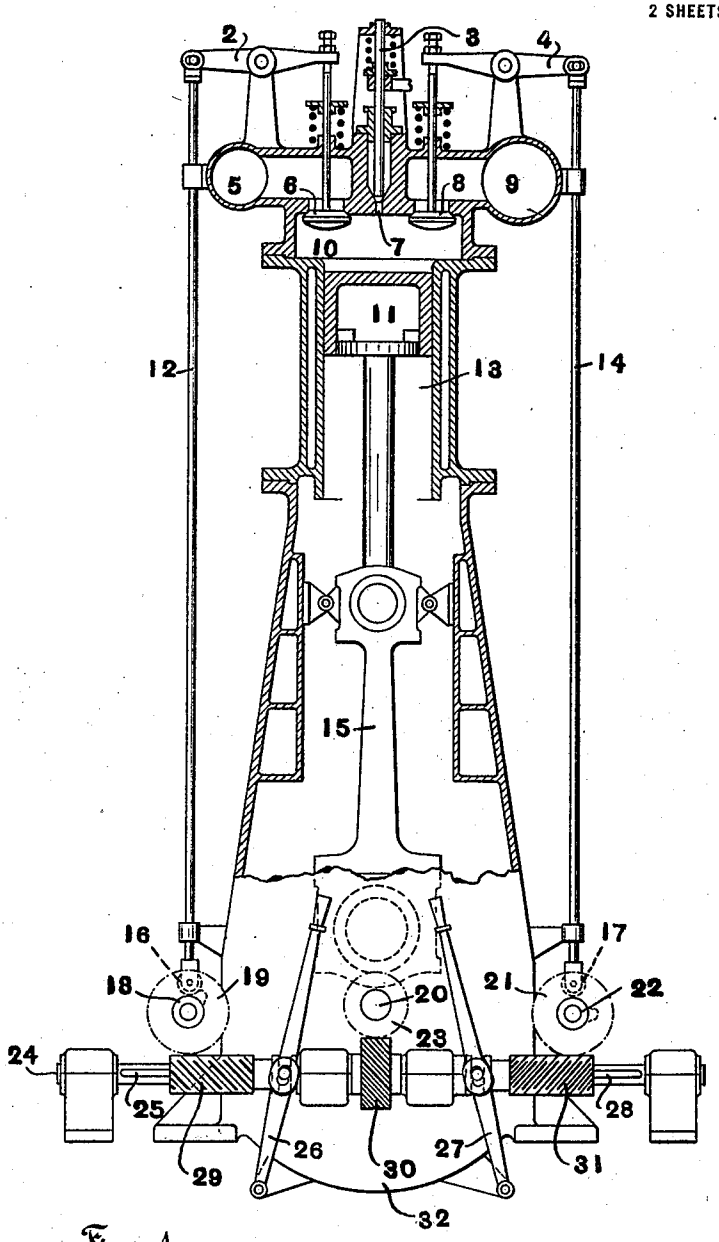


Fig. 1

Inventor
C. G. Sprado
by G. F. Dillon
Attorney

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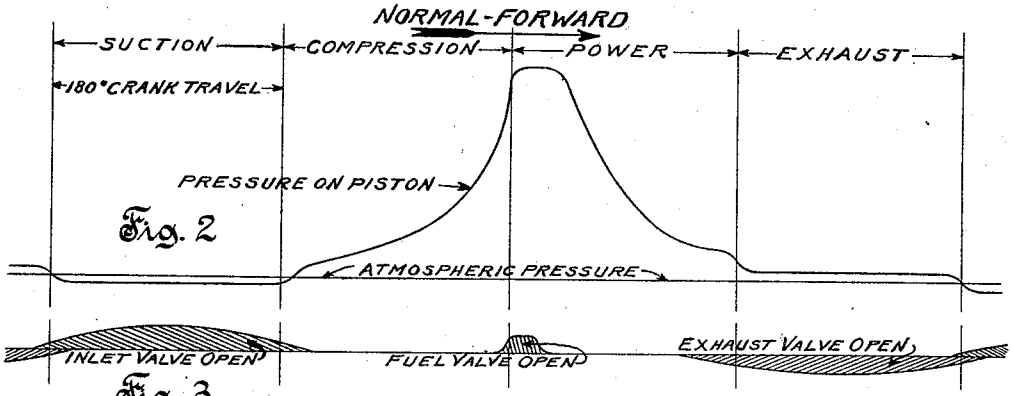


Fig. 2

Fig. 3

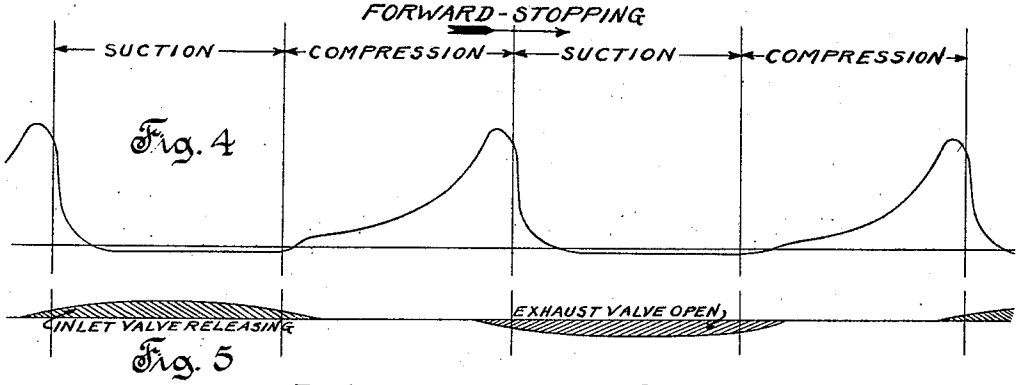


Fig. 4

Fig. 5

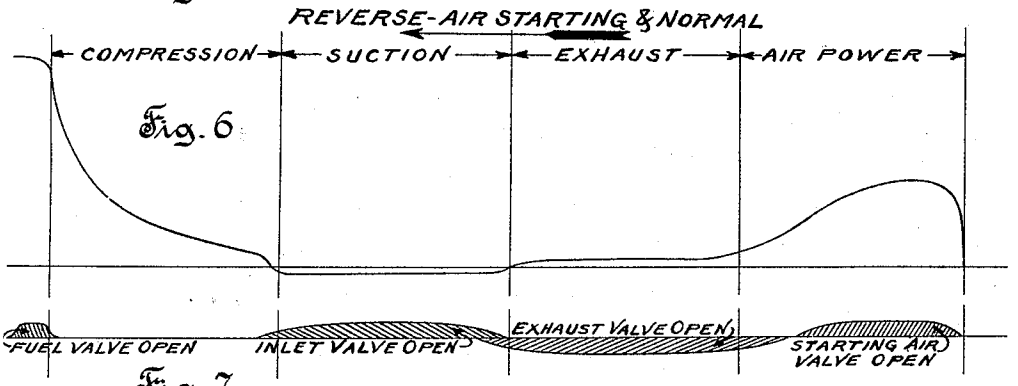


Fig. 6

Fig. 7

Inventor

C. G. Sprado

by G. J. D'Alvia

Attorney

UNITED STATES PATENT OFFICE.

CARL G. SPRADO, OF MILWAUKEE, WISCONSIN, ASSIGNOR TO ALLIS-CHALMERS MANUFACTURING COMPANY, OF MILWAUKEE, WISCONSIN, A CORPORATION OF DELAWARE.

METHOD OF AND APPARATUS FOR MANIPULATING INTERNAL-COMBUSTION ENGINES.

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Application filed October 22, 1919. Serial No. 332,565.

To all whom it may concern:

Be it known that I, CARL G. SPRADO, a citizen of the United States of America, residing at Milwaukee, in the county of Milwaukee and State of Wisconsin, have invented a certain new and useful Improvement in Methods of and Apparatus for Manipulating Internal-Combustion Engines, of which the following is a specification.

This invention relates in general to an improved method of and apparatus for manipulating internal combustion engines and relates specifically to a method of and apparatus for rapidly stopping and effecting subsequent reversal of so-called four-stroke-cycle internal combustion engines.

An object of the invention is to provide a simple and efficient method of manipulating internal combustion engines of the four-stroke-cycle type. Another object is to provide simple and efficient apparatus for effecting such manipulation.

In the operation of internal combustion engines and especially engines of relatively high power employed for marine purposes, it is at times desirable to quickly stop the engine. In order to reverse an engine of this kind it is necessary to bring the same to a dead stop from forward running operation, and to restart the engine in the reverse direction from stopped position, the speed of reversal thus depending upon the rate of stopping. It has been proposed to bring a four-stroke-cycle engine to a standstill by keeping the exhaust valve closed, changing the timing of the cams in relation to the crank shaft, and by opening the suction valve a second time during a cycle, shortly before the end of the compression stroke, thereby permitting the compressed air to escape instead of returning work to the crank shaft during expansion of the air. To effect such reversal, special inlet valve operating mechanism is required.

The present invention contemplates a simpler method of quickly stopping and reversing engines of this type without providing other than the ordinary valve actuating mechanism. The present method consists generally in reversing the exhaust valve gear while the engine is running ahead and simultaneously cutting out the fuel injection valve. By thus reversing the time of operation of the exhaust valve, each instroke of the piston becomes a compression stroke during which the gases confined within the cylinder are compressed. In this way the normal exhaust stroke instead of remaining such is changed to a compression stroke. The timing of both the inlet and the exhaust valve with the former operating normally and the latter reversed, is such that the compression in the cylinder will be relieved before the end of each compression stroke is reached, thus allowing the pressure to quickly drop to some value below atmospheric during the initial part of the succeeding suction stroke. After the engine has been stopped, the inlet valve gear is also reversed, the fuel injection valve is placed in condition for reverse operation, and the air starting gear is thrown into operation. As the engine assumes speed in the reverse direction and the fuel injection valve mechanism becomes effective, the air starting gear is thrown out and the engine assumes the condition of normal reverse operation.

A clear conception of an embodiment of the invention and of the steps of the method forming the subject thereof, may be had by referring to the drawings accompanying and forming a part of this specification, in which like reference characters designate the same or similar parts in the various views.

Figure 1 is a diagrammatic disclosure of a single cylinder, single acting, four-stroke-cycle internal combustion engine of the oil fuel utilizing type.

Fig. 2 is a diagram showing the pressures on the piston of the engine during the four strokes comprising a cycle of normal forward operation.

Fig. 3 is a diagram showing the periods and extent of opening of the various valves of the engine during normal forward operation thereof. This figure is complementary to Fig. 2.

Fig. 4 is a diagram showing the pressures on the piston during the cycle of operation just preceding stopping of the engine and while the same is moving in a forward direction.

Fig. 5 is a diagram showing the periods

and extent of opening of the various valves while the engine is being brought to a stop. This figure is complementary to Fig. 4.

Fig. 6 is a diagram showing the pressures on the piston during the period that the air starting mechanism is effective for bringing the engine into reverse movement from stopped position, and also showing the variations in pressure acting upon the piston during the first two strokes of normal reverse operation of the engine.

Fig. 7 is a diagram showing the periods and extent of opening of the various valves during the reverse air starting and normal reverse operation of the engine. This figure is complementary to Fig. 6.

It will be understood that the engine disclosed in Fig. 1 is merely illustrative of the general structure of a vertical internal combustion engine of the four-stroke-cycle type and that the invention is applicable to other forms of engines of the same type. The engine comprises in general a frame 32 having a cylinder 13 associated with the upper end thereof. The main engine shaft 20 with which the propeller or other energy absorber is associated, is provided with the usual crank which is connected with the reciprocable piston 11 by means of a connecting rod 15. The cylinder 13 is provided with the usual head within which is formed a combustion chamber 10. Fuel is admitted to the combustion chamber 10 through an orifice 7, the admission of the fuel being controlled by means of a fuel injection valve 3 and actuating mechanism of usual form. The air under pressure for supporting combustion, is admitted to the combustion chamber 10 from a source of air supply 5 past an inlet valve 6. The gases of combustion are delivered from the combustion chamber 10 past an exhaust valve 8 to an exhaust chamber 9. A compressed air starting valve of usual form, located out of the plane of the drawing and not shown therein, is also provided for starting the engine.

The inlet valve 6 is operable by means of a lever 2 associated with the upper extremity of an actuating rod 12, the lower extremity of which rod carries a roller 16 coactable with a cam 18 secured to a rotary counter shaft. The rotary cam shaft to which the cam 18 is secured, also has a spiral gear 19 secured thereto, which meshes with an adjustable spiral gear 29 slidably associated with the main counter-shaft 24, by means of a spline 25. The spiral gear 29 is shiftable along the shaft 24 by means of a lever 26 for purposes hereinafter explained. The exhaust valve 8 is operable by means of a lever 4 associated with the upper extremity of an actuating rod 14, the lower extremity of which rod carries a roller 17 coactable with a cam 22 secured to a rotary counter shaft. The rotary cam shaft to which the cam 22 is secured, also has a spiral gear 21 secured thereto, which meshes with an adjustable spiral gear 31 slidably associated with the main counter shaft 24 by means of a spline 28. The spiral gear 31 is shiftable along the shaft 24 by means of a lever 27 for purposes hereinafter explained. The counter shaft 24 has rigidly secured to its medial portion, a spiral gear 30 which meshes with a spiral gear 23 rigidly secured to the main engine shaft 20.

As the engine is placed in motion, the main shaft 20 is rotated and causes the main counter shaft 24 to rotate in a given direction by virtue of the coacting gears 23, 30. The rotating counter shaft 24 causes the gears 29, 31 to rotate, this rotary motion of the gears being transmitted to the cams 18, 22 through the gears 19, 21 and intervening counter shafts. As the cams 18, 22 are rotated they intermittently raise the rods 12, 14 and permit opening of the valves 6, 8. By moving the gears 29, 31 along the shaft 24, the timing or time of opening of the valves 6, 8 may be varied relatively to the period of rotation of the main shaft 20 and hence relatively to the position of the piston. With this general description of the construction and operation of an engine of this type, the present novel method of reversing such an engine should be apparent by following the cycles of operation illustrated diagrammatically on sheet two of the drawings.

When the engine is running normal forward as represented in the diagrams of Figs. 2 and 3, each operating cycle comprises successively; suction, compression, power or expansion, and exhaust strokes, each of which represents motion of the crank through an angle of 180°. The inlet valve 6 is opened during the suction or outstroke as indicated in Fig. 3, and air is admitted to the combustion chamber 10 through the inlet valve 6. During the following compression or instroke the inlet valve 6 is closed and the air previously admitted to and now confined in the combustion chamber 10 is compressed by the advancing piston 11, as indicated by the pressure curve in Fig. 2. As the end of the compression stroke is reached the fuel injection valve 3 is opened for a short period of time to admit the desired amount of fuel. This admission takes place during the latter part of the compression stroke and the initial part of the preceding power or outstroke, as shown in Fig. 3, the fuel being injected under a pressure above that of the maximum compression in the combustion chamber 10. After sufficient fuel has been admitted and ignition has taken place, the fuel valve is closed, the ignited gases expanding as indicated in the diagram, Fig. 2, in the power stroke. As the end of the

power stroke is reached the exhaust valve is opened as shown in Fig. 3, and the spent gases of combustion are delivered from the cylinder during the final exhaust or instroke of the cycle. As this cycle of operations is repeated, the engine continues its normal forward operation.

If it is desired to reverse the engine the first step is to bring the same to rest or dead stop position. This is accomplished by manipulating the lever 27 to produce reversal of operation of the exhaust valve, and by simultaneously interrupting or preventing operation of the fuel injection valve 3. When the operation of the exhaust valve is reversed, the normal operation of the inlet valve is not affected. With the valve gear thus set, the operation is as follows, specific reference being made to Figs. 4 and 5: During the suction or outstroke the inlet valve 6 is opened as illustrated in Fig. 5, and air is admitted to the combustion chamber 10. During the following compression or instroke the air confined within the chamber 10 is compressed as indicated by the diagram of the second stroke in Fig. 4. This compression continues to a point near the end of the stroke and acts to partially arrest the motion of the engine. As the end of the compression stroke is reached and while the piston 11 is still moving toward the chamber 10 and also during the succeeding suction or outstroke, the exhaust valve is opened as shown in Fig. 5, thereby relieving the pressure in the cylinder without producing an outward impelling force upon the piston. Near the end of this second suction or outstroke, the exhaust valve is closed and the return motion of the piston 11 again produces compression of the confined air within the cylinder 13. This alternate opening of the inlet and exhaust valves during every other stroke of the engine and alternate compression and release of the air confined within the cylinder while all valves are closed, rapidly absorbs the inertia of the moving parts of the engine and brings these parts to a stop.

After the engine has been thus brought to a standstill and in order to effect reverse movement thereof, it is first necessary to reverse the timing of the inlet valve 6 and to reverse and throw into effective position the fuel injection valve gear. The air starting valve is then open as indicated by the stroke represented by the first division to the right of Figs. 6 and 7, thus starting the engine crank moving in the reverse direction. During the first air power or outstroke of the reverse operation, the engine is propelled by the compressed air admitted through the starting valve. The succeeding instroke of the engine is an exhaust stroke during which the exhaust valve 8 is open and the compressed air previously admitted is allowed to escape. It may be necessary to repeat this air pressure operation several times but as the engine assumes sufficient speed in the reverse direction to produce the necessary compression during an instroke thereof, the fuel injection valve mechanism becomes effective to produce a normal cycle of reverse operation. The inlet valve 6 will then act during the suction or outstroke to admit air which during the succeeding compression or instroke will be compressed in the chamber 10. During the latter part of this compression or instroke and during the inital part of the succeeding or power stroke fuel will be injected and ignited, the expansion of this ignited fuel then supplementing the compressed air operation in effecting normal reverse running of the engine. The starting air valve is then thrown out of operation and the cycles subsequently followed will be the reverse of that illustrated in Figs. 2 and 3.

It will thus be noted that by employing this method of operation, an internal combustion engine of the four-stroke-cycle type may be quickly stopped and if desired, reversed. By properly timing the opening of the inlet and exhaust valves, the compression on the piston during stopping may be carried to a relatively high degree sufficient to completely stop the engine within one or two revolutions. In engines having a number of cylinders and pistons associated with a common crank shaft, the compressed air confined in one or more of the cylinders may even be sufficient to start the engine in the reverse direction without utilizing other starting agencies. The rate at which the engine may be stopped will however depend upon its normal rate of speed and the inertia of the moving parts but under any operating conditions the stopping of the engine may be relatively quickly effected. It will be noted that the essential step of the process is the reversal of operation of the exhaust valve in advance of the inlet valve. The fuel injection valve is however made inoperative simultaneously with the reversal of the exhaust valve in order to prevent admission of fuel during the stopping operation. It will be obvious that any other method of starting may be employed in place of the air pressure system herein specifically illustrated, without departing from the present invention.

By utilizing two lay-shafts for actuating the cams 18, 22, the exhaust valve timing may be reversed independently and without affecting the operation of the inlet valve. This construction also eliminates necessity of providing special valve actuating mechanism for stopping the engine. The shiftable spiral gears 19, 21, 29, 31 are so constructed that the pressures on the teeth thereof will automatically hold them in en-

gagement with the adjacent bearings for the shaft 24, thus preventing end displacement of the gears 29, 31. During reversal of the exhaust valve mechanism and while the engine is running in a forward direction, it will however be necessary to hold the gear 31 in a position corresponding to reverse operation until the engine is stopped. While the present invention is especially applicable to engines of relatively high power wherein reversal of the energy absorber is effected by actually reversing the engine rather than through reversing transmission gearing, it may be desirable to utilize the invention in smaller units as well.

It should be understood that it is not desired to limit the invention to the exact details of the method as described, for obvious modifications may occur to a person skilled in the art.

It is claimed and desired to secure by Letters Patent:

1. The method of stopping a four-cycle internal combustion engine, which comprises, manipulating the valve operating mechanism to produce compression in the cylinder during each instroke of the piston and simultaneously interrupting operation of the fuel injection valve.

2. The method of stopping a four-cycle internal combustion engine, which comprises, manipulating the exhaust valve operating mechanism only to produce compression in the cylinder during each instroke of the piston.

3. The method of stopping a four-cycle internal combustion engine, which comprises, reversing the normal exhaust valve operation to produce compression in the cylinder during each instroke of the piston.

4. The method of stopping an internal combustion engine, which comprises, placing the exhaust valve actuating mechanism into normal reverse condition while the engine continues its forward direction of movement.

5. The method of reversing an internal combustion engine, which comprises, reversing the exhaust valve operation in advance of reversal of the inlet valve operation.

6. The method of reversing an internal combustion engine, which comprises, simultaneously reversing operation of the exhaust valve actuating mechanism and interrupting the fuel injection valve operation, and subsequently reversing the inlet and fuel injection valve operations.

7. The method of reversing an internal combustion engine, which comprises, establishing normal reverse operation of the exhaust valve to stop the engine, starting the engine in reverse direction, and permitting the inlet and injection valves to become effective to produce normal reverse operation.

8. The method of reversing an internal combustion engine, which comprises, simultaneously reversing the exhaust valve operation and interrupting the fuel injection valve operation, permitting the engine to come to a stop with the valves in this condition, reversing the inlet valve operation and making the injection valve effective for reverse operation while the engine is stopped, and subsequently reversing the operation of the engine.

9. In a four-cycle internal combustion engine, means for reversing the operation of the inlet and exhaust valves independently of each other.

10. In a four-cycle internal combustion engine, reversing mechanism for the exhaust valve, and independently reversible mechanism for the inlet valve.

11. In a four-cycle internal combustion engine, a plurality of gears operable by and independently adjustable relatively to the main engine shaft, an exhaust valve operable by one of said gears, and an inlet valve operable by the other of said gears.

12. In a four-cycle internal combustion engine, a valve actuating gear movable along its axis to reverse the operation of a valve, and means coöperable with opposite ends of said gear, said means coacting with said gear, the one to automatically maintain said gear in normal forward position and the other to automatically maintain said gear in normal reverse position.

13. In a four-cycle internal combustion engine, an exhaust valve, an inlet valve, and means for reversing the operation of said exhaust valve in advance of reversal of the operation of said inlet valve.

In testimony whereof, the signature of the inventor is affixed hereto.

CARL G. SPRADO.