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[54] **ENGINE WITH INTERNAL CHARGE DILUTION AND METHOD**

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[52] **U.S. Cl.** ..... **123/119 A,** 123/75 E

[51] **Int. Cl.** .. **F02b 33/00,** F02b 75/02, F02d 39/02

[58] **Field of Search** ..... 123/75 E, 119 A

[56] **References Cited**

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Assistant Examiner—Louis T. Casaregola
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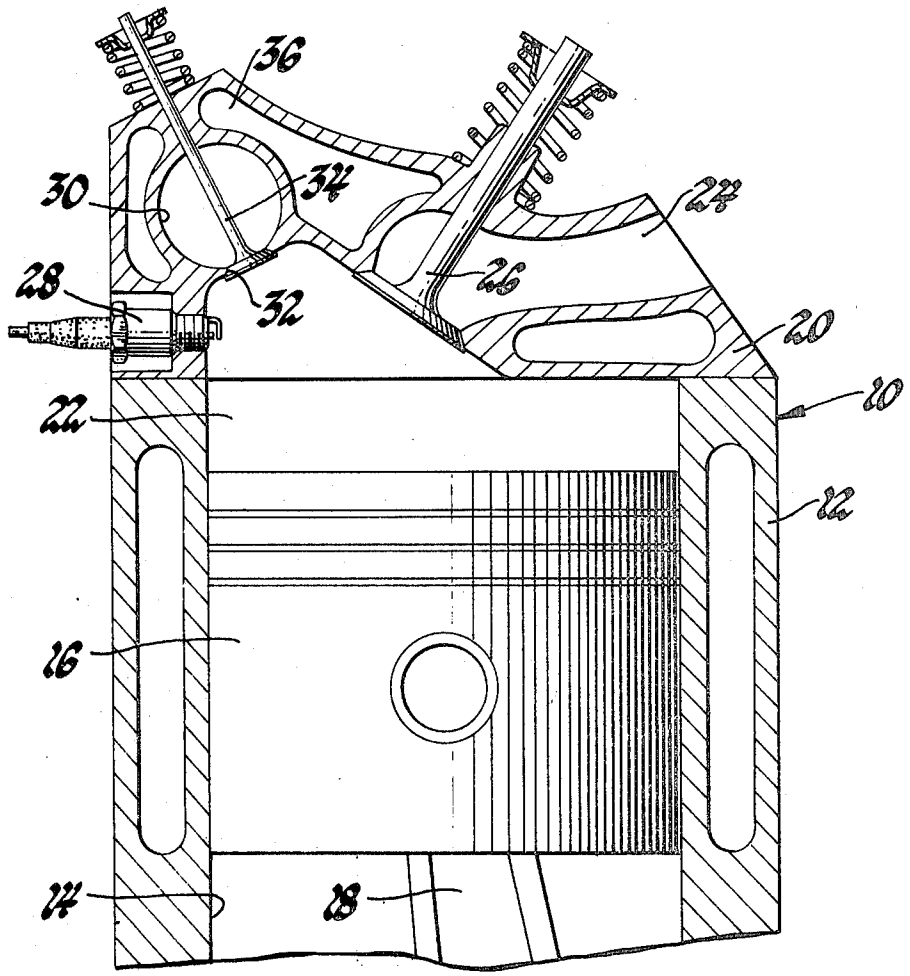
[57] **ABSTRACT**

In a preferred embodiment, a spark-ignited internal combustion engine is provided with a valved receiver chamber connected with the combustion chamber adjacent the spark plug. The receiver valve is open at peak combustion pressures to admit combustion chamber gases which are retained in the receiver until discharged to the combustion chamber after ignition of the charge on the following cycle. The arrangement and method provide substantial combustion chamber charge dilution for limiting nitrogen oxide emissions without adversely affecting ignition of the air-fuel mixture.

4 Claims, 2 Drawing Figures



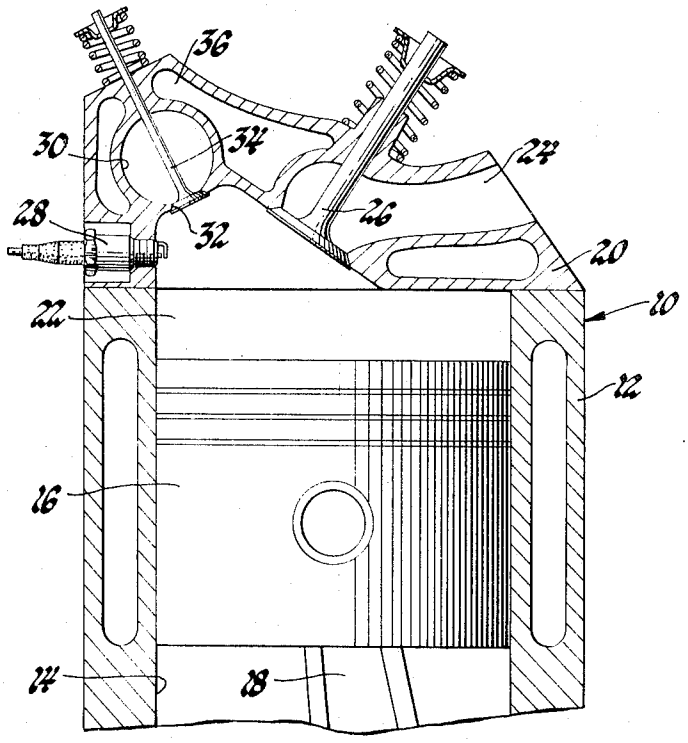

36
30
34
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Fig. 1

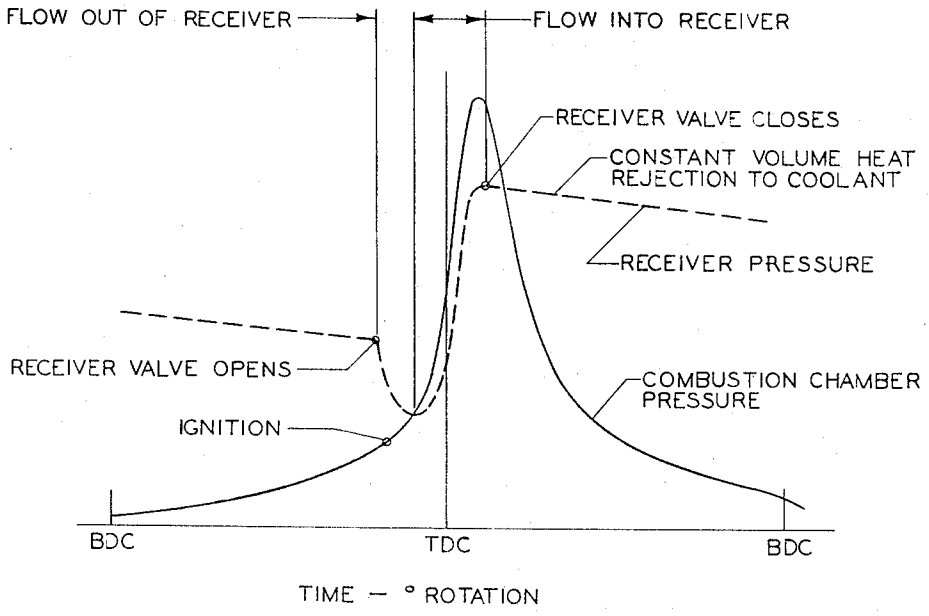
FLOW OUT OF RECEIVER
FLOW INTO RECEIVER
RECEIVER VALVE CLOSES
CONSTANT VOLUME HEAT REJECTION TO COOLANT
RECEIVER PRESSURE
RECEIVER VALVE OPENS
COMBUSTION CHAMBER PRESSURE
IGNITION
BDC
TDC
BDC
TIME — ° ROTATION

Fig. 2

ENGINE WITH INTERNAL CHARGE DILUTION AND METHOD

BACKGROUND OF THE INVENTION

This invention relates to internal combustion engines and, more particularly, to internal charge dilution means cooperating with the combustion chambers of spark-ignition engines, as well as operating methods for reduction of nitrogen oxides in such engines.

It is known that emissions of nitrogen oxides from internal combustion engines may be substantially reduced by dilution of the cylinder charge with exhaust or other gases which act to limit the combustion temperatures reached in the cylinder. Various methods have been proposed or utilized for accomplishing such dilution, including external exhaust recirculation, increased valve overlap and increased exhaust back pressure. However, these methods increase the dilution of the charge before ignition occurs and consequently are limited in effectiveness by the tendency for erratic combustion and misfiring of the engine at high percentages of dilution. If these adverse effects upon ignition of the charge could be overcome, it is believed that further reductions of nitrogen oxide emissions could be effected with reasonably smooth operation of the engine and good drivability of the vehicle in which it is installed.

SUMMARY OF THE INVENTION

The present invention provides an engine arrangement which incorporates an internal receiver chamber adjacent each combustion chamber of the engine to receive burned combustion chamber gases at peak pressure and return them to the combustion chamber on the following cycle, after ignition of the charge. This arrangement and method of operation provides for an increase in the residual fraction of recirculated or retained exhaust gases that may be tolerated in the engine combustion chamber without adversely affecting ignition of the charge and consistency of combustion.

A further feature of the invention is that the receiver chamber is located adjacent the spark plug so that the charge-diluting gases mix first with the initially burned portions of the combustion chamber charge, thus maximizing the reduction of nitrogen oxide emissions.

These and other features of the invention will be more fully understood from the following description of the preferred embodiment, taken together with the accompanying drawing.

BRIEF DESCRIPTION OF THE DRAWING

In the drawing:

FIG. 1 is a cross-sectional view showing one cylinder of an internal combustion engine having receiver means according to the invention; and

FIG. 2 is a pressure-time diagram illustrating the relative pressures in the combustion and receiver chambers during portions of one engine cycle and the relative points of operation of the receiver chamber valve and ignition means during the engine cycle.

DESCRIPTION OF THE ILLUSTRATED EMBODIMENT

In the drawing, numeral 10 generally indicates an internal combustion engine of the spark-ignition type. Engine 10 includes a cylinder block 12 having therein a plurality of cylinders 14, only one of which is shown.

A piston 16 is reciprocably disposed in the cylinder 14 and is connected by means of a connecting rod 18 to a conventional crank mechanism, not shown. A cylinder head 20 closes the end of cylinder 14 and defines therewith a variable volume combustion chamber 22.

The cylinder head includes an inlet port 24 connecting the combustion chamber 22 with external means, not shown, for supplying a combustible air-fuel mixture to the chamber. Port 24 is closed at the entrance to chamber 22 by a conventional poppet valve 26. Adjacent the inlet port the cylinder head is also provided with an exhaust port, not shown, which communicates the combustion chamber with an engine exhaust system and is closed by an exhaust poppet valve, not shown, in conventional fashion similar to that illustrated for the inlet port.

In a wall of the combustion chamber generally opposite the valves there is mounted a spark plug 28 which extends into the chamber 22 for the purpose of igniting air-fuel mixture supplied thereto. Closely adjacent the spark plug there is formed within the cylinder head a generally spherically shaped receiver chamber 30 which is closed except for an opening 32 which connects the receiver chamber 30 with the combustion chamber 22 at a point closely adjacent the spark plug 28. Opening 32 is closed by a poppet valve 34 which extends through the chamber 30 and outside the cylinder head for actuation by suitable means, not shown.

The engine is provided with ignition means, including the spark plug, and valve gear for actuating the inlet and exhaust valves, as well as the receiver valve 34, all of which are connected to operate in timed relation with the reciprocating action of the piston 16 to perform a specific operating cycle, as will be subsequently described.

In operation of the engine, the piston 16 is reciprocated through a four-stroke cycle, including the events of intake, compression, expansion and exhaust. It is, however, within the scope of the invention to utilize a two-stroke cycle mode of operation or any other desirable operating cycle.

During the intake stroke, the intake valve 26 is opened, admitting to the combustion chamber a charge of air and fuel mixture supplied in combustible proportions by an external carburetor or the like. This mixture is then compressed on the upward compression stroke of the piston 16, increasing the pressure in the combustion chamber, as illustrated in FIG. 2, as the piston moves from its bottom dead center (BDC) position toward its top dead center (TDC) position.

Shortly in advance of the piston's reaching the top dead center position, the spark plug is fired, igniting the compressed mixture in the combustion chamber. At about the same time, the receiver valve 34 is opened, allowing compressed gases stored during the previous engine cycle to enter the combustion chamber 22 adjacent the spark plug. Due to the lag in movement of the gases, the opening of the receiver valve may begin somewhat in advance of the ignition of the combustion chamber mixture or, if desired, may be delayed until shortly after this point.

The gases from the receiver chamber enter the combustion chamber and mix with the burned and burning mixture adjacent the spark plug, reducing the gas temperatures particularly in the earliest burned portions of the mixture, thereby limiting the maximum temperatures reached in the combustion chamber during the

combustion process. This effectively reduces the nitrogen oxides formed during combustion and subsequently emitted with the exhaust gases.

As combustion continues in chamber **22**, the gas pressure rises and reaches a peak shortly after the piston passes its top dead center position. The receiver valve **34** remains open during this period so that pressure in the receiver chamber which dropped initially upon delivery of its charge to the combustion chamber, is subsequently increased by receiving burned gases through its connection with the combustion chamber. At about the point where the receiver chamber pressure reaches a maximum, which is at or shortly after the occurrence of maximum pressure in the combustion chamber, the receiver valve **34** is closed, retaining the compressed gases in the receiver chamber while the piston moves downwardly on its expansion stroke.

Following expansion, which produces positive work, the exhaust valve is opened and the burned gases are forced out of the combustion chamber on the upward exhaust stroke of the piston. The cycle is then repeated, beginning with another intake stroke.

The arrangement of the receiver chamber within the cylinder head is preferably such as to provide for cooling of the gases retained in the receiver by the engine coolant passing through passages **36** of the coolant jacket which are in heat exchange relation with the walls of the chamber **30.** The cooling of the retained gases causes some reduction in the pressure of the gases in the receiver during the period between the closing of the receiver valve **34** and its subsequent opening near the ignition point of the next cycle. While this pressure reduction has the effect, as shown in FIG. **2,** of limiting the force by which the retained gases are returned to the combustion chamber on the following cycle, this disadvantage is believed to be offset by the advantages of the reduced gas temperatures which make more effective the diluting and temperature-reducing effects of the receiver-stored gases upon their readmission to the combustion chamber.

The specific size and shape of the receiver and combustion chambers and the location of the receiver chamber relative to the spark plug will require experimental determination for best operation in a particular engine. However, it is believed that an acceptable reduction of nitrogen oxide emissions may be obtainable by sizing the receiver chamber to provide a charge dilution of about **22** percent of the total cylinder charge with suitable control of the gas temperature through cooling of the receiver chamber and proper location of the chamber near the point of ignition of the air-fuel charge.

While the invention has been described by reference to a particular embodiment, it should be understood that numerous changes could be made within the spirit and scope of the inventive concepts disclosed. Accordingly, the invention is intended to be limited only by the language of the following claims.

I claim:

1. An internal combustion engine comprising

means defining a cylinder closed at one end,

a piston movable in said cylinder and defining therewith a variable volume combustion chamber,

means for admitting air and fuel to the combustion chamber, igniting the mixture and exhausting burned products from the combustion chamber, said admitting, igniting and exhausting means being operative in timed relation to the movement of the piston to cause repetitive performance of an operating cycle, including the steps of admission of air-fuel mixture to the combustion chamber, compression of the mixture, ignition and burning of the compressed mixture, expansion of the burned mixture with an output of power and exhaust of the burned gases from the combustion chamber,

an enclosed receiver chamber in said cylinder-defining means adjacent and connecting with said combustion chamber, and

means controlling communication between said combustion and receiver chambers, said controlling means being operative in timed relation with movement of the piston to permit such communication during portions of the various cycles substantially coincident with the burning process in the combustion chamber and to prevent communication during the remaining portions of the cycles.

2. An internal combustion engine comprising

a housing defining a closed end cylinder,

a piston reciprocably movable in said cylinder and defining therewith a variable volume combustion chamber at said cylinder closed end,

inlet and exhaust ports connecting with said combustion chamber in said housing and valves controlling said ports,

a closed receiver chamber in said housing, said receiver chamber being connected with said combustion chamber by an opening, a valve in said opening and operable to permit communication between said chambers, and

spark ignition means in said housing and extending within said combustion chamber near said receiver chamber opening,

said piston being sequentially movable through intake, compression, expansion and exhaust strokes and being operably interconnected with said valves and spark ignition means whereby said intake port valve is open during the intake stroke, said spark ignition means operates near the end of the compression stroke, said receiver valve is opened near the end of the compression stroke and closed near the beginning of the expansion stroke and said exhaust valve is open during the exhaust stroke.

3. The method of operating an internal combustion engine for internal charge dilution, said method comprising

admitting a charge of combustible air-fuel mixture to an enclosed combustion chamber,

contracting the chamber to compress the mixture,

igniting and burning the compressed mixture with a resultant increase in gas pressure within the chamber,

opening communication of the combustion chamber with a receiver chamber early in the burning process to receive previously stored gases into the combustion chamber for dilution of the charge and subsequently closing of such communication near the end of the burning process at about the point of maximum gas pressure in the combustion chamber, thereby retaining a charge of burned gases for reintroduction to the combustion chamber on the subsequent cycle,

expanding the gases in the combustion chamber with an output of power, and

exhausting the burning gases from the combustion chamber.

4. The method of claim **3** and including the further step of cooling the gases stored in the receiver chamber.

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