July 1, 1930. R. E. BRUCKNER 1,769,675

FUEL INJECTION AND ATOMIZATION BY STREAM IMPACT

Filed April 11, 1927

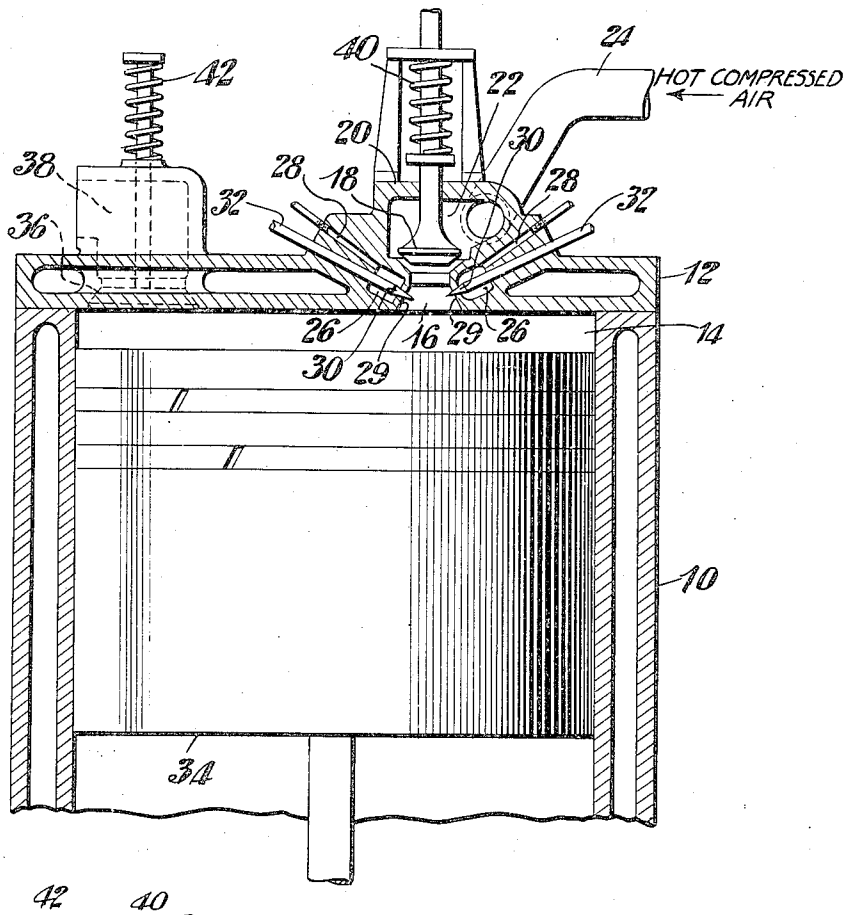

Fig. 1.

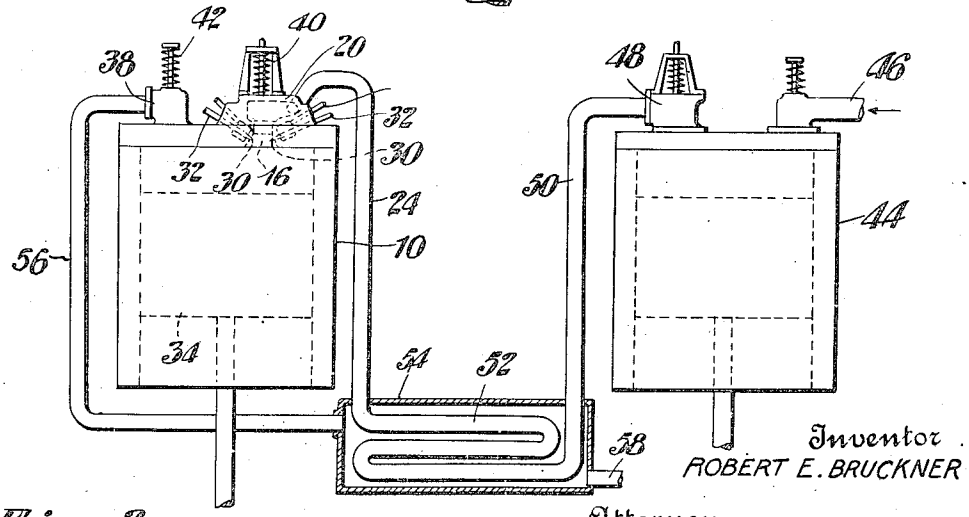

Fig. 2.

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Patented July 1, 1930 1,769,675

UNITED STATES PATENT OFFICE

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FUEL INJECTION AND ATOMIZATION BY STREAM IMPACT

Application filed April 11, 1927. Serial No. 182,968.

It is recognized that the pressure in internal combustion engines of the heavy oil type seldom follows a smooth curve during combustion. This is an indication of irregular burning. Pulsations of pressure are themselves undesirable and, further, the irregular burning increases the amount of unburned fuel in the exhaust for given speeds and fuel rates of injection of fuel.

One of the principal objects of the present invention is to provide a means and method for producing rapid and thorough mixing of fluid fuels in the combustion spaces of internal combustion engines.

Another object of the present invention is to increase the efficiency and scope of application of the "solid" injection method of introducing heavy oil fuel into internal combustion engines.

Other objects and advantages of the present invention will be obvious to those skilled in the art from the following description, the novel features of the invention being pointed out particularly in the appended claims.

One form of apparatus according to the present invention, and one adapted to carry out the method according to the present invention, is illustrated in the accompanying drawing in which

Fig. 1 is a central section through a cylinder of an engine according to the present invention.

Fig. 2 is a central section, somewhat diagrammatic in character, of an apparatus according to the present invention and in which the engine of Fig. 1 is combined with a recuperator and an external air compressor.

In the drawing, 10 is the working cylinder of an internal combustion engine having a head 12. Air for supporting combustion in the combustion space or chamber 14 in the upper end of cylinder 10 is introduced into space 14 from above through a downwardly flaring port 16 in the upper head 12. The air going into the chamber 14 is preferably compressed and preferably heated to the temperature of ignition of the fuel to be used. However, the present invention is not limited to compressing the air for combustion externally of the working cylinder or to heating the air prior to its introduction to the combustion chamber. The flow of air to and through the port 16 is controlled by an inlet valve 18. The apparatus as illustrated is designed for the use of hot compressed air and is consequently provided with an enlargement or boss 20 on the outside of the head 12 within which is an air chamber 22 for the reception of the preheated compressed air and which is introduced into the chamber 22 through pipe 24. As illustrated, the valve 20 is placed to control the flow of air from chamber 22 to the port 16. According to the present invention the fuel is introduced into the stream of air flowing through port 16. For this purpose, the engine illustrated is provided with two chambers 26, 26 within the head 12. Chambers 26 lie alongside of and partly surround the port 16. Fuel under pressure is introduced into the chambers 26, two ducts 28, 28 being provided in the boss 20 for this purpose. The heavy oil or other fuel to be used in the engine is conducted to the ports 28 through suitable pipes. No air or other substance of vaporous or gaseous nature under conditions existing in the ports of fuel valves 30 is introduced into chambers 26. The atomization of the heavy fuel oil by valves therefore is that due solely to the liquid pressure of the oil at said valves. The method of injection employed is therefore that commonly referred to as "solid" injection. The fuel is permitted to escape from the chambers 26 at desired intervals through ports in the walls 29, 29 between the chambers 26 and port 16. Walls 29 flare outwardly in the direction of flow of the air through port 16. The fuel ports just mentioned are normally closed by needle valves 30, 30 which are opened at the proper times and for the desired intervals by suitable mechanism not shown. The valves 30 are at the ends of spindles 32, 32 whose axes are at right angles to walls 29 and, when extended, intersect at a point preferably either within or without the port 16, depending upon the exact nature of the superposed conditions of combustion, but, at any rate, within the air stream which is passing thru or which has passed through

the port 16. Consequently, when the valves 30 are drawn back from their seats to permit the admission of fuel into port 16, the resulting streams of fuel are inclined forwardly in the direction of flow of the air. Also, the fuel streams intersect and the particles of the two streams collide with impact, thus producing an atomizing action in addition to that naturally occurring at the needle valves. The valve 18 is timed to be open through the interval during which valves 30 are open. Consequently the fuel is injected into a stream of moving air and the thorough mixing of the air and fuel is promoted not only by the turbulence caused by spraying two streams of fuel into the air stream at angle to its path, but also by the additional atomization and turbulence caused by the impact of the streams of fuel. It will be understood, therefore, that the present invention is not limited, in its broadest aspect to causing impact between particles in the two streams of fuel, although this is preferred.

If the air introduced into chamber 14 is at the ignition temperature of the fuel being used, the fuel is ignited as it enters the chamber from port 16. It will be seen that the combustion produced is non-explosive, the mixture of fuel and air burning at the same rate at which it enters chamber 14. In case the air is not sufficiently preheated to ignite the fuel, the air and fuel mixture is ignited by means (not shown) within chamber 14 to cause combustion in the chamber. The burning of the fuel in chamber 14 pushes down piston 34 with the production of power in the usual manner. Products of combustion are exhausted from chamber 14 through port 38 controlled by the exhaust valve 36.

Both valves 18 and 36 are normally held closed by springs 40 and 42 respectively but are opened at the proper instants and held open for proper periods of time by suitable mechanism not shown.

Preferably the heat for preheating the air introduced through port 16 is obtained from the heat in the gases exhausted from chamber 14. A suitable arrangement for carrying out the transfer of heat from the exhaust to the combustion air is illustrated diagrammatically in Fig. 2. In Fig. 2, the air for supporting combustion in cylinder 10 is first drawn in from the atmosphere into an air compressor 44, illustrated also as being preferably of the pistoned type. The air enters the cylinder of compressor 44 through port 46 and is compressed in the cylinder in the usual manner. The compressed air leaves compressor 44 through port 48 and is conducted through pipe 50, coil 52 and pipe 24 to the intake port 16 of cylinder 10. Air is heated while in the coil 52 which forms a part of a recuperator having a casing 54. Hot gases for heating the coil 52 are conducted from the exhaust port 38 of cylinder 10 through pipe 56 to the interior of the casing 54. After transferring most of the heat to the air within coil 52 the exhaust gases pass from the casing 54 to the atmosphere through the port 58.

Preferably the piston of compressor 44 is operated from the shaft (not shown) of the engine including cylinder 10, the compressor thus forming a part of the engine.

While I have illustrated no means for operating the valves of cylinder 10 or of the compressor 44, such means are well-known in the arts of internal combustion engines and of air compressors and need no description herein to enable those skilled in the art to practice the invention. Also, it is well known to supply fluid fuels such as heavy oil, to internal combustion engines under pressure and to control the injection of the fuel into the combustion space by means of needle valves. Suitable means for operating the needle valves 32, 32 are therefore well-known and are not described herein in detail.

While a single embodiment of the present invention has been illustrated and described herein in detail, it will be understood that the present invention is not limited to details of construction, arrangement or operation except in so far as such details are clearly and positively included in the appended claims.

Having thus described my invention I claim:

1. The method including atomizing a plurality of streams of fluid fuel into an air stream entering the combustion space of an internal combustion engine and under conditions producing turbulence, and burning the resulting mixture of air and fuel as the said mixture is formed in said space.

2. The method including atomizing by solid injection a plurality of streams of fluid fuel into an air stream entering the combustion space of an internal combustion engine and under conditions producing turbulence and burning resulting mixture of air and fuel as said mixture is formed in said space.

3. The method including atomizing a plurality of streams of fluid fuel into a stream of air heated to the temperature of ignition as said air stream is entering the combustion space of an internal combustion engine and under conditions producing turbulence, and burning the resulting mixture of air and fuel as the mixture is formed in said space.

4. The method including atomizing by solid injection, a plurality of streams of fluid fuel into a stream of air heated to the temperature of ignition of said fuel as said air stream is entering the combustion space of an internal combustion engine and under conditions producing turbulence, and burning the resulting mixture of air and fuel as said mixture is formed in said space.

5. The method including atomizing a plurality of streams of fluid fuel into an air

stream entering the combustion space of an internal combustion engine and under conditions producing impact in said fuel streams, and burning the resulting mixture of air and fuel as said mixture is formed in said space.

6. The method including atomizing by solid injection, a plurality of streams of fluid fuel into an air stream entering the combustion space of an internal combustion engine and under conditions producing impact of said fuel streams, and burning the resulting mixture of air and fuel as said mixture is formed in said space.

7. The method including atomizing a plurality of streams of liquid fuel into an air stream heated to the temperature of ignition of said fuel as said air stream is entering the combustion space of an internal combustion engine and under conditions producing impact and burning the resulting mixture of air and fuel as said mixture is formed in said space.

8. The method of introducing fuel and air into an internal combustion engine comprising setting up a stream of air passing into a combustion space of the engine and injecting into said stream near its point of entrance into said space, a plurality of streams of fuel, said fuel streams being atomized as they enter said air stream and being projected along intersecting paths whereby impact of fuel particles is produced in said air stream.

9. The method including atomizing a plurality of streams of liquid fuel into an air stream as said air stream is entering the combustion space of an internal combustion engine, the path of said fuel streams being inclined to that of said air streams whereby turbulent mixing of the air and fuel is produced.

10. The method including projecting a plurality of streams of finely divided fluid fuel into an air stream as said air stream is entering the combustion space of an internal combustion engine.

11. The method including projecting a plurality of streams of finely divided fluid fuel into an air stream as said air stream is entering the combustion space of an internal combustion engine, while maintaining conditions producing turbulent mixing of said air and fuel streams.

12. The method including projecting a plurality of streams of finely divided fluid fuel into an air stream as said air stream is entering the combustion space of an internal combustion engine, the direction of said fluid streams being inclined forwardly in the direction of flow of said air stream.

13. The method of infusing an air stream entering a combustion chamber with fluid fuel comprising impacting with one another within said air stream, a plurality of jets of said fluid fuel.

14. The method of infusing an air stream entering a combustion chamber with atomized fluid fuel comprising impacting with one another within said air stream, a plurality of jets of said fluid fuel.

15. In an apparatus of the class described, the combination of a combustion chamber having an air port therein, said port flaring outwardly in the direction of motion of air through the port, and means for atomizing a plurality of streams of liquid fuel through the flaring walls of said port along lines substantially at right angles to the flaring wall of the port and into a stream of air passing into said chamber.

16. In an apparatus of the class described, the combination of a combustion chamber having an air port therein, means for creating a current of air passing into said chamber through said port, and means for spraying fuel in a plurality of streams into said air stream and in directions inclined forwardly in the direction of motion of the air stream.

In testimony whereof I affix my signature.

ROBERT EARLL BRUCKNER.