E. V. BEALS.

INTERNAL COMBUSTION ENGINE.

APPLICATION FILED JUNE 14, 1916. RENEWED NOV. 20, 1918.

1,398,667. Patented Nov. 29, 1921.

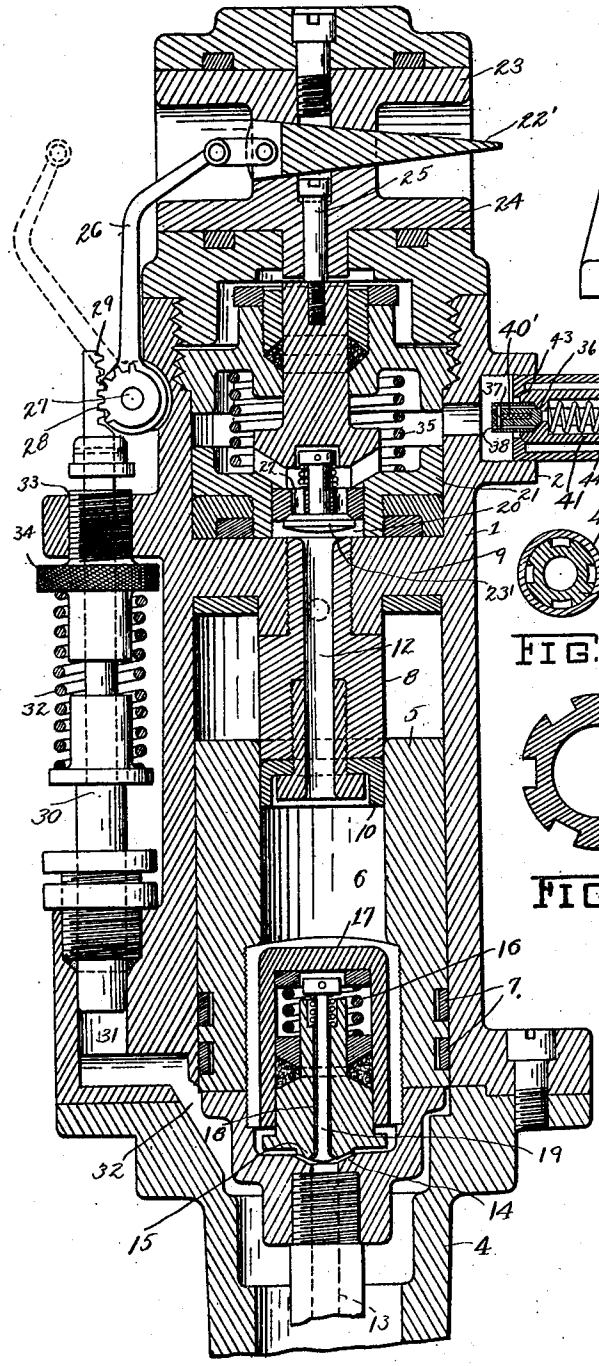


FIG. 1.

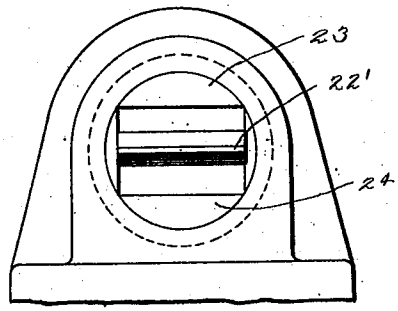


FIG. 2.

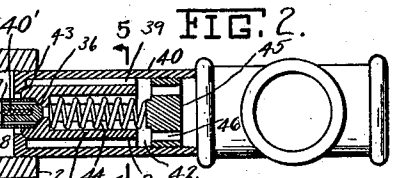


FIG. 5.

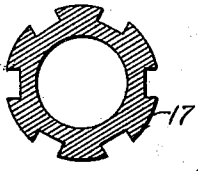


FIG. 4.

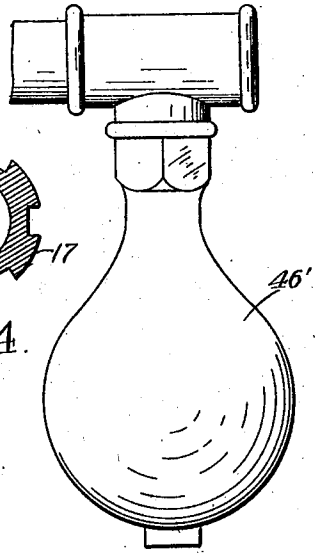


FIG. 3.

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INTERNAL-COMBUSTION ENGINE.

1,398,667. Specification of Letters Patent. Patented Nov. 29, 1921.

Application filed June 14, 1916, Serial No. 104,126. Renewed November 20, 1918. Serial No. 263,438.

To all whom it may concern:

Be it known that I, ERL V. BEALS, a citizen of the United States, residing in Arlington Heights, in the county of Middlesex and State of Massachusetts, have invented an Improvement in Internal-Combustion Engines, of which the following description, in connection with the accompanying drawings, is a specification, like letters on the drawings representing like parts.

The present invention relates to an internal combustion engine, and is embodied in improved means for injecting a liquid, preferably water, into the combustion chamber at the time of the explosion, for the purpose of absorbing and utilizing the excess heat, which is commonly carried off and wasted. The invention can be embodied in a complete appliance adapted to be incorporated in existing engines, or it may be made as an integral part of an engine properly designed for the purpose.

In accordance with the invention, the apparatus consists of an injecting device operated by the force of the exploding gases themselves, and so arranged as to introduce into the cylinder, each time an explosion takes place, a certain amount of water properly proportioned to the amount of fuel which is being burned.

An important feature of the invention consists in automatically regulating the amount of liquid introduced at each cycle so that the invention is practically adapted for use with variable speed engines such as those used in automobile work.

In accordance with the invention, there is a reservoir capable of containing the maximum amount of liquid needed for each explosion, and this reservoir is continually filled to its capacity. To expel the water from the reservoir a plunger is provided with a piston or abutment adapted to be directly acted upon by the force of the exploding gases and moved to an extent sufficient to expel all the liquid in the reservoir. In order, however, to control the amount of water expelled, the device is provided with a secondary plunger also acted upon by the exploding gases and arranged to operate a variable controlling device whereby a portion of the water in the reservoir is allowed to escape without being forced into the engine cylinder, in case the charge is lighter than the maximum.

The amount of liquid thus allowed to escape is delicately regulated by the supplemental controlling device so that the amount used at each explosion is exactly the amount required. The automatic controlling device is further provided with means for initial regulation and is so arranged that this regulation can be made while the engine is running.

It is an important feature of the invention that the regulation, as well as the injecting action itself, is brought about by the pressure of the burning charge, so that the actions are simultaneous.

Figure 1 is a longitudinal section of an appliance embodying the invention shown as attachable to a cylinder of any existing internal combustion engine; Fig. 2 is an elevation of the upper portion of Fig. 1 looking toward the left; Fig. 3 is a detail showing an air chamber connected to the liquid inlet shown in Fig. 1; Figs. 4 and 5 are details to be hereinafter referred to.

Referring to Fig. 1, the appliance embodying the invention consists of a cylindrical shell 1 having at one side an opening 2 in which is coupled the inlet passage 3 for the liquid. At the end of the casing there is an extension 4 which is adapted to be fastened in an opening in the engine cylinder so that the explosive gases pass through said extension and act on the operative parts which are contained in the casing 1.

The part of the device which is acted upon directly by the exploding gases is a piston or plunger 5 located in the lower part of the casing 1, the said piston being hollow as shown at 6 and provided with piston rings 7 near the lower end to prevent the exploding gases from entering the casing 1. The hollow part 6 surrounds a stationary downward extension 8 which is connected with a transverse partition 9 near the upper part of the casing 1 there being a cup leather packing 10 at the end of this partition so that the space between the end of the projection and the end of the piston 5 constitutes a liquid tight reservoir. The liquid entering the appliance through the inlet 3, controlled as will be hereinafter described, flows through a

passage 12 in the projection 8 thus keeping the reservoir 6 full of liquid at all times. The main piston 5 is closed at the end except for a comparatively small opening in communication with an outlet 13 which extends toward the engine cylinder; a passage in the piston which leads to said outlet being surrounded by a valve seat 14 upon which a valve 15 is normally pressed by means of a spring 16, the strength of which is sufficient to maintain said valve seated against any pressure less than that of the burning gases. The said valve 15 is mounted in a spider 17 a section of which is shown in detail, Fig. 4, the said valve being packed in an internal bore in said spider 17 which also constitutes a casing for the spring 16. This spider is closed at the top and is stationary with relation to the plunger 5, being screw-threaded in the open end thereof. In spite of the packing of this valve, there is possibility that liquid may get into the interior of the spider and interfere with the working of the valve so that as a matter of precaution I have provided the said valve with a by-pass 18 and a light check valve 19 which will permit the escape of any water within the spider without interfering in any way with the normal operation. So far as relates to the piston 5 the operation of the explosion is to force the said piston upward in the casing 1, so that the water in the reservoir 6 will be discharged by the stationary plunger 8 through the valve 14 into the engine cylinder.

In order, however, to control the amount of liquid actually injected into the cylinder, I have provided means whereby a regulable amount of the liquid contained in the reservoir 6 may be provided with a separate avenue of escape so that only part thereof is forced into the engine cylinder.

For this purpose, I have provided the appliance above the partition 9 with a chamber 20 in direct communication with the passage 12, the capacity of said chamber being regulable and the said chamber being of sufficient capacity to contain the maximum amount of water which can be contained in the reservoir 6. This chamber is provided with a piston 21 through which there is a passage 22 controlled by a check valve 23′ to permit water from the intake 3 to flow freely into the chambers 20 and 6 although no water can flow back beyond the chamber 20 on account of the check valve. With the parts in the position shown, the piston 21 is at the bottom of the chamber 20; and so long as it is allowed to remain there, the full stroke of the piston 5 will discharge the entire contents of the reservoir 6 into the engine cylinder. If, however, the piston 21 is left free to be raised in response to the exploding pressure acting through the water trapped in the chamber 6, it is obvious that the water in the said chamber 6 will flow back into the additional space thus provided; and since the preponderating pressure is on the piston 21, the latter will yield instead of the valve 15, so that no water will pass into the engine cylinder until the piston 21 is positively arrested.

The area of the piston 21 is much greater than that of the valve 15, and while the said piston is provided with a spring 35, the purpose of which will be hereinafter described, this spring is much weaker than the spring 16 which tends to close the valve 15. If, therefore, the movement of the piston 21 were not positively controlled as to its extent, the said piston would travel the full extent of movement permitted at each explosion of the fuel in the engine cylinder; and the valve 15 would remain permanently closed. In this case the water would merely pass back and forth between the chambers 6 and 20, and none would be injected into the engine cylinder at all.

The movement of the piston 21 which is due to the displacement of the water below it, as described, is, however, controlled as to its extent by the pressure of the exploding gases; and the arrangement is such that the amount of water allowed to escape from the chamber 6 into the chamber 20 is directly proportional to the strength of the explosion. This operation is provided for by means of a movable stop which is under the direct influence of the gas pressure, and the position of said stop determines the position where the piston is arrested, and therefore determines the capacity of the chamber 20.

I have shown the stop which controls the extent of movement of the piston 21 as consisting of a wedge 22′ which is longitudinally movable between a stationary abutment 23 at the end of the casing 1 and a movable abutment 24 which is connected by means of a bolt 25 with the piston 21. The abutments 23 and 24 are provided with inclined surfaces at opposite sides of the wedge 22′; and the bolt 25 is so arranged, as shown, that there is a slight lost motion connection between the abutment 24 and the piston 21 so that the wedge 22 is always free to move without binding when there is no pressure exerted on the piston 21. The longitudinal movement of the wedge 22′ is controlled directly by the force of the explosion, said wedge being shown as connected with a rocker arm 26 pivoted at 27 and provided with gear teeth 28 in mesh with a rack 29 connected with a plunger 30 the end of which enters a cylindrical chamber 31 and constitutes a small piston which receives the force of the corresponding gases through a passage 32 from the extension 4. When, therefore, an explosion takes place, the plunger 30 will be moved

a certain extent which is directly proportional to the force of the explosion and will correspondingly move the wedge 22′, thus controlling the extent of movement permitted the piston 21.

The movement of the plunger caused by the pressure of the gases, is opposed by the spring 32, the strength of which is properly proportioned to the pressure area of the plunger 30, and the initial position of the wedge 22′ can be controlled by an adjustment nut 33 having a knurled portion 34 whereby the entire plunger 30 can be moved up and down with relation to the casing 1, without changing the tension of the spring 32 which is accurately and permanently fixed. In the position shown it is assumed that an explosion of maximum pressure has just taken place forcing the plunger to its upward limit so that the wedge 22′ is in such a position as to prevent any movement of the piston 21.

The valve 15 is also shown as open and it is assumed that the piston 5 is about to move upward. In this case it is obvious that the entire contents of the reservoir 6 will be forcibly ejected into the engine cylinder.

If we assume however, the opposite extreme, that is an explosion so light that it will not unseat the valve 15 or move the plunger 30, the wedge 22′ will be withdrawn to a position corresponding to the dotted line position of the arm 26 and the piston 21 will be free to move upward its entire extent so that the water in the reservoir 6 will flow back into the chamber 20, none being injected into the engine cylinder at all. In this case, the water lying between the piston 21 and the upper part of the casing will be forced back into the inlet pipe the said inlet pipe being provided with a controlling valve the construction of which will be hereinafter described. In order to insure the prompt return of the piston 21 to its normal position, I have provided said piston with a spring 35 which tends to hold the piston at the bottom of the chamber. This spring as previously stated, is much lighter than the spring which holds the valve 15 seated, so that when a light charge is in the engine cylinder, the action, so far as relates to the injection of liquid into the engine cylinder is *nil*.

The valve which controls the water inlet is so arranged as to permit the water, under whatever pressure is used to maintain the supply, to flow freely into the casing 1 when unopposed by any other pressure, provision being made, however, to allow the water to flow back under the influence of the exploding gases when the conditions are such that only a portion of the water in the reservoir 6 is to be admitted to the engine cylinder. The inlet valve, which is a light check valve 36, is located at the inner end of a cup 37, having outlet openings 38 at the closed end for the escape of the water, the said cup having wings or extensions 39 which are threaded so that the cup can be screwed into the end of a tube 40 which forms part of the inlet pipe. The cup 37 constitutes a guide for the valve 36 and also for the light spring 40′ by which said valve is kept seated. The valve seat is located at the end of a secondary valve 41 which is in the form of a cylindrical spider fitting in the tube 40 and having a bore 42 through which the water passes to the valve 36 and thence to the casing 1.

At its inner end, the said valve 41 cooperates with a seat 43 at the end of the tube 40, and is normally held closed by means of a stiff spring 44 of predetermined strength which bears at its inner end against a stationary abutment 45 which is screwed into the tube 40 and has openings 46 through which the liquid can pass.

In the operation of the device, the water flows freely into the chamber 6 at all times when there is no opposing pressure from the engine cylinder, so that the said chamber 6 is continually filled to its entire capacity. When, however, the wedge 22 is in such a position as to admit of the movement of the piston 21 under the excess pressure of the explosion, the said pressure will be transmitted through the mass of water trapped above the piston 21 to the end of a spider which constitutes the secondary valve, thus unseating the same and allowing the water to flow back through the spaces between the wings which surround the tube 44.

This allows the excess water to flow back into the inlet; but the parts are restored to their normal position by the spring 44 just as soon as the excess pressure is relieved by the gases.

In order to prevent water hammer due to the sudden shock of excess pressure and the forcing of the water back against the normal pressure, the inlet pipe is provided beyond the valve with an air dome or chamber 46′ of sufficient size to cushion the shock effectually.

What I claim is:—

1. In an internal combustion engine, the combination with the explosion chamber; of means operated by the pressure of the exploding charge for forcing liquid into the said explosion chamber while the charge is burning; and a separate device also operated by the pressure of the exploding charge for regulating the amount of liquid forced into the cylinder.

2. The combination with the engine cylin-

der; of a chamber adapted to contain liquid; a plunger operated by pressure in the engine cylinder, said plunger being adapted to expel the entire contents of said chamber; a pressure controlled valve governing an outlet from said chamber leading to the engine cylinder; a supplemental chamber in free communication with said chamber for liquid; and means for automatically regulating the size of said supplemental chamber.

3. In an internal combustion engine, the combination with the engine cylinder; of means actuated by the pressure of the burning charge for injecting liquid into said cylinder while the gases are burning; and means also actuated by said pressure and operating independently of the first mentioned means for automatically regulating the amount of liquid injected.

4. In an internal combustion engine, the combination with the engine cylinder; of a plunger actuated directly by the pressure of the burning gases in said cylinder; a chamber for liquid; means for keeping said chamber continually supplied with liquid, the liquid being expelled from said chamber into the engine cylinder; a secondary plunger also acted on by the pressure of the burning gases; and a device operated by said secondary plunger for determining the proportional amount of liquid expelled from said chamber into the engine cylinder.

5. A device for injecting liquid into the combustion chamber of an engine comprising a chamber for liquid; means for supplying said chamber with liquid; a plunger adapted by its movement to expel the liquid from said chamber; a supplemental chamber in free communication with the chamber first named; means for varying the capacity of said chamber; and a secondary plunger directly operating said varying means; both of said plungers being directly acted on by the pressure in the engine cylinder.

6. In an internal combustion engine, the combination with the engine cylinder; of a main chamber adapted to contain liquid; a supplemental chamber in open communication with the main chamber; a movable piston constituting one wall of said supplemental chamber; a movable element adapted by its own movement to variably control the movement of said piston and thereby vary the capacity of the supplemental chamber; a main plunger adapted to expel the liquid from the main chamber; and a supplemental plunger connected with said movable element, both of said plungers being directly subjected to the pressures in the engine cylinder.

7. In an internal combustion engine, the combination with the explosion chamber, of means operated solely by the pressure of the exploding charge for forcing water into said chamber, and means actuated by the pressure and moving independently of the first mentioned means for automatically regulating the amount of water introduced at each explosion.

8. In combination with the cylinder of an internal combustion engine, means operated solely by the pressure due to combustion for forcing water into said cylinder, and means independent of the movement of the first mentioned means dependent upon said pressure for determining the amount of water introduced.

9. In combination with a cylinder of an internal combustion engine, means comprising a plunger subjected to pressure within the cylinder for forcing a liquid into the cylinder, and means responsive to the pressure within the cylinder and arranged to operate in advance of said plunger for controlling the extent of the liquid forcing movement of said plunger.

10. In combination with a cylinder of an internal combustion engine, an agent movable in response to pressure within said cylinder for forcing liquid into the engine cylinder, and means responsive to pressure within said cylinder and arranged to operate in advance of said agent for controlling the operation of said agent.

11. In combination with a cylinder of an internal combustion engine, means responsive to the explosion pressure within said cylinder for forcing liquid into said cylinder, and means responsive to the pressure within said cylinder and adapted to operate in advance of said liquid forcing means for controlling the operation of said means.

12. In combination with a cylinder of an internal combustion engine, means responsive to the explosion pressure within said cylinder for forcing liquid into the cylinder, and quick acting means responsive to pressure within said cylinder and operating in advance of said liquid forcing means for controlling the operation of the liquid forcing means and thereby regulating the amount of liquid delivered to the cylinder in response to variations in the explosion pressure.

13. In combination with a cylinder of an internal combustion engine, means for forcing liquid into the engine cylinders during the explosion period comprising a plunger subjected to the pressure within the cylinder and movable in response to an explosion pressure, and a valve carried by the plunger and opened by liquid pressure accasioned by a movement of the plunger, and means for regulating the amount of liquid delivered, comprising means movable in response to variations in liquid pressure occasioned by a pressure responsive movement of said plunger, and a stop movable to different posi-

tions and actuated by pressure within the cylinder for regulating the delivery of liquid to the cylinders.

14. In combination with a cylinder of an internal combustion engine, sluggishly operating means responsive to the explosion pressure within the engine cylinder for forcing liquid under pressure into said cylinder, and quick acting means responsive to pressure within the cylinder and arranged to operate in advance of said sluggishly operating means for controlling the amount of liquid forced into said cylinder.

In testimony whereof, I have signed my name to this specification.

ERL V. BEALS.