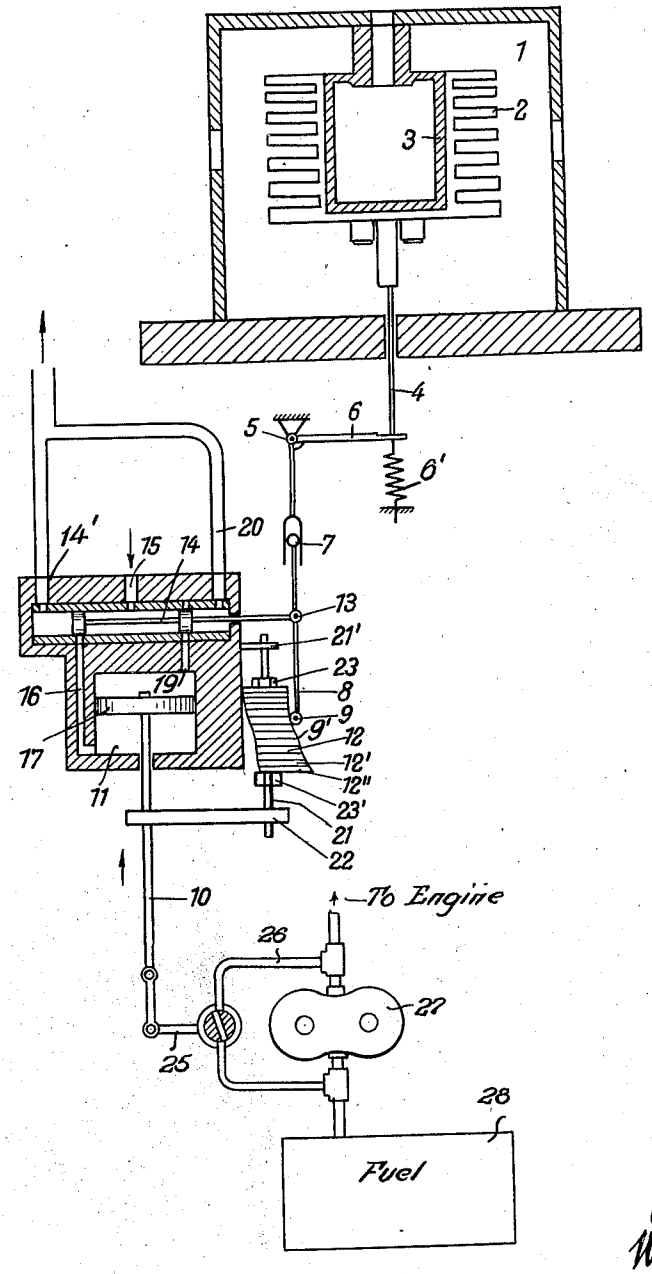
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APPARATUS FOR CONTROLLING THE FUEL FEED IN INTERNAL COMBUSTION ENGINES

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APPARATUS FOR CONTROLLING THE FUEL FEED IN INTERNAL COMBUSTION ENGINES

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This invention relates to apparatus for controlling or adjusting the fuel feed in internal combustion engines more particularly those for use in aircraft, and in which the fuel feed is controlled or adjusted in accordance with the density of the combustion air.

For controlling or adjusting the fuel feed in accordance with the pressure or density of the combustion air means responsive to pressure or density variations is used.

As the controlling force or impulse generated by such means is relatively weak, it is preferable to effect such control through the medium of power operated means for amplifying the controlling impulse. Power operated means for this purpose are known as relay and servo-motor mechanisms. Preferably also the servo-motor will exert a restoring impulse on the controlling relay as will be more fully explained hereinafter, thereby also increasing the stability of the device.

As the impulse imparted by a pressure or density responsive device is not a linear function of changes in density of the air, while, on the other hand, the fuel feed normally increases linearly with the path or stroke of the means controlling the quantity of fuel fed to the engine, it is therefore one object of this invention to provide a linear or other desired relation between the changes in density and fuel feed by modifying the restoring action exerted on the controlling relay by the servo-motor.

When a bellows or Sylphon, inclosing a charge of gas, is used, for instance, for detecting changes in air density, the expansion path or stroke of the vessel will stand in a hyperbolic relation to changes in air density, arising from the fact that the inclosed charge of gas expands to a volume reciprocal or hyperbolic to the air density, providing the temperature remains constant. The usual construction of such vessels permitting an expansion in one direction only (for instance the longitudinal axis of a Sylphon), the stroke thus becomes a linear function of the inclosed volume and thereby a hyperbolic function of the air density.

If therefore the restoring action of the servo-motor is made to vary in a hyperbolic ratio in dependence on the position of the piston of the servo-motor (each position of said piston naturally corresponding to a corresponding density or to a definite stroke of the means responsive to changes in atmospheric density) it will be apparent that a linear ratio between the atmospheric density and the position of said piston will be obtained.

A further object of this invention is to modify the restoring action so, as to insure a relation between the fuel feed and the density of the combustion air as will correspond to the most favorable combustion condition, thereby preventing undue heating of the engine due to too thin a gas mixture.

Other objects of the invention will appear in the course of the following description.

The invention and its aims and objects will be readily understood from the following description taken in connection with the accompanying drawing of an illustrative form of apparatus in accordance with our invention for carrying out our novel method, the scope of the invention being more particularly pointed out in the appended claims.

In the drawing there is shown a sectional side elevation largely diagrammatic of an illustrative embodiment of the invention.

In the figure a device responsive to variations in air density or pressure is shown generally at 1. Said device will preferably be provided in, or connected to, the air intake passage or chamber of the engine and herein illustratively comprises a bellows 2, or Sylphon, which may be of any suitable construction. Herein said diaphragm preferably comprises a plurality of superposed plates. In the illustrative embodiment of the invention, the power operated means which actuates the means controlling the supply of fuel to the engine conveniently consists of a servo-motor operated by suitable power preferably by pressure fluid and comprises a cylinder 11 in which works a piston 17. Pressure fluid is supplied to said cylinder at opposite ends of said piston through passages 16 and 19 respectively which are controlled by a suitable relay operated by said means which is responsive to changes on the atmospheric pressure.

In the illustrative embodiment of the invention herein shown said relay conveniently comprises a slide valve gear 14 and valve casing 14', to which fluid, herein oil, is supplied through a passage 15, preferably from the lubricating oil pump of the internal combustion engine.

The impulses or strokes of said diaphragm are transmitted to said valve gear through a rod 4 connected thereto, and the size of said chamber is such that the volume of air contained in the diaphragm represents but a small proportion of the entire interior volume of said diaphragm, to enable the air therein to expand to six or

more times its volume without danger of the stroke of the diaphragm being opposed or hindered by spring action or resiliency of the latter.

The free end of said rod 4 abuts against an arm of an angle lever 6 adapted to rock about a fixed pivot 5, the forked free end of the other arm of said angle lever engaging a movable fulcrum 7 of a lever 8 at one end of the latter, said lever being pivotally connected to said valve gear 14 at 13. The other end of said lever forms another fulcrum 9 which is adapted to engage a movable member of suitable means to exert a restoring or return movement upon said valve gear 14, said means herein comprising a cam surface of hyperbolic or other surface 9'. The cam member 12 is shown as composed of a plurality of superimposed laminations or plates 12', 12'' provided with slots (not shown) extending parallel to the plane of the figure and through which extends the rod 21. Clamping nuts 23, 23', having screw threaded engagement with said rod at opposite ends of the series of plates 12', serve adjustably to clamp said plates 12' firmly together upon said rod 21. By loosening said nuts 23, 23', said plates 12', 12'' . . . 12^n may be relatively adjusted parallel to their planes to vary the outline of the cam surface. The cam member 12 is rigidly connected to the piston rod 10 of the piston 17 of said servo-motor 11 by rods 21 and 22, said cam member being guided for movement with and parallel to said piston by said rod 21 which slides in a suitable guide member 21'.

Said piston rod 10 will be connected in any suitable manner to the means serving to control the fuel feed to the engine.

For this purpose there is shown in the illustrating example a by-pass valve 25 controlling the by-pass 26 of a pump 27 supplying fuel from a tank 28 to the engine. Obviously, by opening the by-pass the amount of fuel fed to the engine will be diminished.

A compression spring 6' will preferably be provided to maintain contact between the free end of said rod 4 and the arm of said lever 6. Said spring bears with one end against a fixed part 7a of the apparatus and with its other end against the arm 8a of said lever 6.

From the above it will be apparent that should the pressure or density of the air in the air supply passage or chamber diminish, for example, thus causing said diaphragm to expand, rod 4 will turn angle lever 6 clockwise about its pivot 5, thereby swinging lever 8 contraclockwise about its fulcrum 9 and moving valve gear 14 to the left. Passage 16 will thus be uncovered and pressure oil will flow from the valve casing 14' through said passage into the chamber below the piston 17 and will cause the latter to rise. Oil above the piston will escape through passage 19, also uncovered by said valve gear, and out through a discharge passage 20.

Said upward movement or stroke of said piston 17 effects a corresponding movement of said cam surface. A hyperbolic cam will therefore restore the valve to a neutral position by a displacement of the lever pivot 9 which is a hyperbolic value of the piston stroke. As the controlling movement of the bellows 2 and correspondingly the pivot 7 was a hyperbolic function of the change in density, the result is a movement of the piston which is a linear function of the change in density. It follows that the quantity of fuel fed to the engine will be diminished in response to the density of the air.

Under certain conditions it is desirable to modify a strict linear relation between fuel feed and density somewhat. It is often advantageous, for instance, to prevent overheating of the engine due to the high combustion temperature of a thin mixture, i. e. a mixture containing relatively little fuel per air volume. In such cases it is desirable to feed more fuel than would correspond to the linear ratio in order to obtain a richer mixture that will develop less heat in burning.

On the other hand there are certain engines which require that the normally constant fuel to air ratio by weight shall be varied in favor of the fuel in the case of lower air densities. In practice it is found that for almost every type of engine there exists a definite curve or graph of the most favorable fuel consumption.

Another object of the present invention is therefore to vary the restoring action or return movement of the servo-motor in dependence upon the position of the piston of the latter in a ratio determined by the curve or graph of the most favorable fuel consumption, or otherwise stated, to vary the restoring action of the fuel control in dependence upon the state from time to time of the fuel feed controlling action in a ratio determined by the most favorable fuel consumption.

This result may be conveniently obtained by adjusting the cam surface 12 so that the path or stroke of the piston rod 10, that is to say the variation in the fuel feed dependent upon said stroke, shall stand in a ratio to the changes in atmospheric density determined by the fuel consumption curve or graph. It is thus possible by adjusting or exchanging the restoring cams to adjust one standard regulating device to engines of different fuel consumption characteristics.

We are aware that our invention may be embodied in other specific forms than those herein illustrated and described without departing from the spirit or essential attributes thereof, and we therefore desire the present embodiments to be considered in all respects as illustrative and not restrictive, reference being had to the appended claims rather than to the foregoing description to indicate the scope of the invention.

We claim:

1. Apparatus for controlling the fuel feed of internal combustion engines, more particularly for aircraft, comprising, in combination, a servo-motor connected to control the fuel feed; a relay connected to actuate said servo-motor; means responsive to variations in combustion-air density and connected to exert a controlling action on said relay which is a predeterminable function of the air density; and means responsive to movements of said motor and connected to exert a restoring action on said relay which is an identical function of the servo-motor movement, whereby the servo-motor movements become directly proportional to the variations in density.

2. Apparatus for controlling the fuel feed of internal combustion engines, more particularly for aircraft, comprising, in combination, a servo-motor connected to control the fuel feed; a relay connected to actuate said servo-motor; a bellows inclosing a charge of gas and responsive to variations in density of the combustion air, said bellows being connected to exert a controlling impulse on said relay which is substantially a hyperbolic function of the air density; and means responsive to movements of said servo-motor and connected to exert a restoring impulse on said relay which is also substantially a hyperbolic

function of the servo-motor movement, whereby the servo-motor movements become directly proportional to variations in density.

3. Apparatus for controlling the fuel feed of internal combustion engines, more particularly for aircraft comprising, in combination, a pressure fluid operated servo-motor connected to control the fuel feed; a valve connected to control the flow of operating fluid for the motor; a bellows inclosing a charge of gas and responsive to variations in density of the combustion air, said bellows being connected to exert a controlling impulse on said valve which is substantially a hyperbolic function of the air density; and a cam actuated by the servo-motor and being so shaped as to exert a restoring impulse on said valve which is substantially a hyperbolic function of the servo-motor movement, whereby the servo-motor movements become directly proportional to variations in density.

4. Apparatus for controlling the fuel feed of internal combustion engines, more particularly for aircraft, comprising, in combination, a servo-motor connected to control the fuel feed; a relay connected to actuate said servo-motor; means responsive to variations in combustion-air density and connected to exert a controlling action on said relay which is a predeterminable function of the air density; and means responsive to movements of said servo-motor and connected to restore the said relay to its neutral position thereby to arrest the servo-motor upon the servo-motor reaching a position corresponding to the most favorable fuel feed, said fuel feed condition being predeterminable for each engine as a function of the density of the combustion air.

5. Apparatus for controlling the fuel feed of internal combustion engines, more particularly for aircraft, comprising in combination, a servo-motor connected to control the fuel feed; a relay connected to actuate said servo-motor; a bellows inclosing a charge of gas and responsive to variations in density of the combustion air, said bellows being connected to exert a controlling impulse on said relay; a cam actuated by the movements of the servo-motor and connected to exert a restoring impulse on said relay, said cam being so shaped as to restore said relay to its neutral position upon the servo-motor reaching the most favorable fuel feed condition, which is predeterminable for each engine as a function of the combustion air density, respectively of the controlling impulse created by the bellows.

6. Apparatus for controlling the fuel feed of internal combustion engines, more particularly for aircraft, comprising, in combination, a pressure fluid operated servo-motor connected to control the fuel feed; a valve connected to control the flow of operating fluid for the motor; a bellows inclosing a charge of gas and responsive to variations in density of the combustion air; said bellows being connected to exert a controlling impulse on said valve which is a predeterminable function of the air density; and a cam actuated by the servo-motor and connected to exert a restoring action on the said valve, said cam being so shaped as to restore the valve to its neutral position and thereby arrest the servo-motor upon the servo-motor reaching a position corresponding to the most favorable fuel feed condition for the respective air density, said fuel feed condition being predeterminable for each engine as a function of the controlling impulse imparted by the bellows.

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