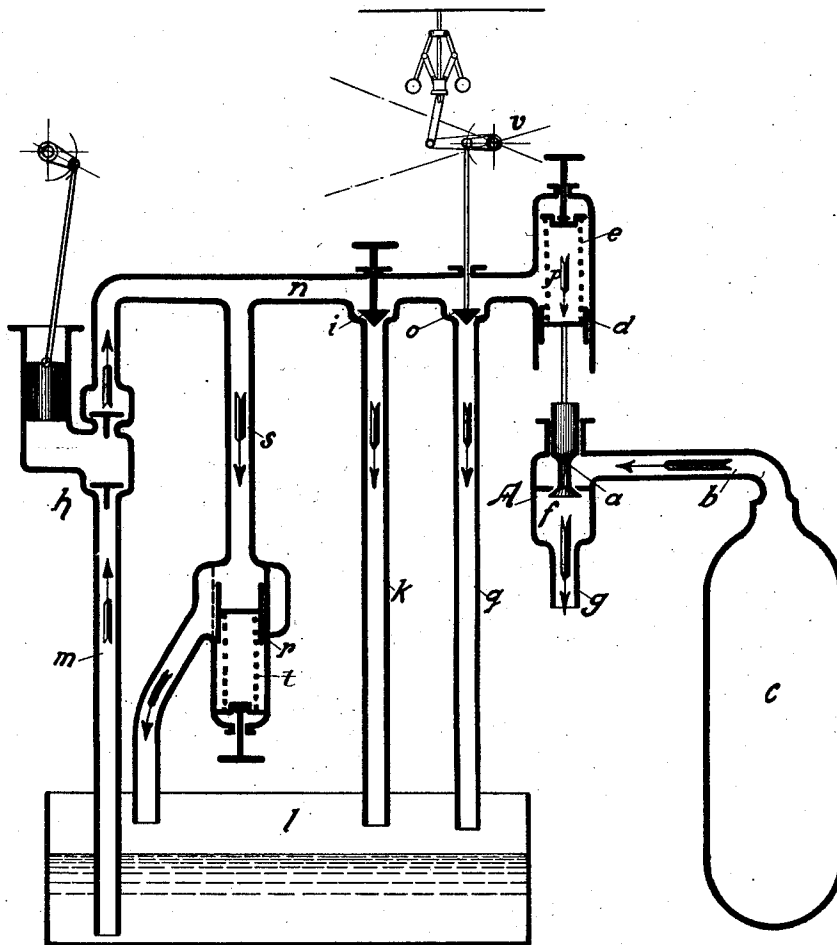


L. T. EBERMANN.
 APPARATUS FOR REGULATING THE PRESSURE AT WHICH AIR IS BLOWN INTO INTERNAL
 COMBUSTION ENGINES.

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Witnesses
 J. M. Wyntkoop.
 Sanford D. Bowler.

Inventor
 Ludwig Theodorus Ebermann,
 By Knights Bros
 Attorneys

UNITED STATES PATENT OFFICE.

LUDWIG THADDÄUS EBERMANN, OF AUGSBURG, GERMANY, ASSIGNOR TO MASCHINEN-FABRIK AUGSBURG-NÜRNBERG, AKTIENGESSELLSCHAFT, OF AUGSBURG, GERMANY, A CORPORATION OF GERMANY.

APPARATUS FOR REGULATING THE PRESSURE AT WHICH AIR IS BLOWN INTO INTERNAL-COMBUSTION ENGINES.

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To all whom it may concern:

Be it known that I, LUDWIG THADDÄUS EBERMANN, a citizen of the Austro-Hungarian Empire, and residing at Augsburg, Germany, have invented certain new and useful Improvements in Apparatus for Regulating the Pressure at which Air is Blown into Internal-Combustion Engines, of which the following is a specification.

10 My invention relates to apparatus for regulating the pressure at which air is blown into internal combustion engines.

In internal combustion engines in which the air for combustion is separately compressed and the fuel afterward introduced into the highly compressed air by means of compressed injection air, particularly in those machines which run at a high and very variable speed, it has been found necessary to vary the pressure of the injection air corresponding to the speed and to the quantity of fuel requisite at any time. When both the speed and the quantity of fuel supplied are high, the injected air must have a high pressure, when the speed is low this air must have a lower pressure, but when the quantity of fuel supplied is small both at a high and at a low speed, the pressure of the injected air must be correspondingly lower. This must be brought about in such a way that when the speed is high and the quantities of fuel supplied are large (*i. e.* at heavy loads), all the fuel is introduced into and properly sprayed in the cylinder in the very short time at disposal, but when the speed is low, high combustion pressures and shocks due to the fuel being introduced much too quickly must be avoided, and also when the quantity of fuel is small, those misfires must be avoided which occur, as experience has proved, when the pressure of the injection air is much too high, or the quantity of such air much too large. Methods of varying the pressure of the injection air by hand or by automatic devices are known.

A primary object of my invention is to provide improved automatic apparatus for regulating the injection air in dependence on the speed and load of the engine. To this end I insert a pressure-reducing valve in the injection pipe between the air-vessel

supplying the injection air and the fuel valve. This pressure-reducing valve is influenced by the pressure of a liquid which is set in motion by a pump, said pressure varying, owing to the variation of the velocity of flow of the liquid, according to the hydraulic law of outflowing liquids. To influence regulating members by a pressure regulated according to the said hydraulic law is known *per se*. In the present case special advantages are obtained:—firstly, I am able in a specially simple manner to bring the pressure of the injection air into two-fold dependence on the speed and on the load, and, secondly, I am able to make this dependence result according to a law, which can be predetermined as desired, by means of the addition of a device described hereinafter.

One embodiment of my invention is diagrammatically represented in sectional elevation by way of example in the accompanying drawing which illustrates an apparatus for automatically regulating the pressure of the injection air in an internal combustion engine.

Referring to the drawing, I employ a balanced pressure-reducing valve *a* which is not influenced in its action by the pressure in the vessel *c* which contains the injection air and is connected to said valve by the pipe *b*. In the first place, the pressure-reducing valve *a* is influenced on a projection *d* by the pressure of a spring *e* which tends to hold the valve open. This pressure of the spring *e* is opposed by a pressure in the chamber *f* of the casing *A* of the pressure-reducing valve which tends to close the valve *a*. The pressure of the spring *e* is so adjusted that the valve *a* allows that pressure of injection air which is necessary when starting the engine. This is at the same time the lowest injection pressure which the valve *a* can adjust assuming that the air in the air-vessel *c* is always at a high pressure. The chamber *f* of the valve casing *A* is directly connected by the injection-pipe *g* with the fuel-valve of the engine.

Now in order to vary the pressure in the injection-pipe *g* corresponding to the speed, *i. e.*, to obtain at a high speed a high injection pressure and at a low speed a low in-

jection pressure; the pressure-reducing valve a is also influenced by the pressure of a liquid p under pressure which acts on the projection d of the valve a having the form of a piston, and consequently reinforces the pressure of the spring e . The said liquid is delivered by a pump h driven directly by the engine, and is discharged through a valve i and a pipe k into a tank l , from which it is lifted by the pump h through the pipe m . The valve i is adjusted to a predetermined section of passage. Since the pump h delivers the same quantity each revolution, the quantity delivered per second is proportional to the speed, and the pressure of the liquid in the pipe n varies with the quantity delivered per second according to the hydraulic law of the resistance and outflow of liquids, the section of passage through the valve i being constant. Consequently, the pressure p acting on the piston d also varies, and thus the force tending to open the valve a , which is held balanced by a closing pressure of corresponding value in the chamber f . Therefore when the speed is high the pressure in the chamber f will be high in accordance with the high pressure of the liquid p , and when the speed is low the pressure in the chamber f will be low in accordance with the low pressure of the liquid.

In order to make the pressure in the injection-pipe g variable in accordance with the quantity of fuel or the load in such a manner that, at a given speed, the injection pressure may be less with a small quantity of fuel, *i. e.* a small load than with a large load, an additional valve o is provided which is connected with the regulating rod v of the fuel-pump or of the regulator, so that the valve o , which at full load is closed or opened very little, opens a large section of passage at light loads or during idle running, through which the liquid can flow away from the pipe n through the pipe g into the tank. Consequently the pressure of the liquid in the pipe n diminishes owing to liquid flowing away through the valve o ; the liquid therefore exercises on the piston d or valve a a reduced pressure, whereby the injection pressure in the chamber f and injection pipe g is reduced, *i. e.*, is made to vary according to the degree of admission in such a manner that when a large quantity of fuel is admitted, the pressure is high, while when a small quantity of fuel is admitted, the pressure is low.

It is obvious that the two valves i and o could be united in a suitable manner.

Another method of making the pressure of the liquid in the pipe n , and consequently the injection pressure, dependent on the load consists in regulating the quantity of liquid delivered each revolution, by the pump h in correspondence with the required output of the engine. In this case the valve i

only will be employed, it being fixedly adjusted to a predetermined section of passage.

Should the injection pressure need to be adjusted according to another law than one that corresponds to the law of hydraulic flow and resistance applicable to the valves i and o , a slide valve r may be provided in a pipe s connected to the pipe n , which valve is loaded by the pressure of the liquid and counterbalanced by a spring t , and which valve when the pressure of the liquid increases, uncovers apertures and thereby causes said pressure to diminish, or on the other hand closes apertures in order to raise said pressure. The injection pressure may consequently be automatically raised or lowered as required.

I claim:—

1. A device for regulating the pressure of combustion air, comprising a duct for the combustion air, said duct connecting with the fuel injection pipe of an internal combustion engine; a regulating valve in said duct adapted to close the inlet to the fuel injection pipe; a spring tending to open the valve and counteracting the pressure in the fuel injection pipe, means for automatically increasing the pressure on said regulating valve in the direction to open, said increase of pressure depending on the increased speed of the engine.

2. A device for regulating the pressure of combustion air, comprising a duct for the combustion air, said duct connecting with the fuel injection pipe of an internal combustion engine; a regulating valve in said duct adapted to close the inlet to the fuel injection pipe, a spring tending to open the valve and counteracting the pressure in the fuel injection pipe, means for automatically increasing the pressure on said regulating valve in the direction to open, said increase of pressure depending on the increased speed of the engine; said means comprising a charging pump driven by the engine, a conduit connecting said pump with said valve, a fluid supply pipe to said pump and a discharge pipe from said conduit, a manually operated discharge valve for opening said conduit into said discharge pipe.

3. A device for regulating the pressure of combustion air comprising a duct for the combustion air, said duct connecting with the fuel injection pipe of an internal combustion engine; a regulating valve in said duct adapted to close the inlet to the fuel injection pipe, a spring tending to open the valve and counteracting the pressure in the fuel injection pipe, means for automatically increasing the pressure on said regulating valve in the direction to open, said increase of pressure depending on the increased speed of the engine; said means comprising a charging pump driven by the engine, a

conduit connecting said pump with said valve, a fluid supply pipe to said pump and a discharge pipe from said conduit, a discharge valve for opening said conduit into
5 said discharge pipe, said discharge valve actuated by the governor of the engine.

4. A device for regulating the pressure of combustion air comprising a duct for the combustion air, said duct connecting with
10 the fuel injection pipe of an internal combustion engine; a regulating valve in said duct adapted to close the inlet to the fuel injection pipe, a spring tending to open the valve and counteracting the pressure in the
15 fuel injection pipe, means for automatically increasing the pressure on said regulating valve in the direction to open, said increase of pressure depending on the increased speed of the engine; said means comprising
20 a charging pump driven by the engine, a conduit connecting said pump with said valve, a fluid supply pipe to said pump and a discharge pipe from said conduit, a discharge valve for opening said conduit into
25 said discharge pipe, a spring tending to close said discharge valve and a member for manually adjusting the spring pressure on said discharge valve.

5. A device for regulating the pressure
30 of combustion air comprising a duct for the combustion air, said duct connecting with the fuel injection pipe of an internal combustion engine; a regulating valve in said duct adapted to close the inlet to the
35 fuel injection pipe, a spring tending to open the valve and counteracting the pressure in the fuel injection pipe, means for automatically increasing the pressure on said regulating valve in the direction to open, said
40 increase of pressure depending on the increased speed of the engine, a member for manually adjusting the pressure of said spring, said means comprising a charging pump driven by the engine, a conduit connecting
45 said pump with said regulating valve, a fluid supply pipe to said pump, and a plurality of discharge pipes from said con-

duit, and a discharge valve opening said conduit into one of said discharge pipes, said discharge valve actuated by the gov- 50
ernor of the engine, and an adjustable discharge valve for opening said conduit into another of said discharge pipes, a spring tending to close said adjustable discharge valve, and a member for manually adjust- 55
ing the spring pressure on said adjustable discharge valve.

6. A device for regulating the pressure of combustion air comprising a duct for the combustion air, said duct connecting with
60 the fuel injection pipe of an internal combustion engine; a regulating valve in said duct adapted to close the inlet to the fuel injection pipe, a spring tending to open the valve and counteracting the pressure in the
65 fuel injection pipe, means for automatically increasing the pressure on said regulating valve in the direction to open, said increase of pressure depending on the increased speed of the engine, a member for manually ad- 70
justing the pressure of said spring, said means comprising a charging pump driven by the engine, a conduit connecting said pump with said regulating valve, a fluid supply pipe to said pump, and a plurality 75
of discharge pipes from said conduit, and a discharge valve opening said conduit into one of said discharge pipes, said discharge valve actuated by the governor of the en-
80 gine, and an adjustable discharge valve for opening said conduit into another of said discharge pipes, a spring tending to close said adjustable discharge valve, and a member for manually adjusting the spring pressure on said adjustable discharge valve, and 85
a manually operated discharge valve for opening said conduit into still another of said discharge pipes.

In testimony whereof, I affix my signature in the presence of two witnesses.

LUDWIG THADDÄUS EBERMANN.

Witnesses:

RICHARD LEMP,
JOHANNA STERN.