No. 890,620. PATENTED JUNE 16, 1908.

R. DIESEL.

PROCESS AND APPARATUS FOR INJECTION OF LIQUID FUELS INTO INTERNAL COMBUSTION ENGINES.

APPLICATION FILED JULY 1, 1905.

Fig. 2.

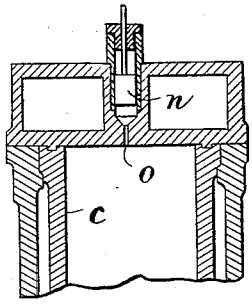
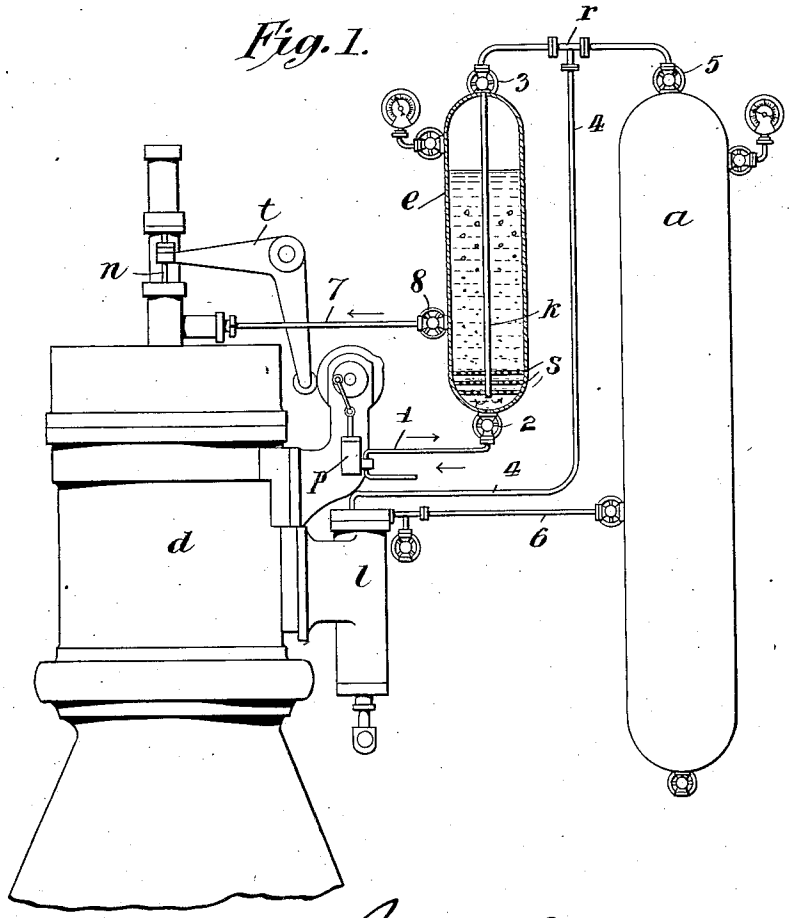


Fig. 1.



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UNITED STATES PATENT OFFICE.

RUDOLPH DIESEL, OF MUNICH, GERMANY.

PROCESS AND APPARATUS FOR INJECTION OF LIQUID FUELS INTO INTERNAL-COMBUSTION ENGINES.

No. 890,620. Specification of Letters Patent. Patented June 16, 1908.

Application filed July 1, 1905. Serial No. 267,969.

To all whom it may concern:

Be it known that I, RUDOLPH DIESEL, a subject of the Emperor of Germany, and residing at Munich, Germany, have invented certain new and useful Improvements in Processes and Apparatus for Injection of Liquid Fuels into Internal-Combustion Engines, of which the following is a full, clear, and concise specification.

My invention relates to a method of introducing or injecting liquid fuel directly into the body of compressed air in the compression space of internal combustion engines and relates more particularly to means which accomplish or bring about the immediate and thorough atomization of the liquid fuel as it enters the said space.

When liquid fuels are injected in jets through very small nozzles and under very high pressure into a combustion or other chamber containing air or gas, the impact of the liquid into the gas induces a mechanical sub-division of the liquid jet into minute particles. This atomizing action is observed to increase as the ratio of the pressures inside and outside of the receptacle from which the liquid flows. The absolute pressure of the gas in the chamber also affects the atomizing action, for the higher the pressure of this gas the more compact is the body which the liquid jet encounters. This atomizing action of the liquid fuel is facilitated and increased according to the present invention by previously saturating the same with air or oxygen under high pressure, so that when it enters the lower pressure of the combustion chamber the rapid release of the contained gas aids materially in reducing the fuel to a finely comminuted state, in which condition its energy is more readily converted into useful work. At the same time, the atomization of the fuel may be further facilitated and hastened by heating the fuel, which may be accomplished either by impregnating the fuel with the compressed gas while the latter is still giving off its heat of compression, or by warming the fuel by an independent instrumentality or by both.

In further describing the process and the apparatus with which it may be carried out, I shall refer to the accompanying sheet of drawings forming a part hereof in which

Figure 1 shows a portion of a Diesel engine with the fuel injection mechanism shown diagrammatically according to this invention and having its fuel receptacle shown in vertical section, and Fig. 2 is a vertical section of a portion of the combustion or compression space of the said engine, it being understood that the said drawings are intended to be merely descriptive of the process and the relations of the several parts, and are not to be considered as working drawings; and it should be here stated that the present invention is capable of embodiment in various forms and adaptation to different types of engines, according to conditions or requirements.

The reference character *d* represents the internal combustion engine which includes a cylinder *c* in which fuel material is adapted to be compressed and combusted in the well known manner. The fuel is injected into the cylinder through the restricted opening *o*, controlled by the fuel valve *n* which is appropriately operated through its valve stem by the customary valve gearing *t*, not necessary to be here described.

The saturating apparatus whereby the liquid fuel is saturated with the gas comprises a receptacle *e* which may be filled with fuel through pipe 1 and stop-cock 2, by means of the small pump *p*, which latter may be driven by hand when desired. A gas pipe *k* also enters the said receptacle debouching near the bottom of the same or at least below the level of the liquid therein, and screens or finely perforated plates *s*, *s*, are interposed between the mouth of the pipe or passage *k* and the level of the liquid, so that the gas emitted therefrom is subdivided into small bubbles which rise through the liquid and are absorbed by it. The pipe *k* communicates through a stop-cock 3 and pipe or passage *r* with a force pipe 4 of the air pump *l* and also with an air or gas reservoir *a*, the latter communication being controlled by the stop-cock 5. The air pump *l* just referred to is arranged to be driven at times by the engine, to fill the reservoir *a* with compressed air, oxygen or other gas which may be subsequently used for injecting fuel and also for starting the engine. The pump *l* is also employed for forcing compressed gas, which it may draw through pipe 6 from the reservoir, into the force pipe 4 and from thence into the gas pipe *k*, the several stop-cocks shown being appropriately manipulated to produce this result. The receptacle *e* has communication through the pipe 7 and cock 8 with the

fuel valve *n* of the engine, and this communication is, of course, controlled by the position of the valve gearing thereof.

When the engine is at rest, the reservoir *a* may be filled with air of 50 or 60 atmospheres remaining from the previous run, and the injection tank or fuel receptacle *e* may contain no liquid fuel except possibly a small residuum left from the previous run. By opening the cocks 3 and 5, the pressures in the reservoir and receptacle may be equalized through the pipe *r* and after closing the cock 3 the pump *p* may be worked by hand to force the oil or other liquid fuel into the said receptacle to fill the same and produce therein the desired high pressure which is a multiple of that of the compression space. When the engine is set in motion, the fuel is injected into the compression space thereof through the pipe 7 by reason of the said higher pressure, and the several cocks are so adjusted and regulated that the air pump *l* draws air from the reservoir and forces it through pipe *k* into the oil by which it is absorbed, as above described. The air coming directly from the pump into the oil receptacle, gives off its heat of compression and thereby raises the temperature of the oil. As the jet of warmed air-saturated and oxygenated oil strikes the body of air in the cylinder of the engine, which is usually compressed to about 30 or 35 atmospheres it immediately becomes thoroughly pulverized or atomized in such manner as to insure perfect combustion. The liquid jet may be supplied, if desired, with any of the various well known forms of injection nozzles, such as rose nozzles, or mixing nozzles in which the entering jet draws in air through lateral openings, or the atomization may be increased by means of impact plates or by the use of two jets intersecting from opposite or different directions.

Having described my invention, what I claim and desire to secure by Letters Patent of the United States, is the following:

1. A process of injecting fuel into internal combustion engines which consists in injecting a jet of liquid fuel previously oxygenated, into a body of compressed air in the compression space of the engine.

2. A process of injecting liquid fuel into internal combustion engines which consists in oxygenating the fuel and injecting such oxygenated liquid through a restricted opening directly into a previously compressed gas within the compression space of the engine.

3. A process of injecting liquid fuel into internal combustion engines, which consists in compressing said fuel and also air or oxygen, forcing the latter in mechanically divided particles through said fuel for the purpose of oxygenating same and injecting the fuel thus saturated directly into a body of air in the compression space of said engine.

4. A process of injecting liquid fuel into internal combustion engines which consists in previously compressing said fuel in a receptacle, introducing air or oxygen into the bottom of oxygenated liquid receptacle and injecting the said fuel therefrom directly into a body of compressed air in the combustion chamber of said engine.

5. A process of injecting liquid fuel into internal combustion engines which consists in compressing air or oxygen and introducing the same into a confined or closed fuel receptacle, further compressing the air or oxygen in said receptacle by forcing fuel into the same, passing subdivided particles of air or oxygen through said confined fuel and then injecting the same into a body of compressed air within the compression space of the engine.

6. A process of injecting liquid fuel into internal combustion engines, which consists in compressing air or oxygen and forcing the same through previously compressed liquid fuel before it loses its heat of compression to thereby heat said fuel, and then injecting said liquid fuel directly into the compression space of the engine.

7. A process of injecting liquid fuel into internal combustion engines, which consists in injecting into a body of compressed air liquid fuel which has been previously oxygenated with air or oxygen and heated.

8. In fuel injection mechanism for internal combustion engines, the combination of a liquid fuel receptacle and a pipe or passage adapted to deliver compressed air or oxygen below the level of the liquid therein, a second pipe for conducting said oxygenated fuel to the compression space of the engine and means for creating sufficient pressure in said receptacle to produce injection of the fuel through said second pipe.

9. In a fuel injection mechanism for internal combustion engines, a liquid fuel receptacle, an air or oxygen pipe passage debouching below the level of the liquid therein, and means for subdividing the air or oxygen emitted therefrom, in combination with a fuel injection pipe or passage forming a communication between the liquid part in said receptacle and the compression space of the engine, and a pump for forcing air or oxygen through said gas pipe and thereby creating or preserving a pressure in said receptacle higher than the compression of the engine.

10. In a fuel injection mechanism for internal combustion engines, a liquid fuel receptacle having communication with the combustion chamber of the engine, and means for introducing compressed air or oxygen into the liquid therein, in combination with a reservoir and a pump for forcing the air or oxygen thereof into the said fuel receptacle.

11. In a fuel injection mechanism for internal combustion engines, a liquid fuel re-

ceptacle having communication with the combustion chamber of the engine, and a fuel pump for filling the same with fuel, in combination with a gas reservoir, a gas pump adapted to compress gas therein and pipe connections from said gas pump whereby it may be caused to force the gas in said reservoir into the liquid in the said receptacle.

In testimony whereof, I have signed my name to the specification in the presence of two subscribing witnesses.

RUDOLPH DIESEL.

Witnesses:
ULYSSES J. BYWATER,
ABRAHAM SCHLESINGER.