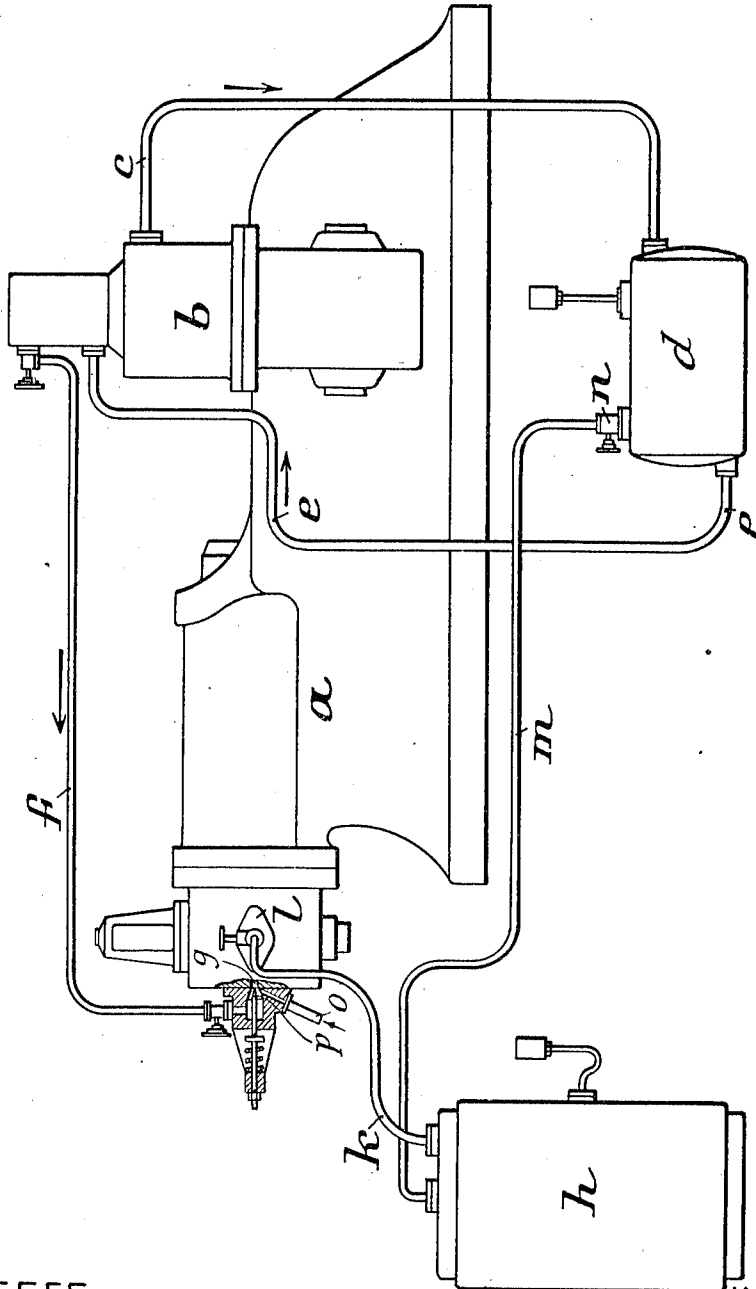


L. GENTZEN.
INTERNAL COMBUSTION ENGINE.
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1,066,401.

Patented July 1, 1913.



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LUDWIG GENTZEN, OF MÜLHEIM-ON-THE-RHINE, GERMANY.

INTERNAL-COMBUSTION ENGINE.

1,066,401.

Specification of Letters Patent.

Patented July 1, 1913.

Application filed January 10, 1911. Serial No. 601,844.

To all whom it may concern:

Be it known that I, LUDWIG GENTZEN, engineer, a subject of the German Emperor, residing at 5 Franzstrasse, Mülheim-on-the-Rhine, Germany, have invented certain new and useful Improvements in Internal-Combustion Engines for Use in Mine-Shafts; and I do hereby declare the following to be a full, clear, and exact description of the invention, such as will enable others skilled in the art to which it appertains to make and use the same.

My invention relates to improvements in means for starting internal combustion engines, and more particularly combustion engines of that type which operate with compression of pure air within the working cylinder and self-ignition of the fuel, and in which the liquid fuel is forced into the cylinder through an atomizing nozzle and by means of compressed air. Engines of this class are ordinarily started by means of compressed air, until the compression within the cylinder and the pressure of the air supplied to the fuel nozzle are sufficient to atomize the fuel and to ignite the same. In engines of this class the air for forcing the fuel into the cylinder has heretofore been forced into the working cylinder, directly from the high pressure cylinder of the air compressor without first passing through a storing receptacle. This operation of the engine is objectionable in this respect that when starting the engine a comparatively large number of revolutions is necessary, before the high pressure cylinder of the compressor supplies air at the high pressure required for injection of the fuel. The reason for this is that while the engine is out of operation the cooler interposed between the low pressure cylinder and the high pressure cylinder of the compressor does not keep the normal pressure at which it is ordinarily admitted to the high pressure cylinder, because it is not closed by high pressure valves but by the valves of the compressor cylinders and by means of flanges, which are not sufficiently tight. Therefore when starting the engine the latter must be operated by means of compressed air and without combustion, until the pressure of the air within the cooler has been brought to its normal, so that the high pressure cylinder can supply the injection air at the pressure which is necessary to overcome the compression

within the working cylinder and for atomizing the fuel.

The object of my improvements is to obviate these objections and to so operate the engine, that the time of driving the engine by means of compressed air and without combustion is reduced to a minimum. With this object in view, I have provided means whereby, before starting the engine, the cooler may be supplied with compressed air from the receptacle within which the air required for starting the engine is stored, so that the air within the cooler assumes its normal pressure. Thereby the direct injection of fuel from the high pressure cylinder of the compressor can be started from the beginning.

For the purpose of explaining the invention more in detail an example embodying the same has been shown in the accompanying drawing in which the plant is shown in a diagrammatical way.

Referring to the example illustrated in the drawing a combustion engine *a* is equipped with a compound compressor *b* the pistons of which are operated from the crank shaft of the engine in any known or preferred way. Between the high and low pressure cylinders of the said compressor a cooler *d* is interposed which communicates with the low pressure cylinder through a pipe *c* and with the high pressure cylinder through a pipe *e*. The air which has been partly compressed within the low pressure cylinder is forced from the latter into the cooler from which it is admitted to the high pressure cylinder. Through a pipe *f* the air which has been compressed to the necessary pressure within the high pressure cylinder is conducted to a nozzle *g* for forcing the fuel into the cylinder. Through a pipe *h* a starting valve *l* of the cylinder communicates with a receptacle *k* for storing compressed air which is required to start the engine while ignition does not yet take place. The said storing receptacle communicates with the cooler *d* through a pipe *m* which is adapted to be closed by a valve *n*.

In normal operation the engine is operated by means of fuel which is forced into the cylinder through the nozzle *g*, and which is atomized by means of air from the compressor *b*. In such operation the pressure of the air within the cooler *d* is sufficient to enable the high pressure cylinder of

the compressor to compress the air to the pressure required for forcing the same into the cylinder together with the fuel and against the pressure of the air compressed within the cylinder. If however the engine has been out of operation for a certain length of time, the pressure within the cooler falls off, so that, when starting the engine, the high pressure cylinder supplies air at a pressure which is not sufficient to overcome the pressure within the cylinder. Therefore the engine must be operated by compressed air from the receptacle *h* by opening the starting valve *l*, until the pressure supplied by the high pressure cylinder attains its normal value. To reduce the time of operating the engine by means of compressed air, and thereby to reduce the size of the storing receptacle *h* the cooler is supplied with compressed air from the said receptacle *h* by opening the valve *n* before starting the engine. Therefore the compressor *b* is able to supply air at the normal pressure after one or two revolutions after starting the engine by means of compressed air from the receptacle *h*. Therefore the amount of compressed air required for starting the engine is reduced to a minimum, and the capacity of the receptacle *h* can be reduced accordingly. The storing receptacle *h* is filled during the normal operation of the engine by the low pressure cylinder of the compressor and through the cooler *d* and pipe *m*. Fuel is conveyed to the nozzle *g* through a fuel supply pipe *o*, the injection being timed by a mechanically operated needle-valve *p*.

I claim herein as my invention:

1. In a combustion engine of the internal combustion type, the combination of a working cylinder, an injector nozzle for said cylinder, connections for leading fuel and a gaseous medium under pressure to said nozzle, a multi-stage compressor for delivering the gaseous medium under pressure to one of said connections, and normally inoperative means, extraneous to the path which connects the low pressure cylinder of the compressor with the high-pressure cylinder, for storing a gaseous medium, and means for delivering said medium, for the purpose of starting the engine, to the high-pressure cylinder of the compressor at substantially the same pressure at which said medium is supplied from the low-pressure cylinder during the normal operation of the engine.

2. In a combustion engine of the internal combustion type, the combination of a working cylinder, an injector nozzle for said cylinder, connections for leading fuel and a gaseous medium under pressure to said nozzle, a multi-stage compressor for delivering the gaseous medium under pressure to one of said connections, a cooler interposed between successive stages of the

compressor, a receptacle for storing a gaseous medium under pressure, means for temporarily connecting said receptacle with the working cylinder to start the engine, and means for temporarily connecting the said receptacle with the cooler to supply it with the gaseous medium under pressure.

3. In an internal combustion engine, the combination of a working cylinder, a connection for supplying fuel, a multi-stage compressor arranged to deliver a gaseous medium under pressure to the working cylinder, a receptacle adapted to contain a gaseous medium under pressure, a cooler interposed between successive stages of the compressor, a connection from said receptacle to the working cylinder and means for controlling this connection, another connection from said receptacle to the cooler, and means for controlling the last-named connection.

4. In an internal combustion engine, the combination of a working cylinder, a connection for supplying fuel, a multi-stage compressor arranged to deliver a gaseous medium under pressure to the working cylinder, a receptacle adapted to contain a gaseous medium under pressure, a connection through which the gaseous medium under pressure may flow from said receptacle to the working cylinder and means for controlling this connection, and another connection extending from the receptacle to a portion of the compressor between two stages thereof, said connection serving at times to supply compressed gaseous medium to the receptacle, and at other times to convey such medium from the receptacle to the compressor, and means for controlling the last-named connection.

5. In an internal combustion engine, the combination of a working cylinder, a connection for supplying fuel, a multi-stage compressor arranged to deliver a gaseous medium under pressure to the working cylinder, a receptacle adapted to contain a gaseous medium under pressure, a connection extending from the said receptacle to a portion of the compressor between two stages thereof, said connection serving at times to supply compressed gaseous medium to the receptacle, and at other times to convey such medium from the receptacle to the compressor, and means for controlling the last-named connection.

6. In an internal combustion engine, the combination of a working cylinder, a connection for supplying fuel, a multi-stage compressor arranged to deliver a gaseous medium under pressure to the working cylinder, a receptacle adapted to contain a gaseous medium under pressure, a connection through which the gaseous medium under pressure may flow from said receptacle to the working cylinder and means for con-

trolling this connection, a cooler interposed between successive stages of the compressor, a connection extending from the said receptacle to the cooler, said connection serving at times to supply compressed gaseous medium to the receptacle, and at other times to convey such medium from the receptacle to the cooler, and means for controlling the last-named connection.

10 7. In an engine of the internal combustion type, the combination of a working cylinder, an injector nozzle for said cylinder, connections for leading fuel and a gaseous medium under pressure to said nozzle, a
15 multi-stage compressor for delivering the

gaseous medium under pressure to one of said connections, a cooler interposed between successive stages of the compressor, a receptacle for storing a gaseous medium under pressure, and means for temporarily
20 connecting said receptacle with the cooler of the compressor.

In testimony, that I claim the foregoing as my invention, I have signed my name
25 in presence of two subscribing witnesses.

LUDWIG GENTZEN.

Witnesses:

LOUIS VANDORY,
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Copies of this patent may be obtained for five cents each, by addressing the "Commissioner of Patents,
Washington, D. C."