(No Model.)

H. A. STUART.

ENGINE OPERATED BY THE EXPLOSION OF MIXTURES OF GAS OR HYDROCARBON VAPOR AND AIR.

No. 502,837. Patented Aug. 8, 1893.

Fig. 2.

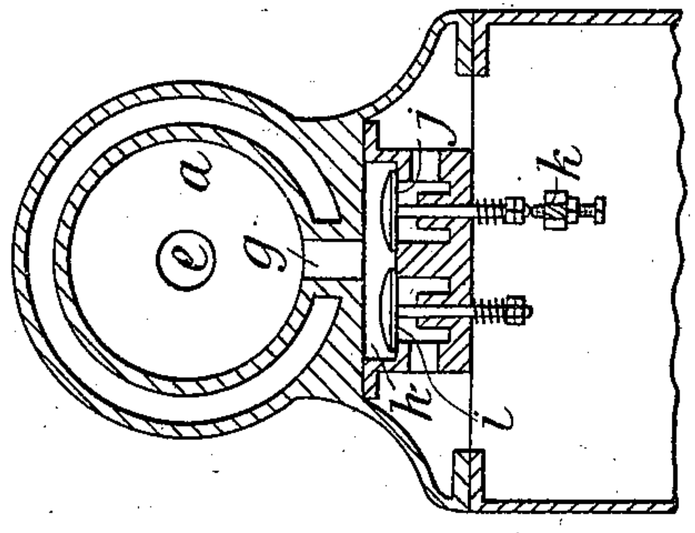
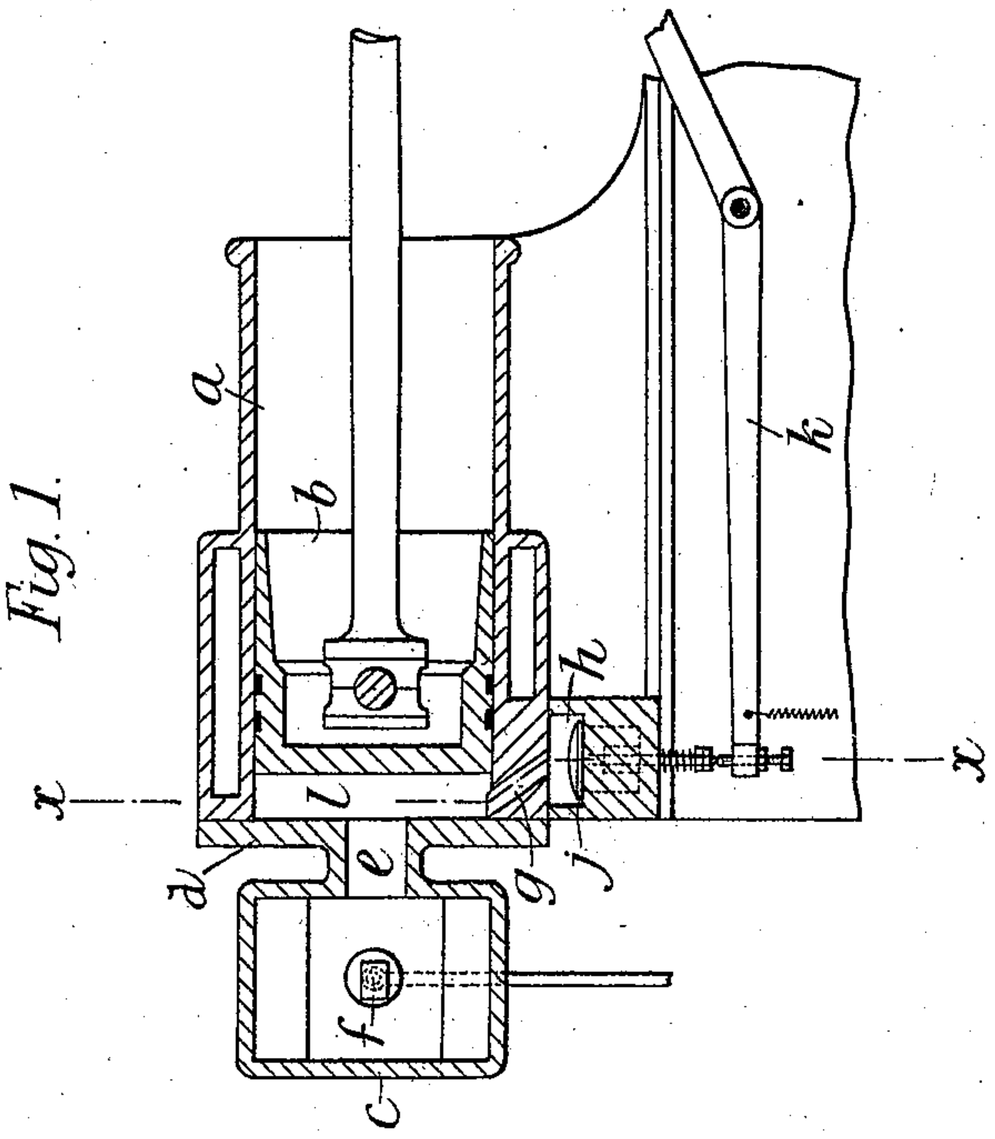


Fig. 1.



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UNITED STATES PATENT OFFICE.

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ENGINE OPERATED BY THE EXPLOSION OF MIXTURES OF GAS OR HYDROCARBON VAPOR AND AIR.

SPECIFICATION forming part of Letters Patent No. 502,837, dated August 8, 1893.

Application filed September 15, 1891. Serial No. 405,748. (No model.) Patented in England October 8, 1890, No. 15,994; in Germany December 7, 1890, No. 59,882; in France September 4, 1891. No. 215,920; in Belgium September 5, 1891, No. 96,282; in Switzerland December 4, 1891, No. 4,226; in Cape Colony December 29, 1891, No. 729; in Italy December 31, 1891, XXVI, 30,879, and LXI, 73; in Victoria January 9, 1892, No. 9,371; in South Australia January 13, 1892, No. 2,151; in Transvaal January 13, 1892, No. 313; in Spain January 21, 1892, No. 12,814; in New Zealand January 23, 1892, No. 5,395; in Brazil January 30, 1892, No. 1,389; in Straits Settlements March 25, 1892; in Austria-Hungary May 8, 1892, No. 42,619 and No. 15,802, and in Canada May 12, 1892, No. 38,934.

To all whom it may concern:

Be it known that I, HERBERT AKROYD STUART, a subject of the Queen of Great Britain, residing at Bletchley, England, have invented new and useful Improvements in or Connected with Engines Operated by the Explosion of Mixtures of Combustible Vapor or Gas and Air, (for which I have received Letters Patent in Germany, No. 59,882, dated December 7, 1890, and by patent of addition, No. 64,696, dated September 17, 1891; in France September 4, 1891, No. 215,920; in Belgium September 5, 1891, No. 96,282; in England October 8, 1890, No. 15,994; in Switzerland December 4, 1891, No. 4,226; in Cape Colony December 29, 1891, No. 729; in Italy December 31, 1891, XXVI, 30,879, and LXI, 73; in Victoria January 9, 1892, No. 9,371; in South Australia January 13, 1892, No. 2,151; in Transvaal January 13, 1892, No. 313; in Spain January 21, 1892, No. 12,814; in New Zealand January 23, 1892, No. 5,395; in Brazil January 30, 1892, No. 1,389; in Straits Settlements March 25, 1892; in Austria-Hungary May 8, 1892, No. 42,619 and No. 15,802, and in Canada May 22, 1892, No. 38,934,) of which the following is a specification.

My invention relates to engines operated by the explosion of mixtures of gas or hydrocarbon vapor and air.

In the specification filed with my application for Letters Patent on or about December 29, 1890, Serial No. 376,112, I have described means for preventing the premature or pre-ignition of an explosive charge of combustible vapor or gas and air when a permanent ignitor (such as a continuous electric spark or a highly heated igniting chamber) is in communication with the interior of the cylinder, by first of all compressing the necessary quantity of air for the charge, and then introducing into this quantity of compressed air the necessary supply of combustible liquid, vapor or gas to produce the explosive mixture.

The chief object of my present invention is to provide means, whereby the necessary quantities of combustible vapor or gas and of air may be drawn in during the suction or outstroke of the piston, when a permanent ignitor is employed, without liability of pre-ignition, and for this purpose I attach to one end of the cylinder an explosion chamber (which chamber in a liquid hydro-carbon engine also serves as the vaporizer) of sufficient capacity to contain the combustible charge; the opening or passage which establishes communication between the cylinder and the explosion chamber being contracted in area, that is to say, of much less diameter or area than the cylinder or the explosion chamber in transverse section; and I form the inlet for the air in the walls of the cylinder and that for the hydrocarbon liquid or other combustible vapor or gas in the walls of the explosion chamber, so that air can only enter the explosion chamber from the cylinder through the contracted passage.

To enable my invention to be fully understood I will describe the same with reference to the accompanying drawings, in which—

Figure 1 is a longitudinal section of a portion of a liquid hydrocarbon engine having my improvements applied thereto; and Fig. 2 is a section on the line *x x*, Fig. 1.

a indicates the engine cylinder, and *b* the piston or trunk.

c is the explosion chamber, which, as shown, is formed integral with the cylinder-cover *d*, and *e* is the contracted passage which establishes communication between the explosion chamber and the cylinder.

f is a nozzle through which liquid hydrocarbon is injected into the explosion chamber, and *g* is the passage through which air is drawn into the cylinder. This passage com-

municates with a chamber *h* containing two valves *i*, *j*, the former of which may either open automatically under the action of the suction or be actuated to admit air during the outstroke of the piston, while the latter is operated by a cam through the medium of a lever *k* or by other suitable means at the proper times to allow the products of combustion to be exhausted from the cylinder.

The engine shown in the drawings is designed to have liquid hydrocarbon injected into the explosion chamber and formed into spray before impinging upon the heated walls of the said chamber; it will be obvious, however, that where the explosive mixture is to be composed of gas and air, the gas-inlet to the explosion chamber can be provided with a valve adapted to admit gas by suction or in any other suitable manner.

When liquid hydro-carbon is employed the injections may be so timed as to occur at the beginning or at any portion of the suction stroke or during the compression stroke. I prefer, however, to give sufficient time for complete vaporization in order to obtain the maximum economy of combustible liquid, and this can be accomplished by injecting the hydrocarbon during the suction stroke when the combustible liquid after coming in contact with the hot walls of the explosion chamber vaporizes very completely and occupies the combustion space displacing a small portion of its contents (air or the burned gases of the previous explosion) through the contracted passage *e*. The piston *b* is in the meantime performing its outstroke and a charge of air is being drawn into the cylinder through the valve *i* and the passage *g*, and although a small portion of inflammable vapor may pass from the explosion chamber into the air in the cylinder, yet no mixing sufficient to cause an explosion will take place owing to the contracted area of the communicating passage until on the return or compression stroke of the piston sufficient air is forced from the cylinder into the explosion chamber to produce a mixture capable of explosion. The cubical contents of the engine cylinder and the explosion chamber are so proportioned that the mixture in the explosion chamber during compression is rendered explosive in time to secure the ignition at or near the end of the compression stroke.

In practice I prefer to make a relatively large clearance space *l*, as shown, whereby a layer of air remains between the piston and the charge in the explosion chamber. I have found that when no clearance space or only the usual very small clearance space is left, the back of the piston and walls of the cylinder become rapidly fouled with deposit and that, when a clearance space of, say, a quarter of a diameter is left, this deposit is obviated. I believe the layer of air in the clearance space has the effect of preventing the contact of the products of combustion with the piston and the walls of the cylinder and thereby obviating the deposit thereon. The volume of relatively pure compressed air also supplies an excess of oxygen to complete the combustion originated in the explosion chamber and thereby burn up the carbon, which might otherwise form deposit.

When the explosion chamber is used as a vaporizer the internal surface thereof may be ribbed (as described in the specification before referred to) or corrugated; and instead of injecting the liquid hydro-carbon by means of a pump it may be drawn into the cylinder by the partial vacuum produced in the cylinder during the suction stroke, suitable arrangements being made to measure the liquid charges and prevent admission of air in any prejudicial quantity.

When the engine is used as a gas engine or as an oil engine, using a liquid fuel vaporizer outside the combustion chamber, the inflammable gas or vapor may also be drawn or forced into the explosion chamber. In such cases the explosion chamber may or may not be highly heated, and it may or may not be used to fire the explosive charge when formed by the compression of air (from the cylinder) into the chamber. When the chamber is not highly heated, ignition of the explosive charge may be effected by an incandescent tube, by continuous electric sparks or by other known means of igniting. I preferably, however, use the highly heated explosion chamber for igniting the charges, and I heat it by a lamp or other means when starting the engine, the successive explosions serving to maintain the explosion chamber at the requisite temperature for igniting the charges, as described in the specification before referred to.

Having now particularly described and ascertained the nature of my said invention and in what manner the same is to be performed, I declare that what I claim is—

1. In an engine operated by the explosion of a gaseous mixture such as described, a chamber at the rear of the cylinder adapted to be highly heated for vaporizing and igniting the explosive mixture, said chamber being combined with and communicating directly with the working cylinder by a contracted passage always open to the said cylinder, a hydro-carbon inlet for said chamber and an air-inlet valve located at the end of the cylinder, whereby the air on entering is prevented from passing into the vaporizing chamber until compressed by the return stroke of the piston, by which arrangements premature ignition is rendered almost impossible, substantially as and for the purposes specified.

2. An engine of the kind above described having an explosive chamber communicating with the working cylinder through a contracted passage at all times freely open and in which the combustible liquid, vapor, or gas

and the air are introduced separately, namely, the one into the combustion chamber and the other into the cylinder as set forth, the explosive chamber serving by means of its hot surfaces, to ignite an explosive charge, substantially as described.

3. In combination, the explosion chamber *c.* formed integral with the cylinder cover *d.* and having a nozzle *f*, and free passage *e.*, the cylinder *a.* having the air passage *g.*, piston *b.*, and the chamber *h.* provided with valves *i.* and *j.*, the combination being and operating substantially as set forth.

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