June 2, 1925. 1,539,938

E. FRANCHIMONT ET AL
APPARATUS FOR THE PRODUCTION OF GAS
AT HIGH TEMPERATURE AND PRESSURE
Filed Feb. 19, 1921

Fig. 1

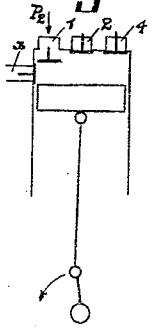


Fig. 2

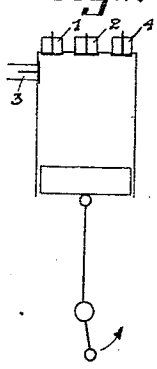


Fig. 3

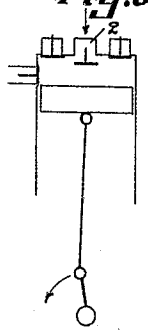


Fig. 4

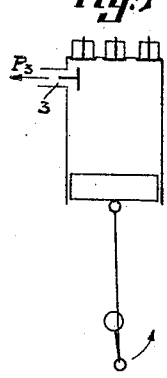


Fig 5

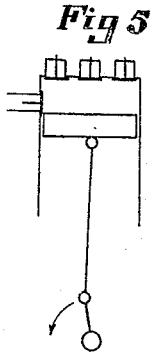


Fig. 6

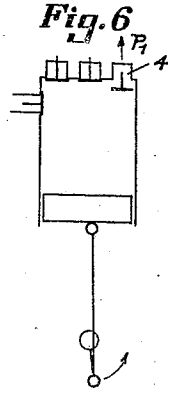
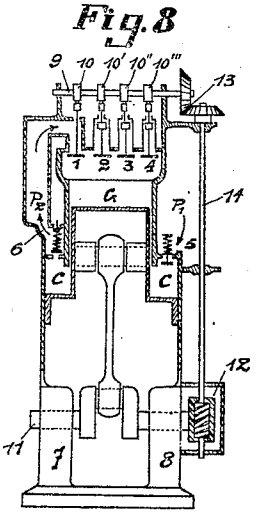


Fig. 7

Fig. 8



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UNITED STATES PATENT OFFICE.

EUDORE FRANCHIMONT AND VITAL CÉSAR, OF IXELLES, BELGIUM.

APPARATUS FOR THE PRODUCTION OF GAS AT HIGH TEMPERATURE AND PRESSURE.

Application filed February 19, 1921. Serial No. 446,477.

(GRANTED UNDER THE PROVISIONS OF THE ACT OF MARCH 3, 1921, 41 STAT. L., 1313.)

To all whom it may concern:

Be it known that we, EUDORE FRANCHIMONT and VITAL CÉSAR, subjects of the King of Belgium, and residents of Ixelles, in the Kingdom of Belgium, have invented certain new and useful Improvements in Apparatus for the Production of Gas at High Temperature and Pressure (for which we filed an application in Belgium, Feb. 16, 1920, Patent No. 285,068); and we 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, reference being had to the accompanying drawings, and to letters or figures of reference marked therein, which form a part of this specification.

This invention relates to apparatus for the production of hot gases under pressure and more particularly to an internal combustion six stroke engine of the Diesel type, so designed that the expansion of combustion gases in the cylinders is continued only as far as necessary in order to ensure economic continuity of the working thereof.

In other words, the object of this invention is an internal combustion engine of reduced volume, wherein the motive couple is reduced to zero in order to release, available for other industrial uses, the greatest possible quantity of combustion gases.

The appliances of this kind known hitherto have among others the following disadvantages:—

(1) They fail to spread over a sufficient number of strokes the heat produced by combustion, which heat is stored within the walls of the cylinders and in the timing-gear during at least two complete strokes (compression and combustion), whatever be the cycle utilized.

(2) They do not permit the production on economic lines of large volumes of gas at comparatively high pressure of 12 to 20 atmospheres for instance.

(3) They do not embody sufficient means of regulation to ensure the proper working of the generator.

(4) At each cycle they imprison within the cylinders a compartively large quantity of noxious residual gases—we mean thereby those hot gases under pressure which are not forced out of the cylinders and which prevent normal admission of fresh air for the next following cycle.

In this invention, the above drawbacks are eliminated by causing the thermo-dynamic generator to work according to a cycle having the following essential stages and which consequently comprises at least six different strokes:

(1) Admission of fresh compressed air.

(2) Further compression of the above compressed air.

(3) Injection of the combustible fluid—combustion and partial expansion of the gases resulting from combustion.

(4) Forcing under pressure, towards the utilization apparatus, of part of such partly expanded hot gases.

(5) Expansion—eventually as complete as possible—of the gases remaining in the combustion chamber.

(6) Expulsion of such residual gases—(eventually completely expanded).

In addition this invention provides for the case when the above described six-stroke cycle is completed by additional strokes, with a view to achieving any other desired ends, such as more complete exhaust or sweeping of the gases from the cylinders.

The drawings annexed hereto represent by way of example a way of carrying out this invention involving the utilization of a six-stroke cycle.

Figures 1 to 6 show diagrammatically a cylinder at each of the six strokes of the cycle,

Fig. 1 showing the position at the time of admission of compressed air,

Fig. 2 at the time of compression,

Fig. 3 at the time of injecting combustible fluid,

Fig. 4 at the time of driving back under pressure, a portion of the hot gases,

Fig. 5 at the time of beginning of the final expansion of the gas remaining in the combustion chamber, and

Fig. 6 at the time of the beginning of scavenging of the burnt gases.

Figure 7 is the standard dynamic diagram of the appliance illustrated in Figures 1 to 6.

Figure 8 shows a generating cylinder working according to a cycle comprising at least six strokes, in conjunction with the compressor used for the air to be fed thereto.

In Figures 1 to 6, the generator cylinder diagrammatically represented is provided with four positively operated valves.

Valve 1 is the inlet valve for fresh air compressed under pressure P^2 by any known method.

Valve 2 is that which serves for injection for the combustible fluid under pressure. Valve 3, is that used for the exhaust or forcing out of the burnt gases at high pressure P^3 and at a high temperature, towards the apparatus or tanks used for the industrial application of such gases.

Valve 4 is that utilized for final exhaust under atmospheric pressure P^1 of partially expanded residual gases.

These valves will actually be operated by cam-shaft rotating at one-third crank shaft speed.

In the diagram, Fig. 7, the various pressures P^1 P^2 P^3 indicated on the ordinate OP are: P^1—atmospheric pressure; P^2—pressure of compressed air admitted at the first stroke:—and P^3—pressure of the burnt gases swept out for the purpose of the industrial utilization thereof.

When the generator works as per the diagram in Fig. 7, valve 1 (Fig. 1), opens at the commencement of the first stroke and admits air compressed at P^2 pressure.

Air will be admitted into the cylinder of the apparatus substantially according to the horizontal line AB (Fig. 7) which relates to the first stroke of the cycle. At the second stroke (Fig. 2) all valves 1, 2, 3, 4 being closed, the return motion of the piston effects further or additional compression and the heating of the air which had been admitted during the first stroke. The second is represented by the more or less adiabatic curve BGC in Fig. 7.

The third stroke (Fig. 3) comprises two parts (*a*) part CD being the period of injection and combustion of the fluid injected from the moment this stroke commences, by valve 2 (*b*) and part DE which is the period of partial expansion of the gases resulting from combustion.

At the fourth stroke (Fig. 4) valve 3 opens through which hot and partially expanded gases at P^3 pressure, are forced out of the cylinders into the apparatus provided for the utilization of such gases. This stroke is represented by line EFGH. The opening moment of valve 3 may be timed with such advance as may in practice be found necessary for the proper and efficient working of the machine, thus causing the sudden fall of pressure EF.

At the fifth stroke (Fig. 5) all the apertures or valves are closed; the burnt gases remaining in the combustion chamber expand. This expansion is represented in the diagram shown in Fig. 7 by the curve HIJ.

Towards the end of this stroke, the exhaust port 4 commences to open, this may be timed with such advance as may be required, thus causing the sudden fall of pressure represented by the line JK. Consequently, aforesaid fifth stroke is represented by curve HIJK.

The cycle is completed by the sixth stroke (Fig. 6) during which the piston forces out into the open, at P^1 pressure, the expanded gases remaining in the cylinder. During all this time, valve 4 remains open having in fact opened towards the end of the previous stroke. The sixth stroke is represented in the diagram of Fig. 7 by line KA'.

It should be observed that diagram (Fig. 7) consists of two portions, viz:

(*a*) Motive parts (areas representing driving power) represented by areas CDEFG and AIJKA'.

(*b*) The resisting part (areas representing the work done) represented by surface HGBI.

It goes without saying that in order to ensure the continuity of the working of the apparatus, the injection of the fuel must be regulated in such a manner that the sum of the working or motive parts be periodically equal to the value of the resisting part HGBI, increased by the value of such a surface as is proportionate to the work of the passive resistance since the latter may comprise the work necessary for the compression of fresh air at pressure P^2.

Diminution of the resisting portion HGBI of the diagram shown in Fig. 7 and even the transformation thereof into a motive part will obviously favour the starting or the maintenance of the speed of the machine. Therefore this will be desirable either for starting purposes or for making provision for any heavy diminution or even any temporary suppression (for economical purposes) of the combustible oil injection.

In connection with the resisting surfaces of the diagram, we have referred hereinbefore to the question of the work necessary for the compression of fresh air to P^2 pressure. In the case of a cycle comprising at least six strokes, this work which relates to large volumes of air, sucked in at atmospheric pressure, can be performed in a specially efficient manner through the combination, represented in Fig. 8, of the generator cylinder G with a compressor cylinder C.

The capacity of said compressor may in effect be comparatively very reduced seeing that it works in a two-stroke cycle, whilst the corresponding generator cylinder works according to a cycle comprising at least six

strokes. In other words, this compressor—at each compression cycle—is called upon to suck in at 5 and drive out at 6—towards the air tank at P^2 pressure, only one third—this being the maximum—of the air sucked in at 1 and required, each cycle, by the generator cylinder in conjunction with which the compressor is used. Due to the reduced capacity of said compressor, the latter does not in practice prove to be a cumbrous addition relative to bearings 7 and 8. This arrangement is a most happy one and is the result of the adoption of a cycle comprising at least six strokes.

In Figure 8, which better than the previous figures, shows the whole arrangement of a generator cylinder together with feed air compressor, there has been shown at 9 the shaft carrying the cams 10, 10′, 10″, 10‴ operating the valves numbered 1, 2, 3, 4 whose meaning is similar to that of the same numerals in Figures 1 to 6. 11 represents the main crank shaft of the generator. Due to the gears 12 and 13 and the intermediate shaft 14, shaft 9 here revolves at one third the speed of crank shaft 11.

It should be observed that the advantages indigenous to the six-stroke cycle are as follows:—

(1) A greater time interval is afforded between the periods of high temperature and consequently better cooling of the cylinders is secured.

More time between periods of high temperature is absolutely indispensable in order to ensure the proper preservation of the cylinders and timing gears in good condition, in the case of a high-pressure and high-temperature gas generator.

(2) Utilization whilst ensuring the expansion thereof prior to the expulsion thereof into the open of the gases which remain in the cylinder after driving out or exhaust towards industrial apparatus, resulting in the realization of a motive diagram of such nature as will increase the thermic output of the thermo-dynamic generator.

(3) Possibility of using a small sized compressor cylinder in conjunction with each generator cylinder.

Due to the admission of air under pressure at the first stroke of the cycle, it is possible, in the case of a generator cylinder of any given diameter to reduce the stroke of the piston, this resulting in the reduction of the volume and therefore of the space required and consequently reduction of the price of the cylinders, and in the possibility, the lineal speed of the piston being equal, of increasing the rotation speed of the generator shaft, producing an increase in the production power.

Due to a cycle affording high further compression it is possible to obtain a reduction of the volume of the combustion chamber and therefore a minimum or negligible quantity of burnt gases remaining within the cylinder when fresh air is admitted.

What we claim is:

The method of generating high pressure and temperature gases which comprises feeding a six-stroke cycle internal combustion engine on the first stroke with compressed air which is further compressed on the second stroke, injecting combustible fluid and effecting the combustion and partial expansion of the gases on the third stroke, driving out part of the hot and partially expanded gases for use on the fourth stroke, expanding residual gases on the fifth stroke and finally, on the sixth stroke, expelling the residual gases.

In testimony whereof we affix our signatures in presence of two witnesses.

EUDORE FRANCHIMONT.
VITAL CÉSAR.

Witnesses:
LEONARD LÈVA,
PIERRE BECQUET.