

H. GRAFTON.  
STEAM ENGINE.

No. 427,231.

Patented May 6. 1890.

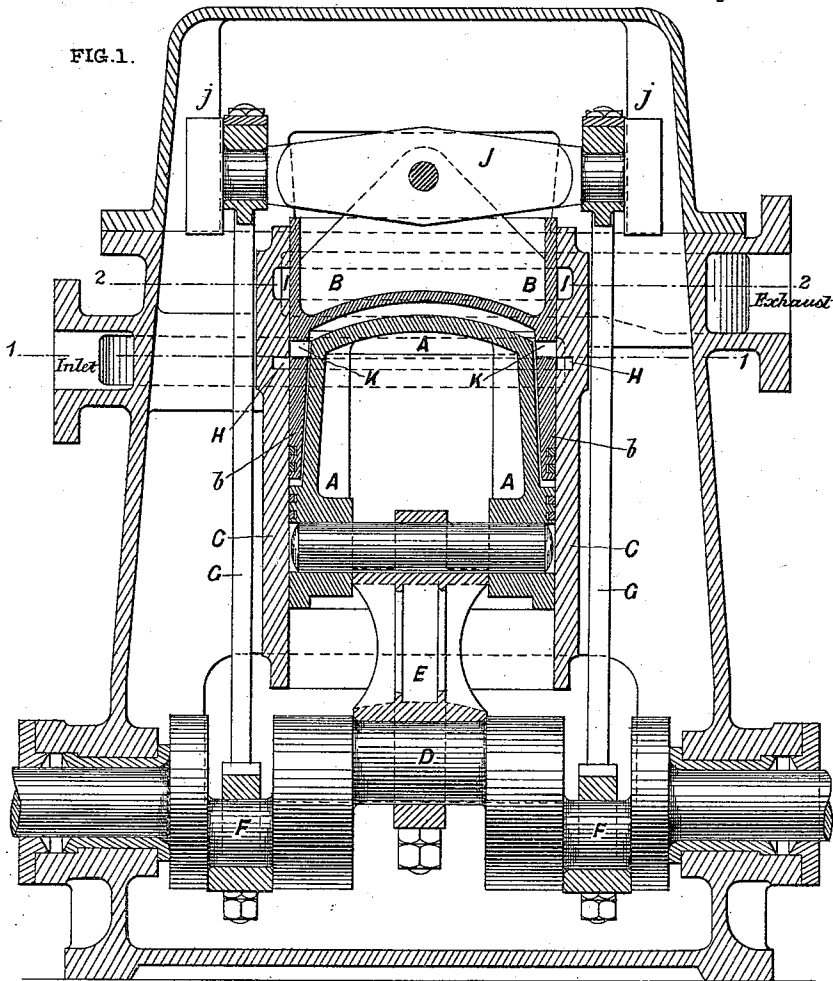
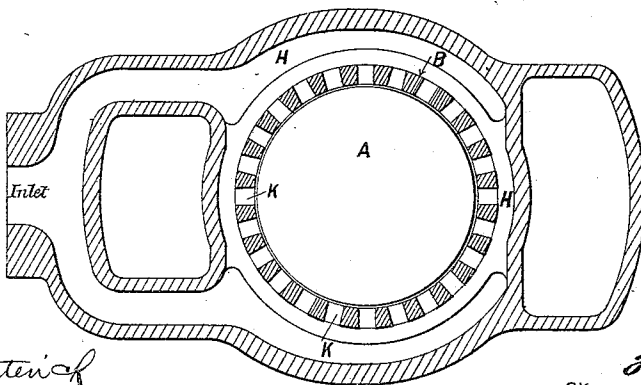


FIG. 3.



WITNESSES:  
*Chas. Dietrich*  
*John M. Spear*

INVENTOR  
*Henry Grafton*  
 BY *Briese, Steele & Smith*  
 ATTORNEYS

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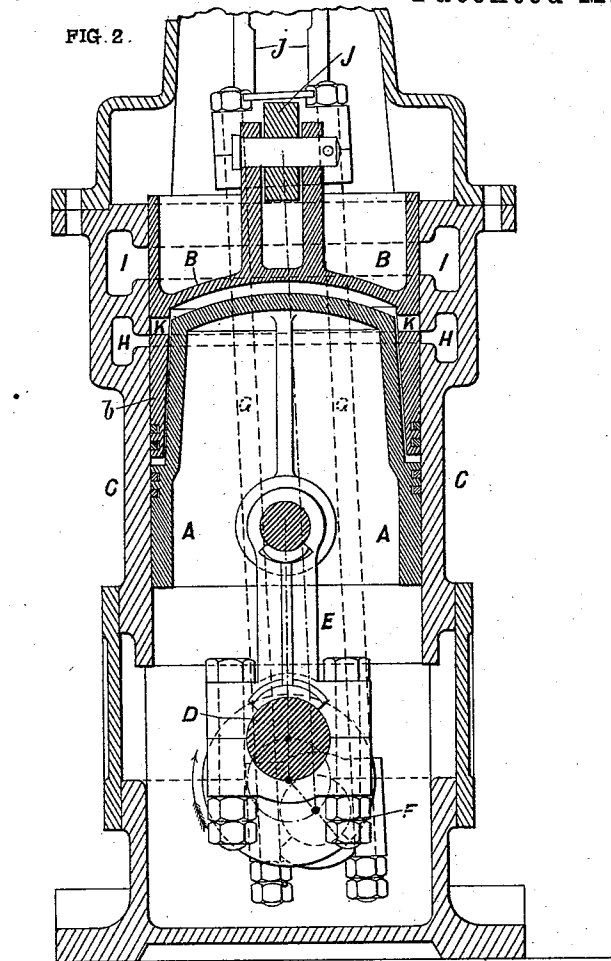
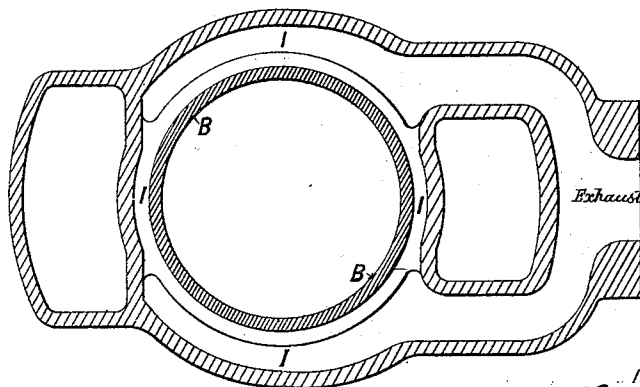


FIG. 2.

FIG. 4.



WITNESSES:

*Aug. Dietrich*  
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# UNITED STATES PATENT OFFICE.

HENRY GRAFTON, OF 26 WILLES ROAD, KENTISH-TOWN, COUNTY OF MIDDLESEX, ENGLAND.

## STEAM-ENGINE.

SPECIFICATION forming part of Letters Patent No. 427,231, dated May 6, 1890.

Application filed September 27, 1889. Serial No. 325,330. (No model.)

*To all whom it may concern:*

Be it known that I, HENRY GRAFTON, engineer, of 26 Willes Road, Kentish-Town, in the county of Middlesex, England, have invented new and useful Improvements in Steam and other Engines, of which the following is a full, clear, and exact description.

My invention relates to engines (worked by steam or other elastic fluid supplied under pressure) which, owing to the small number of their moving parts and other special features of construction hereinafter referred to, are especially adapted to run at very high speeds.

The improved high-speed engine of my invention resembles to some extent that class of engines in which two pistons move in opposite directions in the same cylinder. It may be said to be valveless, inasmuch as it has no part acting solely as a distribution-valve; but one of the pistons fulfills the function of a distribution-valve, wholly controlling both the admission and exhaust, as well as of a driving-piston.

The invention has for its principal object to make a simple engine whereof the moving parts balance each other as nearly as is practically possible consistently with the fulfillment by the piston of the function of a valve.

The invention has also for its object to obtain by means of the piston itself an early cut-off, and consequently a high grade of expansion, such as would only be obtainable in a simple engine by means of a very large valve having a long stroke and fulfilling no other function than that of controlling the admission and exhaust of the steam or other motive fluid.

The grade of expansion obtained in my engine is equivalent to that obtainable in many engines only by a complicated valve-gear or in a compound engine.

The invention consists of an engine wherein two oppositely-moving pistons (whereof one is adapted to act also as the distribution-valve) work in the same cylinder and are combined with a two-throw crank-shaft whose cranks are placed at such an angle that the strokes of the pistons, although for the most part opposite in direction, will be timed with regard to each other differently to the timing

of the said strokes in regard to the cylinder, which is necessary to enable the one piston to act as a valve. The combined effect of the two pistons upon the crank-shaft will be approximately equal to the sum of the power exerted by them and equivalent to that of a single piston of the same area whose length of stroke is equal to twice the angular distance between (*i. e.*, twice the chord of the arc subtending) the said cranks, while the actual length of stroke of each of the pistons is only equal to twice the radius of the individual crank to which it is connected. Moreover, the minimum length of the connecting-rod of the piston nearest to the crank-shaft, being proportional to the actual radius of the crank, is little more than a half of that necessary with a single piston having the greater stroke above mentioned, so that the length of the engine is much less than usual.

Reference is to be had to the accompanying drawings, forming part of this specification, wherein—

Figure 1 is a vertical section of the engine, taken in the plane of the crank-shaft. Fig. 2 is a central vertical section at right angles to Fig. 1. Fig. 3 is a horizontal section on line 1 1, Fig. 1. Fig. 4 is a similar section on line 2 2, Fig. 1.

The same letters of reference indicate the same parts in all the figures.

The engine consists of two single-acting pistons A B, both working in the bore of a stationary cylinder C and connected with a crank-shaft common to both, the piston A being connected with a middle crank D by a connecting-rod E, and the other piston B with a pair of side cranks F F by connecting-rods G G. The cranks F F are placed in line with one another and as nearly as possible diametrically opposite to the crank D consistently with the operation of the piston B as a valve. I find in practice that a deviation of about forty degrees from the diametrically-opposite position affords the best compromise between the irreconcilable conditions of a perfect balance of the pistons and the admission of steam to the cylinder. The crank D is therefore placed at about one hundred and forty degrees from the cranks F F.

The piston B acts as the distribution-valve

by cutting off against the inner face of the working-cylinder C, and for this purpose the cylinder has two internal circumferential ports H I, which are respectively the admission and exhaust ports, and respectively communicate with the inlet and exhaust passages, as shown.

In the drawings the ports H I are shown as continuous circumferential passages; but it will be obvious that they may be divided into rows of apertures similar and corresponding to the ports in the piston. This division of the circumferential grooves H I into rows of apertures is necessary to form a continuous bearing-surface for the said rings and prevent them springing out into the steam or exhaust ports in passing over the latter.

The piston B, which acts as a valve as well as a piston, is formed with a cylindrical trunk *b*, fitting in the cylinder C, and furnished with a circumferential row of ports K, which at the proper times coincide with the admission and exhaust ports H I of the cylinder. The ports K are symmetrically spaced around the piston, and, the ports H I of the cylinder being placed to correspond, the steam-pressure acting on the circumference of the valve-piston is entirely balanced.

The connecting-rods G take onto the ends of a cross-head J, pivoted to a central stem on the piston B. The cross-head has no motion on its pivot when the engine is working; but in case of unequal wear of the connecting-rod brasses the pivoting of the cross-head will insure that the strain shall always be equally divided between the two connecting-rods without throwing side strain on the piston. The ends of the cross-head J work in guides *j*, by which the strain due to the variable obliquity of the connecting-rods is wholly resisted, so that no side strain whatever can come upon the piston B, which is not therefore liable to wear unequally, this being highly important, having regard to the dual function which it fulfills.

In order that the valve-piston shall not uncover the steam-ports when at the outward end of its stroke, it is necessarily of considerable length, and in order to avoid long passages through the said piston it is made of trunk form; and to avoid dead-spaces the piston A enters the trunk of the piston B, but does not fit therein, the trunk *b* being slightly conical internally, and the part of the piston A which enters therein being conical externally, and clearance being left between them when in their closest position.

The whole engine may be inclosed in a casing, part of which is cast in one piece with the cylinder, the steam and exhaust passages, and the upper halves of the crank-shaft bearings. This part of the casing is bolted onto a box-casting forming the crank-chamber, in which the cranks run in a bath of oil and water, the crank-shaft bearings being provided with stuffing-boxes and glands to prevent leakage. The casing is closed at top by

a hood, and the crank-shaft is provided with a fly-wheel external of the casing.

The operation of the engine is as follows: Supposing the parts to be in the position shown and the engine running in the direction of the arrow, the valve-piston B is descending and about to uncover the admission-port H. Immediately this occurs steam is admitted between the pistons, and as soon as the cranks D and F have passed their dead-centers the pistons are moved apart by the pressure of the steam. As soon as the piston B on its upward stroke again reaches the position shown the admission is cut off, and the steam then acts expansively in the cylinder until the ports K coincide with the exhaust-port I, the momentum of the fly-wheel completing the stroke and carrying the engine to the position shown, thus completing a revolution, the exhaust being closed before the completion of the revolution in order to obtain the cushion necessary to resist the momentum of the parts and so prevent knock.

The advantages of this engine may be summarized as follows: simplicity and cheapness of construction, high speed with durability, high grade of expansion (five times) and consequently economy of steam without compounding or complication of valve-gear, balanced valve with large area of port and short passages, small radius of crank relative to effective stroke, short stroke and consequently little momentum of reciprocating parts compared with effective stroke, long connecting-rods in proportion to radius of cranks and consequently little friction on guides, approximate balancing of moving parts, which are all employed in the transmission of available power.

I do not here claim the herein-described engine having two pistons working in the same cylinder and coupled the one to a middle crank and the other to a pair of side cranks on the same crank-shaft, arranged as described, nor the combination, with the piston farthest from the crank-shaft and with its connecting-rods passing alongside the cylinder, of a cross-head pivoted centrally to the said piston by a transverse axis intersecting the axis of the cylinder and of guides for the cross-head, whereby the side strain of the connecting-rods is resisted and the piston is subjected to no unbalanced side strains, because I have made a separate claim for this part of my invention in a separate application for patent—to wit, application Serial No. 340,322, filed February 13, 1890.

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

1. An engine constructed and operating substantially as herein specified, and consisting, essentially, of two pistons working in the bore of the same cylinder, the one piston being adapted to act also as a distribution-valve, wholly controlling both the admission and

exhaust, as herein described, and the two pistons being coupled to cranks on the same crank-shaft placed at such an angular distance apart that the two pistons will move in the cylinder in opposite directions for the greater part of the revolution, and that the one piston will act both as a distribution-valve and piston, substantially as set forth.

2. The herein-described engine, consisting, essentially, of two pistons working in the bore of the same cylinder, (and moving therein in opposite directions for the greater part of the revolution,) the one piston acting also as a distribution-valve, wholly controlling both the admission and exhaust, and the two pistons being coupled to cranks on the same crank-shaft, placed at such an angular distance apart as to cause the motion of the pistons to be as nearly balanced as is compatible with the most effective operation of the one piston both as a distribution-valve and piston, substantially as set forth.

3. In the herein-described engine having two pistons working in the same cylinder and coupled to cranks on the same crank-shaft, placed at such an angular distance apart as to cause the pistons to nearly balance each other and yet admit of the one piston acting as distribution-valve to wholly control both the admission and exhaust, the combination of an all-round circumferential row of ports in a trunk of the said piston with all-round circumferential rows of admission and exhaust ports formed in the cylinder, substantially as and for the purpose specified.

4. In the herein-described engine having two pistons working in the same cylinder, the combination, with the same crank-shaft, of the one piston coupled with a middle crank by a single central connecting-rod of the other piston, coupled by means of connecting-rods passing alongside the cylinder, with two side cranks placed at such an angular distance from the middle crank as to cause the pistons to as nearly balance each other as is compatible with the effective operation of the one piston as a distribution-valve wholly controlling the admission and exhaust, as specified.

5. In the herein-described engine having two pistons working in the same cylinder and coupled to cranks on the same crank-shaft, arranged as described, the combination, with a trunk-piston adapted to act as a distribution-valve wholly controlling both the admission and exhaust, as described, of the second piston entering the trunk-piston when the pistons approach each other, but without coming into contact therewith, so as to avoid waste spaces or long passages on the valve-piston, as described.

The foregoing specification of my improvements in steam and other engines, signed by me this 11th day of September, 1889.

HENRY GRAFTON.

Witnesses:

CHAS. BERKLEY HARRIS,  
*Notary Public, London.*

T. F. BARNES,  
*Clerk to Messrs. Scorer & Harris, Notaries Public, 17 Gracechurch Street, London.*

It is hereby certified that in Letters Patent No. 427,231, granted May 6, 1890, upon the application of Henry Grafton, of 26 Willes Road, Kentish-Town, County of Middlesex, England, for an improvement in "Steam-Engines," errors appear in the printed specification requiring correction, as follows: In line 107, page 2, the word *in* should be inserted after the word "claim," and in line 112, same page, the word "nor" should be stricken out; and that the said Letters Patent should be read with these corrections therein that the same may conform to the record of the case in the Patent Office.

Signed, countersigned and sealed this 10th day of June, A. D. 1890.

[SEAL.]

CYRUS BUSSEY,  
*Assistant Secretary of the Interior.*

Countersigned:

C. E. MITCHELL,  
*Commissioner of Patents.*