No. 815,104. PATENTED MAR. 13, 1906.

L. J. J.-B. LE ROND.

ENGINE.

APPLICATION FILED JUNE 21, 1904.

2 SHEETS—SHEET 1.

Fig. 1.

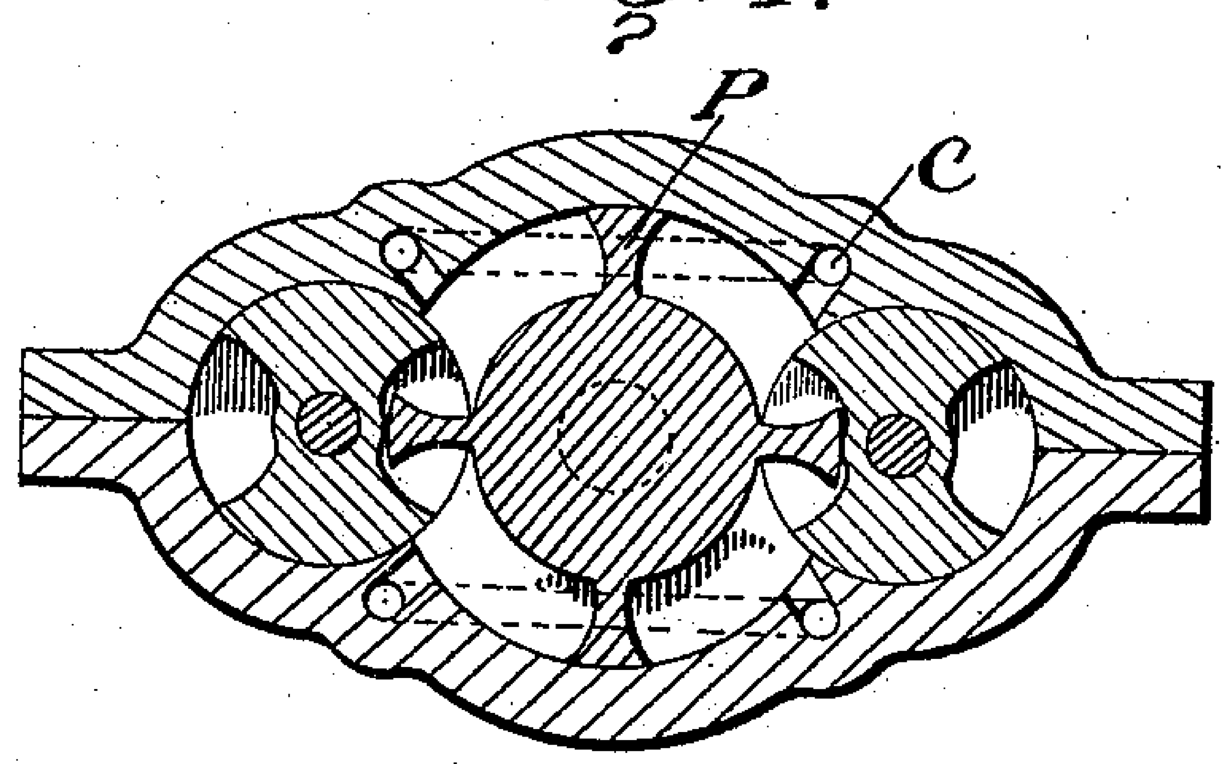


Fig. 2.

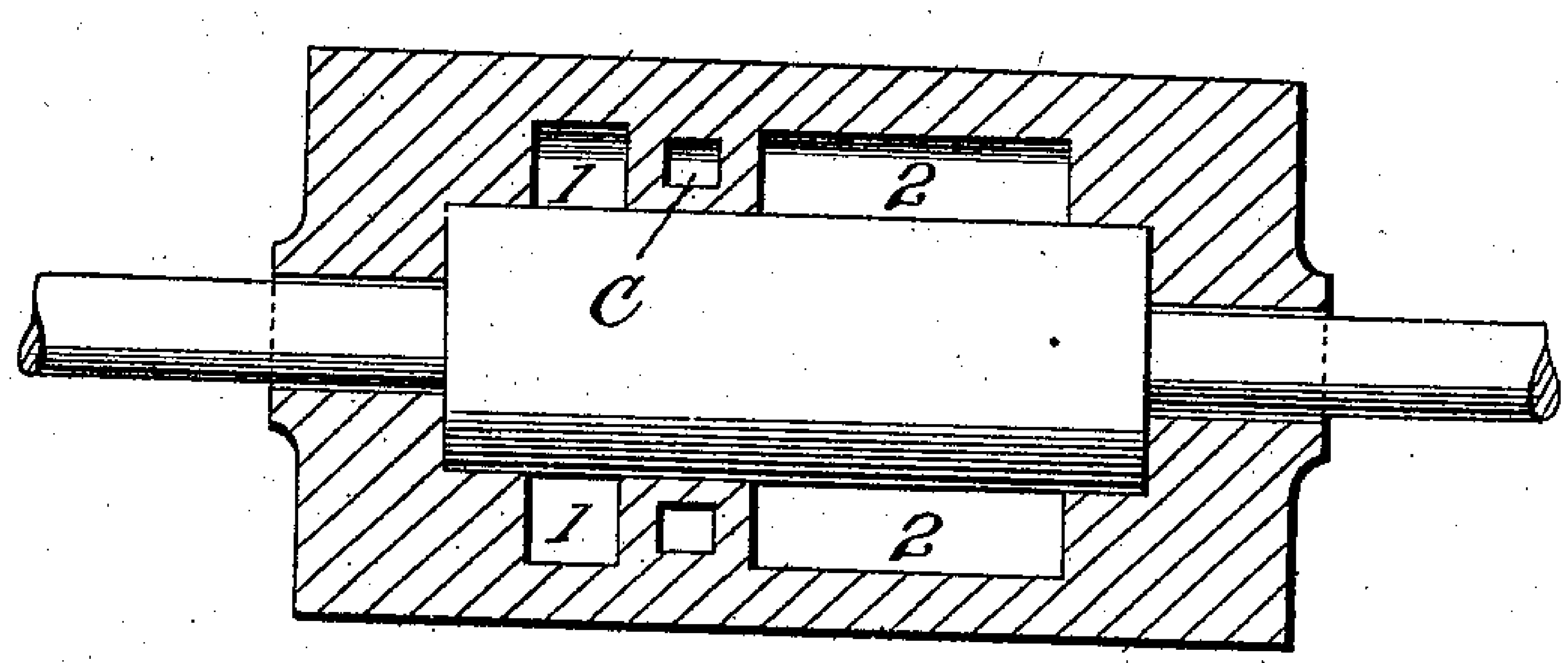
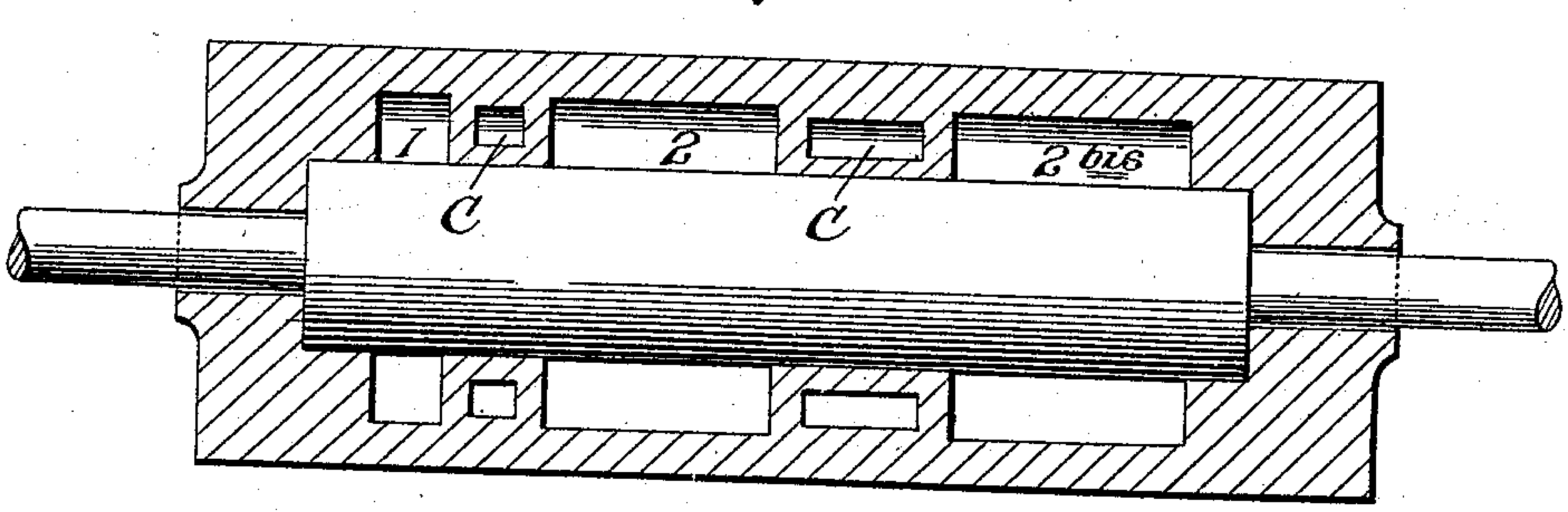


Fig. 3.



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2 SHEETS—SHEET 2.

Fig. 4.

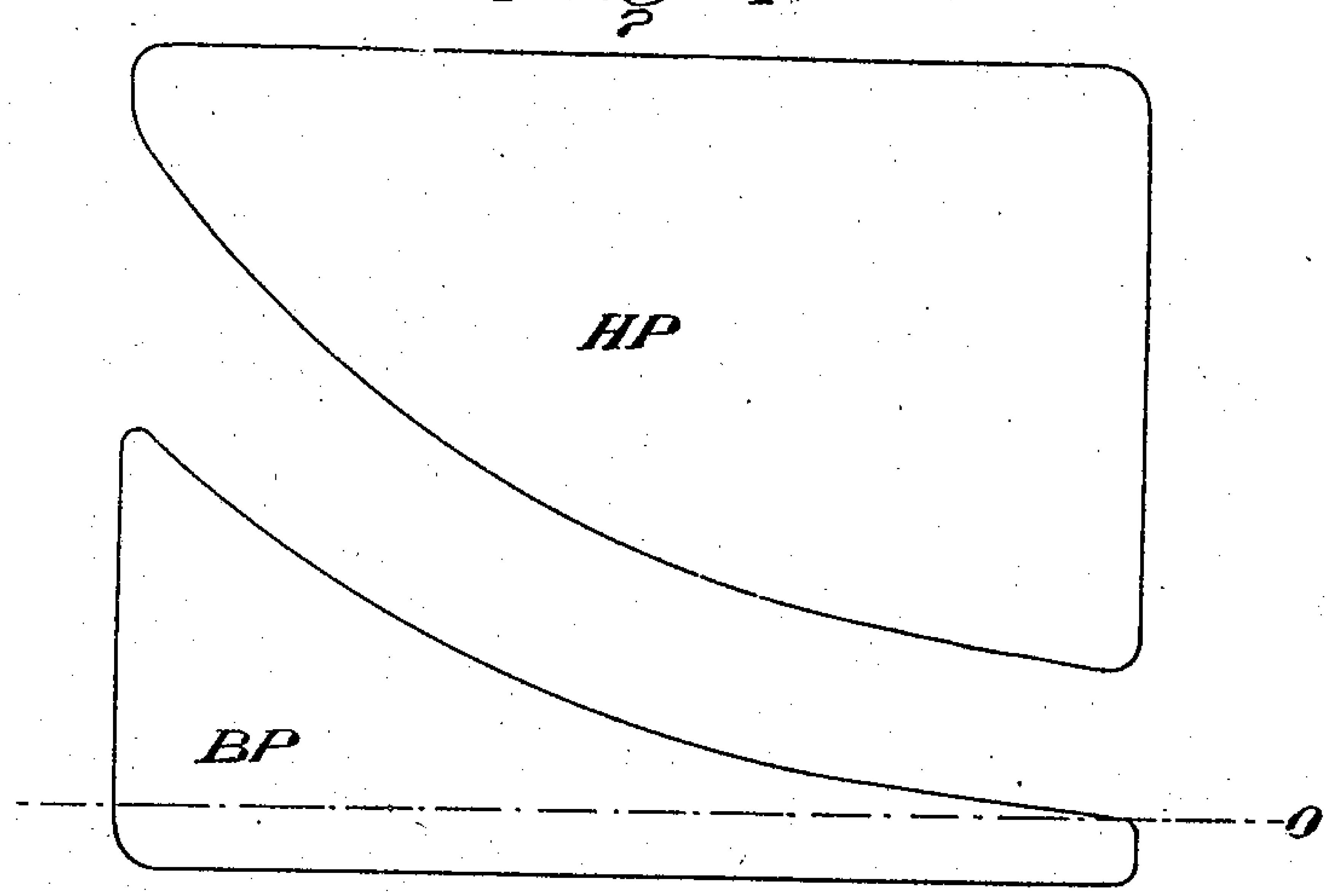
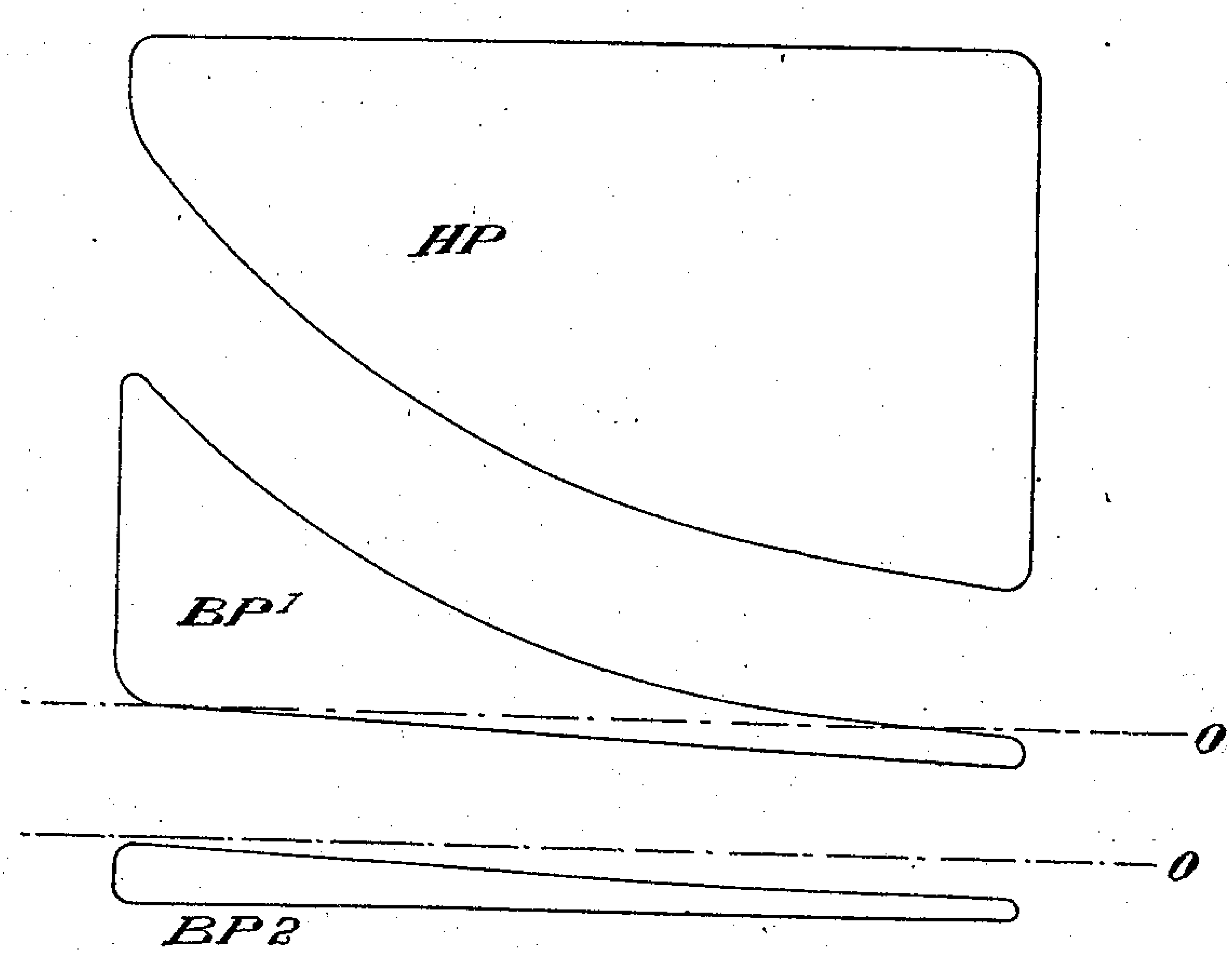


Fig. 5.



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UNITED STATES PATENT OFFICE.

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ENGINE.

No. 815,104. Specification of Letters Patent. Patented March 13, 1906.

Application filed June 21, 1904. Serial No. 213,573.

To all whom it may concern:

Be it known that I, Louis Jules Jean-Baptiste Le Rond, a citizen of the Republic of France, and a resident of Paris, France, have invented a new and useful Improvement in Engines or Pumps, which improvement is fully set forth in the following specification.

My invention relates to improvements in pumps or engines, and more especially consists in the provision of means for obtaining the benefits of steam-tightness and an economical working by the use of a recuperator constructon and without the employment of packings or other friction or rubbing means. This recuperator construction comprises a chamber or chambers associated—for example, in a double-expansion engine—either with the high-pressure chamber or the low-pressure chamber, its characteristic features being that the said chamber or chambers is or are of substantially the same size as the chamber with which it or they are associated, or an independent construction may be associated with both of said chambers.

It has been determined that if an ordinary double-expansion engine with high and low pressure chambers rendered steam-tight by packings, &c., is employed, this engine would render as much work as would an engine similar thereto, but to which has been added a cylinder or chamber substantially equal in size, for example, to the low-pressure chamber, if the latter engine were also steam-tight; but if the steam-tightness is not perfect in this latter construction the presence of this additional chamber effects a diminution of the escape of steam to the condenser and increases the pressure in the low-pressure chamber in a manner to be set forth in detail hereinafter.

In many cases it is very advantageous to use this recuperator construction instead of providing the engine or pump with packings—for example, in the case of rotary engines in which the linear displacement of the pistons being always considerable with relation to the work produced the packings when they are employed absorb a large proportion of the motor-work. Further, in ordinary reciprocatory machines superheated vapors cannot be employed at temperatures as high as can be used in turbines, because with the high temperatures used in the latter the lubricant burns and the segments wear with extreme rapidity even if they do not grip. This inconvenience of steam-tightness by packings and rubbing elements limits, therefore, the employment of the superheated fluid in the machines of reciprocatory movement or others, and in gas-motors of blast-furnaces one of the principal difficulties which has to be overcome results from the presence of carbon particles carried by the gas, which produce wear on the packings in the cylinders despite the lubricant.

From a technical point of view the novelty of the results consists in providing means for obtaining the same work secured with a machine furnished with packings with a machine employing no packings, and this characteristic will permit the application of such last-mentioned machines in cases where the ordinary motors supplied with packing would give only bad results or would not function—as, for example, in the case of the rotary motors, motors of superheated vapors, or of gas-motors used with blast-furnaces, to which reference has been made.

The invention will be better understood by reference to the accompanying drawings, illustrating the application of the invention to a rotary engine or motor, and in which—

Figure 1 is a transverse vertical sectional view through the high or low pressure chamber of an ordinary double-expansion engine or through the recuperator-chamber used in conjunction with said ordinary double-expansion engine. Fig. 2 is a longitudinal sectional view of an ordinary double-expansion engine. Fig. 3 is a longitudinal sectional view of a double-expansion engine embodying the recuperator device of the present invention. Fig. 4 illustrates diagrams of high and low pressure of an engine with two work-chambers, supposedly steam-tight; and Fig. 5 illustrates diagrams of an identical engine, but in which the steam-tight packings are replaced by a recuperator-chamber of the same dimensions as the low-pressure chamber.

Although the recuperating device of my invention may be placed at any part of the machine desired—as, for example, next to the high-pressure chamber—so long as said chamber or chambers are of substantially the same volume as that of the chamber with which it or they are associated, in view of the fact that the sole escapes of steam which constitute a complete loss are the escapes to the condenser, it is accordingly at the chamber of low pressure that it is best to apply the arrangement.

Referring to the drawings, passage c, Figs. 1, 2, and 3, is a conduit leading the escapement from the high-pressure chamber 1 to the admission of low-pressure chamber 2. Passage C, formed likewise, Fig. 3, leads the escapement from the chamber of low pressure 2 to the admission of the second equal-sized low-pressure chamber 2^{bis}. Under these conditions if it is supposed that the machines are completely steam-tight the machine represented by Fig. 3 would do no more work than that represented in Fig. 2. In fact, piston P, Fig. 1, of chamber 2, for example, will have in said chamber 2 on its upper face the motor-pressure M and on its lower face the counter-escapement pressure E. It will be subjected, therefore, to a motor effort equal to $M-E$. In Fig. 3 the piston P of chamber 2 will be subjected on its upper face to the motor-pressure M equal to the preceding. On its lower face it will be subjected to the intermediate pressure I, which reigns in the two communicating parts of the equal chambers 2 and 2^{bis}. The motor-pressure on the piston will therefore be equal to $M-I$.

The corresponding piston of chamber 2^{bis}, Fig. 3, will have on its upper face the intermediate pressure I and on its lower face the counter-pressure of escapement E. It will be subjected, therefore, to the motor-pressure $I-E$. The combination of the pistons P of the two chambers 2 and 2^{bis} will be subjected, therefore, to the motor-pressure

$$M-I+I-E=M-E,$$

that is to say, the same pressure as in Fig. 2.

Suppose now that the machines are not exactly steam-tight, which condition is almost necessary in rotary machines. The chamber 2 of Fig. 2 loses a certain part of its pressure, which will be proportional, on the one hand, to the mechanical play and, on the other hand, to the excess of the mean pressure M (indicated in Fig. 4, BP, of the first group of diagrams) over the counter-pressure E in the condenser. If E is the loss of pressure resulting, the motor-pressure will thus be reduced to $M-E$. The chamber 2^{bis} of Fig. 3 loses also a certain part of its pressure, which will be proportional to the same mechanical play and also to the excess of motor-pressure over the counter-pressure E; but here the pressure in 2^{bis} is the pressure I of escapement from the chamber 2—smaller than M. Consequently the escape from 2^{bis}, Fig. 3, will be smaller than the escape from 2, Fig. 1. The constant motor-pressure which acts in 2^{bis} is thus: $I-\alpha$, α being smaller than E. Note this first diminution of escape. Further, observe what passes in chamber 2: This chamber vents into chamber 2^{bis}, and it follows from this that there will be a certain loss of pressure η; but this leak is also proportional to the mechanical play, which remains the same, and to the difference of the pressure existing in the chambers 2 and 2^{bis}, a difference of pressure which is less than that which exists in Fig. 2 between chamber 2 and the condenser. It follows from this that $\eta<\varepsilon$. Therefore in substituting the construction of Fig. 3 for that of Fig. 2 we shall have, on the one hand, diminished the escape to the condenser and, on the other hand, increased the pressure in chamber 2. We shall see now approximately to what extent. If the escape is smaller than unity (which it must be in an operative machine) and equal, for example, to $\frac{1}{n}$ as this escape is proportional to the mechanical play of which it is the consequence, the mechanical play is also proportional to $\frac{1}{n}$. It will have, therefore, a value to a nearly constant coëfficient $\frac{1}{n}\times v$, v being the speed of flow of the fluid; but, on the other hand, this speed v increases with the difference of pressure and confines this difference in factor to a certain power δ. We have, consequently, in the case of Fig. 3 an escape of the order of $\left(\frac{1}{n}\right) 1+\delta$, which is smaller than $\frac{1}{n}$, whatever δ may be. If we admit in order to simplify that δ—1 and, for example, that $\frac{1}{n}=\frac{1}{3}$, we shall have the following results:

First. In the case of Fig. 3 the escape from 2^{bis} to the escapement will be of the order of $\frac{1}{3}$, and the escape from 2 into 2^{bis} will be of the order of $\frac{1}{9}$. If we admit, in order to simplify, by approximation that the escape from 2^{bis} is exactly $\frac{1}{3}$ and the escape from 2 exactly $\frac{1}{9}$, then the motor-pressure will be equal to

$$(M\times(1-\tfrac{1}{9})-(I-\alpha)\times(I-\alpha)-E=\tfrac{8}{9}\times M-E.$$

Second. In the case of Fig. 2 the escape ε is, as we have already demonstrated, larger than $\frac{1}{3}$; but admit even that it is only $\frac{1}{3}$, and the advantage of the construction of Fig. 3 will be no less evident, for we shall then have as a mean motor-pressure in Fig. 2:

$$M\times(1-\tfrac{1}{3})-E=\tfrac{2}{3}M-E, \text{ in place of } \tfrac{8}{9}M-E,$$

the result we found in the case of Fig. 3.

The diagrams represented in Figs. 4 and 5 correspond to the working of my valveless rotary machines, for which United States patents have been granted. Consequently the counter-pressure in a work-chamber is exactly the corresponding pressure in the following chamber. This understood, the first group of diagrams, Fig. 4, requires no further explanation. In the second group, Fig. 5, the motor-pressure of the chamber BP^2 would be constant if there were no escape to the condenser, and the work of this chamber would be represented by a rectangle.

The inclined and nearly straight line which bounds the diagram BP^2 at its upper part represents the deviation of the curve of the pressure by reason of the escape to the condenser. The line of counter-pressure of BP^1 is no other than this same line.

All that I have said in connection with two substantially equal-sized chambers applies *a fortiori* in the case of three or more chambers, and this is true at whatever point in the machine the recuperator construction may be placed, and this recuperator construction may be placed, if desired, after each of the chambers of a multiplex-expansion engine or like apparatus, whatever may be the number of said chambers.

This recuperator construction may be employed in the head of the machine to limit in a precise manner the quantity of vapor that can be admitted at each turn.

What I therefore claim as new, and being my invention, is—

1. In a motor or like apparatus actuated by fluid-pressure, the combination with a primary pressure-chamber having fluid inlet and exhaust ports and a piston working freely therein and permitting limited leakage or escape of the motive fluid to the exhaust-port, of a secondary pressure-chamber of approximately the same capacity as the primary chamber having inlet and exhaust ports the former connected to the exhaust-port of the primary chamber, and a piston working freely in the secondary chamber and permitting limited leakage or escape of the pressure fluid to the exhaust-port of the secondary chamber.

2. In a compound motor or like apparatus actuated by fluid-pressure, the combination with high and low pressure cylinders or chambers and pistons working freely therein and each permitting limited escape or leakage of motive fluid to its corresponding exhaust-port, of a secondary cylinder or chamber having approximately the same capacity as the low-pressure chamber and having inlet and exhaust ports the former connected to the exhaust-port of said low-pressure cylinder, and a piston working freely in said secondary chamber and permitting limited escape or leakage of motive fluid to the exhaust-port.

3. In a motor or like apparatus actuated by fluid-pressure, the combination with a primary pressure-chamber having fluid inlet and exhaust ports and a rotary piston working freely therein and permitting limited leakage or escape of the motive fluid to the exhaust-port, of a secondary pressure-chamber of approximately the same capacity as the primary chamber having inlet and exhaust ports the former connected to the exhaust-port of the primary chamber, and a rotary piston working freely in the secondary chamber and permitting limited leakage or escape of the pressure fluid to the exhaust-port of the secondary chamber.

4. In a compound motor or like apparatus actuated by fluid-pressure, the combination with high and low pressure cylinders or chambers and rotary pistons working freely therein and each permitting limited escape or leakage of motive fluid to its corresponding exhaust-port, of a secondary cylinder or chamber having approximately the same capacity as the low-pressure chamber and having inlet and exhaust ports the former connected to the exhaust-port of said low-pressure cylinder, and a rotary piston working freely in said secondary chamber and permitting limited escape or leakage of motive fluid to the exhaust-port.

In testimony whereof I have signed this specification in the presence of two subscribing witnesses.

LOUIS JULES JEAN-BAPTISTE LE ROND.

Witnesses:

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HANSON C. COXE.