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H. GRAF.

Rotary-Engine.

No. 218,874. Patented Aug. 26, 1879.

Fig. 1

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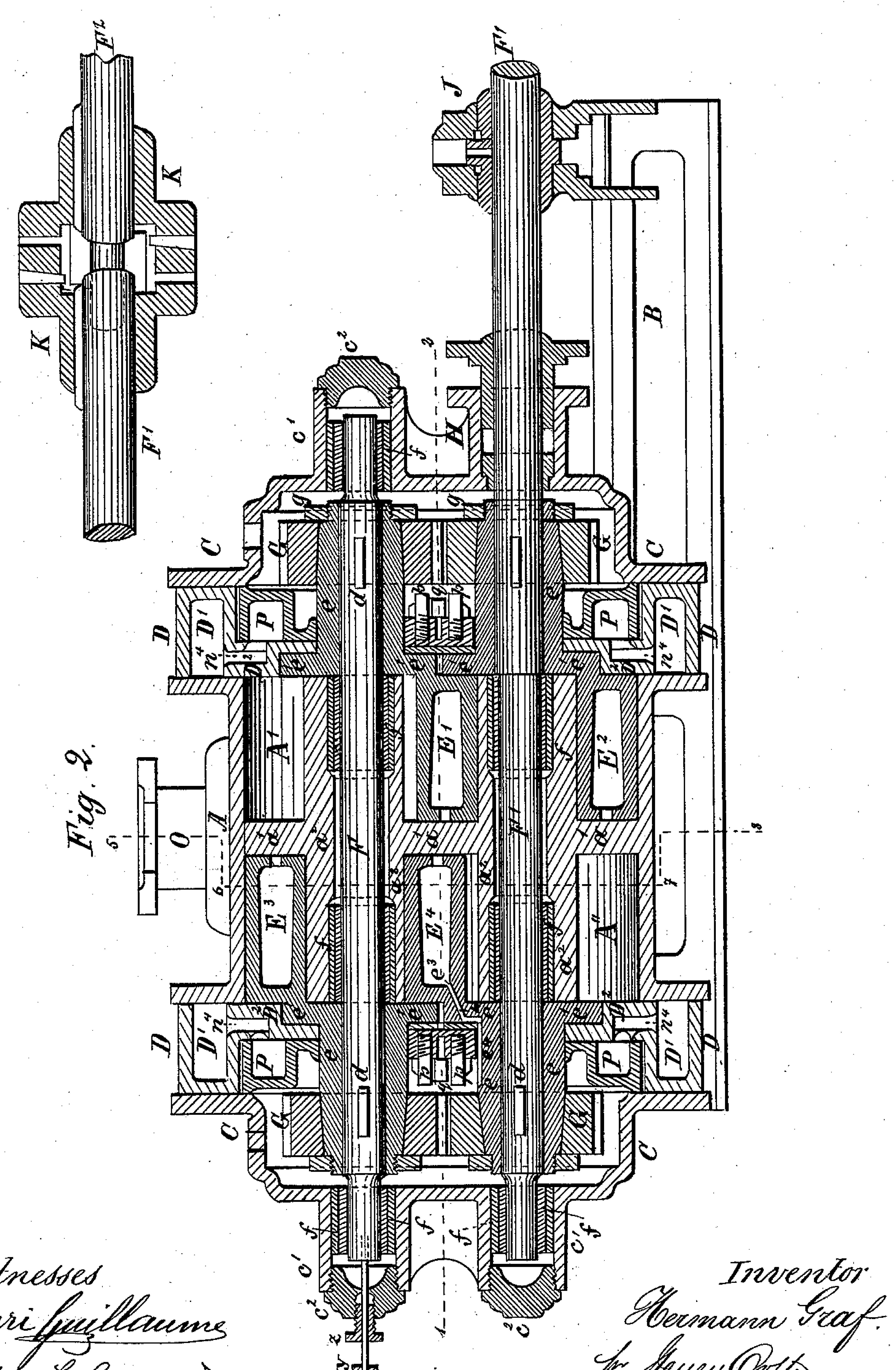

Fig. 2.

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Fig. 3.

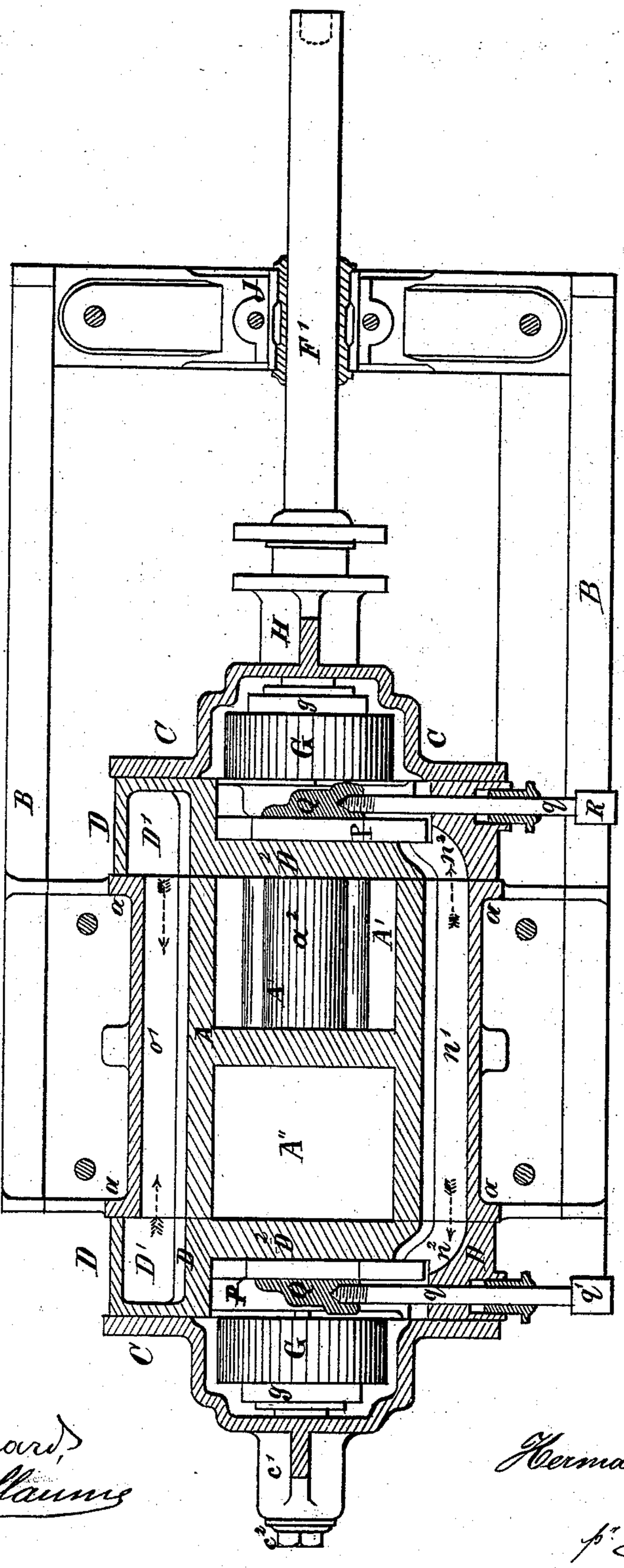

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Fig. 4.

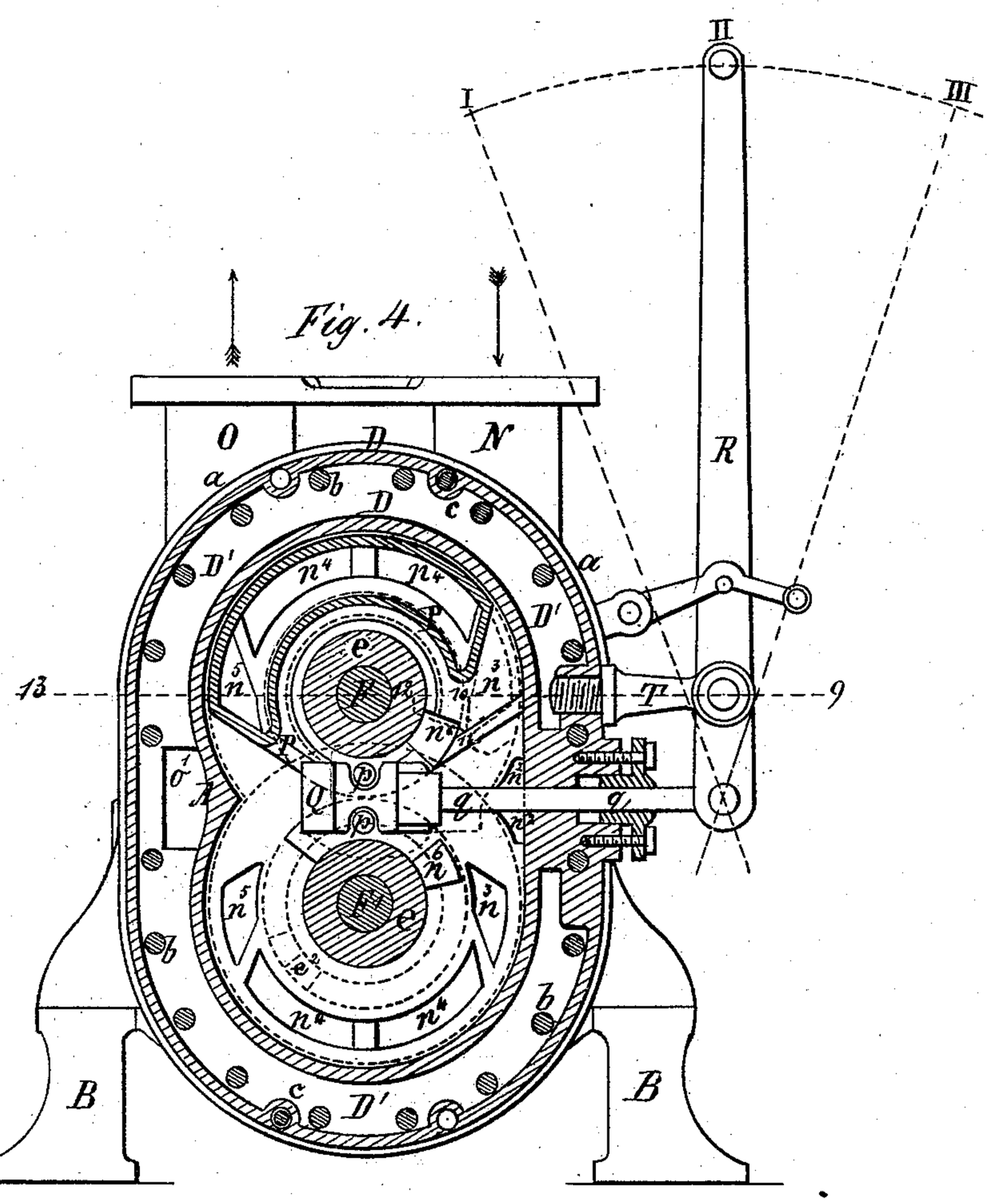

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Fig. 5.

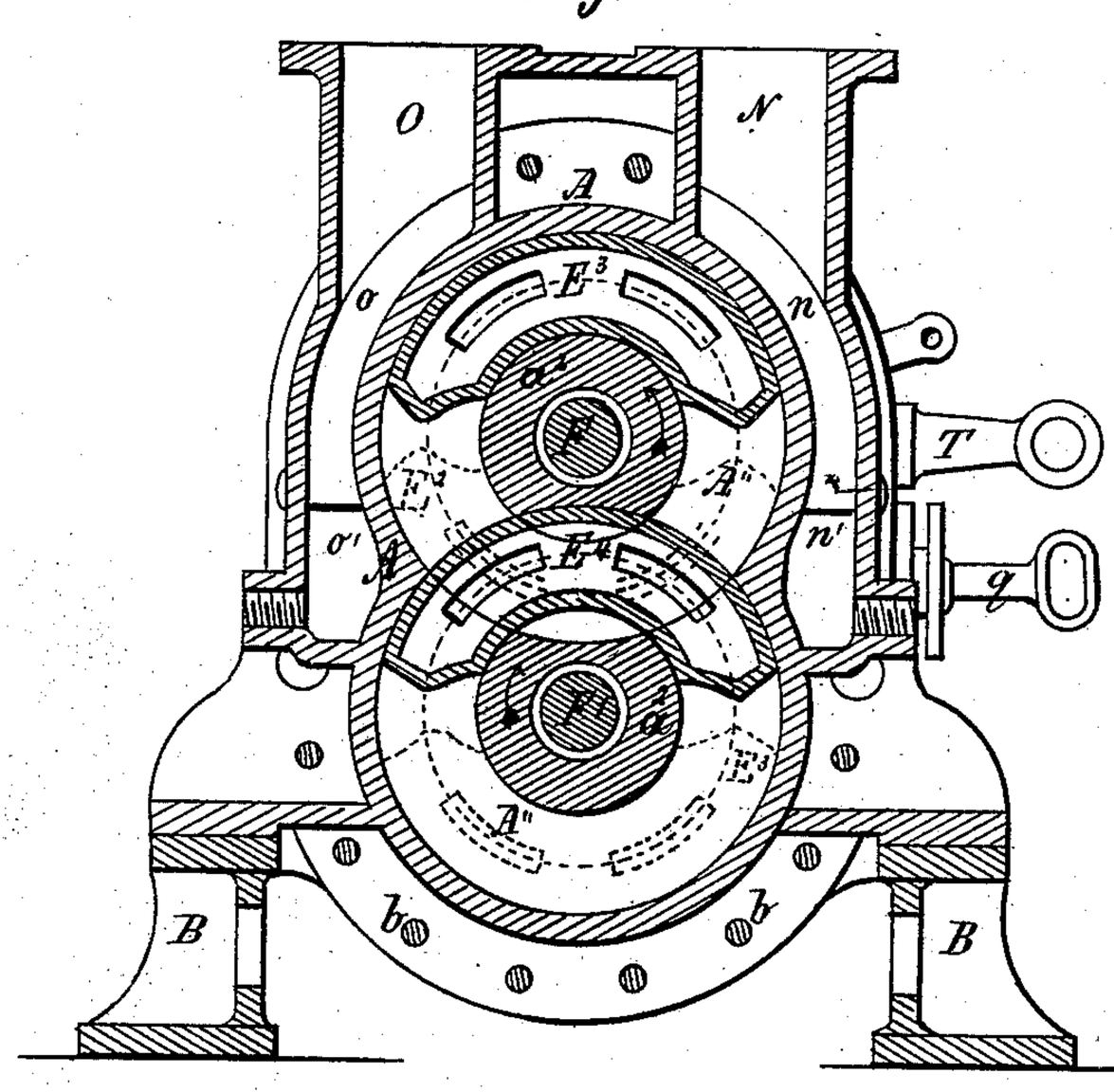
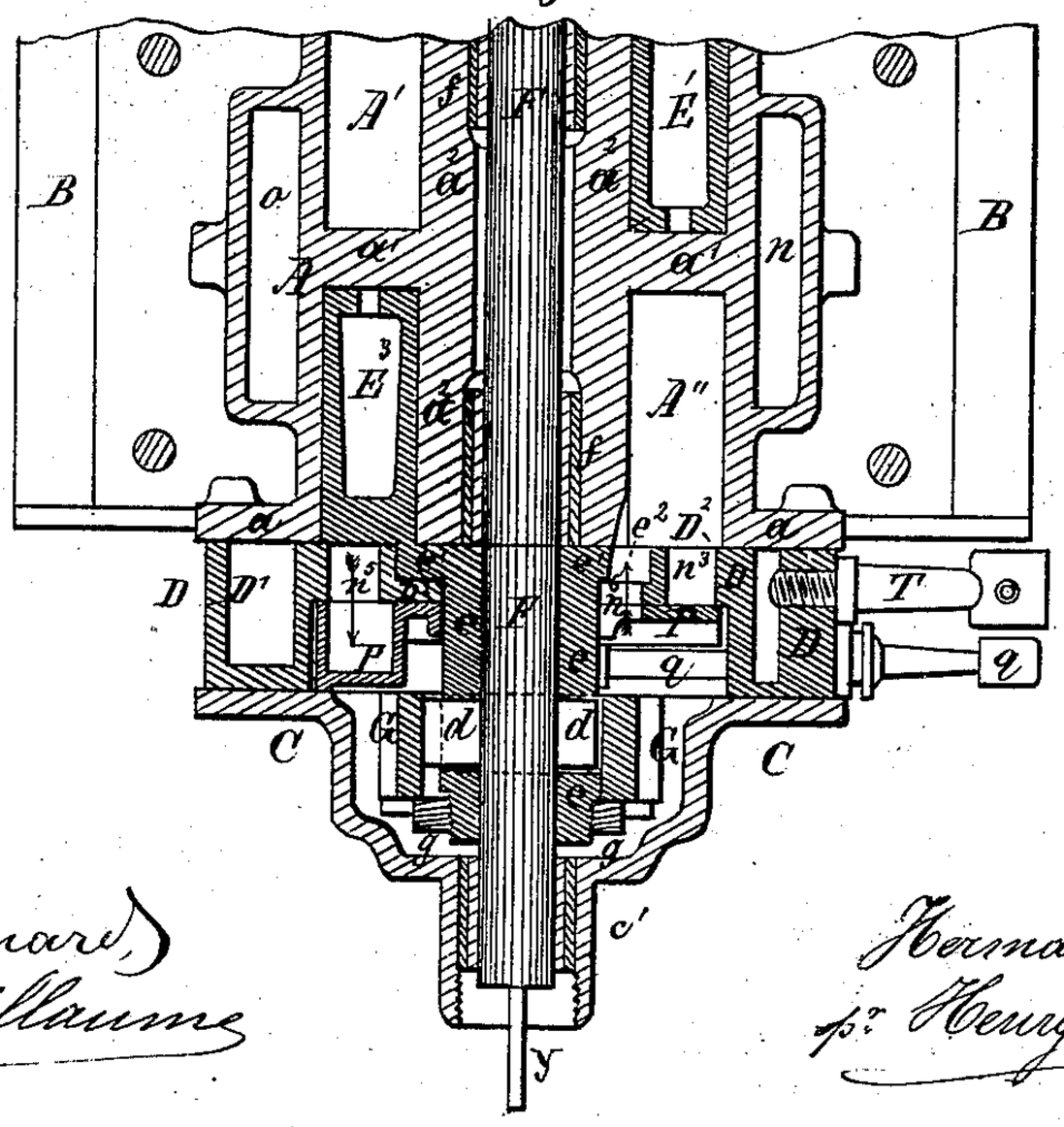


Fig. 6.



Witnesses
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UNITED STATES PATENT OFFICE.

HERMANN GRAF, OF ST. PETERSBURG, RUSSIA, ASSIGNOR TO PRINCE ALEXIS SERGUÉÉVITCH DOLGOROUKY, OF SAME PLACE.

IMPROVEMENT IN ROTARY ENGINES.

Specification forming part of Letters Patent No. **218,874**, dated August 26, 1879; application filed November 6, 1878; patented in France, October 3, 1878; in Italy, October 7, 1878; in Great Britain, October 12, 1878; in Belgium, October 12, 1878; in Germany, October 3, 1878; in Austria-Hungary, February 2, 1879.

To all whom it may concern:

Be it known that I, HERMANN GRAF, of the city of St. Petersburg, in the Empire of Russia, have invented new and useful Improvements in Rotary Steam-Engines, of which the following is a specification.

Patents for the said invention have been obtained in France under date of October 3, 1878; Belgium, October 12, 1878; Italy, October 7, 1878; Great Britain, October 12, 1878; Germany, October 3, 1878; and Austria-Hungary, February 2, 1879.

My invention has for its object an engine of new construction provided with rotating pistons, adapted for use as a motor, acting by pressure of steam, water, gas, or air as a suction or force pump for pumping liquids, gas, or air, and, lastly, as an apparatus for measuring liquids or gas.

In the accompanying drawings, Figure 1 is a side elevation of the engine; Fig. 2, a vertical longitudinal section; Fig. 3, a horizontal section taken on line 1 2 of Fig. 2. Figs. 4 and 5 are vertical sections on lines 3 4 and 5, 6, 7, and 8, respectively of Fig. 2. Fig. 6 is a horizontal section taken on the irregular line 9, 10, 11, 12, 13, and 14 of Fig. 4.

The engine consists of a central cast-iron body or casing, A, of double cylindrical form, Fig. 5, bolted to a bed or foundation plate, B. The casing A is provided with flanges *a*, to which the heads C are bolted by means of bolts *b*, Figs. 1, 4, and 5.

Between the heads C and the casing A are located the valve-casings D, kept firmly in their places by the bolts *c*, Fig. 4. Within the casings D are located the distributing-valves and reversing-slides. (More fully described hereinafter.)

The interior of the main or piston casing A is divided into two equal compartments or chambers, A′ A″, by a central partition, a^1, cast in one piece with the tubular cores or hubs a^2. Within the annular chambers A′ A″ formed by said partition a^1 are located the four pistons E^1 E^2 E^3 E^4, which latter revolve freely in their respective chambers. These pistons are of segmental form in cross-section, and are arranged in their chambers by pairs with perfect symmetry. They are provided with naves or hubs *e*, and are rigidly mounted upon the steel axes or shafts F F^1 by means of keys *d*.

The hubs *e*, at the point of junction with the pistons, are provided with flanges e^1, carefully turned concentrically with the shafts F, and fitting accurately in corresponding cavities formed in the walls of the casings D, as shown in Fig. 2.

Upon the outer end of the hubs *e* are mounted the steel pinions G G, of equal diameter, arranged in pairs on opposite ends of the piston-casing A, and gearing into each other, so as to cause both pairs of pistons and their respective shafts to revolve simultaneously.

In order to secure the firm position of the pinions G on the hubs *e*, the side surface of the latter is formed slightly conical, and screw-threaded to receive the nuts *g* pressing against the pinions G. The projecting part of the keys *d*, Figs. 2 and 6, enter into corresponding grooves formed in the nuts *g*, whereby the pinions G are firmly held against rotary or longitudinal motion upon and independently of the pistons and the shafts.

The ends of the shafts F F^1, being of a slightly-conical shape, form pivots or trunnions, which are incased in two hard-steel sleeves, *f f*, carefully turned and adjusted to each other, the inside sleeve being driven upon the end of the shaft, while the outside sleeve is fitted within the tubular bearing c^1 of the heads C, said bearing being cast with the head, as shown in Figs. 1, 2, and 3. Similar steel sleeves support also the middle parts of the shafts F F^1, Figs. 2 and 6, while the outer ends of the bearings c^1 are closed by screw-caps c^2. Both ends of the upper shaft and one end of the lower shaft are thus supported in tight bearings formed by the steel sleeves *f f*, the tubular bearings c^1, and screw-caps c^2. The other end of the lower shaft passes out through the head C, which is provided for the purpose with a stuffing-box, H, of usual construction, and is supported by the bearing J, mounted upon the bed-plate B. This latter or lower shaft acts as a driving-shaft, and is connected with a transmission-shaft, F^2, of some working mechanism by means of a coupling, K, or in some other manner.

Steam is admitted by the pipe L, through a

tap and valve of ordinary construction, and leaves the engine by the pipe M. Thus the live steam always enters the engine by pipe N, which is cast in one piece with the piston-casing A, and the exhaust-steam leaves the engine by a pipe, O, also cast in one piece with casing A. From pipe N the live steam passes into passage n, thence into passage n^1, which communicates with the passage n, and from thence to both ends of the engine, as shown by Figs. 3 and 5, to fill the heads C. To that effect the walls D^2 of the valve-casings D are provided with ports or passages n^2, which are constantly open. The vertical partitions or walls D^2 of the casings D are further provided with the passages n^3 n^3, n^4 n^4, n^5 n^5, and n^6 n^6, by means of which steam is admitted into and exhausted from the piston-casing A.

The steam is exhausted in the following manner: On the hubs e of the pistons are loosely mounted the distributing-valves P, one upon each hub, said valves having the form of flat sectors, and covering a little more than one-half of the circumference. The outside part of each valve has the form of a hollow segment or box, covering the passages n^4 and n^5. On the inner ends of the sectors P are screwed the pins p, which fit in corresponding grooves or cavities formed in the reversing-slides Q. The latter are connected, by means of the rods q, one to a crank-arm, q', and the other with the lower end or short arm of a reversing-lever, R, said crank q' and reversing-lever being rigidly mounted upon a shaft, S, which has its bearings in the arms T, attached to casings D, as fully shown by Figs. 1 and 4. When the reversing-lever R, Fig. 4, is moved from the vertical position II into position I, which corresponds to working under full head of steam, the slides Q, acting upon pins p of the sector-valves P, will turn the valves in such position as to open the passages n^3 n^3. Although the passages n^4 at the time are partially shut, it has no influence on the action of the engine.

As the passages n^3 pass clear through the walls of the casings D, and, with due position of the valves P, connect the interior space of the heads C with the chambers A′ A″ of piston-casing A, therefore when the valves P are set to establish this communication through passages n^3 the live steam, filling the heads C, as above stated, will enter chambers A′ A″ and act upon the pistons and rotate them in the direction shown by the arrows in Fig. 5, to rotate the shafts F F^1.

When the valves are in the position above described the live steam will constantly act on one or the other of the pistons with full pressure, and as long as the engine is working the four passages n^3 will never be closed at the same time. These passages are closed by turn by the end walls of the pistons lying close to the vertical walls of the casings D. The exhaust-steam issues on the opposite sides of the engine from passages n^5, which, like passages n^3, pass through the inner vertical wall of the casing D. From these passages the exhaust-steam passes from the chambers A′ A″ into the hollow segments of the valves P, Fig. 6, thus establishing communication between the passages n^5 and n^4, which latter are formed in the front face of the inner wall or partition, D^2 of casings D, and from the passages n^4 the exhaust-steam passes into the annular chamber D^1 of the casings D, thence through passage o', Figs. 3 and 5, into pipe O, and, lastly, into the escape-pipe M, Fig. 1.

To obtain a more economical working of the engine, I employ means for using the steam by expansion—*i. e.*, for stopping or suspending the supply of steam when desired. For this purpose the inner vertical partition-wall, D^2, of each casing D, is provided with two more steam-passages, n^6, passing through said partitions, Figs. 4 and 6, which are closed when working under full pressure of steam by the flat part of the valves P; but when the reversing-lever R is brought into position II, Fig. 4, the passages n^6 are opened or uncovered, and the latter will then coincide with the openings made in the flat part of the valves P, being of like form with them.

The passages n^6 are arranged exactly in the cavities wherein the flanges e^1 of the piston-hubs e are placed. (See Figs. 2 and 6.) These flanges are provided with passages e^2, (shown in Fig. 6, and in dotted lines in Fig. 4,) and when these passages e^2 coincide with passages n^6, the communication between the interior space of the heads C and the chambers A′ A″ is re-established—*i.e.*, the entering of steam into these chambers is taking place; but as soon as, by the further motion of the pistons, the passages n^6 are closed by the whole part of the flanges e^1, the steam is cut off from chambers A′ A″, and said steam is then acting by expansion.

The length of time during which steam is admitted depends on the size of the passages e^2 and n^6, thus making it possible to change or vary the degree of expansion within certain limits. In the case represented in the drawings, the steam is acting with full pressure to about one-third of the working-stroke of the pistons.

Moreover, the above-described construction of engine permits a change of direction to the rotation of the pistons to reverse the direction of motion, as it is evident that when the lever R is brought from position I, corresponding to expansion into position III, Fig. 4, the slides Q will turn the distributing-valves P in such position as to close the passages n^6. The passages n^3 then communicate, by means of the hollow or chambered part of said valves P, with the passages n^4 to allow the steam to escape, while the passages n^5 are opened to admit steam, which will act upon the pistons and cause them to rotate in a reverse direction to that indicated by arrows Fig. 5, and consequently reverse the motion of the shafts F F^1.

This reversal of the distribution of the steam and consequent motion of the engine may also be effected by means of a four-way distribut-

ing-cock, of usual construction, placed on top of the piston-cylinder A, to allow the steam to pass to the pistons in the direction wanted, as will be readily understood. This latter arrangement would greatly simplify the construction of the engine, and, under some circumstances, offer material advantages, as the distributing-passages would then become superfluous, except, however, the expansion-passages n^6.

It will be observed that, in consequence of employing four pistons symmetrically arranged upon the shafts F F^1 within the chambers A′ A″, said shafts are completely balanced in the transversal direction, because the live steam enters from either end, and the upper shaft, being placed altogether inside the engine, is also balanced in a longitudinal direction. As to the lower or driving shaft, F^1, one end of which passes out of the engine, in order to balance it longitudinally, the piston E^4 is provided with a steam-passage, e^3, Fig. 2, communicating with the valve-casing D by means of the steam-passage e^4, by which live steam enters into the interior space of said piston, and presses it against the vertical left-hand partition D^2 of the casing D^1, balancing the steam-pressure acting upon the lower shaft, F^1, in the opposite direction.

In order to ascertain the number of revolutions of the engine, the shaft F is provided at its small end with a rod, *y*, passing through the screw-cap c^1, provided with a stuffing-box, *z*, said rod being connected with any of the usual registering devices.

The principal advantages derived from the above-described improved construction of rotary engine are the following: First, the economical use of steam depending on the expansion in the proposed engine; second, the solid construction of the motor and the diminished wear of its parts; third, the regular even working and considerable number of revolutions of the motor obtained in consequence of its perfect equilibrium, securing at the same time an increase of working-power; fourth, the facility and rapidity with which the reversal of motion may be effected.

Having thus described my invention, what I claim, and desire to secure by Letters Patent, is—

1. In a rotary steam-engine, the central double cylindrical casing A, divided by a partition, a^1, into two piston-chambers, A′ A″, and provided with steam-passages $n\ n^1\ o\ o'$, the casings D, provided with induction and eduction ports, and located at opposite ends of said central casing, the valves P, having a chambered or hollow portion, as described, and the heads C, arranged in relation to each other that the steam may be admitted to and exhausted from said chambers A′ A″ at opposite ends of the engine, all combined, constructed, and operating as and for the purpose specified.

2. In a rotary steam-engine, the pistons E^1 E^2 E^3 E^4, having elongated conically-shaped hubs *e*, with their described flanges e^1, in combination with the shafts F F^1 and the pinions G G G G, all arranged, constructed, and operating substantially as described.

3. In a rotary engine, the combination, with the pistons E^1 E^2 E^3 E^4, having hubs *e*, provided with flanges e^1 and ports e^2, of the valve-casings D D, the wall D^2 of which is provided with steam-passages n^6, and the valves P, all arranged, constructed, and operating substantially as and for the purpose specified.

4. In a rotary steam-engine, the piston-casing A, divided into two chambers, A′ A″, the pistons E^1 E^2 E^3 E^4, and the shafts F F^1, arranged in relation to each other, as set forth, in combination with the heads C and valve-casings D, the walls D^2 of which are provided with induction-passages $n^3\ n^5$, and the sector-valves P, all arranged, constructed, and operating substantially as shown and described.

5. In a rotary steam-engine, the combination of the pistons E^1 E^2 E^3 E^4, the valve-casings D, and valves P, having the chambered or hollow portion described, and the chambers D^1, with the induction-ports $n^3\ n^3$ and eduction-ports $n^4\ n^5$, all arranged and operating substantially as and for the purpose specified.

6. In a rotary steam-engine, the reversing-slides Q, arranged to be actuated by a suitable reversing-lever, in combination with the segmental valves P, having the flat and hollow sections or parts, substantially as described, and constructed to operate as set forth.

7. In a rotary engine, the combination, with one of the valve-casings D and its sector-valve P, of the piston E^4, the flange and hub of which are provided with a steam-passage, $e^3\ e^4$, communicating with said casing D, substantially as and for the purpose specified.

8. In a rotary engine, the casing A, having steam-passages $n\ n^1\ o\ o'$, and divided into two annular chambers by means of the partition a^1 and the hubs a^2, in combination with the shafts F F^1 and the pistons E^1 E^2 E^3 E^4, having conical hubs *e*, provided with flanges e^1, geared together as described, all constructed, arranged, and operating as set forth.

9. In a rotary engine, the double cylindrical casing A, having induction and eduction pipes N O, induction and eduction passages $n\ n^1\ o\ o'$, the valve-casings D, having induction-passages $n^2\ n^3$ and eduction-passages n^4 n^5, and forming the chambers D^1, the heads C, having bearings c^1, and stuffing-box H, the shafts F F^1, the pistons E^1 E^2 E^3 E^4, the pinions G, and valves P, and suitable means to operate said valves, all constructed and operating substantially as described, for the purpose specified.

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

HERMANN GRAF.

Witnesses:

NICHOLAS TSCHEXALOFF,

LUDWIG VOSS.