No. 824,559. PATENTED JUNE 26, 1906.

H. L. MAILLARD.

ROTARY EXPLOSIVE ENGINE.

APPLICATION FILED MAR. 16, 1904.

5 SHEETS—SHEET 1.

Fig. 1.

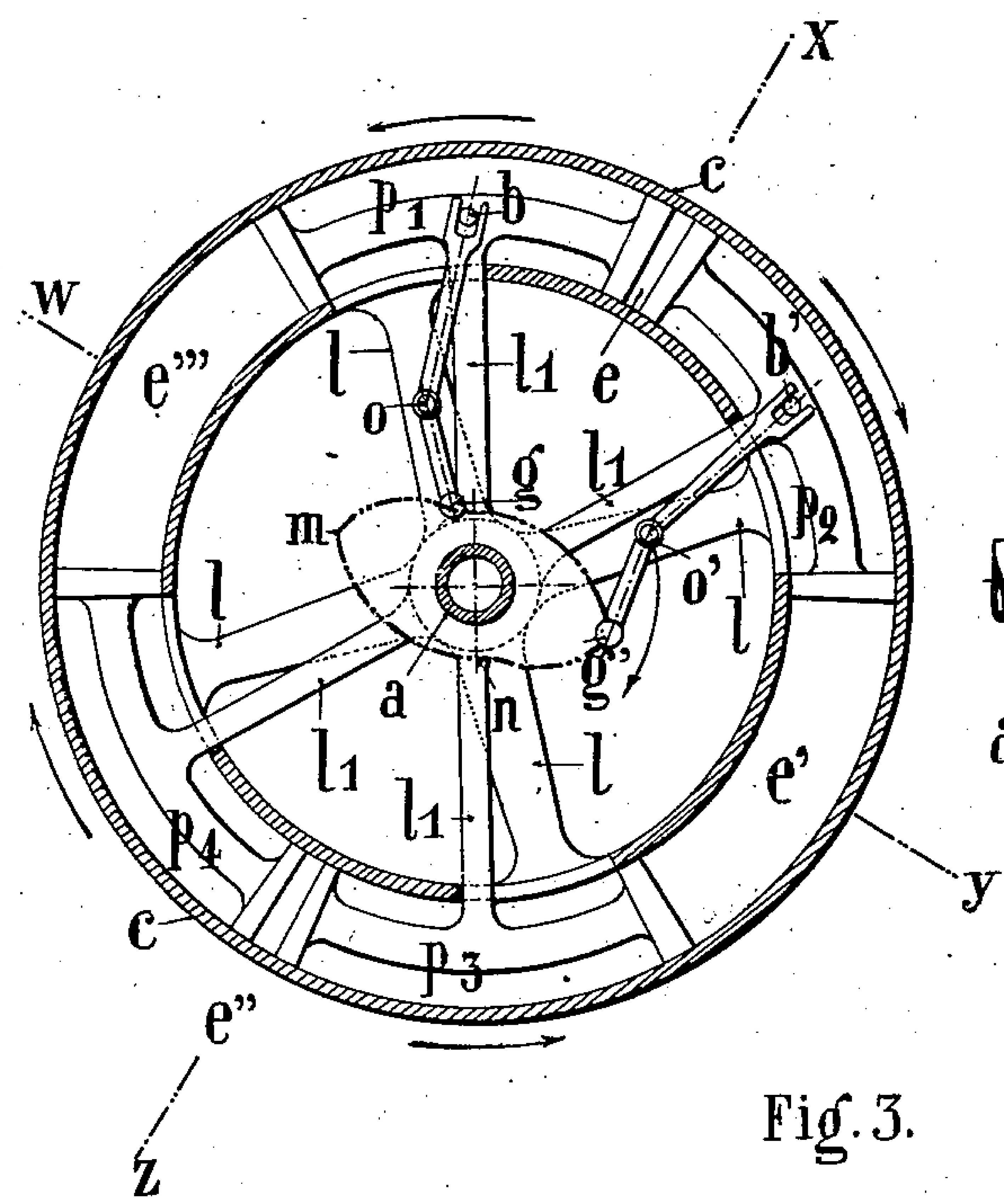


Fig. 2.

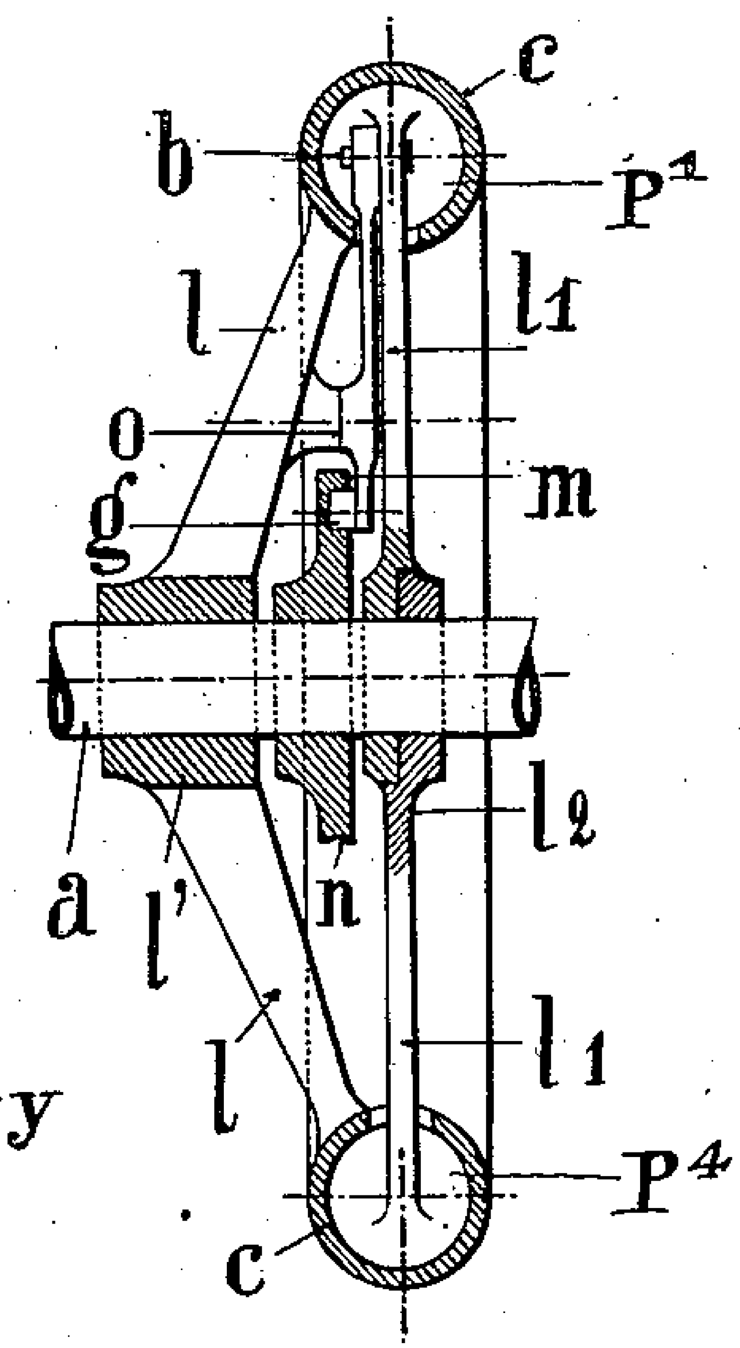
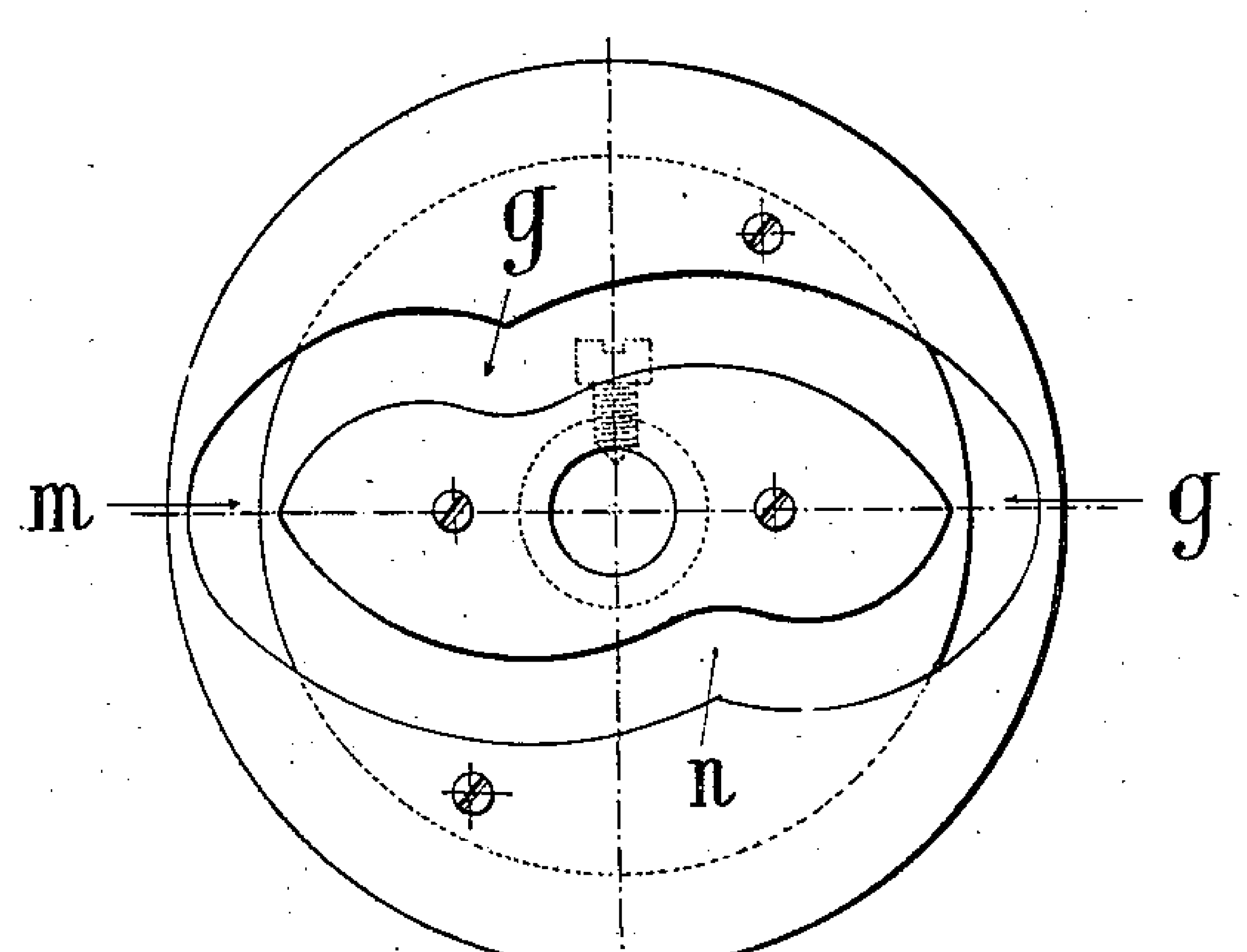


Fig. 3.



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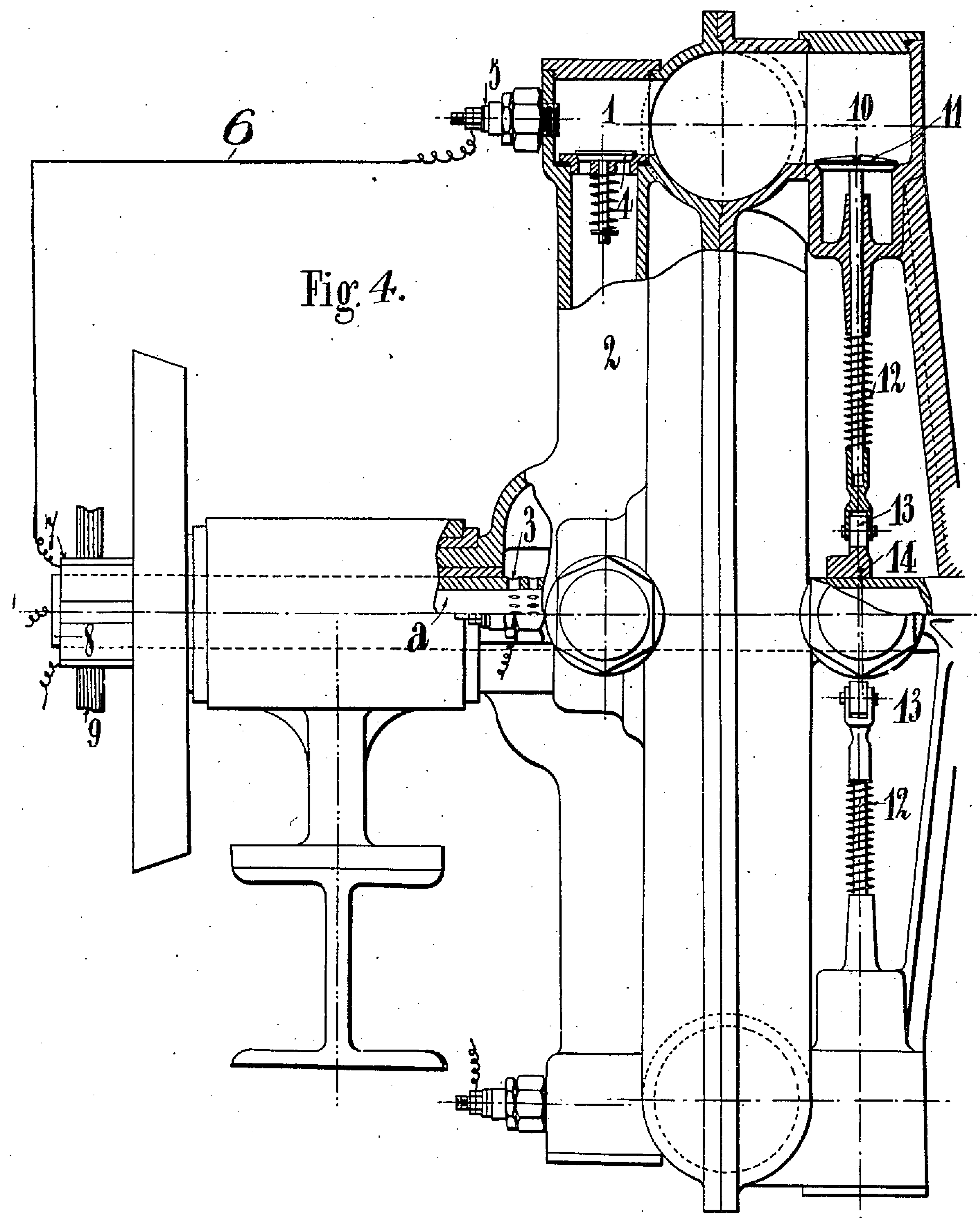

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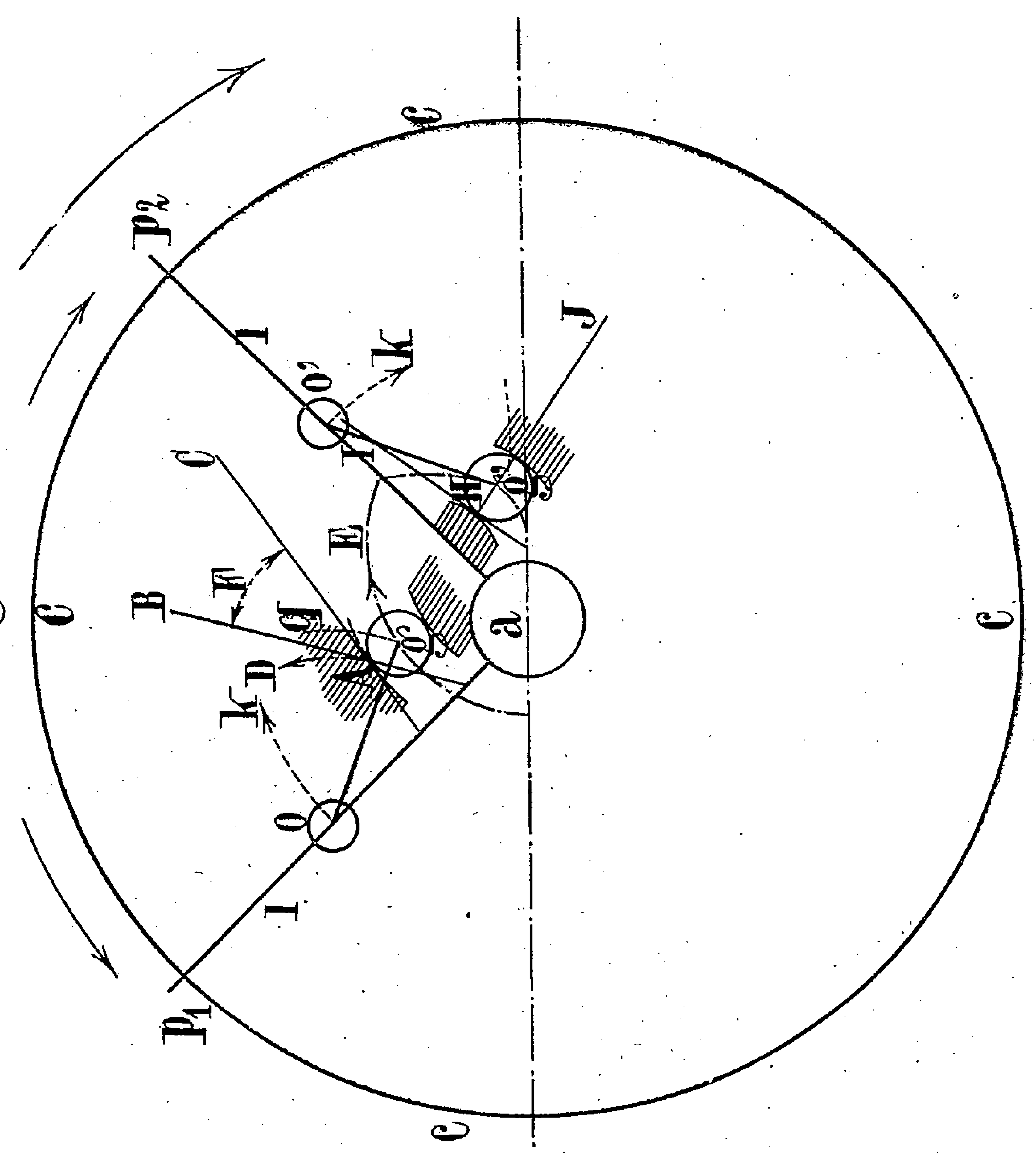
5 SHEETS—SHEET 3.

Fig. 5.



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5 SHEETS—SHEET 4.

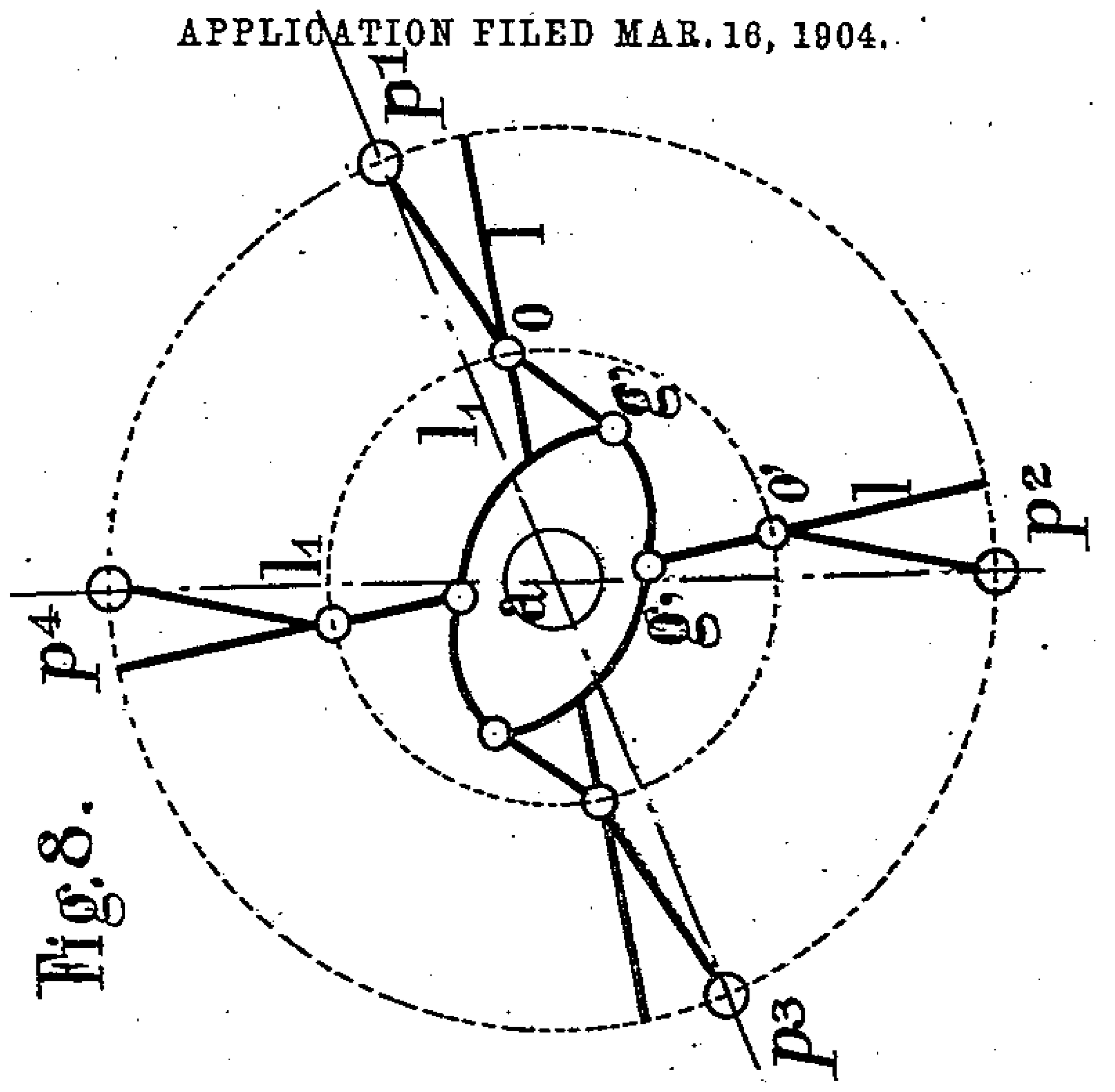

Fig. 8.

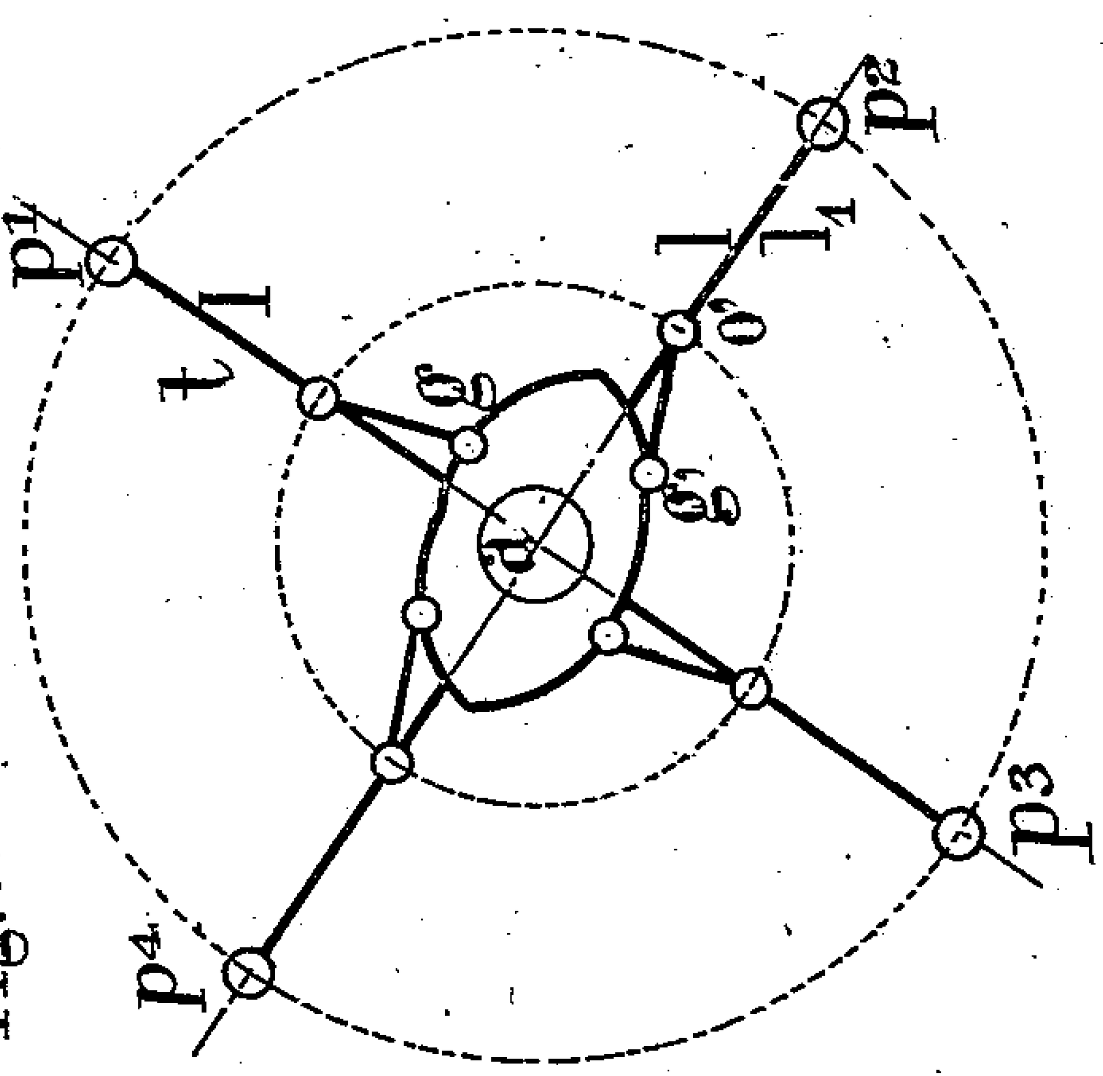

Fig. 7.

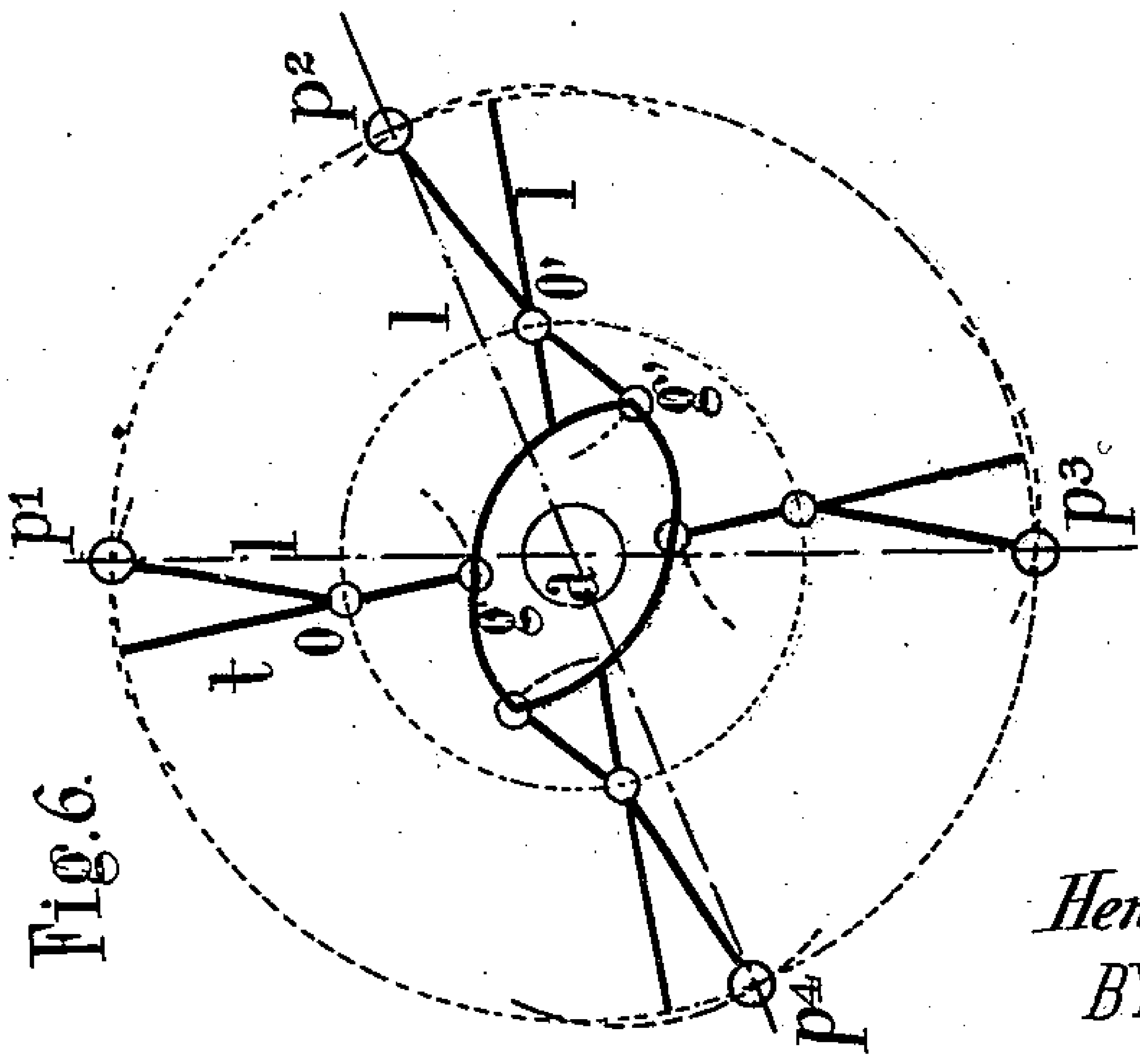

Fig. 6.

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5 SHEETS—SHEET 5.

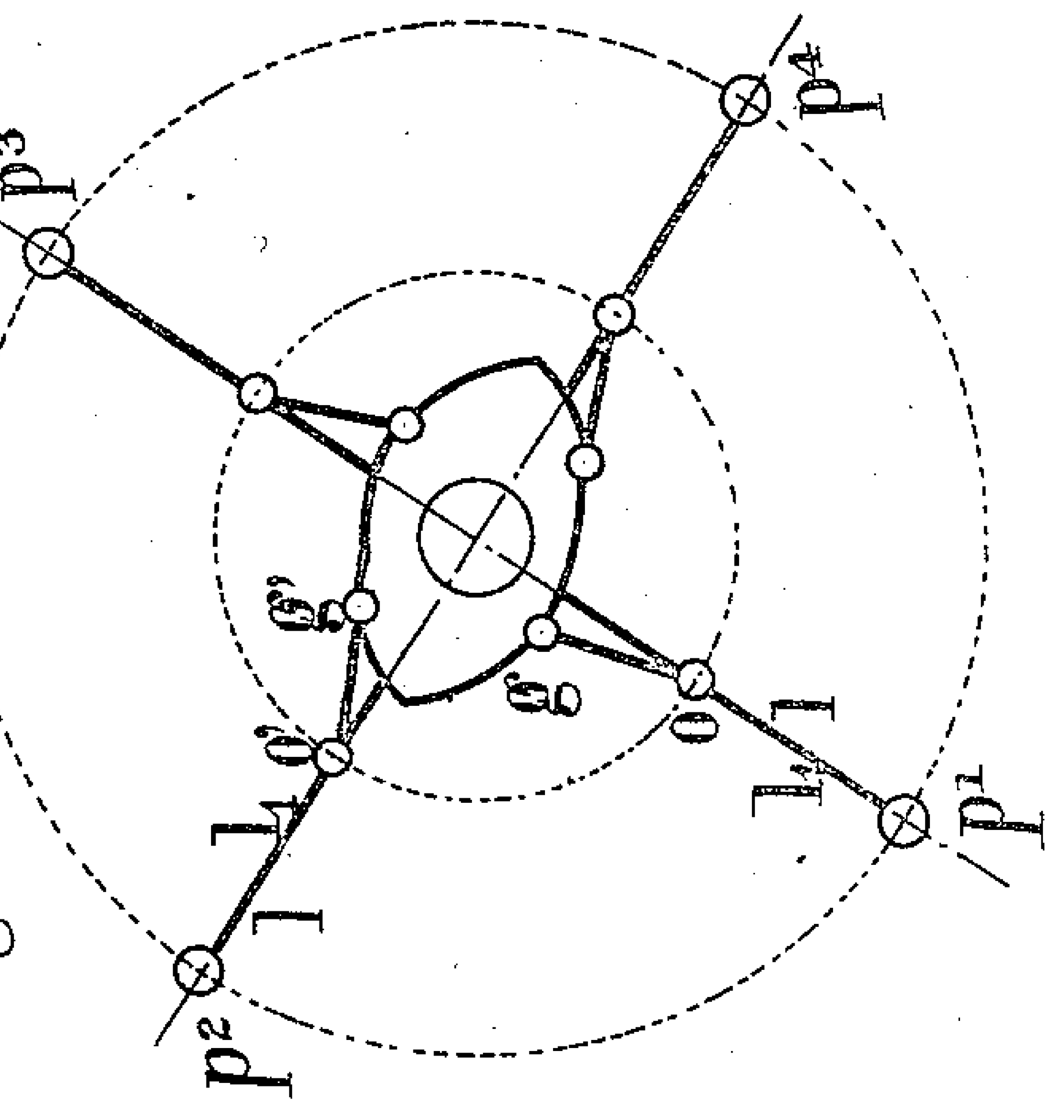

Fig. 11.

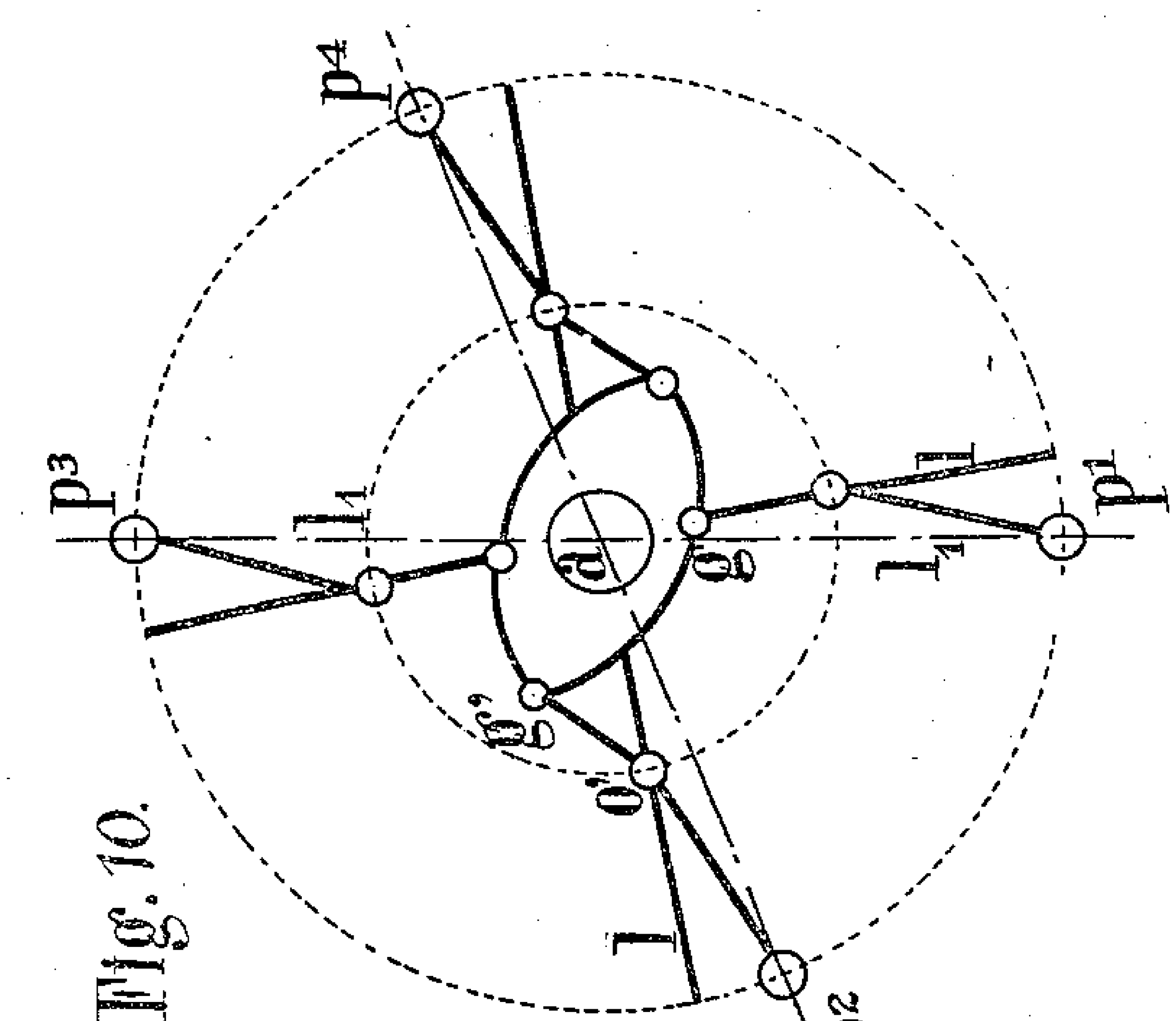

Fig. 10.

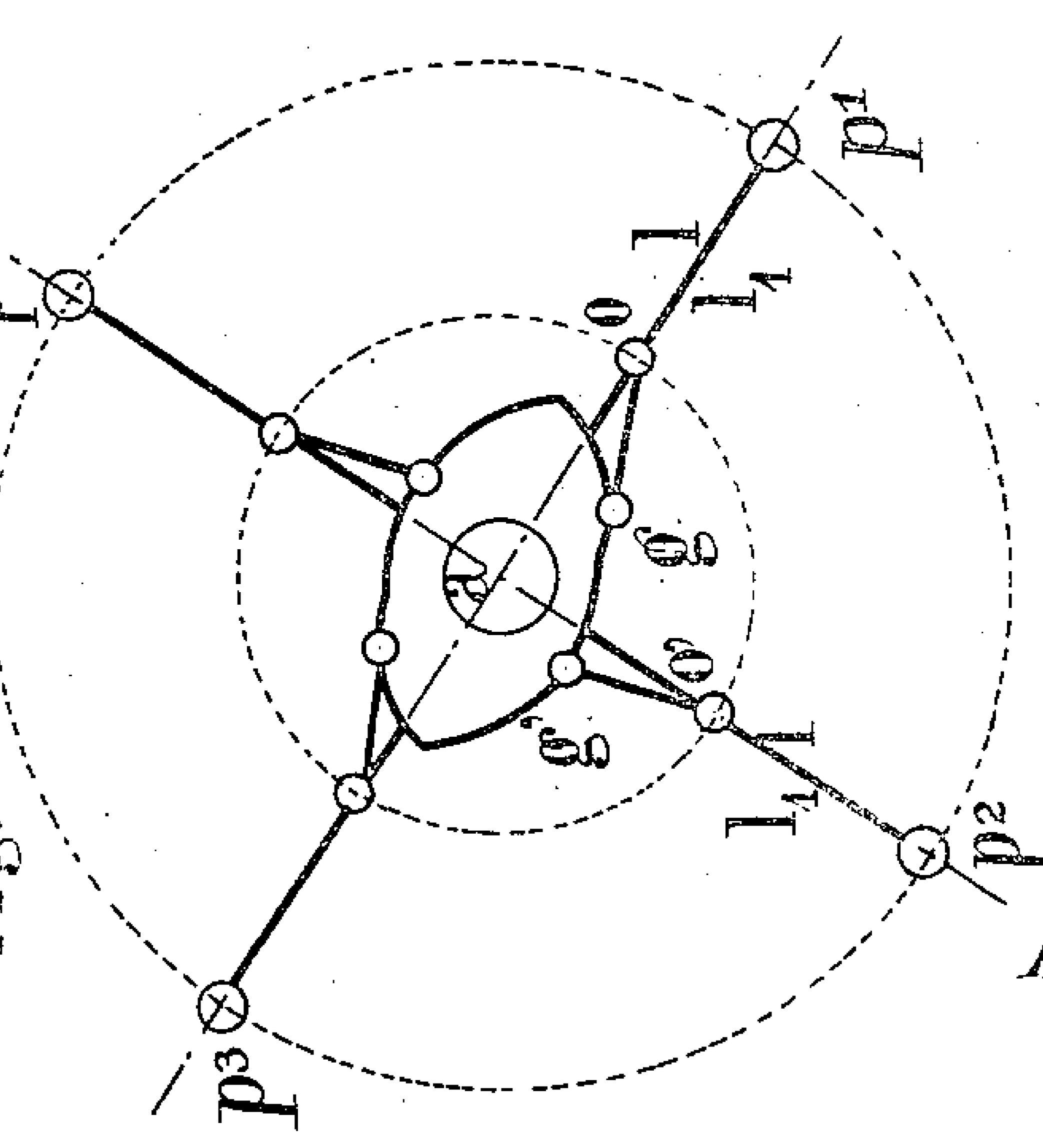

Fig. 9.

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UNITED STATES PATENT OFFICE.

HENRI LÉON MAILLARD, OF PARIS, FRANCE.

ROTARY EXPLOSIVE-ENGINE.

No. 824,559. Specification of Letters Patent. Patented June 26, 1906.

Application filed March 16, 1904. Serial No. 198,520.

To all whom it may concern:

Be it known that I, HENRI LÉON MAILLARD, a citizen of the Republic of France, and a resident of Paris, France, have invented new and useful Improvements in Rotary Explosive-Engines, which improvements are fully set forthin the following specification.

This invention relates to a rotatory engine which will work under the action of any compressed fluid, and also as an explosion or internal-combustion engine.

This rotatory engine, occupying a little space and being very light, is arranged so as to transform the reciprocating action of the pistons into a rotatory motion of the whole. This arrangement is applicable to any engines obtaining their energy from any fluid under pressure, such as water, steam, gas, &c.

An engine according to this invention is illustrated, by way of example, in the accompanying drawings, in which it is shown arranged to work as an explosion-engine. In this case it is a petrol-engine, more particularly intended for propelling motor-vehicles where light weight is of the greatest importance.

Figure 1 shows the engine in vertical cross-section. Fig. 2 is a vertical longitudinal section. Fig. 3 is a detail view of the cam contributing to the conversion of the reciprocating motion of the pistons into a continuous rotatory movement of the crown or rim in which they move. Fig. 4 is a side elevation with the upper portion shown in vertical transverse section of a rotary engine constructed according to the present invention in which a mixture of gas and air is employed as the motor fluid. Fig. 5 is a diagram showing how the reciprocating motion of the pistons is transmitted to the rim in order to impart a rotary motion thereto; and Figs. 6, 7, 8, 9, 10, and 11 are also diagrams showing the different positions of the parts for one complete rotation of the motor.

The engine is chiefly constituted by a tubular cylindrical rim *c*, in which reciprocate four pistons p' p^2 p^3 p^4, forming between them four chambers e e' e'' e'''.

With reference to the positions occupied by the four pistons in Fig. 1 and assuming that the pistons move in the direction indicated by the arrows, the cycle will be as follows: Chamber *e*, explosion; chamber e''', compression; chamber e'', admission; chamber e', exhaust. At the next phase the pistons will move in the opposite directions and the cycle will be as follows: Chamber e''', explosion; chamber e'', compression; chamber e', admission; chamber *e*, exhaust, and so on. If the pistons were free, it is obvious that only those acted upon at the given moment by an explosion would move. In order to avoid this, the four pistons are indirectly connected by a special device to the tubular rim *c*, by which means a continuous rotary motion is imparted thereto, so that it plays the part of a fly-wheel, carrying the pistons over the dead-centers. The connection between the pistons and the rim is as follows: The circular rim *c* is connected, by means of arms *l*, to a sleeve l', mounted loosely on a spindle *a*. Each piston is connected by an arm l' to a sleeve l^2, also mounted loosely on the spindle *a*. These arms l' pass through slots made in the lower part of the tubular rim *c*. The sleeves or ends l^2 of the arms l' of the pistons p^2 p^4 are fixed to each other, and those of the arms of the pistons p' p^3 similarly interconnected, said two sets of pistons, however, being independently movable with respect to each other. Each arm l' being connected in the same way as the others to the rim *c*, it will be sufficient to examine one of these connection devices. Each arm l' is provided near its end with a pin *b*, projecting in a plane normal to the plane of oscillation of the said arm. The said pin *b* is partially inclosed by the bifurcated end of a suitably-bent lever *b o g*. The lever *b o g* is pivoted about a pin *o*, secured to the arm *l*, secured to the rim. The bent lever is provided at *g* with a roller engaging with a cam-groove *g g' n m*, made in a disk *m n*, Fig. 3, keyed to the fixed spindle *a*.

With reference to the positions occupied by the distributing organs, (valve-gear,) it should be noted that the parts effecting ignition may be constituted by four sparking-plugs arranged, respectively, in each of the chambers *w x y z*, and each of such compartments or chambers is provided with an inlet and an exhaust valve preferably operated in the manner now to be described. In the arrangement shown in Fig. 4, in which the engine is operated by an explosive mixture and the admission-port, sparking devices, and exhaust mechanism are shown in detail, each chamber of the tubular rim is provided with an admission-chamber *l*, which by means of a channel 2 communicates with the fixed hollow shaft *a* through the openings 3. Carbureted air is brought by suction into the hollow shaft *a* by means of the channel 2. Each chamber is provided with the usual automatic valve 4. A sparking device 5 is provided in each of the chambers 1, one of the poles thereof being formed by the casing, while the other is connected by any suitable conductor 6 to a metallic sector 7 of a drum 8, which is keyed to the shaft *a*. Brushes 9 are in contact with said drum 8 and are suitably connected to a source of electricity, so that electric communication is established at the proper times, and ignition of the explosive mixture is caused by means of a spark. The exhaust may take place into the atmosphere or into a suitable muffler. Each chamber of the tubular rim communciates with an exhaust-chamber 10, which is in communication with the atmosphere or a muffler and provided with an exhaust-valve 11, the spindle 12 of which is provided with a terminal roller 13, which revolves upon a cam 14, mounted on the fixed shaft *a*, thereby operating said valve 11 at the proper moment.

The working of the apparatus is as follows: The shape of the curve *g g' n m* is such that on the crown or rim *c* rotating forward through an angle of ninety degrees the roller *g* will arrive at *g'*, the roller *g'* will arrive at *n*, the piston *p'* will take up the position of the piston p^2, the piston p^2 the position of the piston p^3, &c.—that is to say, to each passage *g g' g' n n m m g* of the roller *g* in the cam-groove corresponds an oscillation of the lever *l* and a rotation of the rim *c* through an angle of ninety degrees. Inversely, if an explosion takes place at *e* the pistons *p'* and p^2 are driven—the piston p^2 forward and *p'* backward. The piston p^2 carries the lever *b'*, the lever *b' o' g'* oscillates about *o'*, the roller *g'* arrives at the portion *n*, causing the pin *o'*, and consequently also the whole rim *c*, to turn through an angle of ninety degrees round the spindle *a*. The pin *o* is also driven and turned through an angle of ninety degrees, and as the piston *p'* is driven backward the lever *b o g* turns about the pin *o*, while the roller *g* passes from *g* to *g'*. It will thus be seen that, as already stated, the whole apparatus has turned through an angle of ninety degrees, the piston p^2 has assumed the position of the piston p^3, and the piston *p'* that of the piston p^2. The pressure resulting from the explosion on each of the pistons *p'* and p^2 has the effect of forcing *p'* toward the left and p^2 toward the right, as explained. We will now examine in regard to each of the pistons how this displacement effects the transmission in the same direction, which is indicated by the large arrow in Fig. 5, to each of the axes *o* and *o'* and through the arms *l l* on which they are fixed, and consequently through the cylindrical rim *c c c c*, to which they are firmly connected, reference being had particularly to Fig. 5 of the drawings. As to the piston *p'* its displacement toward the left has the effect of oscillating the lever *b o g* around the point *o*, the center *g* of the roller describing the arc *g g*. This roller tends, therefore, at this moment to be supported on the circumferential rim of the cam-groove in which it rotates. Considering now the contact-point A of this roller *g* in connection with the controlling element, it will be seen that said point tends to be displaced, following the arc A *d*—that is to say, the force which is applied at this moment on the controlling element is directed in the course of the tangent formed with this arc at the point A. It results, therefore, that if the angle F between the tangents A B and A C at the point A, on the one hand, to the arc A D, and, on the other hand, to the guiding-curve is less than the sliding angle there will be a sliding of the roller on the curve following the tangent A C, and thereby the displacement of the roller *g* toward the right following the curve *g* E. This displacement is transmitted to the point *o* in the same direction, and by means of the same to the rim *c c c c* in the direction of the general rotation. As regards the piston p^2, it is readily seen that its displacement toward the right transmits the rotation of the lever *o' g'* around the point *o'* in the direction *g'* H. The roller *g'* is therefore applied to the inner circumference of the guide-groove. At the point of contact H of the roller *g'* with the curved member the tangents H I H J to this curved member and to the arc which the point H tends to describe are approximately perpendicular to each other. The roller *g'* finds, therefore, on the curved member a point of support. The other extremity of the lever *o' g'* (not shown) being caused to move toward the right by the piston p^2 there is a rotation of the lever *o' g'* around the point H, which is itself displaced slowly in the curve, and consequently transmission of the point *o'* and of the rim *c c c c* in the same direction following the arc O' K'. It is seen, therefore, that the movement and separation of the two pistons *p'* and p^2, produced by the explosion which has taken place between them, causes the rotation of the entire machine in the direction indicated by the large arrow.

It is only necessary to examine the diagram shown in Figs. 6, 7, 8, 9, 10, and 11, which represent different positions of the parts for one complete rotation of the entire structure, in order to comprehend immediately how the before-described operations are produced regularly for each interval between the two pistons and each displacement corresponding to a quarter of a revolution, so as to obtain the regular rotation of the entire structure. Fig. 6 represents the apparatus at the moment when the explosion is produced between *p'* and p^2. In Fig. 7 the explosion has taken place, the roller *g* is engaged by the groove toward the right, the roller *g'* is at the point of support on the lever

$b' o' g'$, and the rim has turned through a certain angle. Fig. 8 shows the preceding phase completed. The rim has been turned for a quarter of a rotation, and the explosion is produced between p' and p^4. The other figures represent the same phases for the angles of rotation for larger or smaller structures. After the phase represented in Fig. 11 p^2 has arrived at the place of p' in Fig. 6, and after another quarter-rotation, it is then found that the same phases take place indefinitely in the same order, the rotation of the rim continuing also without interruption. The curve g g' n m represents, in fact, the curve of the absolute movement described in the space by the roller g during the two double oscillations effected by the lever l during one complete revolution of the rim c through an angle of three hundred and sixty degrees. By suitably modifying this curve any number of such oscillations per revolution of the rim c could be obtained—that is to say, any number of explosions per revolution. The lengths b o o g and the angle b o g are chosen, so as to get the reactions of the roller g at the different points of the curve on the elements of the groove forming a rest and a guide for it properly directed with reference to the tangents at those points—that is to say, so that the angles between those two directions (reaction on the point of support and the tangent to the curve at that point) should be kept within suitable limits to obtain guidance without shocks and in satisfactory conditions of friction.

I claim—

1. In an engine of the class described, the combination, with a fixed shaft, of a circular tubular rim on said shaft, a plurality of sets of oppositely-reciprocating pistons in said rim, oscillatory levers fulcrumed to a part connected to said rim, the levers being pivoted to said pistons, and means on said shaft for oscillating said levers, whereby continuous rotary movement is imparted to said rim by the movement of said pistons.

2. In an engine of the class described, the combination, with a fixed shaft, of a sleeve rotatable on said shaft, arms radiating from said sleeve, a circular tubular rim carried by said arms, a plurality of sets of oppositely-reciprocating pistons in said rim, oscillatory levers fulcrumed to said rim-carrying arms and pivoted at their ends to said pistons, and means on said shaft for oscillating said levers in order to impart a continuous rotary movement to said rim by the reciprocation of said pistons.

3. In an engine of the class described, the combination, with a fixed shaft, of a circular tubular rim rotatable on said shaft, a plurality of sets of oppositely-reciprocating pistons in said rim, oscillatory levers fulcrumed to a part connected to said rim, the levers being pivoted at one end and to said pistons, and a fixed cam on said shaft for engaging the opposite ends of said levers and operable to impart a continuous rotary movement to said rim when said pistons are actuated.

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

HENRI LÉON MAILLARD.

Witnesses:

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