No. 692,034. Patented Jan. 28, 1902.

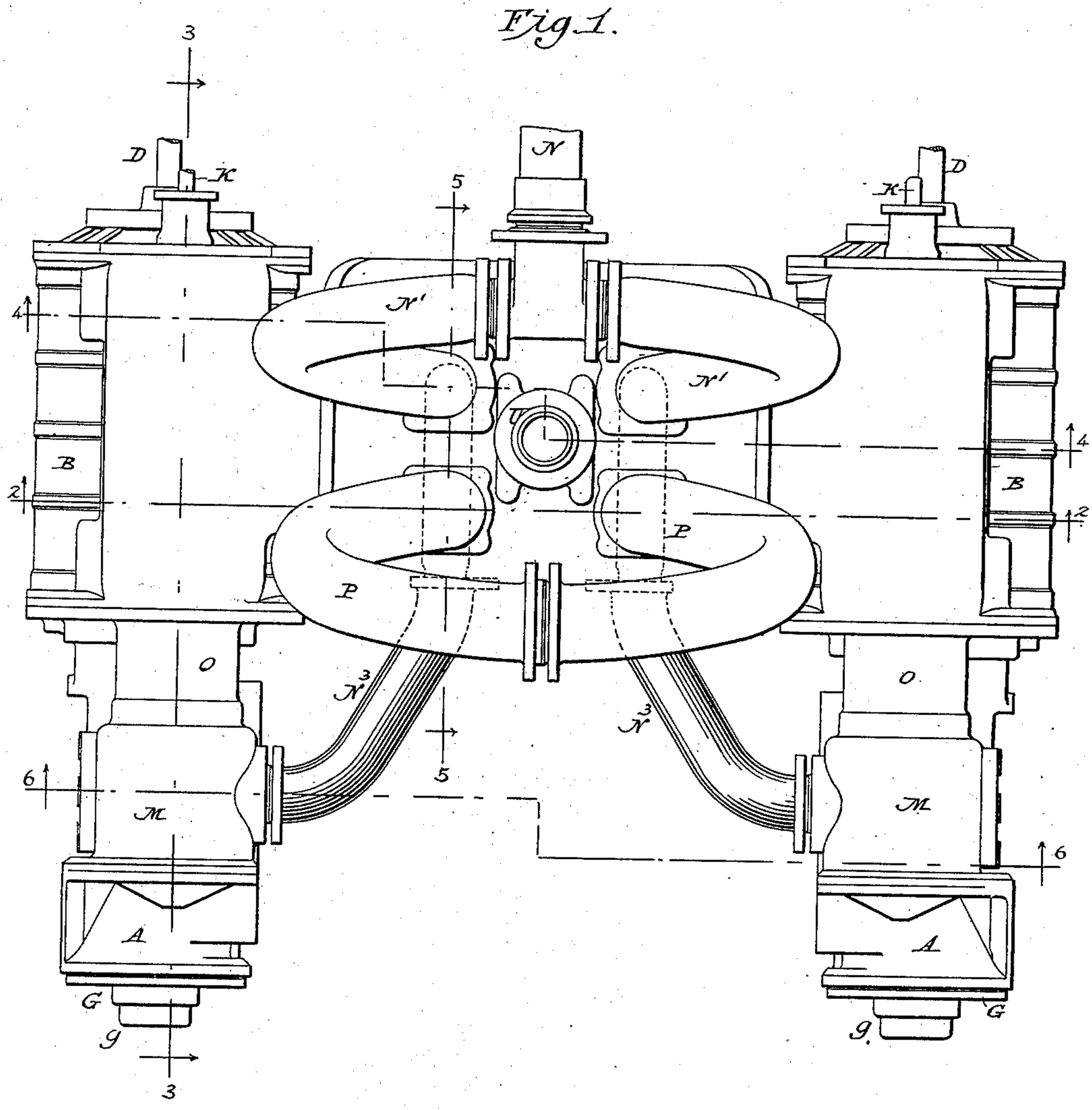
J. E. SAGUE.

COMPOUND STEAM ENGINE.

(Application filed May 10, 1901.)

(No Model.) 7 Sheets—Sheet 1.

Fig. 1.



Witnesses
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A. M. Parkins.

Inventor,
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by his attorneys
Baldwin, Davidson & Wright

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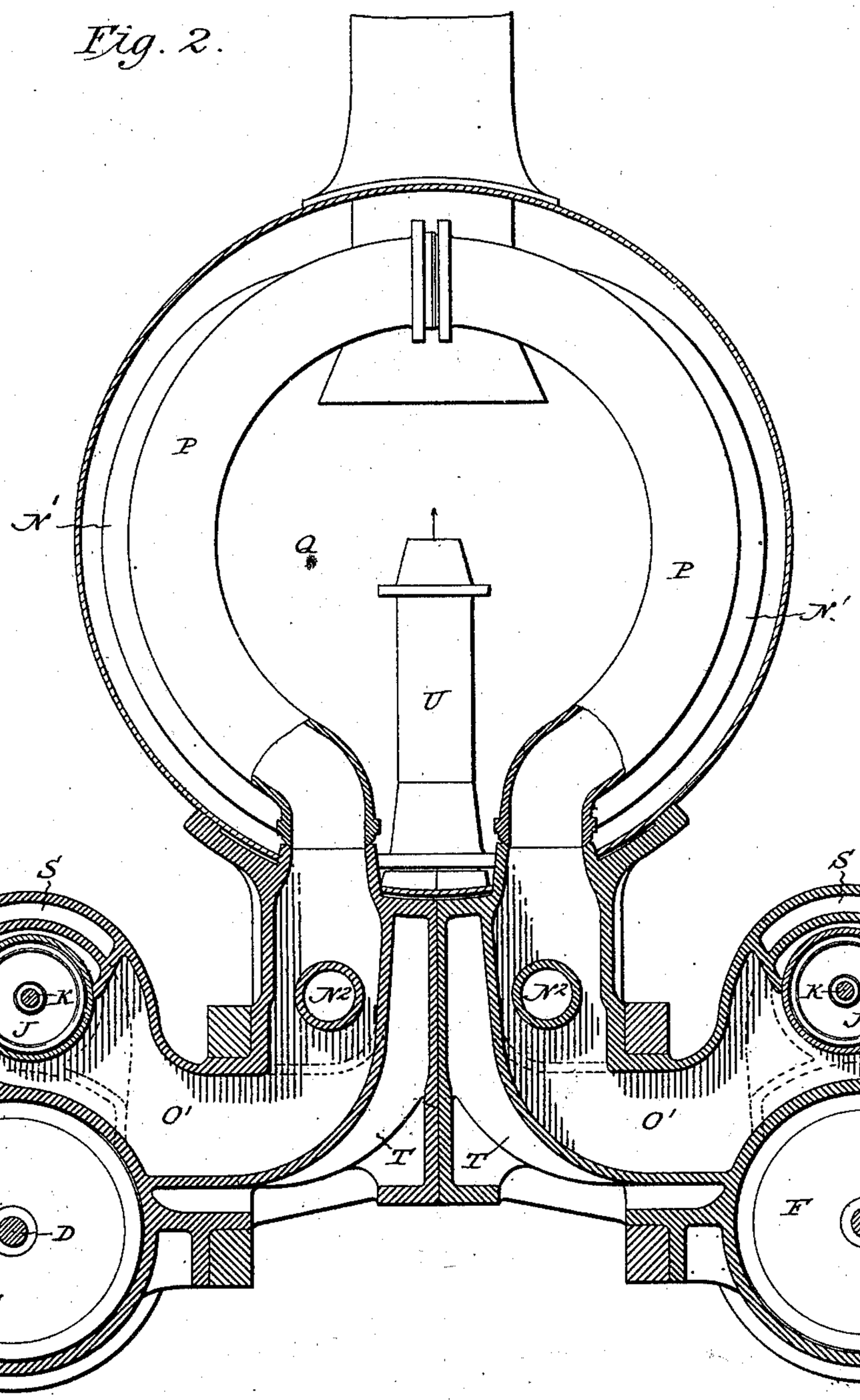
(No Model.) 7 Sheets—Sheet 2.

Fig. 2.



Witnesses
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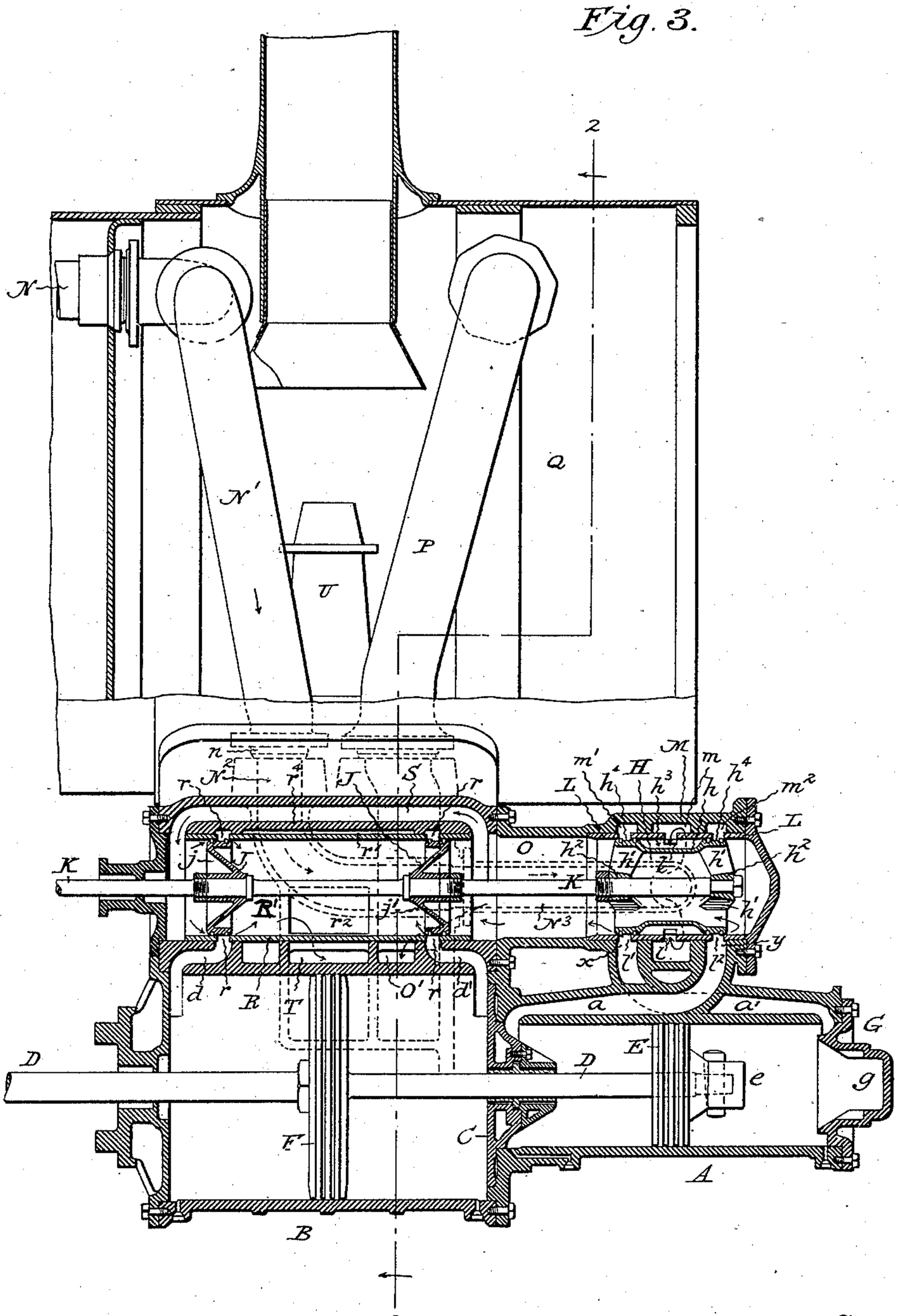
(No Model.) 7 Sheets—Sheet 3.

Fig. 3.



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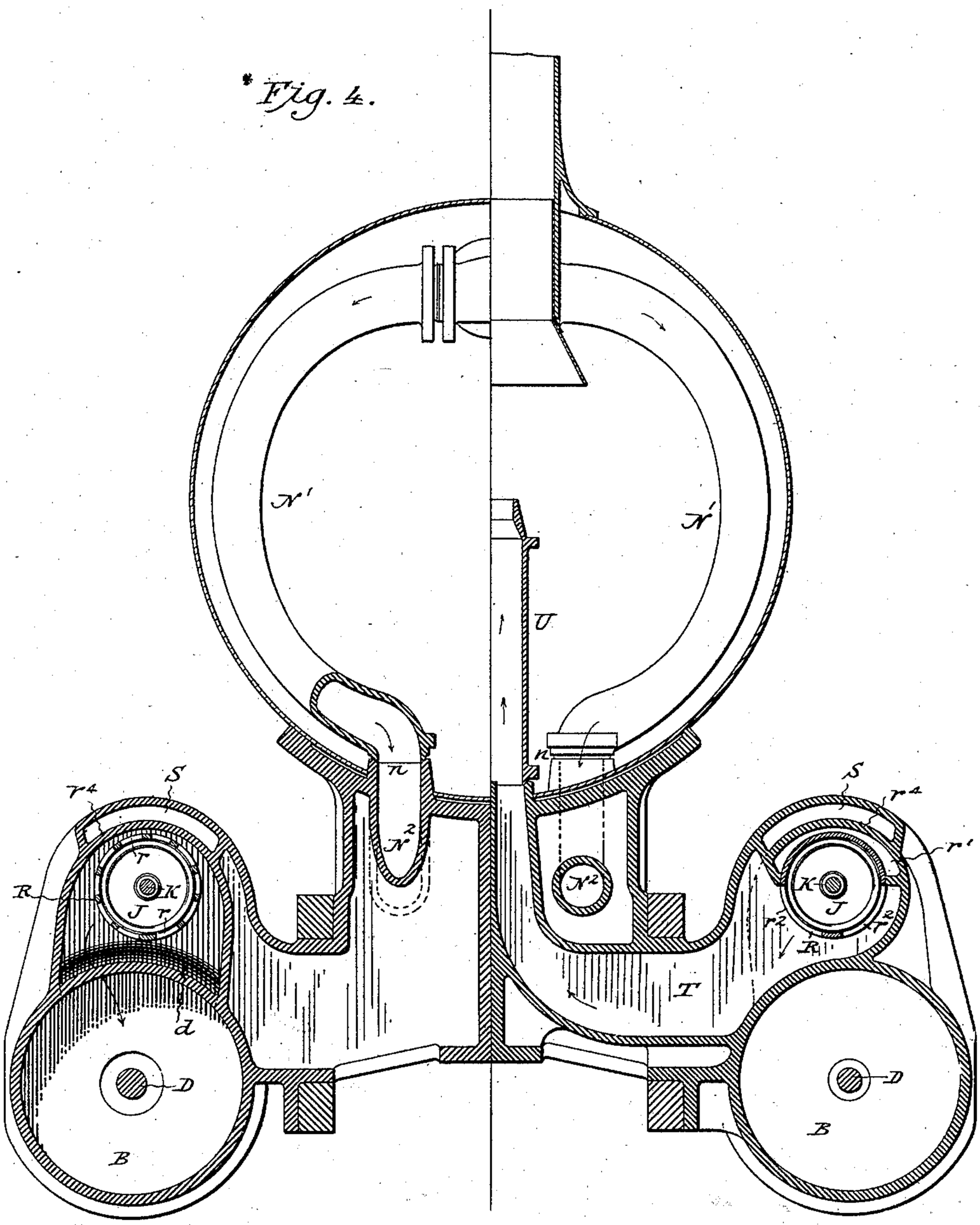
(No Model.) 7 Sheets—Sheet 4.

*Fig. 4.



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(No Model.) 7 Sheets—Sheet 5.

Fig. 5.

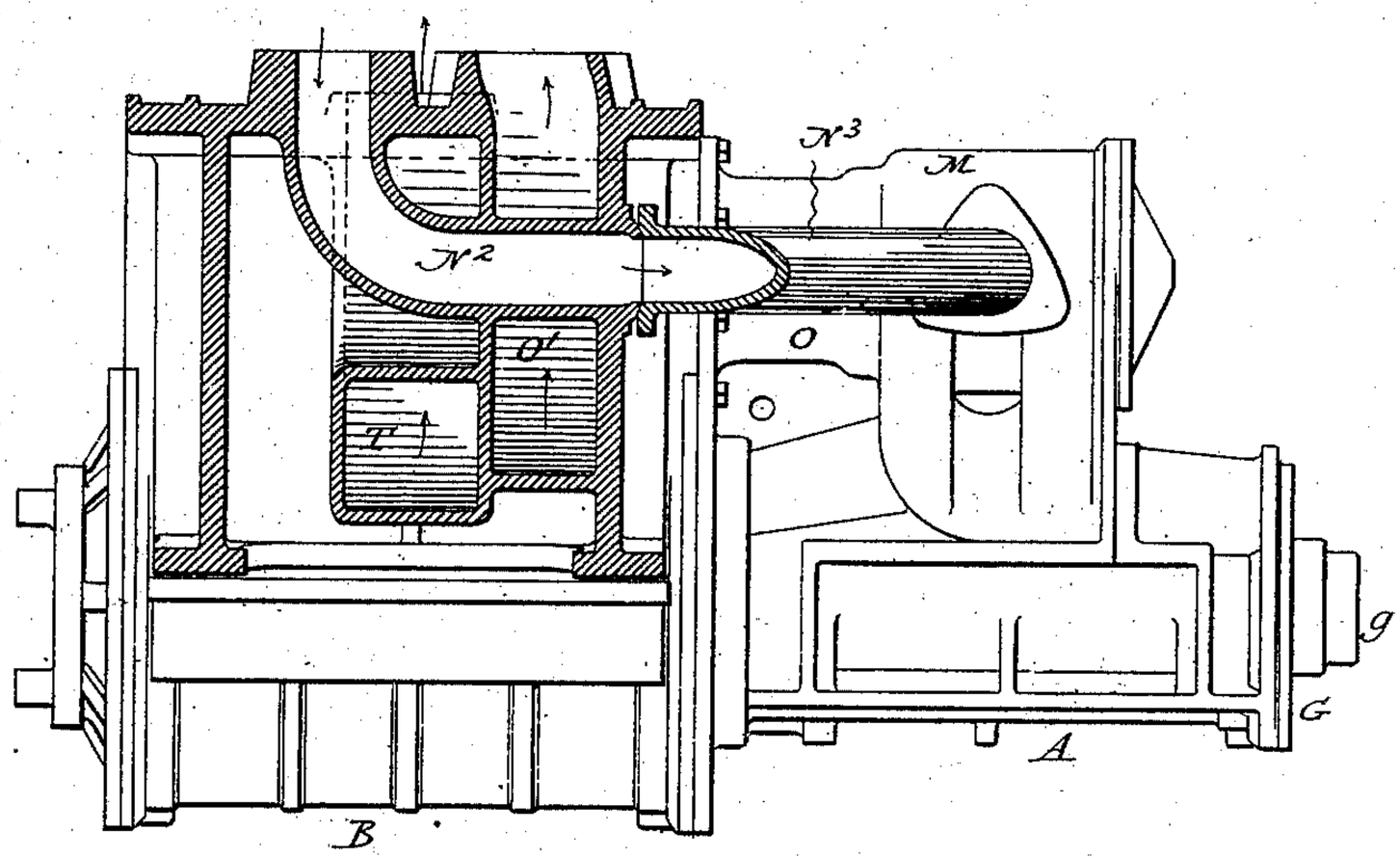
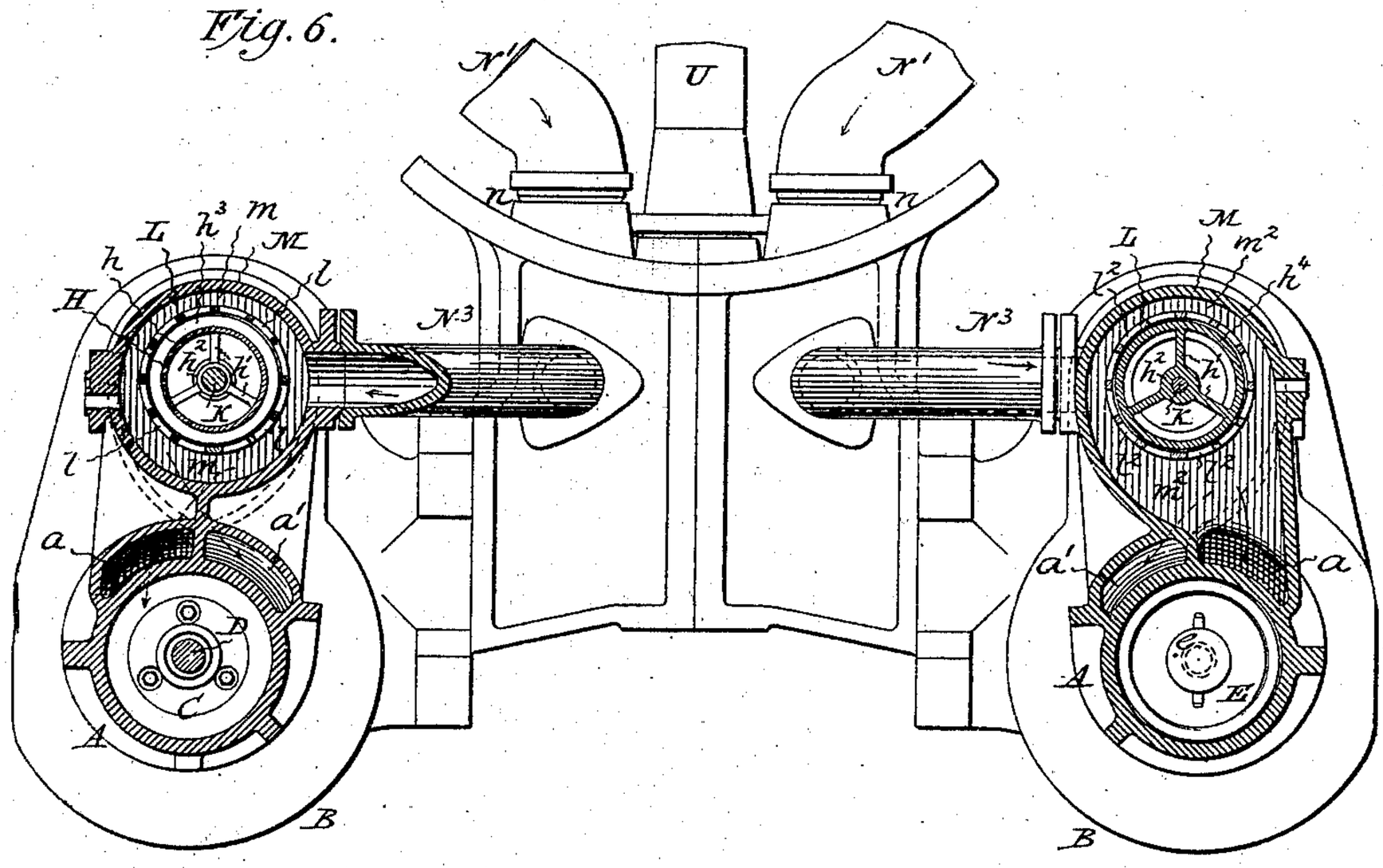


Fig. 6.



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(No Model.) 7 Sheets—Sheet 6.

Fig. 7.

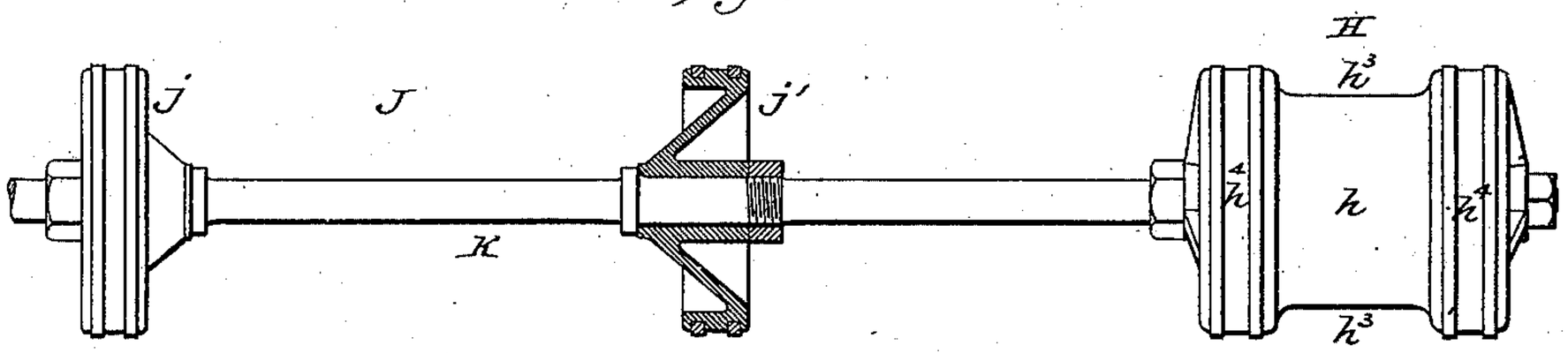


Fig. 8.

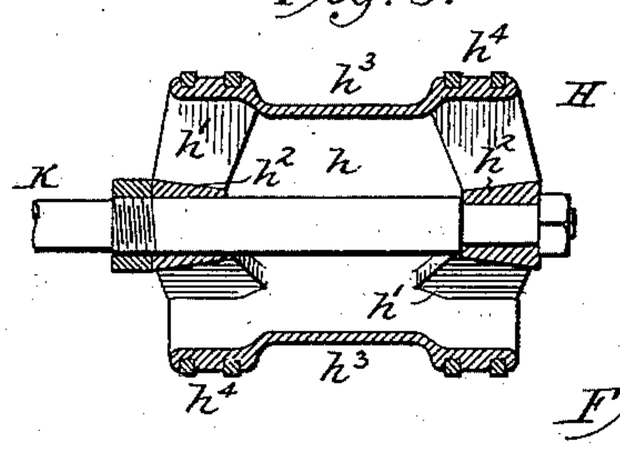


Fig. 9.

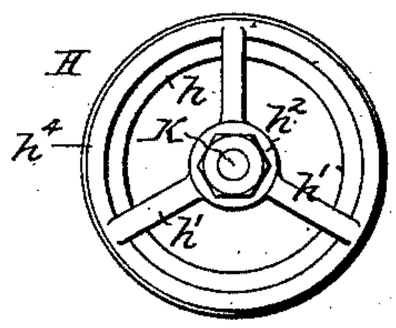


Fig. 10.

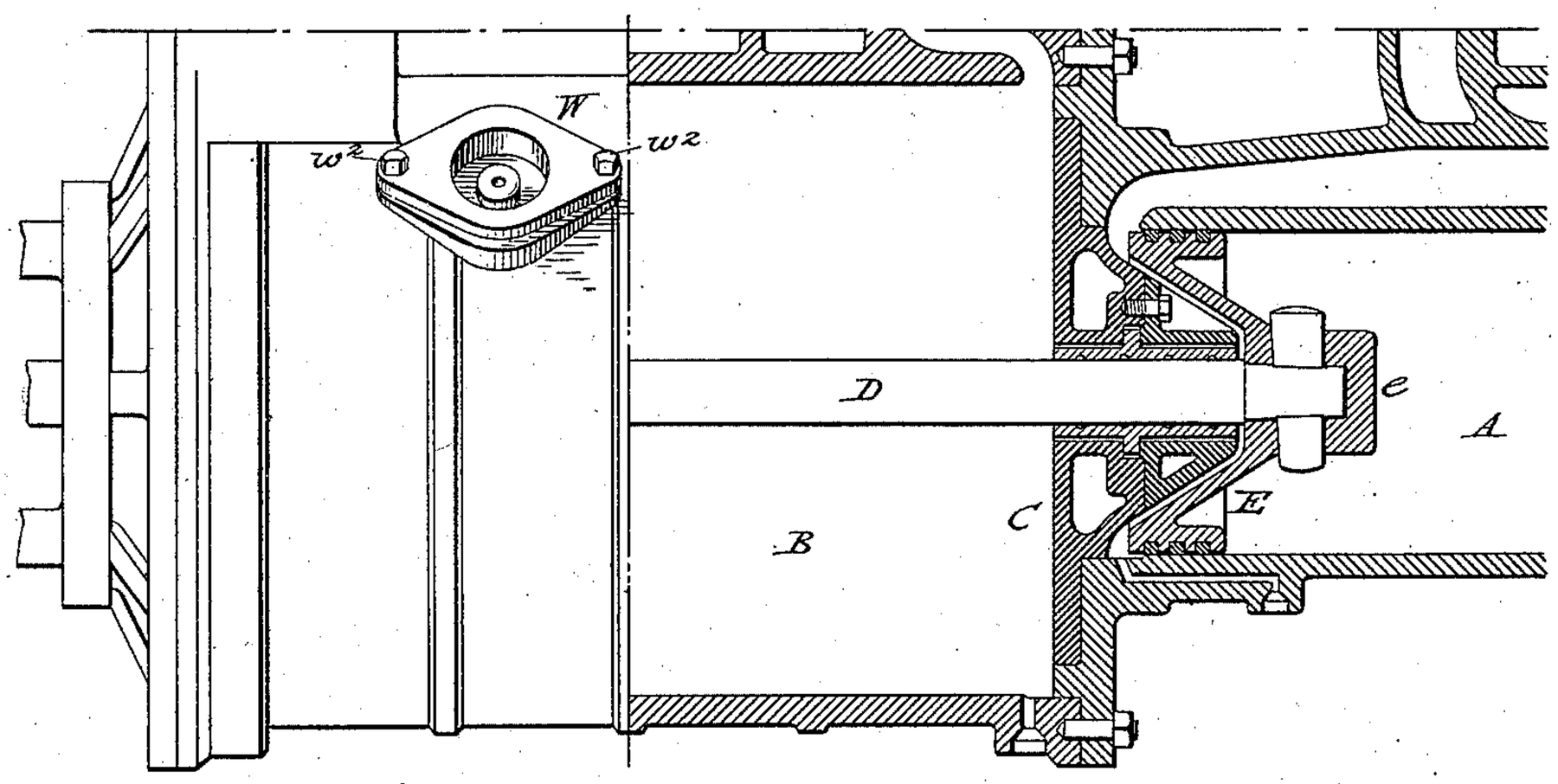


Fig. 11.

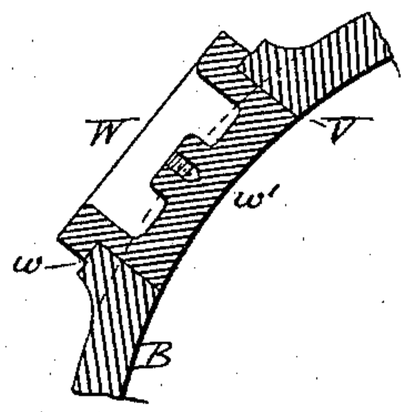
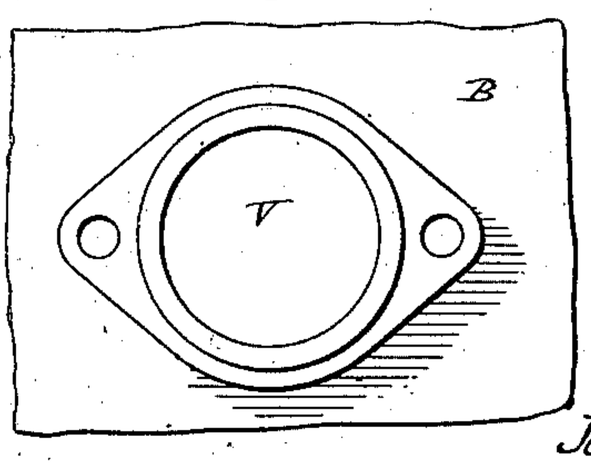


Fig. 12.



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(No Model.) 7 Sheets—Sheet 7.

Fig. 13.

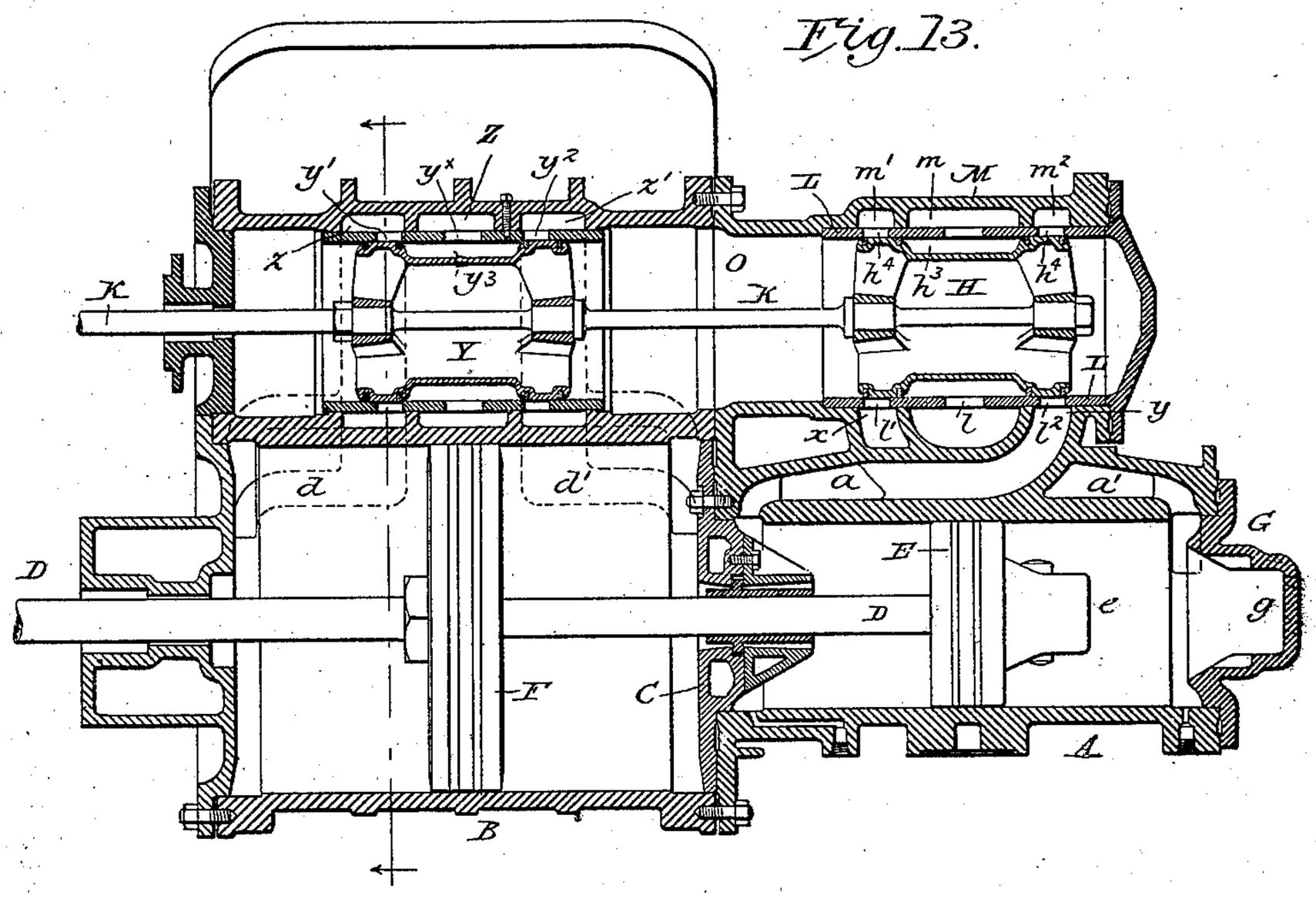
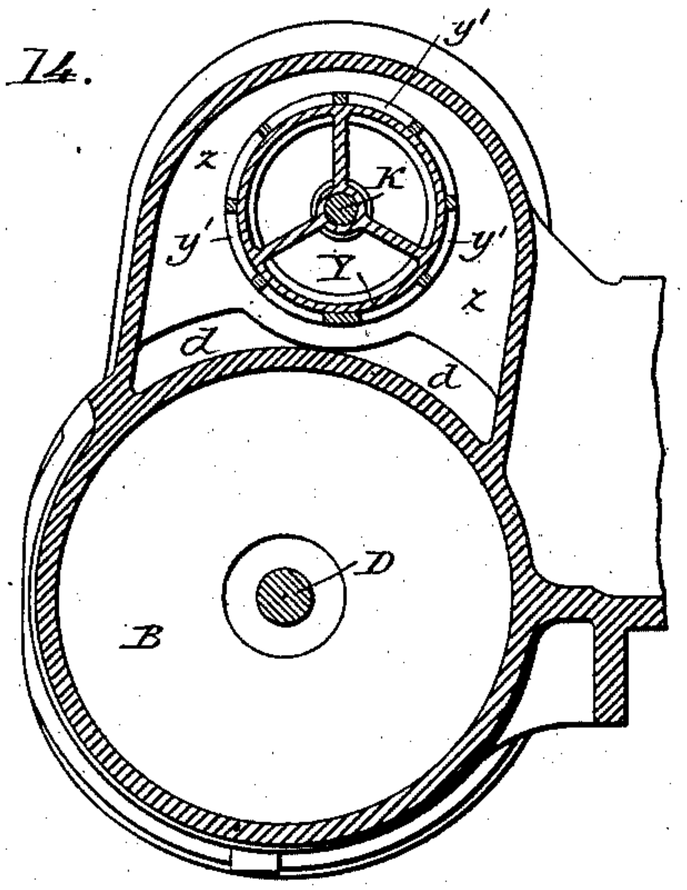


Fig. 14.



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UNITED STATES PATENT OFFICE.

JAMES E. SAGUE, OF SCHENECTADY, NEW YORK.

COMPOUND STEAM-ENGINE.

SPECIFICATION forming part of Letters Patent No. 692,034, dated January 28, 1902.

Application filed May 10, 1901. Serial No. 59,614. (No model.)

To all whom it may concern:

Be it known that I, JAMES E. SAGUE, a citizen of the United States, residing at Schenectady, in the county of Schenectady and State of New York, have invented certain new and useful Improvements in Compound Steam-Engines, of which the following is a specification.

My present invention relates to that class of steam-engines in which live steam is admitted to one or more high-pressure cylinders and exhausted therefrom into one or more low-pressure cylinders. My invention has particular reference to steam-engines of this class in which the cylinders are arranged tandem, or one directly in front of the other. I will therefore show and describe my improvements as applied to engines of the latter type, and as such engines are particularly adapted for use in locomotives. I will illustrate in the drawings a locomotive-engine equipped with my improvements.

The objects of my invention are to improve the construction and increase the efficiency of the valve mechanism for governing the admission and exhaust of the high and low pressure steam and to regulate the pressure of the steam exhausted from the high-pressure cylinders in such manner as to equalize and render uniform at all times the back pressure in the high-pressure cylinders and the forward pressure in the low-pressure cylinders.

In carrying out my invention I arrange the high-pressure cylinders close to the low-pressure cylinders and immediately in front of them, the two pistons being secured to the same piston-rod. The valve for the high-pressure cylinder is arranged in line with the valve for the low-pressure cylinder and is secured to the same rod. Steam enters the valve-chest of each high-pressure cylinder in such manner as to deliver to a centrally-arranged annular groove in a valve which governs the two ports of the high-pressure cylinder. The valve is hollow, and the exhaust-steam from the two ends of the high-pressure cylinder is delivered past the edges of the valve at its opposite ends. The valve of each low-pressure cylinder may consist of two pistons secured to the valve-rod at a considerable distance apart, and these pistons open and close the ports at opposite ends of the low-pressure cylinder in such manner as to admit and exhaust at the proper times. In order to conduct steam to the outside of the piston farthest removed from the high-pressure valve, I provide a passage from a point on the outside of one piston to a point on the opposite side of the other piston of the low-pressure valve, and in order to protect the steam passing through this passage from the cooling effects of the exhaust-steam within the low-pressure valve between the pistons I provide an air-space which is interposed between said passage and the exhaust-chamber in the valve. Instead of using the low-pressure valve above referred to I may use a valve for the low-pressure cylinder which is similar in all respects to the valve used for the high-pressure cylinder. This valve may be of the same dimensions as a high-pressure valve, and in such case the valves are interchangeable. In order that the pistons of the high and low pressure cylinders may properly operate—that is, move in the same direction when using the forms of high and low pressure valves above referred to—I cross the passages for the admission of steam to the high-pressure cylinder, so that steam admitted at one end of the high-pressure valve will enter a passage which leads crosswise of the valve to the opposite end of the high-pressure cylinder, by which arrangement steam is admitted to corresponding ends of the pistons in the high and low pressure cylinders at the same time, and yet I am enabled to use valves which are extremely simple in construction and very efficient in operation. They are very light, and no complicated mechanism is required for the purpose of properly admitting steam in the manner above specified. Crossed passages have heretofore been employed for admitting steam to the high-pressure cylinder of a compound engine; but the engines embodying this feature shown in the patents prior to my invention have employed different valve mechanism of a character not suited for use in compound locomotive-engines as at present constructed. In order to equalize and render uniform the back pressure in the high-pressure cylinders and the forward pressure in the low-pressure cylinders and to improve the distribution of steam, I connect the receiver-space between the high and low pressure

valves on one side of the engine with the receiver-space between the high and low pressure valves on the opposite side of the engine by a pipe which passes through the smoke-box of the locomotive, the low-pressure cylinders exhausting through exhaust-passages in the usual way.

In the accompanying drawings, Figure 1 is a plan view of so much of a compound locomotive-engine as is necessary to illustrate my improvements. Fig. 2 shows a transverse vertical section therethrough on the line 2 2 of Figs. 1 and 3. Fig. 3 shows a longitudinal vertical section through the high and low pressure cylinders and their valves on the line 3 3 of Fig. 1. Fig. 4 shows a transverse vertical section on the irregular line 4 4 of Fig. 1. Fig. 5 shows a local longitudinal section on the line 5 5 of Fig. 1. Fig. 6 shows a transverse vertical section on the line 6 6 of Fig. 1. The several lines in Fig. 1 illustrating where the sections are taken have arrows applied to them, indicating the direction in which the several sections are viewed. Fig. 7 is a detail view, on an enlarged scale, illustrating the construction of the high and low pressure valves. Fig. 8 illustrates by a longitudinal section further details of the high-pressure valve. Fig. 9 shows an end view of the high-pressure valve. Fig. 10 is a view, partly in side elevation and partly in section, showing the manner in which the high-pressure cylinder is joined to the low-pressure cylinder, and it illustrates also an arrangement by means of which the packing of the piston of the high-pressure cylinder may be examined and repaired as well as the bearings between the high-pressure cylinder and the low-pressure cylinder. Fig. 11 is a detail view further illustrating the manhole and its cap, by means of which the packing, &c., may be examined and repaired. Fig. 12 is another detail view of the manhole. Fig. 13 shows a vertical section through high and low pressure cylinders and their valves with my improvements applied. In this case the high and low pressure valves are similar in form and are interchangeable. Fig. 14 shows a vertical transverse section on the line 14 14 of Fig. 13.

I have illustrated in the drawings two low-pressure cylinders and two high-pressure cylinders arranged on opposite sides of a locomotive, but so far as some of my improvements are concerned they may be employed in a single engine—that is, one in which only one low-pressure and one high-pressure cylinder are used—and my improvements may be employed not only in locomotive-engines, but in engines used for other purposes. For convenience I have shown my invention as applied to a locomotive, and will proceed to describe the arrangement which I have adopted for this purpose, setting forth in the claims the subject-matter deemed novel, whether as applied to locomotive-engines or to other engines.

The high and low pressure cylinders and their valves and valve-chests are, as is customary, arranged in or attached to a saddle extending to opposite sides of the front of the locomotive. In the present instance I have shown one low-pressure cylinder and one high-pressure cylinder on each side of the locomotive, and they are similar in construction in all respects. The cylinders on each side are arranged tandem and close together, the high-pressure cylinder A being arranged immediately in front of the low-pressure cylinder B, and the cylinders are separated by a partition C, which is provided with bearings for the piston-rod D. A single rod is employed, the pistons E and F being secured thereto, preferably in such manner as to be readily removable therefrom. The front cap G of the high-pressure cylinder is removable, and it is preferably formed with a conical recess g, into which the end e of the piston E may move. The piston E is hollow and conical, as indicated in Fig. 10, and is adapted to fit over the conical partition C. The valve-chests for the high and low pressure cylinders may be of any suitable construction adapted to contain the valves and permit them to properly operate.

I will first describe the form of valves shown in Fig. 3. In this case the valve H for the high-pressure cylinder and the valve J for the low-pressure cylinder are secured to the same valve-rod K, which is straight, and the valves are in line with each other and move to the same extent at each reciprocation. The valve H is hollow, the cylindrical shell h being imperforate and held around the valve-rod by means of ribs h' radiating from hubs h^2. The shell h is provided with an annular groove or recess h^3 on its periphery, and the annular surfaces h^4 on opposite sides of this groove or recess are provided with packing-rings, as indicated. The valve H slides in a cylindrical bushing L, which is formed with an annular series of perforations l, registering with the annular groove h^3 and with annular series of perforations l' l^2 on opposite sides of the central series l. This bushing is held firmly in place in the casing M, and this casing is formed with a chamber m, communicating with the perforations l, and with chambers m' m^2, communicating with the perforations l' l^2. Live steam passes through the pipe N into the branch pipes N', which lead to opposite sides of the locomotive, and then down the pipes N' to the couplings n. Thence the steam passes through the passages N^2 in the saddle, as indicated in Fig. 5, then through the pipes N^3, and then to the chambers m, above referred to. The passages a a', which lead to the opposite ends of the high-pressure cylinder, cross each other, as shown, so that steam entering at x will pass to the front end of the cylinder, while steam entering at y will pass to the rear end of the cylinder. The live steam which enters the passage m passes through the perforations l into the annular groove or chamber h^3, and thence it passes

into either the chamber l' or the chamber l^2 and thence into either the passage a or the passage a'. The exhaust-steam passes out through the passages $a\,a'$ into the receiver-space O. The exhaust-steam from the high-pressure cylinder, which passes out through the passage a, passes through the hollow valve H in the manner indicated by the arrow and into the receiver-space O. This space O communicates with a chamber O', formed in the saddle. The shape of this chamber is shown in Fig. 2, and, as it will be observed, there are two chambers similar in all respects on opposite sides of the locomotive. These two chambers are connected by means of a receiver-pipe P, which is of an annular form and arranged in the smoke-box Q.

The low-pressure valve J (shown in Fig. 3) consists of two pistons $j\,j'$, secured at a suitable distance apart to the valve-rod K. These pistons are imperforate. Steam cannot pass through them, but must pass by their edges in the manner indicated by the arrows. The pistons move in a bushing R, which is formed near each end with an annular series of perforations r, and between these two series of perforations there is formed in the casing r^4, surrounding the bushing, a wide air-space r'. The bushing is also provided in its lower portion with large exhaust-openings r^2. In order to conduct steam from the receiver-space O to the outer side of the piston j, I provide a passage S, which passes over the top of the bushing, but which is separated therefrom by the air-space r'. This air-space serves to insulate the passage S from the exhaust-steam, which enters the chamber R' of the low-pressure valve between the two pistons. By thus arranging such an air-space the cooling effects of the low-pressure steam upon the receiver-steam passing through the passage S are avoided. The perforations r communicate with the passages $d\,d'$, leading to opposite ends of the low-pressure cylinder. The openings r^2 in the bushing communicate with an exhaust-chamber T in the saddle, and this chamber communicates with the exhaust-pipe U, as indicated in Fig. 4. It will be observed by reference to Fig. 5 that the live-steam pipes N^2 do not pass through the exhaust-chambers, but do pass through the receiver-chambers in the saddle.

In operation live steam passes from the live-steam pipes to the chambers m and thence to the grooves h^3 of the valves H. Referring to Fig. 3, when the valve H moves forward high-pressure steam passes from the chamber m into the passage a and acts upon the left-hand end of the piston E. At the same time steam passes from the front of the high-pressure cylinder through the passage a' and out into the receiver-space O. This space is already filled with receiver-steam, and it will be remembered that this space communicates not only with the receiver-space O' in the saddle, but also by means of the receiver-pipe P with the corresponding receiver-space O' on the opposite side of the locomotive, which in turn communicates with the receiver-space O between the valves H and J on the right-hand side of the engine. Referring again to Fig. 3, steam passes from the receiver-space O into and through the passage S to the left-hand end of the valve-chest, and as the valve H has moved forward the valve J has correspondingly moved forward, and steam enters the passage d in the manner indicated by the arrow and acts upon the left-hand end of the piston F. At this time the exhaust-steam passes through the passage d' and through the perforations r into the space R' between the pistons $j\,j'$. Thence it passes through the openings r^2 into the exhaust-space T and thence out through the exhaust-pipe U. The operation of the mechanism at other stages need not be followed out, as it will be clear from an inspection of the drawings.

The form of low-pressure valve shown in Fig. 3 insures to a large extent the protection of the receiver-steam from the cooling effects of the exhaust-steam. In Figs. 13 and 14 I have shown the same form of high-pressure valve; but the low-pressure valve shown is different from that shown in Fig. 3. In this case I employ for the low-pressure cylinder a valve which is similar in all respects to the high-pressure valve H. Preferably it is made of precisely the same shape and dimensions, so that it may be used interchangeably with the valve H. The construction and operation of the high-pressure valve in this case is the same as that before described, and the same letters of reference have been used in Fig. 13 for the high-pressure valve and the parts connected therewith as were used in connection with Fig. 3; but as the action of the low-pressure valve in Fig. 13 is somewhat different from that in Fig. 3 I will describe the manner in which the steam is admitted and exhausted in such a construction. The low-pressure valve Y, as before stated, is similar in construction to the valve H. The bushing which surrounds the valve is also similar to the bushing L, and it is formed with perforations or ports $y^\times\,y'\,y^2$ similar to the perforations $l\,l'\,l^2$. $d\,d'$ indicate the passages leading to the opposite ends of the low-pressure cylinder and communicating with the annular chambers $z\,z'$, which in turn communicate with the perforations $y'\,y^2$. The annular groove or recess y^3 communicates with a chamber Z, surrounding the bushing, by means of the perforations or openings $y^\times$. The chamber Z is connected with the exhaust-pipe. When constructed in this way, the admission to the opposite ends of the low-pressure cylinder is past the edges of the valve Y, and the exhaust takes place through the chamber y^3. Inasmuch as the passages a and a' are crossed when steam is admitted at one

end of the high-pressure cylinder it will simultaneously be admitted to the corresponding end of the low-pressure cylinder. This would not be the case if the passages were not crossed.

It will be observed that the valve mechanism which I employ is extremely simple and the weight is reduced to a minimum, thus avoiding to a very large extent the extra work and strain on the valve-gear which is often incident to tandem engines of the type herein shown. By using the receiver-pipe P, placed in the smoke-arch, and providing the receiver-spaces O' the receiver capacity is greatly increased and the heated gases of the smoke-box are utilized. By increasing the volume of the receiver-steam in these pipes and chambers the steam distribution is improved and the engine is made more economical, the large volume of steam in the receiver-passages and chambers having the effect of making the back pressure in the high-pressure cylinders, and the forward pressure in the low-pressure cylinders more uniform than is the case with tandem compound engines constructed in the usual manner. In a locomotive, the cranks being at right angles, the equalizing pipes and chambers have a special advantage, inasmuch as exhausts are made at each quarter-revolution, and therefore the pressure will be maintained much more uniformly in the receiver than if no connecting-pipe P were employed.

In order that the packing of the low-pressure piston F may be examined or repaired, I provide a manhole V in the cylinder and cover it by means of a cap or plug W. This may be made of cast-iron, with a ground-joint w, its inner end being faced at w' to conform to the bore of the cylinder. The cap is secured in place by means of bolts w^2. This manhole also affords means for inspecting or repairing the bearing C between the two cylinders.

I do not herein claim the specific form of valve mechanism shown in Figs. 13 and 14 of the drawings, as this is claimed in my application for patent, Serial No. 64,725, filed June 15, 1901.

I claim as my invention—

1. The combination of a high-pressure cylinder, a low-pressure cylinder, pistons for the two cylinders connected to the same rod, valves for the two cylinders connected to the same valve-rod, crossed passages leading to opposite ends of the high-pressure cylinder, a passage extending around the outside of the valve of the low-pressure cylinder to opposite ends of said valve, and ports and passages for admitting and exhausting steam past the high-pressure valve, and ports and passages for admitting and exhausting steam past the low-pressure valve.

2. The combination of the high and low pressure cylinders, their pistons, the piston-rod connecting them, a valve for the high-pressure cylinder having a central peripheral steam-admission recess, and a hollow interior open at opposite ends, a low-pressure valve consisting of two closed pistons arranged a distance apart and secured to the valve-rod with an exhaust-space between them, a passage arranged outside the low-pressure valve and leading from the space between the valve of the high-pressure cylinder and the adjacent piston of the low-pressure valve to the space outside the opposite piston, and ports and passages for the admission and exhaust of steam past the valves.

3. The combination of a low-pressure cylinder, its valve, a passage in the valve-casing connecting the space on one side of the valve with the space on the opposite side of the valve for conducting receiver-steam, a chamber for exhaust-steam within the valve, and an air-space between the chamber within the valve and the passage for conducting receiver-steam.

4. The combination of the high and low pressure cylinders, their pistons, the piston-rod, the valves for the two cylinders, the valve-rod to which they are connected, a receiver-space between the valves of the two cylinders, a bushing within which the high-pressure valve reciprocates, provided with three annular series of openings, a bushing provided near opposite ends with annular series of openings past which the pistons of the low-pressure valve reciprocate, and with openings between the pistons, a passage outside the bushing of the high-pressure valve, for conducting live steam to the valve, crossed passages leading to opposite ends of the high-pressure cylinder, passages leading to opposite ends of the low-pressure cylinder and communicating with the annular series of openings at the opposite ends of the bushing, and exhaust-passages communicating with the openings in the bushing of the low-pressure cylinder between the pistons of the low-pressure valve.

5. The combination of the high and low pressure cylinders and their valves on one side of the locomotive, the receiver-space between the valves, corresponding parts on the opposite side of the locomotive and a receiver-pipe uniting the receiver-space between the valves on one side of the locomotive with the corresponding receiver-space on the opposite side thereof.

6. The combination with the high and low pressure cylinders and their valves on one side of the locomotive, and the high and low pressure cylinders and their valves on the opposite side of the locomotive, of a receiver-pipe connecting them, into which steam exhausted from the high-pressure cylinders passes, and exhaust-passages connected with the low-pressure cylinders through which both low-pressure cylinders exhaust.

7. The combination of the high and low

pressure cylinders and their valves on one side of the locomotive, a receiver-space between said valves, similar cylinders, valves and receiver-space on the opposite side of the locomotive, a receiver-pipe connecting the receiver-space between the valves on one side of the locomotive with the receiver-space between the valves on the opposite side of the locomotive, and passages through which the low-pressure cylinders on both sides of the locomotive exhaust.

In testimony whereof I have hereunto subscribed my name.

JAMES E. SAGUE.

Witnesses:
O. H. WERTENBERGER,
WILLIAM G. GILMOUR.