(No Model.) 5 Sheets—Sheet 1

J. FRÖLICH

VALVE.

No. 436,578. Patented Sept. 16, 1890.

Fig. 1.

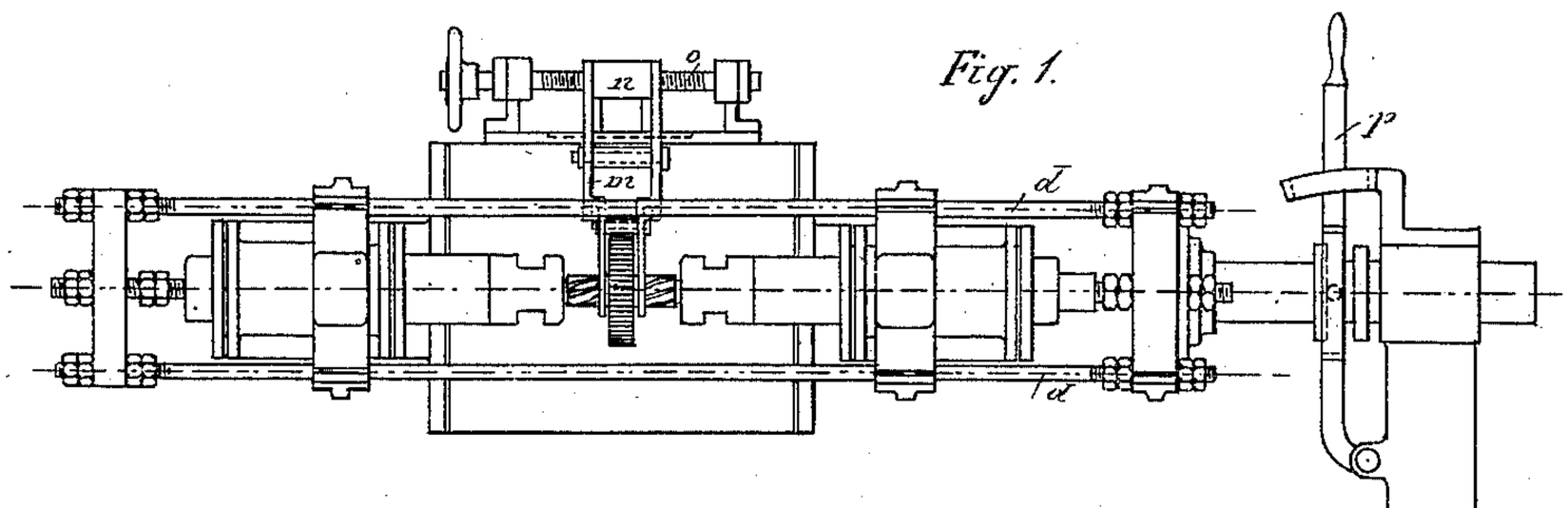


Fig. 2.

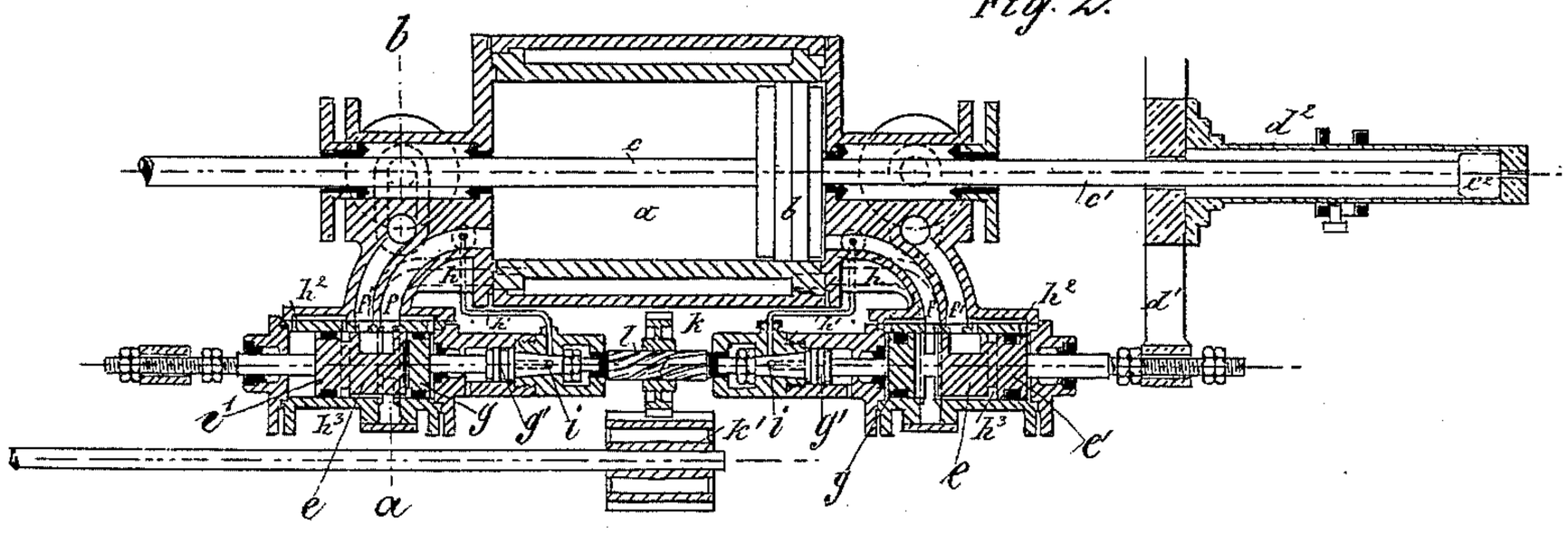


Fig. 3.

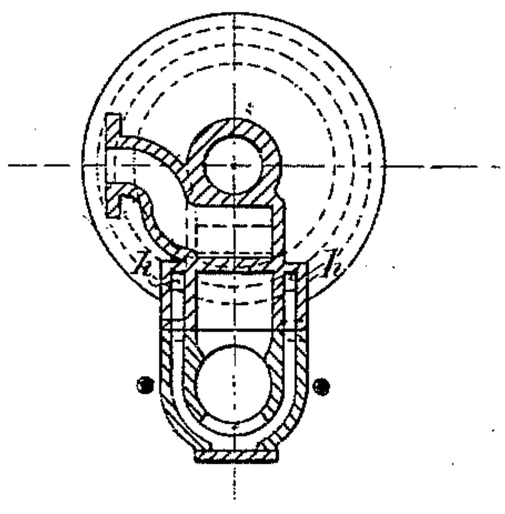


Fig. 4.

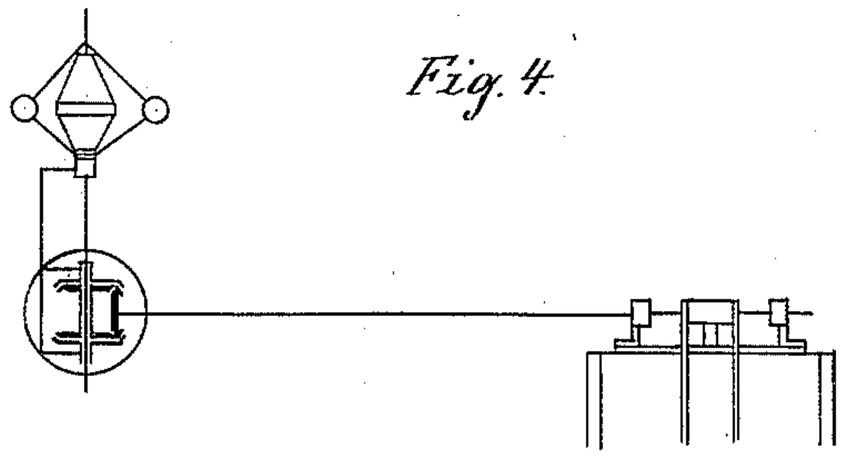
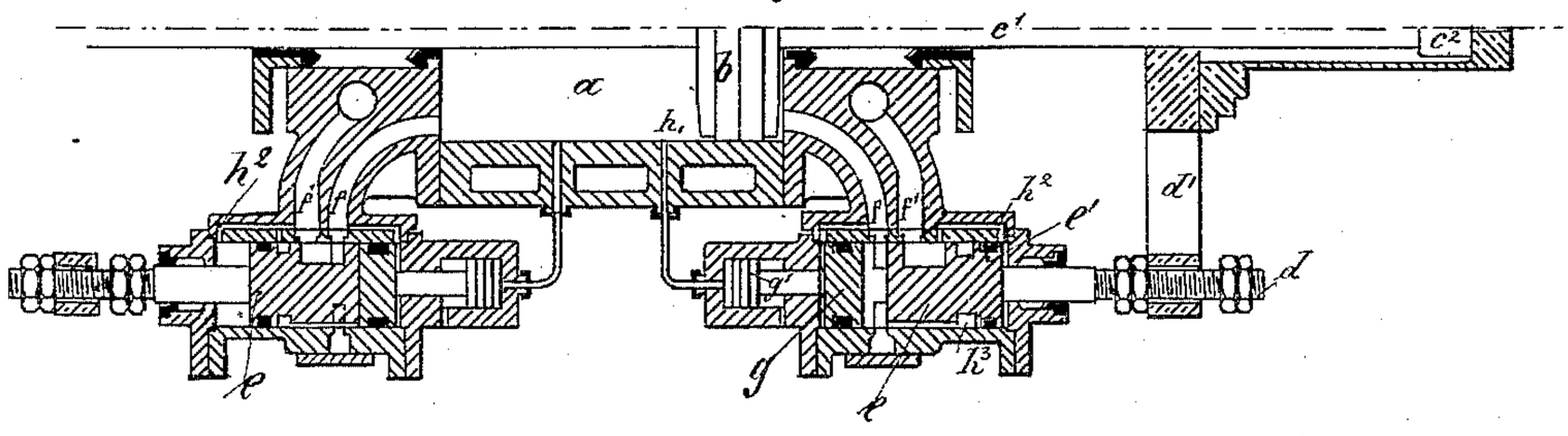


Fig. 5.



Witnesses:
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Carl Kapp

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Julius Frölich
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Hopkins & Thacher
Attorneys

(No Model.)

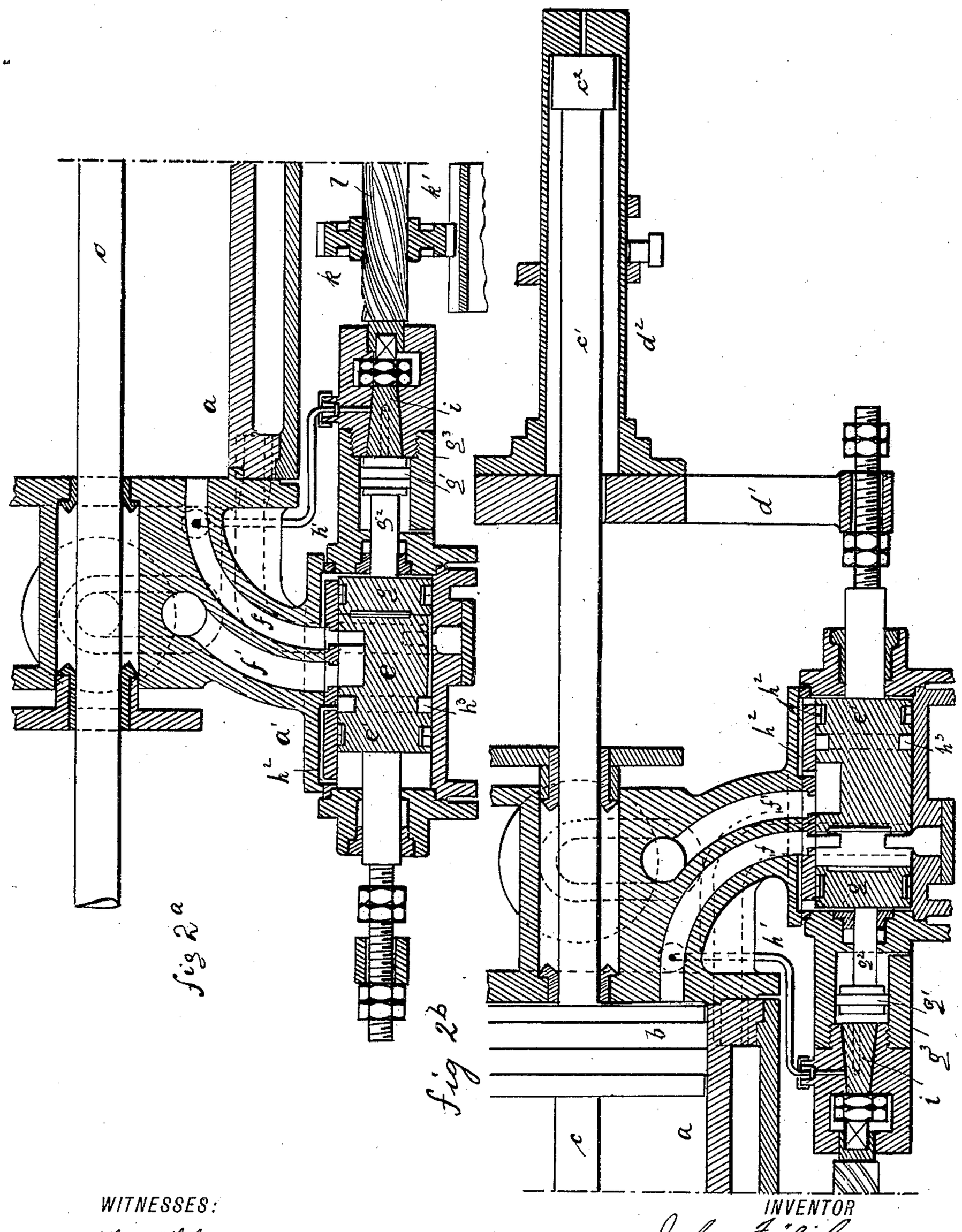
5 Sheets—Sheet 2.

J. FRÖLICH

VALVE.

No. 436,578.

Patented Sept. 16, 1890.



WITNESSES:

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BY Goepel & Wagener

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(No Model.)

5 Sheets—Sheet 3.

J. FRÖLICH

VALVE.

No. 436,578. Patented Sept. 16, 1890.

Fig. 6.

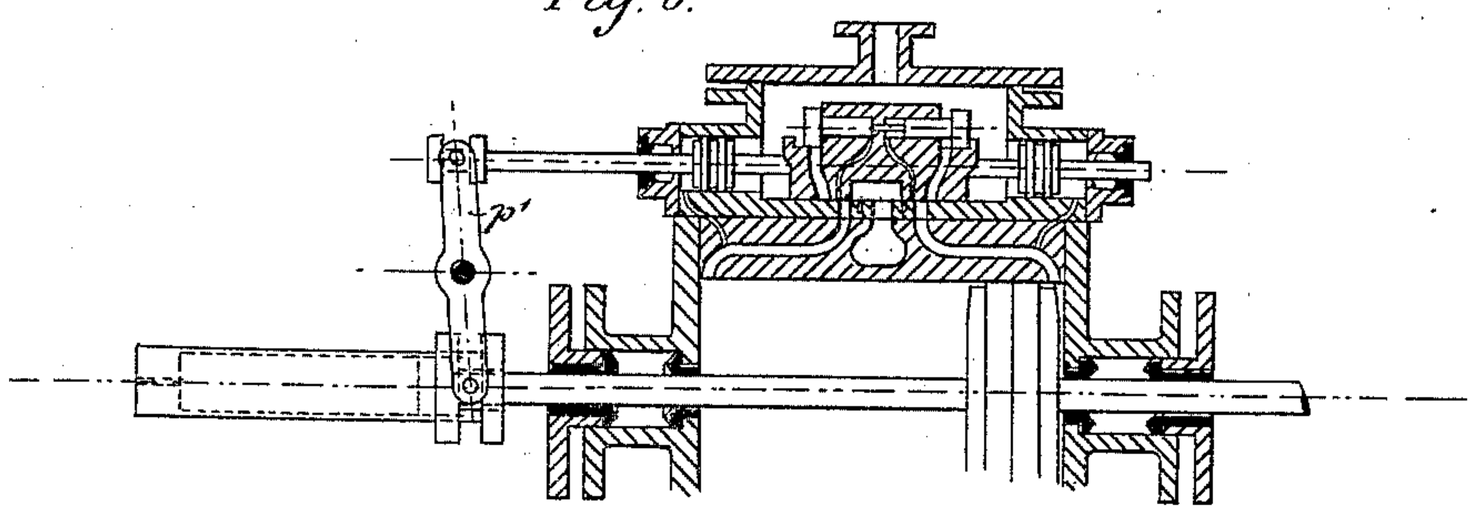


Fig. 7.

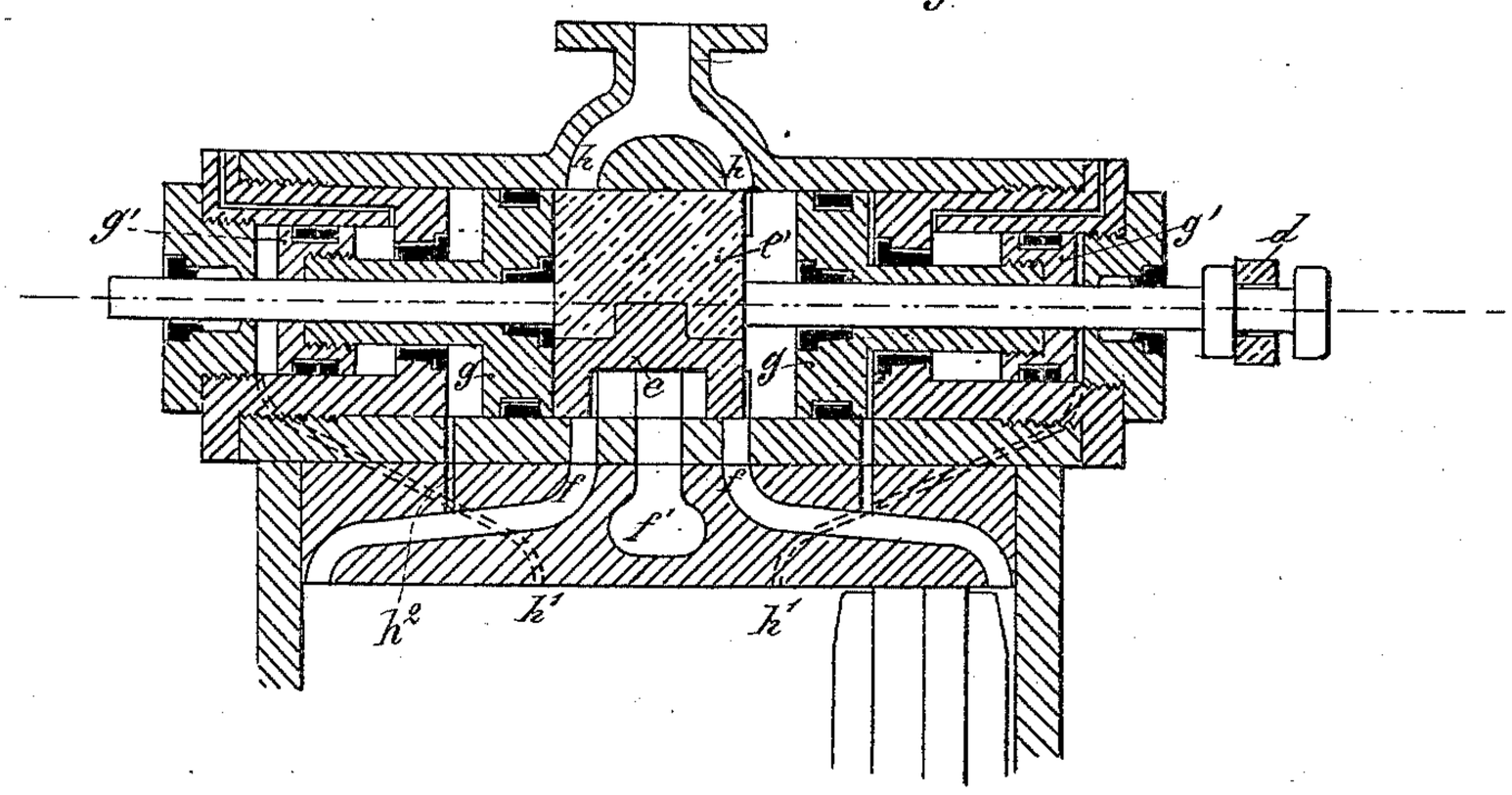
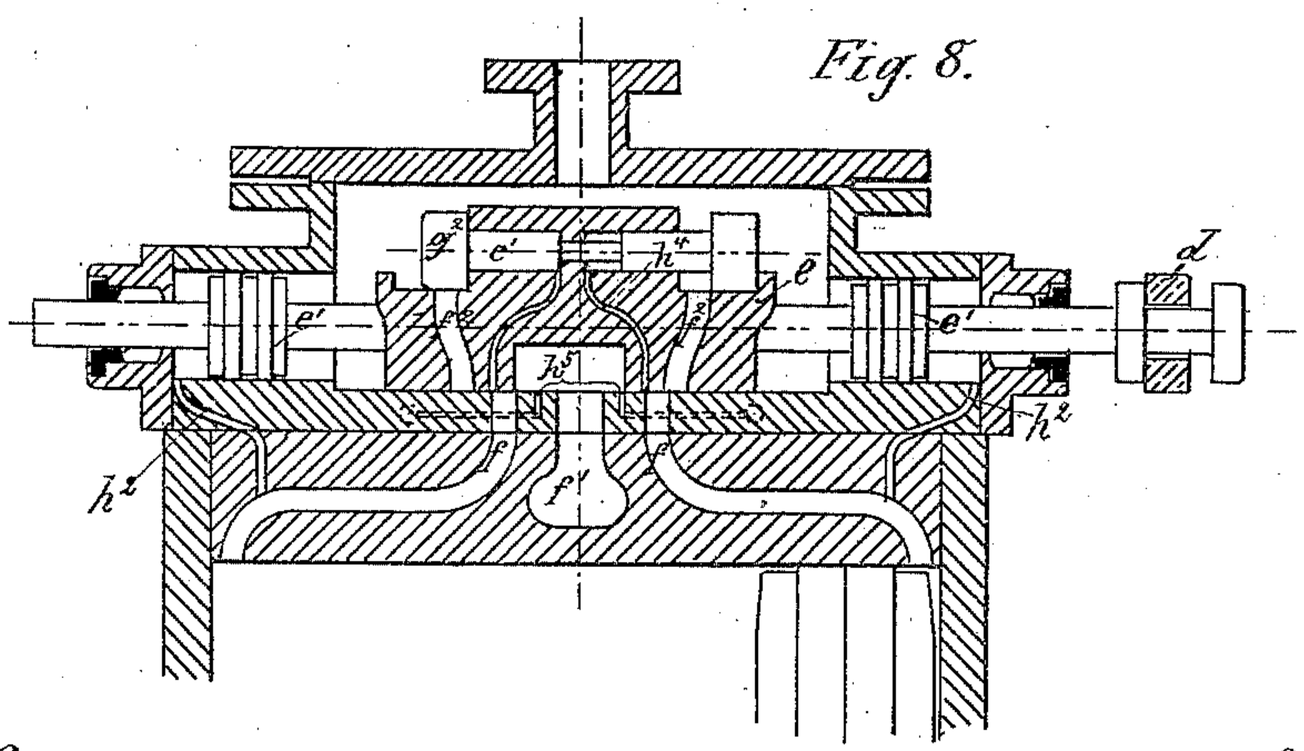


Fig. 8.



Witnesses:
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(No Model.) 5 Sheets—Sheet 4.

J. FRÖLICH.

VALVE.

No. 436,578. Patented Sept. 16, 1890.

Fig. 9.

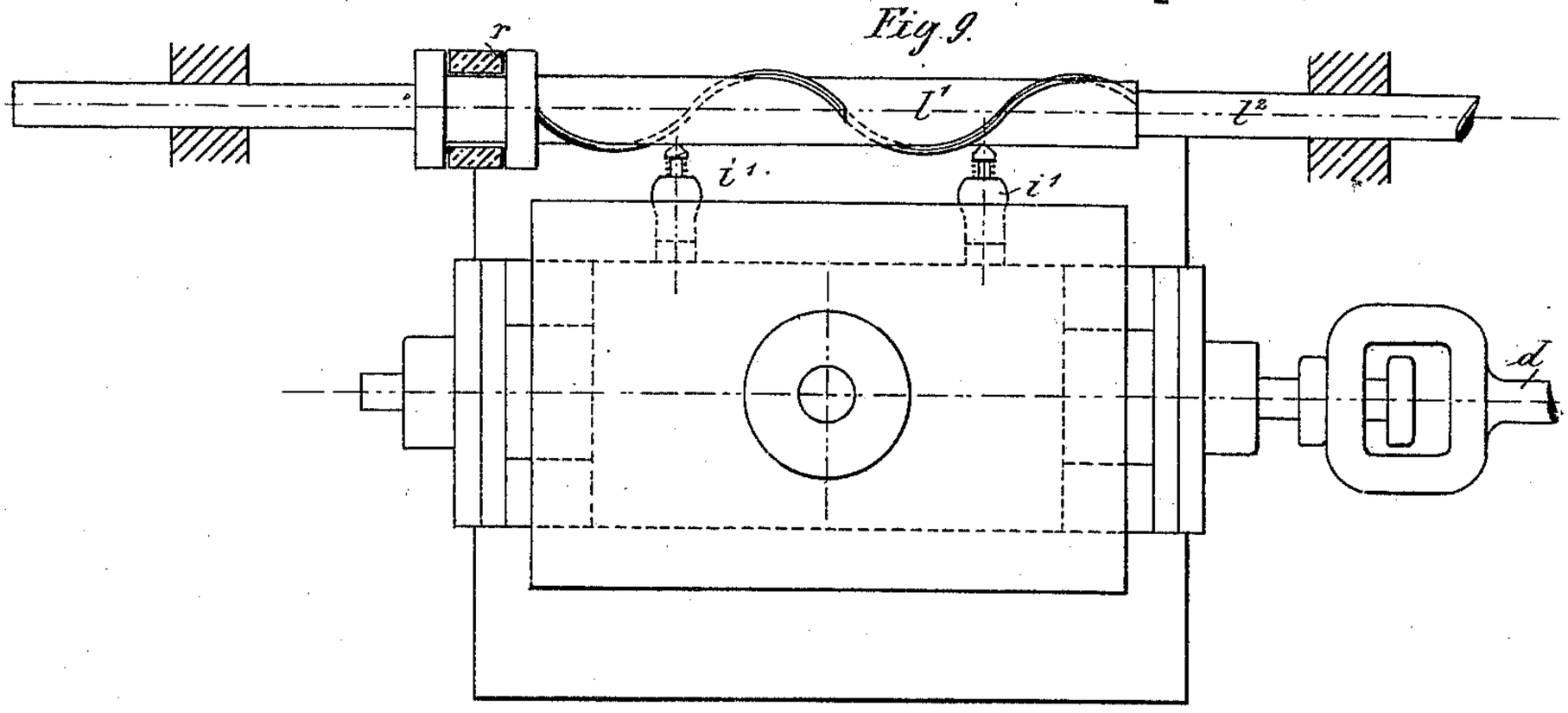


Fig. 10.

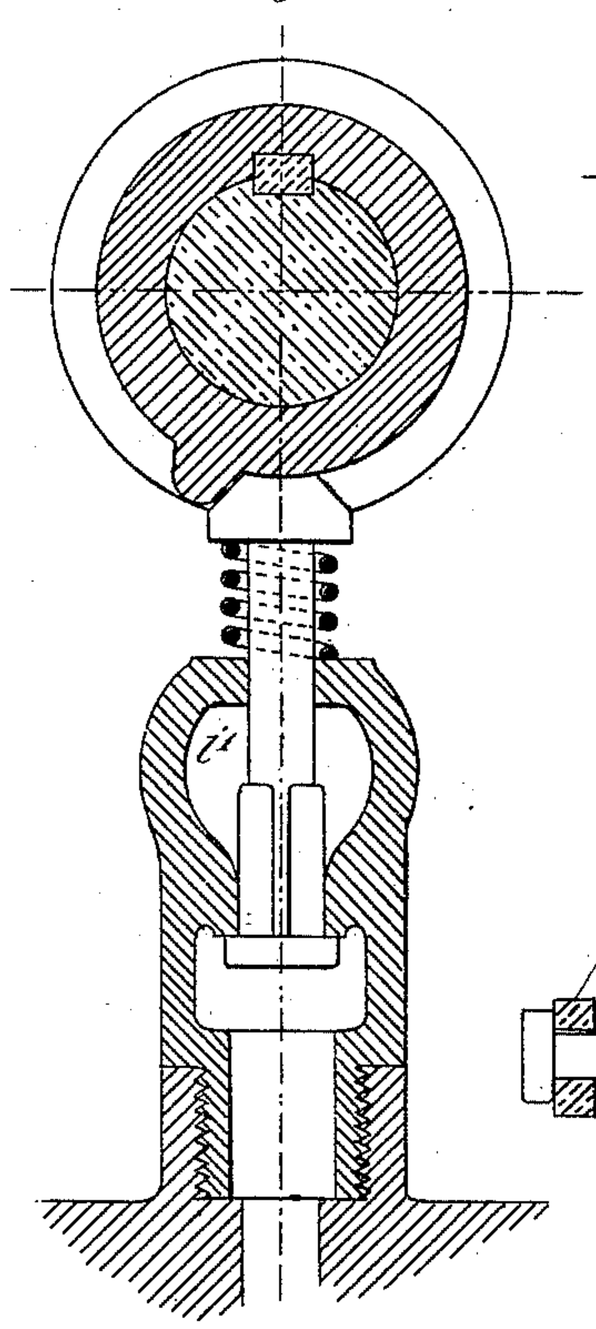


Fig. 11.

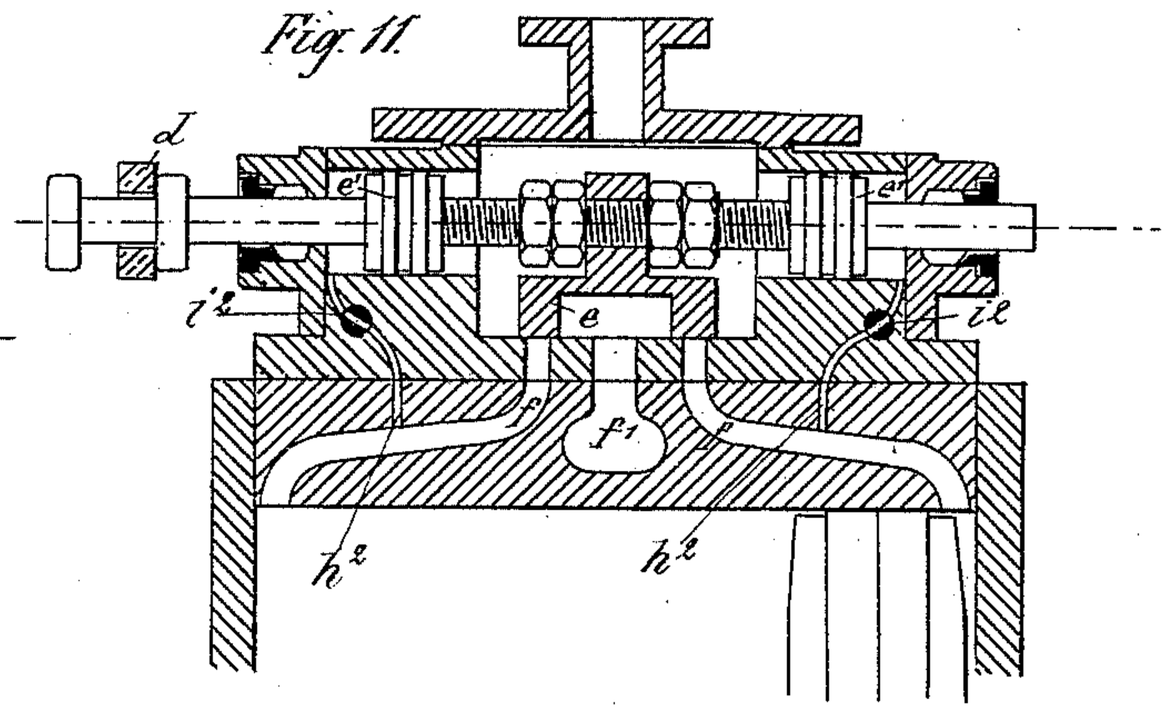
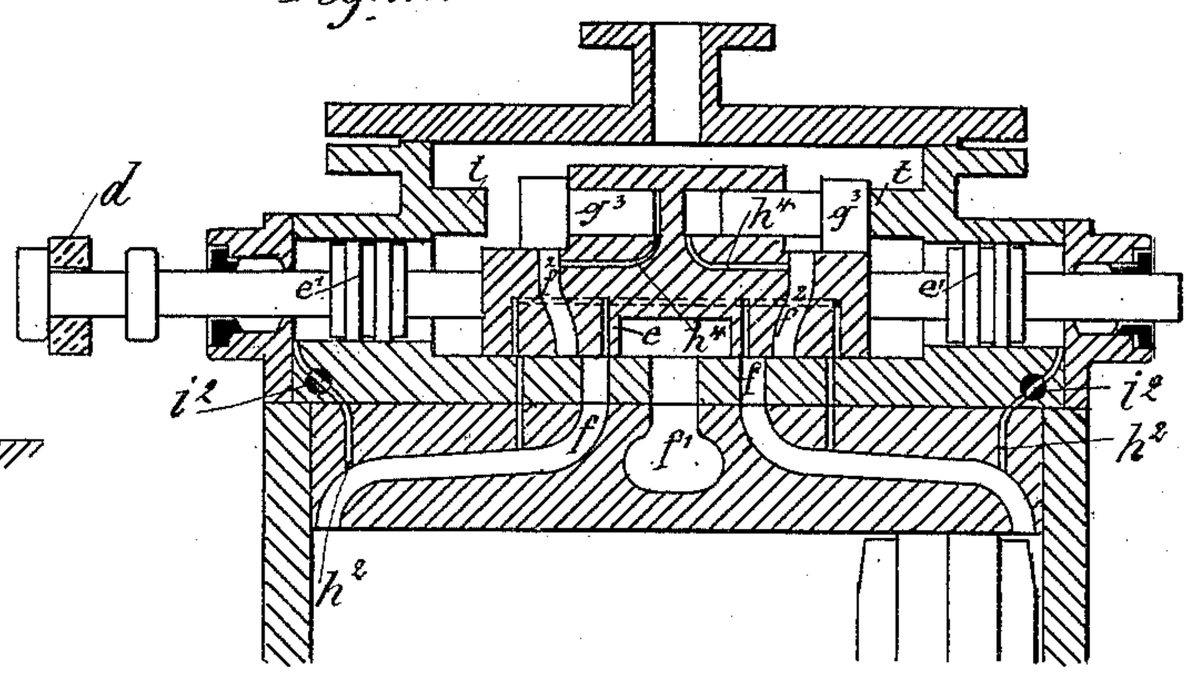


Fig. 12.



Witnesses:
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(No Model.)

5 Sheets—Sheet 5.

J. FRÖLICH.

VALVE.

No. 436,578. Patented Sept. 16, 1890.

Fig. 13.

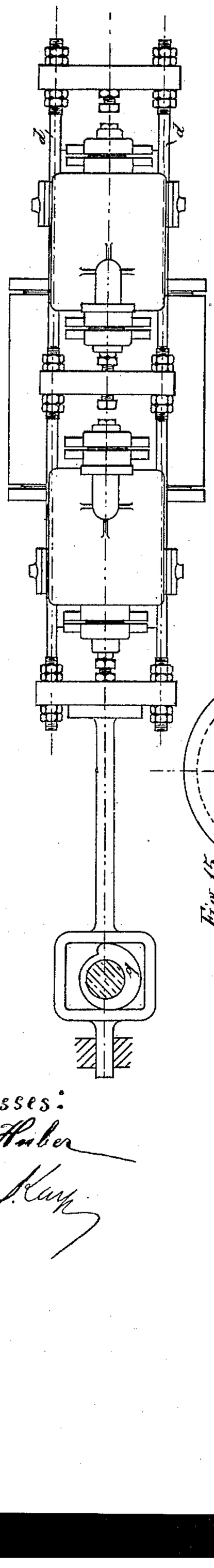

Fig. 14.

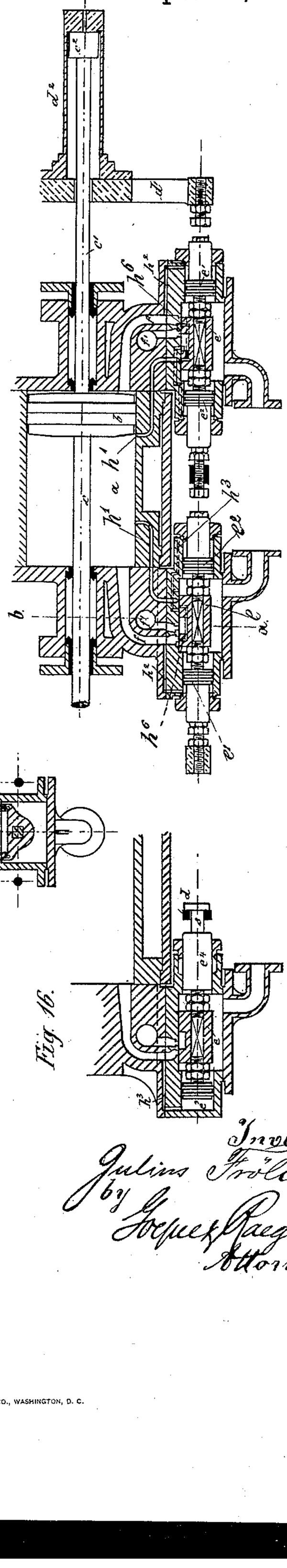

Fig. 15.

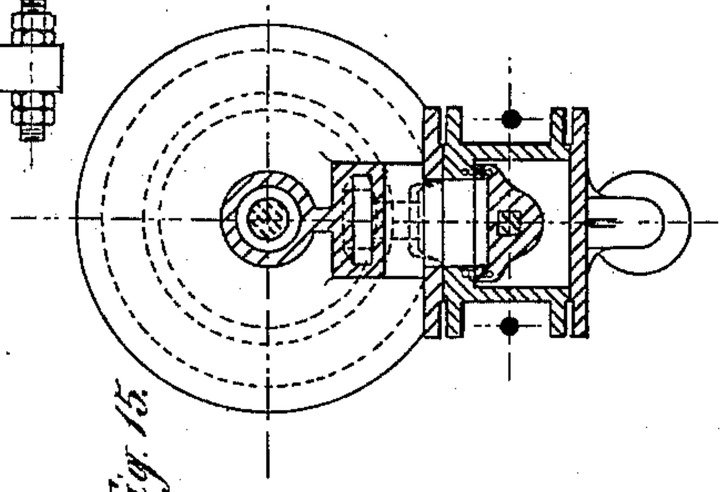

Fig. 16.

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UNITED STATES PATENT OFFICE.

JULIUS FRÖLICH, OF BARMEN, GERMANY.

VALVE.

SPECIFICATION forming part of Letters Patent No. 436,578, dated September 16, 1890.

Application filed December 29, 1888. Serial No. 294,951. (No model.)

To all whom it may concern:

Be it known that I, JULIUS FRÖLICH, a subject of the King of Prussia, residing at Barmen, in the Kingdom of Prussia, German Empire, have invented new and useful Improvements in Valves for the Distribution of Motive Fluids in Motors and Pumps, of which the following is a specification.

This invention relates to improvements in valves for distributing the motive fluid in motor engines and pumps, which valves are moved positively by the piston-rod or crank-shaft only at the beginning of the stroke, while further movement of the said distributing slide-valves required for entirely opening the passage is produced by pistons on which the motive fluid acts. The valves can also be adjusted to act as a constant or variable cut-off, and this valve can also be used in pumps for conveying elastic or non-elastic fluids.

The invention consists in the construction and combination of parts and details, as will be fully described hereinafter, and finally pointed out in the claims.

In the accompanying drawings, Figure 1 is a longitudinal elevation of the valves at the opposite end of a piston and the variable cut-off having mechanism for regulating the same. Fig. 2 is a longitudinal horizontal sectional view of the same. Figs. 2^a and 2^b represent parts of Fig. 2 on an enlarged scale. Fig. 3 is a vertical transverse sectional view on the line *a b* of Fig. 2. Fig. 4 is a diagrammatic view showing the manner of setting the variable cut-off by means of the governor. Fig. 5 shows the same arrangement as Fig. 1 as arranged when working the fluids, having a constant expansion. Fig. 6 represents a slide-valve governing both ends of the cylinder constructed according to my improvement. Fig. 7 shows a vertical longitudinal sectional view showing the substitution of a piston-valve in place of the slide-valve in Fig. 6. Fig. 8 is a vertical longitudinal sectional view of the slide-valve of Fig. 6 as arranged for a variable expansion. Fig. 9 is a plan view of the construction shown in Fig. 8. Fig. 10 is a detail sectional view of the cam and valve shown in Fig. 9. Fig. 11 is a vertical longitudinal sectional view of the slide-valves governing both ends of the cylinder as arranged for non-elastic fluids. Fig. 12 is a vertical longitudinal sectional view of a distributing device for pumps for elastic fluids with separate auxiliary valves. Fig. 13 is a side elevation of a valve-gear for pumps having separate distributing slide-valves for each end of the cylinder, as shown in Figs. 1, 2, and 5. Fig. 14 is a horizontal sectional view thereof. Fig. 15 is a transverse sectional view thereof on the line a' b' of Fig. 14; and Fig. 16 is a detail sectional view of one of the valves, showing a modified construction.

Similar letters of reference indicate corresponding parts.

The valve-cylinders a' are connected with each end of the motive cylinder a by the inlet-passage f, which valve cylinders a are connected by the outlet-passages f' with the exhaust-pipe. (Not shown.) Each valve-cylinder a contains a distributing-valve e, the stem of which is connected with the cross-piece d' of a sleeve d^2, into which the elongations c' of the piston-rod c can reciprocate.

The elongations c' of the piston-rod are provided with heads c^2, that can strike against the closed outer ends of the sleeves d^2. The opposite cross-pieces d' are connected by the rods d. Each valve-cylinder a also contains a piston g, having a piston-rod g^2, on the opposite end of which a piston g' is mounted, upon which the steam can act, which steam is conducted from the cylinder a or from the inlet-channel f through the pipe h' into the cylinder g^3 of said piston g'. (See Fig. 2^a.) The movement of the distributing-valve during that stroke is as follows: As shown in Fig. 5, the left-hand end of the motive cylinder a is connected by the channels f and f' with the exhaust-pipe, whereas the right-hand end of the cylinder a is connected by the channel f with the live-steam or inlet pipe, which is not shown. The steam continues to pass through the channel f into the right-hand end of the cylinder a until the channel h' is brought in communication with the right-hand end of the cylinder. If the piston b while traveling from right to left passes the end of the channel h', the live steam passes through the said channel h into the small cylinder g^3, and acting on the piston g' presses the same and the cut-off piston-valve g, con-

nected therewith, to the right and in contact with the steam-valve *e*, and thus shuts off the live steam from the main cylinder *a*. Near the end of the stroke of the piston from right to left the right-hand head c^2 of the piston-rod elongation *c'* strikes against the right-hand cross-bar *d'* and by means of the connecting-rods *d*, moves both valves *e* positively from right to left. Thereby at the right-hand end of the cylinder *a* the channel h^2 is cut off from the exhaust, and by means of the channel h^3 said channel h^2 is connected with the live-steam inlet. The live steam now acts on the right-hand end of the slide-valve *e* and moves the same to the extreme position toward the left, whereby the right end of the cylinder *a* is connected by the channel *f'* with the exhaust pipe or channel. At the left-hand end of the main cylinder *a* the left-hand end of the slide-valve *e* is connected by the channel h^2 with the exhaust-outlet, and the live steam, acting at the same time on the right-hand end of the slide-valve *e*, moves the same toward the left until the exhaust-channel *f'* is completely opened, and so on. In order to adapt this valve movement for an adjustable cut-off, the channel *h'*, which conducts steam into the small cut-off valve-cylinder g^3, is not connected with the main cylinder *a*, but with the live-steam inlet-channel *f*. In an extension of each cylinder g^3, a cock *i* is arranged, which has an L-shaped bore, which cocks can be turned from the main shaft by gearing in the proportion of one to two, and whenever said cocks are turned from the main shaft the live steam can be cut off. The two cocks *i* are connected by a spindle *l*, having spiral grooves, and on said spindle the toothed wheel *k* is mounted loosely, and is engaged by a barrel-pinion *k'* mounted on the shaft k^2, which is driven from the crank-shaft of the engine in any suitable manner. By adjusting or shifting the toothed wheel *k* on the spindle *l* in the direction of its length the cut-off can be changed at will. When the gearing for driving the spindle *l* is arranged in the proportion of one to two, which is sufficient to turn the spindle *l* one hundred and eighty degrees for adjusting the cocks, so that the steam is not cut off, the live steam passes into the main cylinder *a* throughout the entire stroke.

In place of a spindle having spiral grooves a spindle having a longitudinal groove can be used, and in that case the wheels *k k'* must have screw-teeth. The wheel *k* is adjusted by means of the screw-spindle *o*, Fig. 1, which carries a nut *n*, having two arms *m* embracing the wheel *k*. The spindle *o* can be turned by means of a hand-wheel, as shown in Fig. 1; or it can be connected with the well-known governor, as shown in Fig. 4.

When the engine is to be reversed, the valves *e* are reversed by means of the hand-lever *p* while the engine is in motion.

As shown in Fig. 6, the rods for moving the valves can be operated from the extensions of the piston-rod by means of a pivoted lever *p'*, as shown in Fig. 13, by means of an eccentric disk *q* on the crank-shaft.

It is by no means absolutely necessary with my improved construction of valves that each end of the cylinder be provided with a separate valve, as a common valve can be used for governing the admission and exit of the steam to both ends of the cylinder, which valve can be constructed as a piston-valve, as shown in Fig. 7, or as a slide-valve, as shown in Fig. 8. Fig. 7 shows a valve constructed for a uniform cut-off and Fig. 8 for an adjustable cut-off. In the construction shown in Fig. 7 the rod for operating the valve is moved in the same manner as shown in Fig. 6—that is to say, it moves in the inverse direction of the movement of the piston in the main cylinder *a*.

Fig. 6 shows a piston at the end of its stroke from left to right, the slide-valve *e* having been moved from right to left. The motive fluid now passes through the channel *h* to the right-hand end of the piston in the valve-cylinder, and the valve *e* is moved still farther from right to left until the channels *f* are entirely open. When the piston in the cylinder *a* has been moved so far to the left that the channel *h'* is connected with the right-hand end of the main cylinder *a*, the live steam passes up through said channel *h'* and acts on the right-hand piston *g'*, whereby the cut-off valve *g*, connected therewith, is moved to the left until it rests against the valve *e* and closes the channel *f*, thus cutting off the steam and preventing a further passage of steam through the right-hand channel *f* to the right-hand end of the cylinder. Near the end of the stroke from right to left the valve *e* is moved from left to right and automatically opens the channel *f* for admitting steam into the left-hand end of the main cylinder *a*. If the cut-off is to be made adjustable, the valve *e* is provided with two channels h^4, as shown in Fig. 8, which can be connected by the channels h^5 with the exhaust-channel. Thereby a double piston-valve g^2 is actuated, which closes the steam-inlet. The connection of the channel h^5 with the exhaust-channel is accomplished by means of valves *i'*, Fig. 10, which can be opened and closed at will. For the purpose of opening and closing these valves a shaft l^2, Fig. 9, is arranged at the side of the cylinder, and on said shaft l^2 a sleeve *l'* is mounted, that is provided with spiral projections that can act on the valve-stems and press the same inward, thereby opening said valves. The shaft l^2, and with it the sleeve *l'*, is turned from the main crank-shaft in any suitable manner, and said sleeve *l'* is provided with two collars, between which the prongs of a fork *r* are mounted, which fork is controlled by the governor and transmits longitudinal movement to the sleeve *l'*, thus shifting the same on the rotative shaft *l*. During the movement of the piston in the main cylinder *a* from

left to right the slide-valve *e* is moved from right to left. When the piston in the main cylinder *a* arrives at the end of its stroke, the valve *e* has slightly opened the right-hand channel *f*, so that the fluid behind the left-hand end of the valve *e'* can escape, and as the fluid at the right-hand end of the valve *e* has greater pressure it forces the valve *e* from right to left, whereby the channels *f* are opened and the right-hand end of the main cylinder *a* is brought in communication with the steam-inlet and the left-hand end is brought in communication with the exhaust-outlet. When the valves are in this position, the channel h^4 is in communication with the channel h^5, so that the motive fluid behind the double slide-valve g^2 can escape at the time that the valve *i'* is opened. Thereby the valve *e* can be moved from right to left and the channel f^2 closed. This valve-gear has the advantage that it is well adapted for pumps, as shown in Figs. 11 to 16. Figs. 13, 14, and 15 show the valve-gear for pumping elastic fluids. When the piston *b* is at the extreme right-hand position in the main cylinder *a*, the inlet-channels *f* are closed, and consequently as the piston moves toward the left the air in the right-hand end of the cylinder becomes rarefied, and at the same time also becomes rarefied in the space behind the slide-valve *e'*, as this space is connected by the channels h^2 and *f* with the main cylinder *a*. As the space behind the valve e^2 is connected with the compression-chamber, the greater pressure acting on the right-hand slide-valve *e* moves it from left to right until the channel *f* is opened, and thereby the right-hand end of the main cylinder *a* is connected with the air or any other fluid that is to be compressed. During this time the charge of the left-hand end of the cylinder is being compressed until the pressure in the compression-chamber is reached. If the fluid is compressed still more, the greater pressure acting on the piston *e'* forces the valve *e* from left to right, and thereby the inlet-pipe is closed and the left-hand end of the main cylinder *a* is brought in communication with the compression-chamber. The space in which the outer piston-valve *e* works is connected by the channel h^2 with the main cylinder, and the space in which the inner piston-valve e^2 works is connected by the channel h^3 with the compression-chamber; and the valves must be made of such size that the difference in size in favor of the outer one is such that when the desired degree of compression has been obtained the pressure on the outer piston-valve will be sufficient to overcome the friction and to move the left-hand slide-valve *e* from left to right, and thus bring the left-hand end of the main cylinder *a* in communication with the compression-chamber. During the latter part of the movement of the piston in the main cylinder both piston-valves *e* are moved from right to left by means of the head c^2 and the rods *d*, and thereby at the left-hand end of the main cylinder the channel *f* is disconnected from the compression-chamber and at the right-hand end the channel *f* is disconnected from the inlet-channel *f'*. So as to equalize the pressure in both cylinder ends after a stroke the slide-valves *e* are provided with the channels h^6, which by means of the channels h^7 produce this equalization of pressure. This arrangement can be modified by providing for the piston-valves *e'* e^2 of different sizes the plunger-piston e^4, Fig. 16, at the inner end and solid pistons e^5 at the outer end. The rods *d* for positively moving the valves are then connected with the plunger-pistons or their extensions *s*, whereas the automatic movement is obtained by fluids passing through the channel h^3, which channel at the beginning of the compression-stroke connects the space behind the piston e^2 with the compressed fluid in the cylinder and at the beginning of the suction-stroke creates rarefaction of air.

The pumps can be constructed with a single slide-valve for both ends of the cylinder—as is, for example, shown in Fig. 11, which shows a construction of this kind for pumps used for pumping non-elastic fluids. The rods *d* are moved in the same direction as the piston-rod of the main cylinder. When the piston in the main cylinder moves from left to right, the slide-valve *e* moves from left to right, and when the stroke is completed is in such position as to close both channels *f*. If the piston now moves to the left, the space behind the right-hand piston *e'*, which is connected by the channel *h* with the right-hand end of the main cylinder, is balanced, whereas at the same time a greater pressure is provided behind the left-hand piston *e'*. Thereby the valve is brought into its extreme right-hand position, and the right-hand end of the main cylinder *a* is connected by the channel *f'* with the suction-pipe and the left-hand end with the compression or stand pipe. Near the end of the stroke from right to left the rods *d* are again actuated by one of the heads on the piston-rod, and the slide-valve *e* is moved from right to left until the channels *f* are closed.

In order to decrease the blows of the piston-valves as much as possible, the channels *h* are provided with cocks i^2, by means of which the channels h^2 can be throttled, as desired. When reversed, this construction can be used for water-motors. In this case the mechanism for positively moving the valves must be so arranged as to move reversely to the piston—for example, by means of a lever, as shown in Fig. 6. For pumps for elastic fluids a double slide-valve g^3, Fig. 12, is used, which valve g^3 is moved by a fluid conducted by suitable channels into the space behind said valve, and the mechanism for positively moving the slide-valve must in this instance also move in the direction of the piston. At the end of the stroke both channels *f* are closed, and when the piston in the main cylinder

moves toward the left the right-hand piston-valve e' is balanced, whereas the pressure on the left-hand piston-valve e' is increased, and thereby the slide-valve is moved to the right, so that the right-hand half of the main cylinder is brought in communication with the suction-pipe. During this time the left-hand end of the main cylinder is disconnected from the compression-chamber by the double slide-valve g^3. As soon as the fluid in the left-hand end of the main cylinder has the desired highest pressure the double slide-valve is moved from right to left by the increased pressure in the space behind the piston, and thus the connection made between the cylinder and the compression-chamber. Near the end of the stroke the slide-valve is moved positively in the same direction with the main piston until the channels f are closed. At the same time the double slide-valve g^3 strikes against the projection t, whereby the same is moved back and closes the channel f^2. For the purpose of equalizing the pressure at the end of the stroke the channels h^6 and h^7 have been provided.

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

1. The combination, with a main cylinder and a piston therein, of one or more valve-cylinders connected with said main cylinder by channels for the fluid acting on or acted upon by the piston in the main cylinder, valves in said valve cylinder or cylinders, cut-off pistons in said valve-cylinders, means for operating said cut-off pistons by the fluid in the main cylinder, and mechanism operated from the piston-rod of the main cylinder for positively shifting the valves in the valve-cylinders, substantially as set forth.

2. The combination, with a main cylinder and a piston therein, of one or more valve-cylinders connected by channels with the main cylinder, valves in said valve-cylinders, cut-off pistons in said valve-cylinders, pistons connected with the cut-off pistons, chambers in which said pistons connected with the cut-off pistons can work, channels connecting the cylinder or its inlet-channels with said chambers for the pistons, and means for positively shifting the valves in the valve-cylinder from the piston-rod of the piston in the main cylinder, substantially as set forth.

3. The combination, with a main cylinder and a piston therein, of one or more valve-cylinders connected by channels with the main cylinder, valves in said valve-cylinders, cut-off pistons in said valve-cylinders, operating-pistons connected with said cut-off pistons, chambers in which the operating-pistons work, channels for admitting steam into the chambers of the operating-pistons, cocks for closing said channels leading to the chambers of the operating-pistons, and means for adjusting said cocks from the movable parts of the machine, substantially as set forth.

4. The combination, with a main cylinder and a piston therein, of one or more valve-cylinders connected by channels with the main cylinder, valves in said valve-cylinders, cut-off pistons in said valve-cylinders, operating-pistons connected with said cut-off pistons, chambers in which the operating-pistons work, channels for admitting steam into the chambers of the operating-pistons, cocks for closing said channels leading to the chambers of the operating-pistons, a spirally-grooved shaft connected with the cocks, a wheel mounted loosely on said shaft and having its hub engaged with the spiral ribs on the shaft, a barrel-pinion engaging said toothed wheel, and means for rotating the barrel-pinion from the movable parts of the machine, substantially as set forth.

5. The combination, with a main cylinder and a piston therein, of one or more valve-cylinders connected by channels with the main cylinder, valves in said cylinders, cut-off pistons in said valve-cylinders, operating-pistons connected with said cut-off pistons, chambers in which the operating-pistons work, channels for admitting steam into the chambers of the operating-pistons, cocks for closing said channels leading to the chambers of the operating-pistons, a spirally-grooved shaft connected with the cocks, a wheel mounted loosely on said shaft and having its hub engaged with the spiral ribs on the shaft, a barrel-pinion engaging said toothed wheel, means for rotating the barrel-pinion from the movable parts of the machine, and means for shifting the toothed wheel lengthwise on the spirally-ribbed spindle, substantially as set forth.

6. The combination, with a main cylinder and a piston therein, of a piston-rod projecting from both ends of the cylinder, a sleeve mounted loosely on each end of the piston-rod, a cross-bar connected with each sleeve, rods connecting the cross-bars, one or more valve-cylinders connected by channels with the main cylinder, a valve in each valve-cylinder, which valves are connected with the cross-bars of the sleeves on the main piston-rod, a cut-off valve in each valve-cylinder, and means for operating said cut-off valves by live steam, substantially as set forth.

7. The combination, with a main cylinder and a piston therein, of one or more valve-cylinders connected with the main cylinder, a steam-controlling valve in each valve-cylinder, a cut-off valve in each valve-cylinder, means for operating the cut-off valves by live steam, and means for conducting the live steam from the main cylinder to said means for operating the cut-off valve, substantially as set forth.

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

JULIUS FRÖLICH.

Witnesses:
CARL KRÜGER,
HERMANN KOEPPEN.