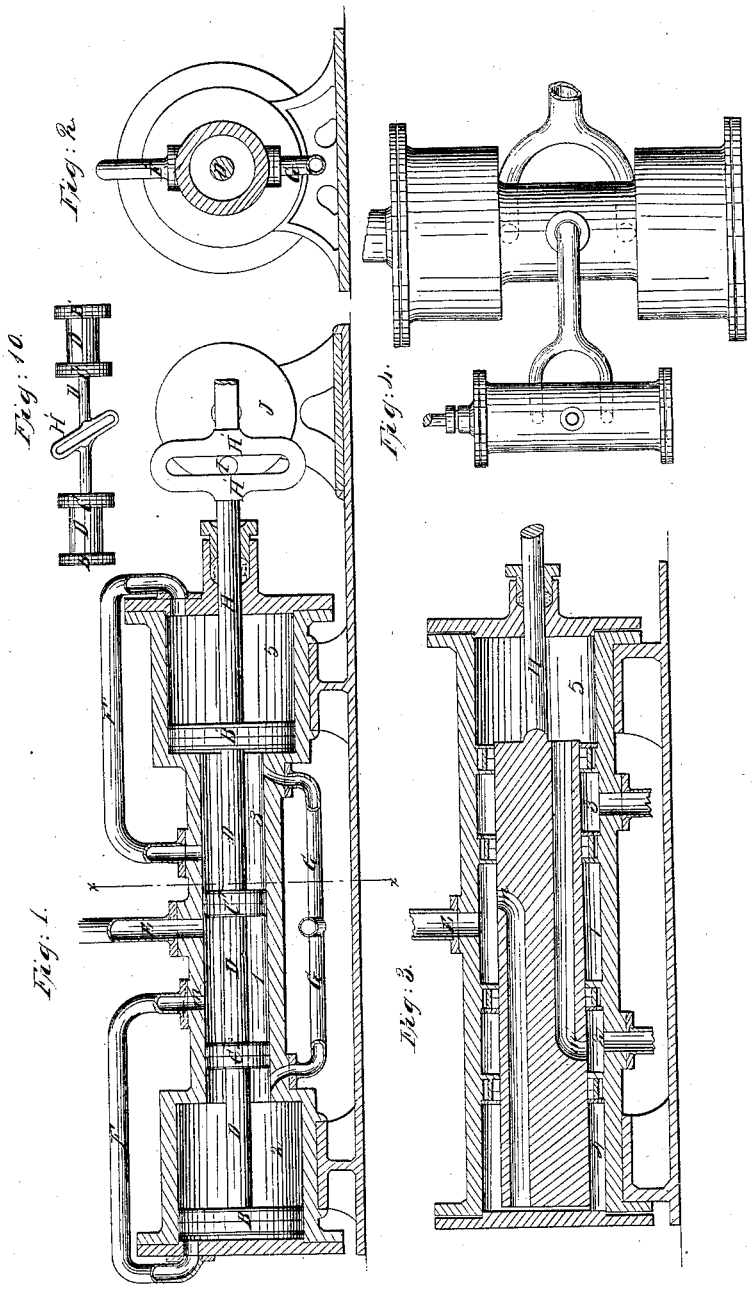
2 Sheets. Sheet 1.

G. I. Washburn,

Steam Slide Valve.

No. 49,809. Patented Sep. 5, 1865.



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2 Sheets. Sheet 2.

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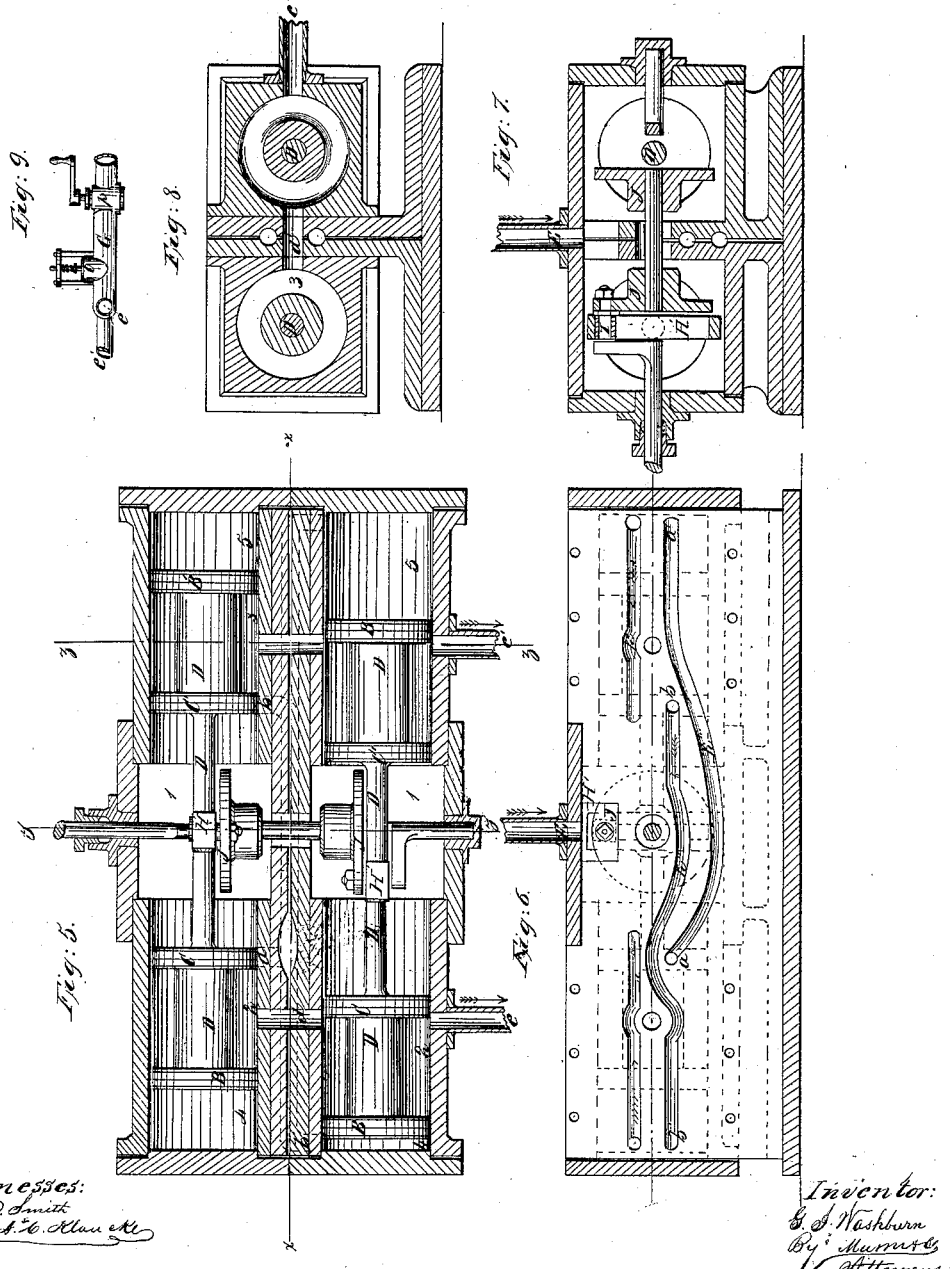

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UNITED STATES PATENT OFFICE.

GEORGE I. WASHBURN, OF WORCESTER, MASSACHUSETTS.

IMPROVEMENT IN STEAM-ENGINES.

Specification forming part of Letters Patent No. **49,809**, dated September 5, 1865.

To all whom it may concern:

Be it known that I, GEORGE I. WASHBURN, of the city and county of Worcester, and State of Massachusetts, have made certain new and useful Improvements in Steam-Engines; and I do hereby declare the following to be a clear and exact description of the same, reference being had to the accompanying drawings, which are made part of this specification, and in which—

Figure 1 is a vertical longitudinal sectional view of a single cylinder engine, which is shown as attached by its piston-rod and loop to the wrist on the disk which is attached to the main shaft. Fig. 2 is a transverse vertical section in the line *x x*, Fig. 1. Fig. 3 is a vertical longitudinal section of a single-cylinder engine in which the piston-packing is fast to the cylinder and the ends of the plug form the piston-surfaces. The passages analogous in their action to the passages K K′ K² K³, Fig. 6, are made in the body of the plug-piston. The spaces 4 2 1 3 5 are all analogous in their action to the corresponding parts in Fig. 1. Fig. 4 is a view of two cylinders, one high-pressure and the other low-pressure, and the latter receiving the exhaust-steam from the former. Fig. 5 is a horizontal central section of a combined double engine, the moving parts being shown in place. Fig. 6 is a central vertical longitudinal section on the line *x x*, Fig. 5. Fig. 7 is a transverse vertical section on the line *y y*, Fig. 5, with the moving portions partly in section. Fig. 8 is a transverse vertical section on the line *z z*, Fig. 5. Fig. 9 shows a portion of the exhaust-pipe with its regulating stop-cock and safety-valve. Fig. 10 shows a modification of the stem-loop.

Similar letters refer to like parts in each of the figures.

The invention consists of a steam cylinder within which are located two single-acting pistons, between which, and upon the same axis or stem with the pistons, are two disks, which, although traversing the cylinder steam-tight, perform no office as pistons to receive or transmit pressure, but serve to separate the space between the single-acting pistons into three spaces, the middle one being open to the steam from the boiler when the steam takes the direction indicated by the arrows, Fig. 6, and the outer ones being always open to the outer air, condenser, or place in which the exhaust-steam is utilized or applied. The steam is, by the reciprocating motion of the moving parts, alternately admitted to and exhausted from the effective spaces at the ends of the cylinders, and this motion, and the consequent opening and closing of certain ports to certain passages, may be utilized for the purposes of a valve; or by connection with the stem on which the said pistons and disks are placed, or by a prolongation of the stem as a piston-rod, any desired connection with machinery may be made, as illustrated in Figs. 1, 5, and 7.

Among the principal objects to be attained is to cause the momentum of the moving parts to be overcome by the elastic pressure of the steam, instead of being overcome by the tension of the materials. Another object is to make the motions of the valve as quick as that of the piston by attaching it to the piston itself.

In engines of ordinary construction the crank and pin receive much of the momentum of the moving parts, and consequently a limit of speed is found in their power of resistance to fracture or displacement. In the engine, Fig. 1, a cushion of live steam receives and overcomes the momentum of the moving parts and causes their return motion. When the piston is at half its stroke the centers of the disks and the centers of the ports coincide. The steam is reversed as soon as the disks have passed these ports, and acts expansively while the disks cover the ports, and the point at which the steam is reversed, as well as the duration of the expansion, is governed by the widths of the disks and that of the ports taken together.

To enable one skilled in the art to which my invention appertains to make and construct my engine, I will proceed to describe it in detail, and will commence with it as illustrated in Fig. 1, which is a double-acting single-cylinder engine.

4 5 are the effective spaces of the cylinder, which are traversed by the pistons B B′, which are attached to the stem D, upon which latter also are disks C C′, which divide the space between the pistons B B′ into three parts, 2 1 3, so that the length of the cylinder is divided by the pistons and disks into five spaces, 4 2 1 3 5, 4 and 5 being included between the pistons and the cylinder-heads, where they con-

stitute the effective spaces to and from which the steam is admitted and exhausted. The central space, 1, is in direct communication with the boiler by means of the pipe E, and alternately in connection with the spaces 4 and 5 by means of the pipes F F′, respectively, and two spaces, 2 3, included respectively between B and C and B′ and C′, which spaces are always in communication with the exhaust-pipes G G′, and alternately in communication with the effective spaces 4 5 by means of the pipes F F′, to exhaust the steam therefrom. The relative distances between the disks and pistons are invariable, and the passage in which they reciprocate may be of equal diameter at all points of its length, or a portion contracted, as in Fig. 1. The disks and pistons may be simply attached to a stem, as in Fig. 1, or B and C, B′ and C′, may be united by enlargements, as in Fig. 5. These are points of detail; but it is understood that the spaces included between these portions maintain their relative positions, and by the motion are brought in relation with certain ports, as described, by which the flow of steam is governed and directed.

I will mention at this point that it is possible to run the engine by reversing the flow of steam, making the inlet the exhaust, &c. In this case the space 1 will become the exhaust and the spaces 2 and 3, respectively, will become the steam-spaces, from which the supply of steam will pass to the effective spaces 4 and 5 of the engine, the steam-pipes being changed so that the space 4 communicates by pipe F with the space 3 and the pipe F′ communicates between 5 and the space 2.

The piston-rod H is shown as connecting by a loop, H′ H′, with the wrist I on the disk J, by which the reciprocating is converted to a rotary motion in a common manner.

Referring to Fig. 1, which illustrates a double acting single-cylinder engine, I will state that, taking the piston at that part of its stroke when the disks have just passed the ports M M′, (and this point of the stroke will be determined by the width of the disks, taken in connection with the width of the ports,) the live steam from the boiler is admitted to the effective space to which the piston is advancing, so as to overcome the momentum of the moving parts within the cylinder by opposing their motion, and upon the return-stroke the live steam, until the disks have covered the ports, acts effectively upon the pistons. Now, assuming that these actions of the live steam are in effect equal to each other, the expansive action of the steam, which takes place while the parts M M′ are covered by the disks, is the effective working power of the engine. This is a valuable feature in an engine which is designed to be driven at great speed under immense pressure.

In Fig. 5 is illustrated a combined engine consisting of two cylinders, Nos. 1 and 2, each constructed in substantially the same manner as that in Fig. 1; but the spaces 2 1 3 and disks C C′, as moved by pistons B B′ of one cylinder, govern the action of the steam in the effective spaces of the other cylinder.

The function of each of the pipes or passages K K′ K² K³ is similar to that of the pipes F F′ of Fig. 1 in connecting effective space with a steam-space and an exhaust-space alternately; but in the case of the combined engine each of these passages opens from an effective space in one cylinder, alternately into a steam and exhaust space in the other cylinder in such a manner that the disks C C′ in one cylinder, in passing the center of their stroke, effect the reversing of the pressure upon the pistons in the other cylinder. To describe this operation in detail: In the cylinder No. 2, Fig. 5, effective space 4 is receiving live steam through the channel K, Fig. 6, from steam-space 1, cylinder No. 1. At the same time space 5, cylinder No. 2, by means of a channel, K′, Fig. 6, is opened to exhaust-space 3, cylinder No. 1. Consequently the pistons of cylinder No. 2 move in the direction of the arrow. It will be seen that disks C C′, cylinder No. 2, are now in the middle of their stroke and cover ports *a* and *b* of that cylinder. When, in the course of their motion, they uncover these ports steam from steam-space 1, cylinder No. 2, passing in at port *b* and through pipe K², Fig. 6, emerges from port *b′* into effective space 4, cylinder No. 1. At the same time, port *a* being opened to exhaust-space 2, cylinder No. 2, the effective space 5, cylinder No. 1, is opened by means of channel K³, Fig. 6, into said exhaust-space, and through passage *d*, across exhaust-space 2, cylinder No. 1, into exhaust-pipe *e* and the outer air. The channels *d d′* connect the exhaust-spaces 2 and 3 of each cylinder respectively at all times, so that their contents may escape by opening *e e′* to the open air. At this point the pistons of cylinder No. 1 commence to move in the same direction as the arrow in cylinder No. 2. When disks C C′, cylinder No. 1, have passed the middle of their stroke and uncovered the ports of that cylinder corresponding to *a b* of cylinder No. 2, at which period the pistons in cylinder No. 2 will be ready to commence their return-stroke, the said disks will have reversed the pressure upon the pistons in cylinder No. 2, giving live steam through pipe K′, Fig. 6, from steam-space 1 of cylinder No. 1 to effective space 5, cylinder No. 2, and allow the steam to exhaust from space 4, cylinder No. 2, through pipe K, Fig. 6, into exhaust-space 2, cylinder No. 1, from which and through pipe *e* it proceeds into the outer air.

Although the motions described do not trace the operation through a complete revolution of the main shaft, yet the succeeding operations are so strictly analogous to those already detailed that it may be readily perceived how the motions of the pistons and disks, together with the spaces 2, 1, and 3 in each cylinder, respectively, produce the desired action of the steam, wherefrom a continuous rotation of the main shafts results.

It will be observed in this connection that

proportioning the width of the disks C C′ on each cylinder and the widths of the ports across which they pass, and thus controlling the period during which the passage leading to and from the effective space is closed, the steam may be used expansively in one effective space of the cylinder, and at the same time act as a cushion in the other effective space of the same cylinder, thus opposing the momentum of the moving parts and relieving the crank-pin of a strain to which it would otherwise be exposed.

The stems D, midway between the disks C C′, are wrought into a loop, H′, similar in its construction and rotation to the crank-pin to that already described in treating of Fig. 1. A double-crank shaft provided with disks J is located transversely to the direction of the motion of the pistons. The cranks are placed at an angle of ninety degrees with each other, and possess the peculiarities and advantages of that peculiar construction. The office of the disks J is to maintain the stems and loops in such a position as not to interfere with the action of the crank-pin.

Fig. 5 may be also taken as illustrative of a valve, by which steam may be alternately admitted to and exhausted from separate exterior chambers. To utilize it for this purpose I may connect the said chamber or chambers with one or more passages, K K′ K² K³, Fig. 6, or with either or both of the cylinders themselves, by means of ports so located as to bear the same relation to the disks C C′ as do the ports *a b*, Fig. 5. This may be used with or without the presence of the cranks and shaft, which, although they modify the motion of the pistons, do not essentially alter its operation as a valve. Whether regarded in its character as a valve or engine, it will be seen that while the moving parts of one cylinder are in the act of reversing the pressure upon those in the other they are themselves under full pressure of steam from the other cylinder, and thus at no time, however short, is the engine or valve free from effective steam-pressure.

The modification shown in Fig. 10 consists of an oblique loop to the stem D, the effect of which is to bring the steam-pressure to bear upon the pistons of the combined engine, (see Fig. 5,) so as to overcome the momentum of the pistons when they arrive near the end of their stroke, and thus save the cranks from strain. The loop, instead of standing vertically, is inclined, so that when the crank-pin is in one end of the loop the mid-length of the stem is forward or beyond the mid-length of the cylinder, and still when the crank-pin is in the center of the loop the piston is just where it would be were the loop not inclined. So the only effect of making the loop inclined is to cause the piston to reach and pass the ports marked *a b* in Fig. 5 before the crank has reached its vertical position, and hence before the other piston has arrived at the end of its stroke. The loop must be so shaped that each end of it, when occupied by the crank-pin, shall be nearer the rear than the front end of its stem, the direction of the motion of the stem determining which is the front end. The piston, by this device, may be made to fly from steam-pressure to steam-pressure, while the crank has only to drive the machinery.

The back-pressure valve O is placed over or within the exhaust port or pipe, to which the exhaust-pipes of the engine converge for the purpose of stopping the action of the engine without allowing the cylinder to become emptied of steam, which is ordinarily the case when the exhaust is left open and the engine stopped by shutting off the steam. I propose to stop the engine by closing the exhaust-opening by means of stop-cock *p*, Fig. 9, which has the effect of causing the exhaust-steam to accumulate, and by its increasing pressure to oppose the motion of the piston. The back-pressure may be allowed to accumulate to any extent desired, and is kept within the proper limits by means of a safety-valve, O, Fig. 9, so arranged as to allow the exhaust-steam to escape when exceeding the desired pressure.

The stop-cock *p*, placed upon the exhaust-pipe, may by its channel permit the flow of the exhaust-steam, and by rotation close the passage, when the valve, which is adjusted to yield at the required pressure, may be brought into action to permit the escape of the steam; or the stop-cock may be so arranged as to shut off the steam, as described, and yield to the steam when it has attained the determinate pressure, thus performing both functions.

In the ordinary method of stopping an engine by shutting off the supply of steam the machine is brought to rest by the friction of the running parts, and during the interval between the shutting off of the steam and the stopping of the machinery those parts which operate within the cylinder in the case of my engine, Fig. 5, being nearly all of the moving portions, are apt to become dry and to cut the friction-surfaces. By means of this retention of steam the moving parts are surrounded by steam at all times, while the engine can be more expeditiously stopped, as well as completely controlled, by means of the said back-pressure.

The difficulties above alluded to are especially apparent in the case of locomotives which shut off the steam while the piston has yet to make a considerable number of revolutions before the stoppage of the engine.

The double-engine shown in Fig. 5 may be utilized by allowing the crank-shaft to project on both sides, placing driving-wheels directly upon it, the cylinder being placed under the boiler, and thus securing a locomotive-engine of great simplicity.

In connection with the above I propose to prolong the piston-rods through the heads of the cylinders and attach pump-pistons thereto, which reciprocate in pump-cylinders, so as to make a locomotive steam fire-engine, suitable

apparatus being applied to disconnect the wheels from the crank-shaft when required. For stationary purposes the projection of the said piston-rod may afford the means of operating pumps, hammers, stamps, molds, blowers, &c., either with or without utilizing the rotation of the crank-axis, to the direct purpose of driving additional machinery by pulleys and band or otherwise.

The device the subject of this specification, in its various suitable modifications, may be used as an engine, a valve, or a meter for fluids of any kind, and, owing to the location of the working parts within the cylinder, less attention is required in the way of lubricating by an attendant and less danger is incurred by the lack of said attention.

I desire to state that my invention is susceptible of several modifications which will be found on examination to embrace the same general principles and to bear a relationship which is nearer than is apparent at first sight.

By referring to the main feature of my invention, as stated in the preliminary syllabus of invention near the commencement of this specification, it will be seen that the essential feature depends upon the arrangement and common action of the pistons and disks which divide the length of the cylinder into spaces, which are brought into certain relation to openings or ports in the cylinder to produce the result which I will not again detail, as it has been already described.

Among the modifications may be found the following:

First. The cylinder may be the moving part, while the pistons are fixed. The re-arrangement would require certain modification of detail sufficiently obvious to an expert.

Second. Inasmuch as the pistons B B′ do not pass over ports, elastic diaphragms attached to the inner periphery of the cylinder and to the piston-rod may be substituted for the pistons, and the packing-rings of the two cylinders, as well as those of the two disks, may be made fast to the cylinder, as in Fig. 3, the piston itself in this case containing the channels *m m′* for the steam, analogous in their functions to the channels F F′ in Fig. 1.

Third. Referring to Figs. 1 and 5 of the drawings, which illustrate the single cylinder and a combined engine, the inlet and exhaust ports may be reversed in their action, making the exhaust-pipe G the inlet and the pipe E the outlet or exhaust. This would necessitate making the port M, Fig. 1, communicate with the effective space 5 and the port M communicate with the effective space 4. The combined engine, Fig. 5, may be reversed by changing the functions of the supply and exhaust pipes.

Fourth. The cylinders of the combined engine may be placed near each other or in separate rooms. They may be attached to a common shaft or to separate main shafts running at separate speeds and driving distinct machinery.

Fifth. They may be placed at an angle with each other when attached to the same shaft.

Sixth. An adjustable cut-off valve may be placed in the steam-pipe E, or two separate ones may be placed in the steam-passages F F′, Fig. 1, and K K′ K^2 K^3, Fig. 5, at which latter points the valves would be nearer their work.

Seventh. Inasmuch as the steam-space of one cylinder supplies the effective spaces of the opposite cylinder when the engine is in motion, I may reverse its motion—that is to say, rotate the main shaft in a contrary direction by changing the flow of steam, so that the steam which flowed from the steam-space of one cylinder to a certain end or effective space of the other cylinder shall flow to the opposite end of the last-mentioned cylinder. The expedients by which this may be accomplished are various, and I will suggest one, which consists in placing a cock or double D-valve in a point of junction between the pipes K K′ K^2 K^3, Fig. 6, so that by its motion the steam may be caused to flow in the required direction.

Eighth. The coactive connection represented in Fig. 5 may be maintained between any number of cylinders, the valve in each cylinder governing the motion of the piston in another, or the exhaust-steam from one cylinder may be made to act as effective in another, (see Fig. 4,) and the second cylinder may be low-pressure condensing.

Ninth. In cases of the very great pressure and high speed which I expect to obtain and use, the steam may leave the cylinder at such a pressure that it can be economically applied in a second high-pressure cylinder, and thus a series of two, three, or more cylinders be found economical; and it should be remarked that the last cylinder, should it be a low-pressure and in connection with the condenser, obtains most of its power from the atmospheric pressure, and as the high-pressure cylinder delivers the steam to the last cylinder, at an effective pressure of about three pounds, consequently any condensation of steam which may take place in the pipe between the two adds as much to the power of the high-pressure cylinder as it subtracts from the power of the low-pressure cylinder, and therefore a long connecting-pipe does not detract from the efficiency of the apparatus.

Having thus described my invention, the following is what I claim as new therein and desire to secure by Letters Patent:

1. The combination of the pistons B B′ and disks C C′, attached to a stem, D, with a cylinder provided with ports which open into the spaces between and beyond the disks and pistons, in the manner and for the purpose described.

2. Combining two or more such cylinders by means of connecting-passages, through which live steam or other fluid under pressure is sup-

plied from one cylinder to another, making the disks C C′, which are located between the pistons of one cylinder, act as a valve to the other cylinder or cylinders, whether the described apparatus be used as an engine or a valve.

3. Arranging a valve which gives steam to the effective spaces between the pistons and upon the same stem with them.

4. Arranging a valve which connects the effective spaces with the exhaust-pipe between the pistons and upon the same stems with them.

5. In combination with the said pistons B B′, disks C C′, and stem D, arranging the crank of the main shaft within the steam or exhaust space of the cylinder.

6. The arrangement of the valves for determining the extent of the expansive action by proportioning the width of the disks and ports as described.

7. Imprisoning a body of steam of not over a determinate pressure within the cylinder for the purpose described by means of closing the exhaust, as described.

8. So arranging the loop on the piston-stem or its equivalent as to cause the piston to pass the mid-length of its cylinder before its crank has reached its midway or vertical position.

To the above specification of my improvement in valve and steam-engine I have signed my hand this 25th of March, 1865.

GEO. I. WASHBURN.

Witnesses:

EDWARD H. KNIGHT,

CHARLES D. SMITH.