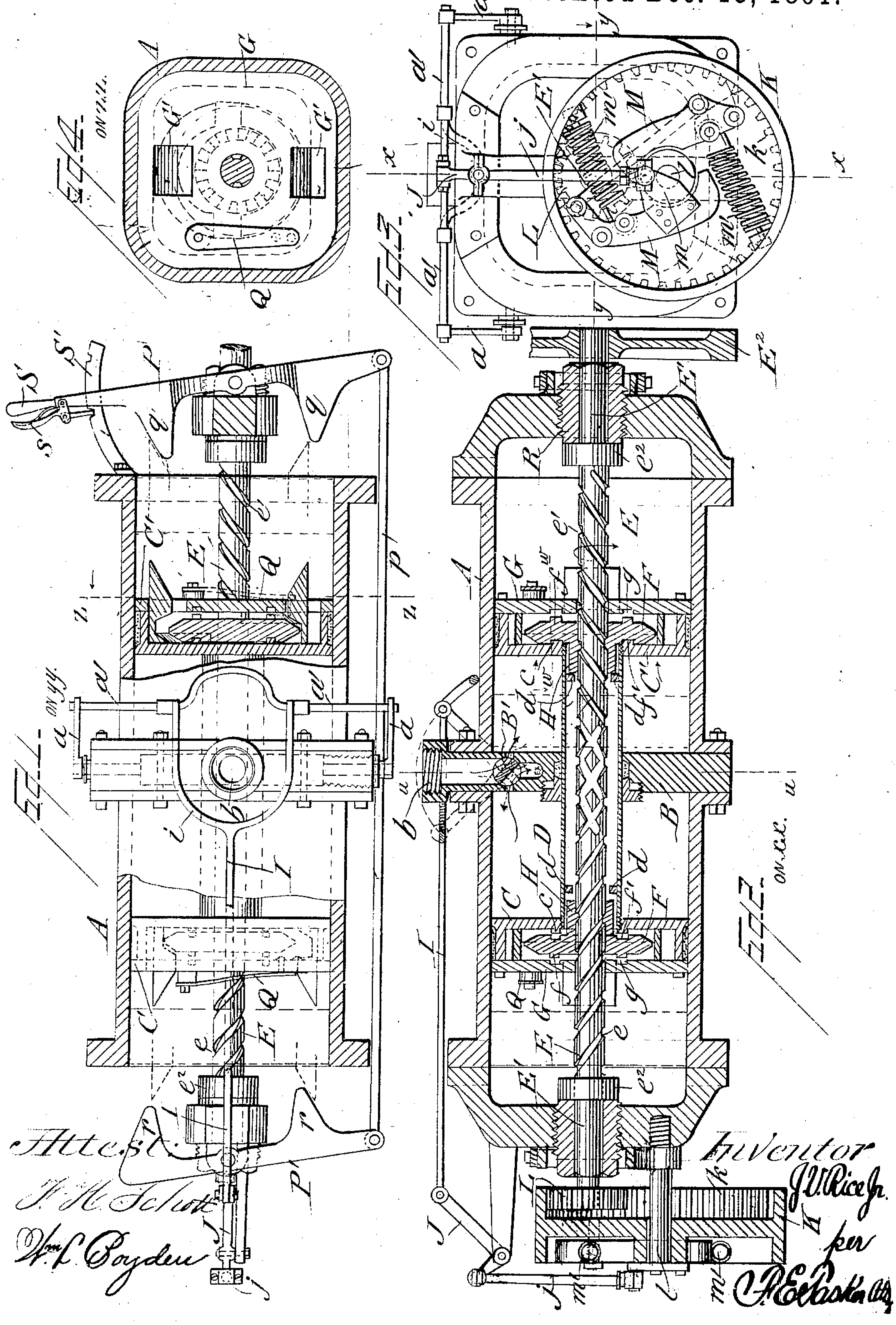
(No Model.)

3 Sheets—Sheet 1.

J. V. RICE, Jr.

STEAM ENGINE.

No. 465,100. Patented Dec. 15, 1891.



(No Model.)

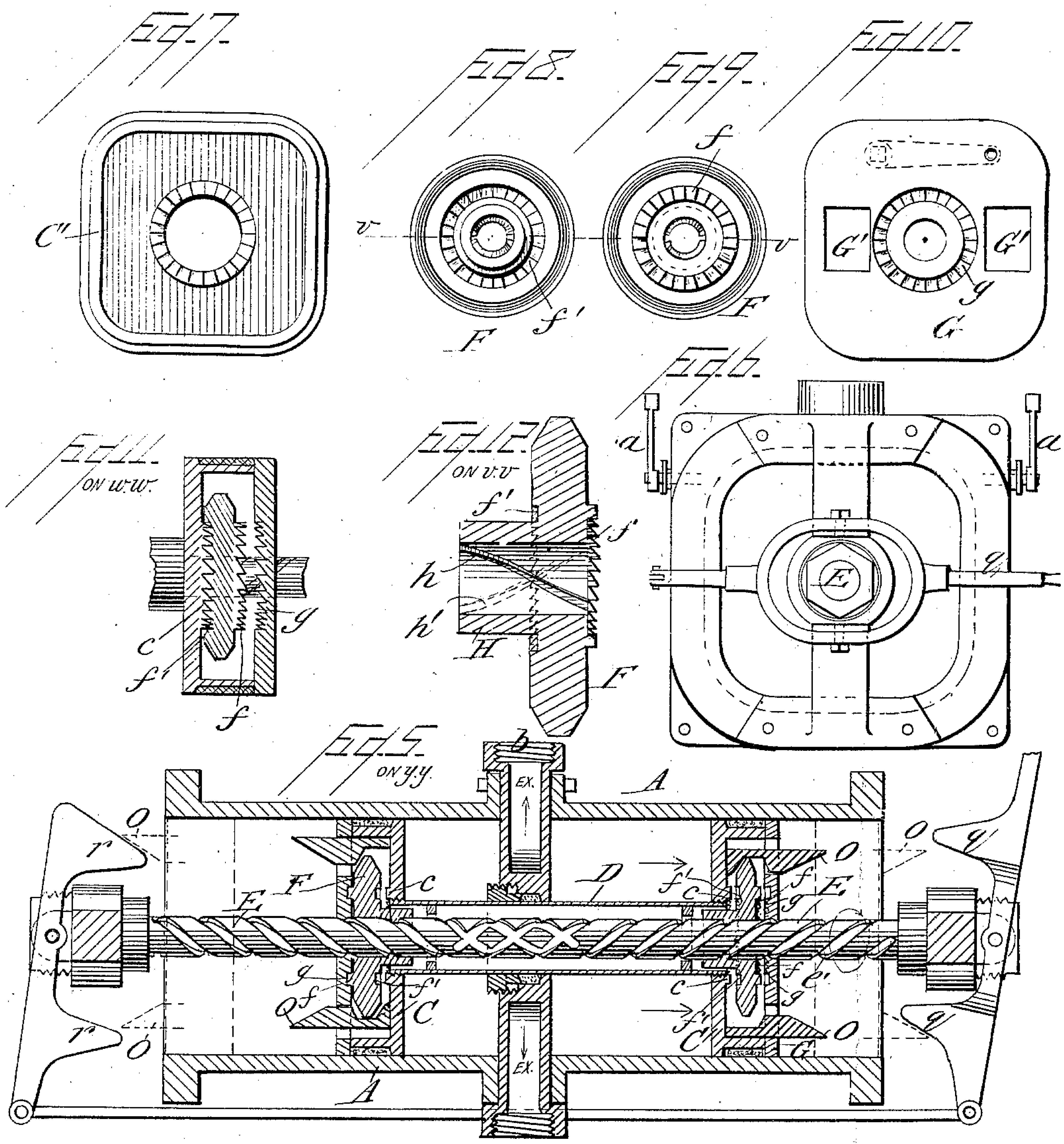
3 Sheets—Sheet 2.

J. V. RICE, Jr.

STEAM ENGINE.

No. 465,100.

Patented Dec. 15, 1891.



Attest:

F. H. Schott

Wm. L. Boyden

Inventor

John V. Rice Jr.

per Fred E. Tasker, Atty

(No Model.) 3 Sheets—Sheet 3

J. V. RICE, Jr.

STEAM ENGINE.

No. 465,100. Patented Dec. 15, 1891.

Fig. 15.

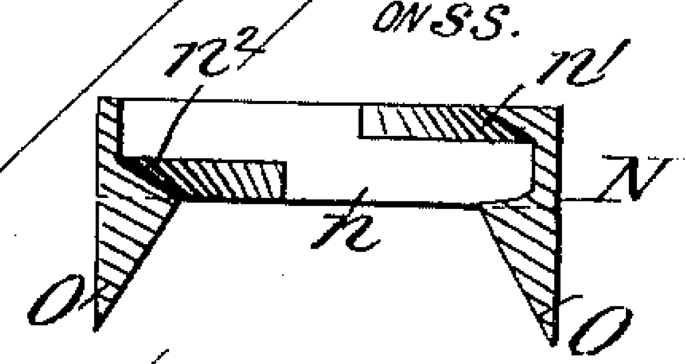


Fig. 13.

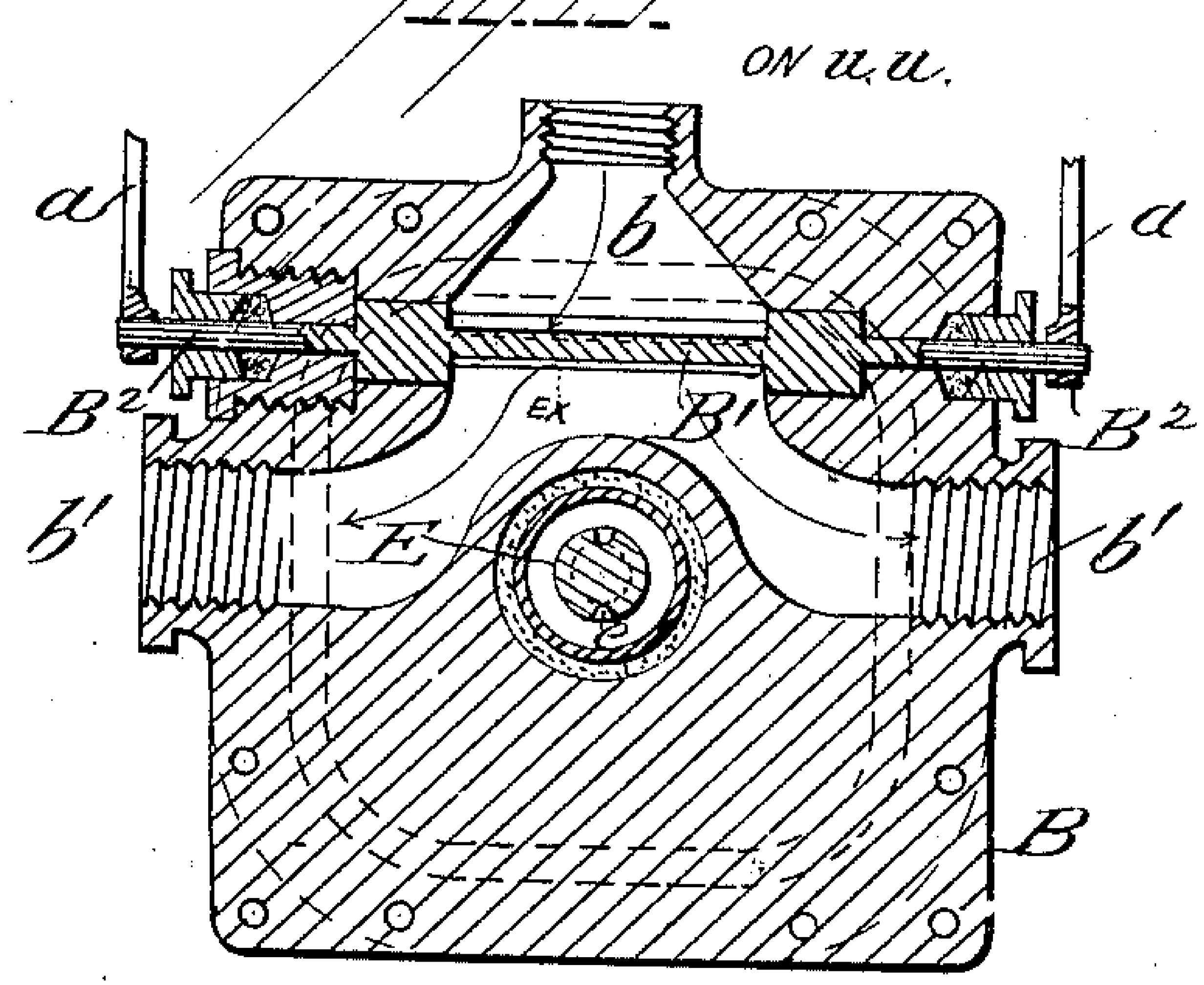


Fig. 16.

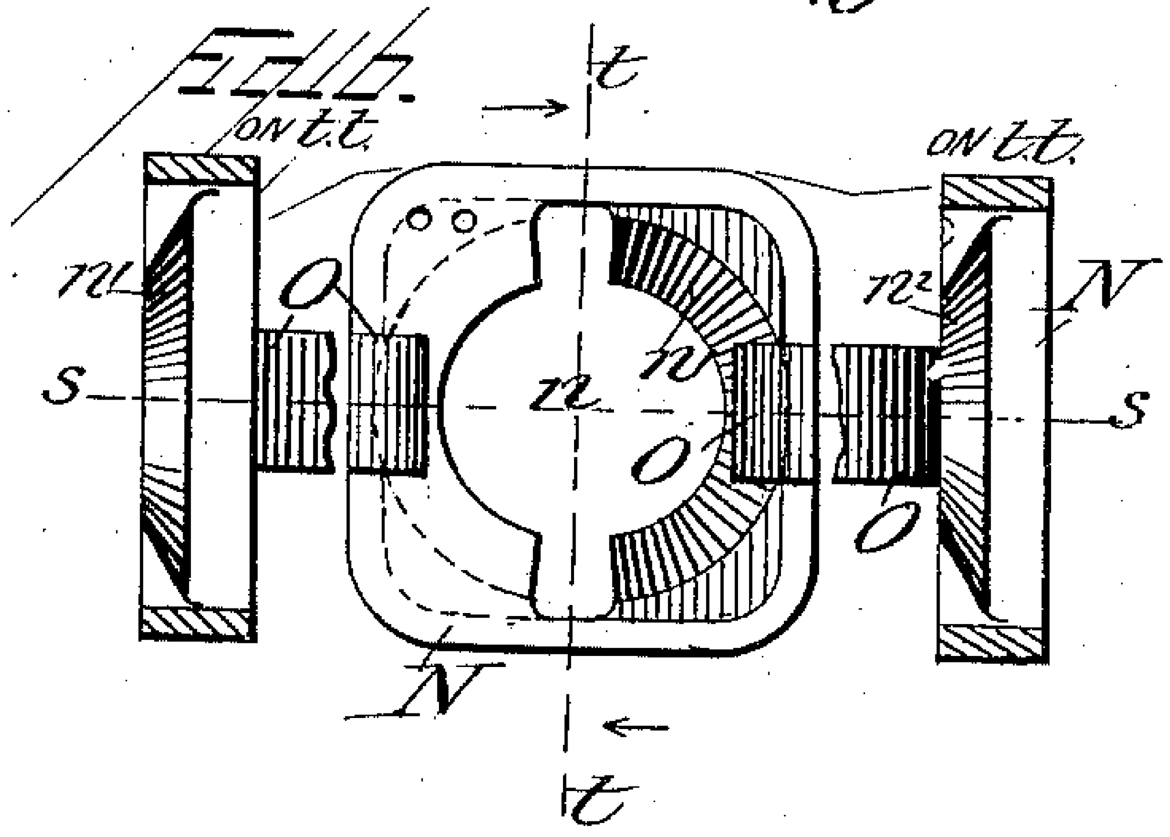


Fig. 14.

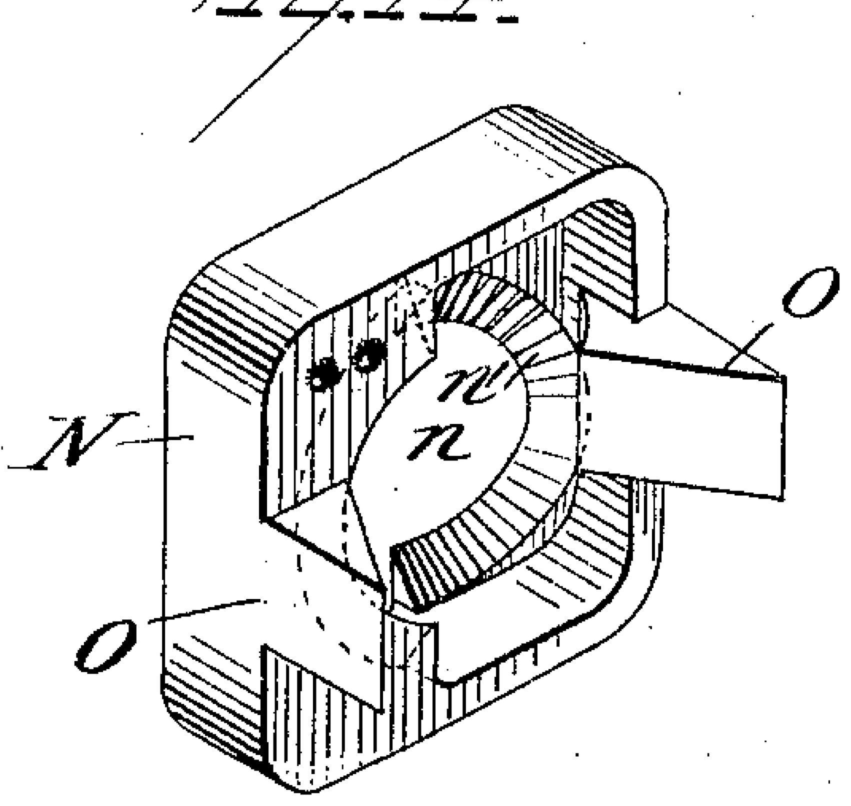


Fig. 17.

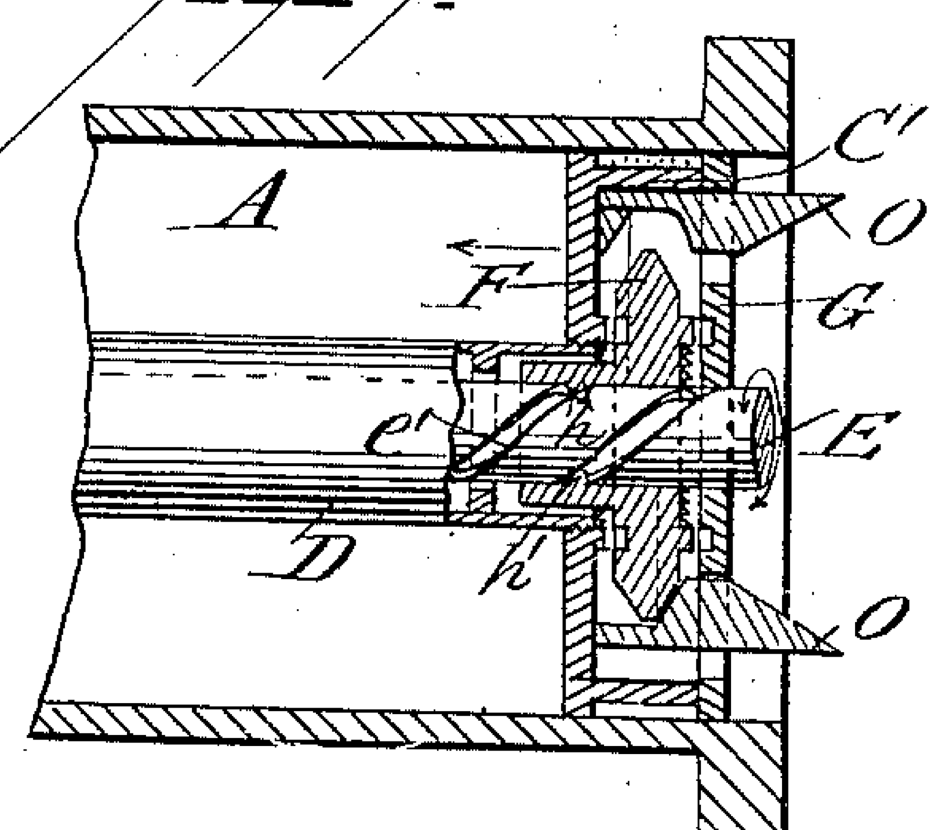
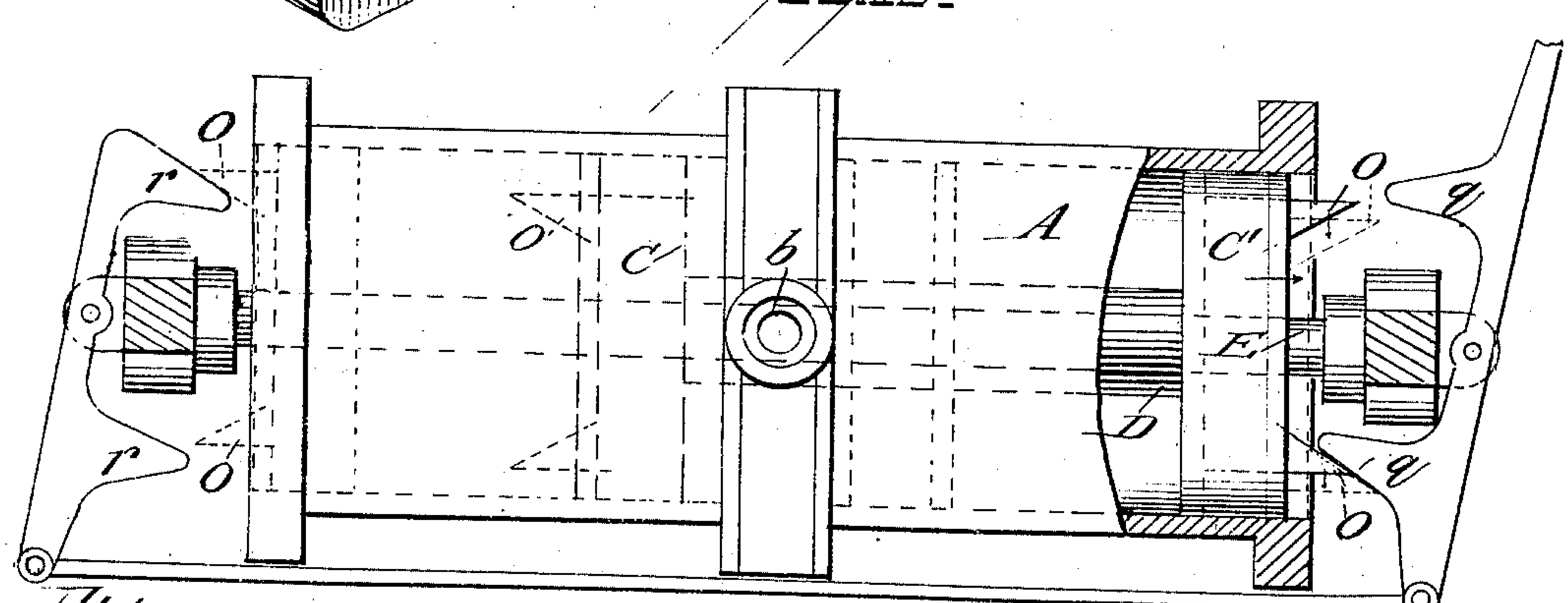


Fig. 18.



Attest:

H. H. Schott

Wm L. Boyden

Inventor

John V. Rice Jr.

per Fred E. Tasker, Atty

UNITED STATES PATENT OFFICE.

JOHN V. RICE, JR., OF CHESTER, PENNSYLVANIA.

STEAM-ENGINE.

SPECIFICATION forming part of Letters Patent No. 465,100, dated December 15, 1891.

Application filed November 4, 1890. Renewed September 12, 1891. Serial No. 405,455. (No model.)

To all whom it may concern:

Be it known that I, JOHN V. RICE, Jr., a citizen of the United States, residing at Chester, in the county of Delaware and State of Pennsylvania, have invented certain new and useful Improvements in Steam-Engines; and I do hereby declare the following to be a full, clear, and exact description of the invention, such as will enable others skilled in the art to which it appertains to make and use the same.

This invention relates to an improvement in steam-engines, and more particularly to that kind or class known as "direct-acting," its object being to provide an engine whereby with a simple organization, easy action, small size, light weight, few parts, and cheap and economical running a high efficiency and great rapidity of operation may be developed; and the invention consists in the construction, arrangement, and combination of parts, substantially as will be hereinafter described and claimed.

In the annexed drawings, illustrating my invention, Figure 1 is a plan view of my improved engine in partial horizontal section on the line *y y* of Fig. 3. Fig. 2 is a vertical longitudinal section of the same on the line *x x* of Fig. 3. Fig. 3 is a left-hand end elevation of the engine as represented in Fig. 2. Fig. 4 is a cross-sectional inner elevation on the line *z z* of Fig. 1. Fig. 5 is a horizontal section on the line *y y* of Fig. 3, it being similar to Fig. 1, but showing the parts in a different relative position, the engine being reversed. Fig. 6 is a right-hand elevation of the engine as represented in Fig. 1. Fig. 7 is an elevation of the interior of one of the piston-heads. Fig. 8 is an elevational view of one side of one of the ratchet-disks. Fig. 9 is an elevational view of the other side of said disk. Fig. 10 is a view of the inner face of one of the piston-head covers. Fig. 11 is an enlarged detail section on the line *w w* of Fig. 2. Fig. 12 is an enlarged section of one of the ratchet-disks on the line *v v* of Figs. 8 and 9. Fig. 13 is a transverse section on the line *u u* of Fig. 2. Fig. 14 is a perspective view of one of the stop-blocks. Fig. 15 is a cross-section of the same on the line *s s* of Fig. 16. Fig. 16 represents a front view of one of these blocks and two reverse sectional edge views taken on the line *t t* of the front view. Fig. 17 is a detail horizontal section showing the parts in a position different from what they occupy in Figs. 1 and 5. Fig. 18 is a plan view of the engine, partly in section.

Similar letters of reference designate corresponding parts throughout all the different figures of the drawings.

In the example of my engine presented in the drawings by way of illustration, A designates the cylinder of an engine of the single-cylinder direct-acting type, said cylinder A being open-ended to the atmosphere, there being at each end a suitable skeleton or other frame arranged to support certain of the mechanical parts.

Midway of the length of the cylinder A is a transverse partition or diaphragm B. (See Figs. 2 and 5, and especially the detail view in Fig. 13.) This partition B is suitably channeled or provided with passages, so that there may be an inlet on the top at *b* and exhaust-outlets on each side of the cylinder at *b′ b′*, all of which is clearly shown in Fig. 13. The steam which enters the passage *b* finds its way into the cylinder through suitable ports or openings in the partition B, as shown in Fig. 2, said ports being controlled by a valve B′, consisting, preferably, of a flat strip arranged to rotate by being provided with journals B^2 B^2, having bearings in the partition. The exhaust likewise takes place through these ports, and therefore the valve B′ regulates both the admission and exhaust of steam. As shown in Fig. 2, it permits the space on one side of the diaphragm to communicate with the steam-inlet for the admission of steam and the space on the other side of said diaphragm to simultaneously communicate with the exhaust-passages for the outlet of the exhaust-steam. When the valve shifts, a reverse condition takes place and steam is allowed to enter at the other side of the partition.

Within the cylinder A is a double-headed piston.

C and C′ denote the piston-heads, which are hollow and are connected together by a tube D, of suitable length and diameter. This tubular connection passes through a perforation in the center of the partition B, a stuffing-box being provided to form a tight fit and prevent leakage during the reciprocatory movements of the piston. Each of the piston-heads C and

C′ is provided with a cover-plate G, removably secured thereto by means of bolts or any other suitable devices. An outer face view of one of the plates G is shown in Fig 4, and an inner face view in Fig. 10. These covers are provided with a pair of oblong openings G′ G′, through which play the beveled projections on the stop-blocks, whose construction and function will be presently explained.

On the outer face of the covers G is a spring Q, carrying a pin which projects through an opening in the cover and enters a hole in the stop-block. This spring serves as a catch to hold the stop-block from being displaced. The tension of this spring is easily overcome when the block is shifted. Said block has two holes, as seen in Fig. 14, so that the pin may engage one of them when the block is in one position and the other when the block is in the other position. The mere shifting of the block operates to disengage the pin therefrom, inasmuch as the spring which carries the pin is of an easy tension, and therefore, the movement of the block is amply sufficient to throw the pin out of the hole.

Inside of each of the piston-heads C and C′ is loosely located a ratchet-disk, which has the function of a clutch for connecting the piston at the proper time with a rotative shaft in such a manner as to impart a movement to the latter, which in turn transmits motion to the valve. In Fig. 12 one of these ratchet-disks is shown enlarged in a detail view, and in Fig. 11 its position within the piston-head is distinctly illustrated. F indicates these ratchet-disks, there being one of them in each head. They each have a sleeve H, which lies within the tubular connection D, said connection being provided with interior stops *d*, against which the inner ends of the sleeve may abut. The periphery of the disk is preferably inclined or beveled on each side, as shown, and for a purpose which will soon appear. Each disk on its face adjacent to the sleeve H is formed with a circular ratchet or circular series of teeth or indentations *f′*, said teeth or indentations being formed within a circular groove, so that they lie below the surface of the disk-face. (See Fig. 8.) The piston-head is provided on its inner face with a corresponding series of ratchet-teeth or indentations *c* (see Fig. 11) directly opposite the teeth *f′*, said teeth *c* projecting from the surface of the head and adapted to engage teeth *f′* when desired. It may be proper to state at this point, what is sufficiently obvious from an inspection of the drawings, that these sleeved ratchet-disks, being loosely placed, have a certain range of movement permitted them within their respective heads, so that at times they are engaged with the ratchet-teeth on the head and at times are disengaged therefrom. Each disk, morover, on its face opposite the sleeve and toward the piston-cover G is provided with another series of ratchet-teeth *f*, which project from the surface of the disk-face. (See Fig. 9, also Figs. 11 and 12.) The cover G of the piston-head is provided on its inner face with a corresponding series of ratchet-teeth or indentations *g*, which are formed within a circular groove, so that they lie below the surface of the face of the cover, (see Fig. 10,) and these teeth *g* are directly opposite the disk-teeth *f* and adapted to be engaged thereby at the proper time. In Figs. 1 and 2 the teeth *f′* and *c* are shown engaged when we look at piston-head C′, and looking at the piston-head C′ in Fig. 11 we see teeth *f′* and *c* in engagement, whereas in viewing piston-head C in Fig. 5 we see teeth *f* and *g* in engagement with each other. Thus it will be seen that these sleeved ratchet-disks are adapted to shift back and forth, so as at different times to be connected with the teeth on the head proper, at other times with the teeth on the cover-plate, and at other times occupying a position between these two where they are not connected with either set of teeth, but are held or kept in this latter position by means of the stop-blocks, to be presently described.

The sleeved ratchet-disks are provided with internal ribs of a partially-spiral form, and denoted by *h* and *h′*. (See Fig. 12.) These spiral ribs are adapted to engage spiral grooves *e* and *e′* on a longitudinal shaft E, located centrally within the cylinder and supported at each end in bearings in the end frames. This spirally-grooved shaft E passes through the piston-heads, and also through their tubular connection. It has collars e^2 e^2 next to its bearings to prevent endwise displacement, and its said bearings for the ends E′ E′ are screwed into the frames, one of them—as R, for instance—being adjustable by rotation, so as to take up any wear that may occur. The spiral grooves *e* and *e′* on the shaft E run in opposite spirals from each end and meet and cross at the middle of the shaft, said middle portion being provided with both spiral grooves, so that both sleeved ratchet-disks may travel over this part.

On one end of the shaft E, which, as is evident, performs the function of the drive-shaft, as well as the other functions which have been and may be attributed thereto, is located outside of the end frame a drive-pulley E^2, which is to be belted to the driven device. On the other end of the shaft E is a pinion L, which engages the internally-cogged rim *k* of a governor-wheel K, turning on a stud *l*, projecting from the main frame. To this governor-wheel are pivoted the weights M M, having springs *m′ m′*, and on one weight is a projection *m*, which connects by a universal joint with a pitman-rod *j*, whose other end is pivotally fastened to one arm of a bell-crank lever J, pivoted on the main frame and having its other arm pivoted to a link I, having preferably a yoked end *i* so formed that it may pass around the steam-inlet pipe, and said yoke *i* is pivotally connected to a transverse shaft *a′*, whose ends are attached to arms *a a*, secured to the journals or pins B^2 of the valve B′. (See Fig. 13.) In this manner the movement of the shaft E in its rotation is transmitted to the valve which supplies and cuts off the steam. There is also located within each of the hollow piston-heads what I term a "stop-block" or "reversing-block," the function of which is to assist in reversing and also in controlling the proper position of the ratchet-disk, holding the same disengaged from both sets of ratchet-teeth whenever needful. One of the stop-blocks is shown in perspective in Fig. 14, and the detailed construction is brought out clearly therein and in Figs. 15 and 16. They consist, simply, of a suitably-shaped block N, adapted to rest in the piston-head loosely enough to permit a certain amount of horizontal movement or sidewise play. The block has a central opening n, large enough to allow the ratchet-disk to pass into and partially through the block when the latter is placed in position. The periphery of this opening n is beveled on opposite sides of the block with oppositely-located inclines to provide sloping faces n' n^2, which faces, it will be seen, are substantially parallel to each other, but lie on opposite sides of the ratchet-disk, and the beveled edges of said disk are adapted to come in contact with said faces n' n^2, although said faces are not near enough together to allow the disk to touch them both simultaneously, and one or the other is brought contiguous to its adjacent edge of the disk by the horizontal shifting of the block. It may be further stated that these faces n' and n^2 form stops, they being so located that they are brought into use separately, as occasion requires, to prevent the disk from being engaged with one or the other set of ratchet-teeth, according to the movements of the engine, and when one stop is acting the other is out of the way, so that although the disk cannot engage with one set of teeth, owing to the interposition of the block, yet it may engage the other set of teeth, and this continues until the block shifts its position in reversing the engine, all of which will be more clearly understood as soon as I describe the operation of the engine. Each of the reversing or stop blocks is provided with a pair of pointed or incline-faced projections O O, which project through the openings G′ G′ in the covers G and play sidewise in these openings whenever the blocks shift. Further, it will be seen that a horizontal lever P is pivoted at one end of the engine, said lever having two inclined projections q q, and that another similar lever P′ is pivoted at the other end of the engine, said lever P′ having a couple of inclined projections r r, the two levers P and P′ being connected by a link p. The lever P has a handle S, provided with a catch s, engaging the segment S′. The projections q q and also the projections r r are so situated as to be struck by the inclined projections O O on the blocks N. So long as the levers P and P′ retain one position the contact of projections O O with projections q q and r r will not effect anything, for they will simply touch them at each stroke; but whenever the engineer desires to reverse the engine and lays hold of handle S and reverses the levers then at the next reciprocation of the piston the points of each block will strike the respective levers and the inclines of one projection O will ride up the incline of one projection q, and on the return stroke the incline of a projection O on the other block will ride up the incline of one projection r, and thus blocks N will be shifted in different directions and caused to occupy their other positions, where they will act as stops for the ratchet-disks.

The operation of my improved engine will now be described. Suppose the valve B′ to be in the position shown in Fig. 2, with steam entering through inlet b in the direction of the arrow shown in full lines into the interior of cylinder A between the diaphragm or partition B and the piston-head C′. This will actuate the piston toward the right, as indicated by the arrow, the piston-head C′ going ahead. (See Fig. 2) Such movement of the piston will cause the loosely-placed sleeved rachet-disk F within head C′ to engage its set of teeth f' with the ratchet-teeth c on the head C′, as shown in Figs. 1, 2, and 11, while its teeth f will not be engaged with teeth g, and thus the disk F will be kept from revolving and caused to pursue a rectilinear movement along with the piston-head, and as said disk is connected with the spirally-grooved shaft by the internal spiral rib working in the spiral groove the latter shaft will revolve in the direction shown by the arrow in Fig. 2. With the other ratchet-disk, which is in piston-head C, a reverse condition of the parts will obtain during this movement of the piston, for both sets of the ratchet-teeth of the disk are disengaged from both sets of teeth on the head, the teeth f' becoming disengaged from teeth c the moment this piston movement begins and the teeth f being prevented from engaging with teeth g by the stoppage of the disk F against the stop-block N adjacent thereto, so that during this reciprocation this ratchet-disk will revolve idly. Again, we are now supposing that the levers P and P′ occupy the position shown in Fig. 1, and that the stop-block in piston-head C keeps the disk therein free during the reciprocation to the right and the stop-block in piston-head C′ keeps the disk therein free during the reciprocation to the left. Further, the twist of the shaft E consequent upon the advance of the piston rotates pinion L and governor-wheel K, and motion is thereby transmitted through pitman j, bell-crank J, link I, rod a', and arms a a to valve B′, which gradually rotates, so that by the time the piston reaches the limit of its stroke the steam will have been cut off from entering into space between partition B and head C′ and directed into space between partition B and head C, the valve assuming the position shown in dotted lines in Fig. 2, and thus opening the exhaust, so that the steam which has done its work against piston-head C′ can find its way out through the exhaust. So much for what takes place at one reciprocation of the piston, which, for the sake of explanation, we have chosen to consider as its first movement toward the right hand.

We will now explain the reverse reciprocation. The steam now entering against head C will drive the piston toward the left. The reverse movement of certain of the parts will now occur. The ratchet-disk within head C′ will have both sets of teeth disengaged from the teeth on the head C′, thus setting it free and permitting it to revolve idly with shaft E. Its position at this time is shown in Fig. 17, where it will be seen how the stop-block serves to hold the disk and keep teeth *f* from engaging teeth *g*, which engagement would naturally take place if the block were not so located as to prevent it, (and which engagement actually does take place when the engine is reversed and the block shifted out of the way.) The ratchet-disk within piston-head C, however, now operates in the same manner that ratchet-disk in head C′ did during the other reciprocation. Its teeth *f* are now engaged with teeth *g* on the piston-head, so that revolution of the disk is prevented, and consequently a rotary movement is imparted to the shaft E, and since this end of the shaft is provided with spiral *e*, which is the reverse of spiral *e′* on the other end of the shaft, the direction of rotation of the shaft E is the same as it was during the last reciprocation. Consequently the same movement of the valve B′ takes place as did during the other stroke, and hence when the piston gets to the end of its reciprocation to the left the valve will have been so changed as to permit another reciprocation to the right to begin immediately; also it is plain that so long as the engine is not reversed the shaft E will revolve in the same direction and a very high speed of revolution will be attained. The governor which I have described will regulate and control the speed in the usual manner. In actual practice I have already attained a speed of four thousand revolutions per minute, so that my engine is especially adapted for use where very great speed is required.

We will now briefly consider what takes place when the engine is reversed. To reverse, the engineer simply takes hold of the handle S and throws the levers P P from the position shown in Fig. 1 to the position in Figs. 5 and 18. During the first reciprocation after reversal the blocks N N will obviously remain in the same position as they were before; but as soon as the inclined projections O O strike the points on the levers standing in their way and now changed in position these blocks N N will be shifted horizontally, so as to take the positions shown in Fig. 5 instead of those depicted in Figs. 1 and 17, and the blocks will maintain these positions until again caused to slide at another reversing. Suppose now we are observing the piston as it makes a reciprocation to the right in the direction of the arrows shown in Fig. 5. The ratchet-disk F in piston-head C′ is disengaged from both sets of teeth on the piston-head, because the stop-block in its new position holds the disk in this way during the reciprocation to the right, whereas before reversal the stop-block kept the disk in head C′ disengaged during the reciprocation to the left. Looking again at Fig. 5, we see that the disk F in head C has its teeth *f* engaged with teeth *g*. Hence the shaft E will be caused to rotate in the direction of the arrow in Fig. 5, which direction is opposite to the direction of rotation of the shaft E in Fig. 2. When the piston moves to the left, the disk F in head C′ will have its teeth *f* engaged with teeth *g* and shaft E will continue its rotation, as shown, the disk F in head C being now free. Further, the motion through the governor and leverage will be transmitted to the supply-valve, as before, causing it to supply and cut off the steam in the necessary way. Thus it will be seen that the engagement of the ratchet-disk with the piston-covers causes shaft E to rotate in one direction, while its engagement with the teeth on the inside of the head proper causes said shaft to rotate in the reverse direction.

Many changes may be made in the construction, arrangement, proportion, size, relation, and form of the various parts without departing from the invention. What I have shown is by way of example and explanation. I can build the engine as may seem best to adapt it to such exigencies and demands as may be needful.

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

1. In an engine, the combination of a cylinder, a double-headed piston, a tubular connection between the heads, a spirally-grooved shaft running through it, an internally ribbed ratchet-disk in each piston-head engaging the shaft and adapted to automatically clutch the piston-heads, so that the shaft may revolve as the piston reciprocates, and a valve operated by said shaft to supply the steam.

2. In an engine, the combination of a cylinder, a double-headed piston, a spirally-grooved shaft, an internally-ribbed ratchet-disk in each head engaging the shaft and intermittently engaging the head, and a reversing stop-block likewise in each piston-head.

3. In an engine, the combination of a cylinder, a double-headed piston whose heads are hollow and have a tubular connection, a spirally-grooved shaft, and ratchet-disk and stop-block in each piston-head.

4. The combination of a cylinder, a double-headed piston therein whose heads have a tubular connection, a spirally-grooved shaft

running through the same, a valve operated by said shaft to supply the steam, and a ratchet-disk and stop-block in each piston-head.

5. The combination of a cylinder, a double-headed piston whose heads are hollow and have a tubular connection, a grooved shaft running through the same, a valve connected to and operated by the shaft, a governor between the shaft and valve, and a ratchet-disk and stop-block in each piston-head.

6. The combination of a cylinder, a double-headed piston whose heads are hollow and have a tubular connection, a shaft provided with oppositely-running spiral grooves and located through the piston, sleeved ratchet-disks having internal spiral ribs to engage the shaft and teeth to engage corresponding teeth on the piston-heads, and a stop-block in each piston-head.

7. The combination of an open-ended cylinder having a central transverse partition, a double-headed piston whose heads are hollow and have a tubular connection and are on opposite sides of the partition, a spirally-grooved shaft running through the piston, a ratchet-disk and a stop-block in each piston-head, and a valve connected by intermediate means with the shaft.

8. The combination of the partitioned cylinder, a double-headed piston whose heads are hollow and have a tubular connection, a shaft provided with oppositely-running spiral grooves and located through the piston, sleeved ratchet-disks having internal spiral ribs to engage the shaft and sets of teeth on their opposite faces to engage corresponding sets of teeth on the piston-heads, and a stop-block in each piston-head.

9. In an engine, the combination of a cylinder, a piston moving therein having hollow heads connected by a tubular connection, a grooved shaft passing through the piston, a disk permanently connected to the shaft and intermittently connected to the piston, so that the reciprocations of the piston may rotate the shaft, a valve for supplying the steam, and also a suitable governor.

10. The combination of the partitioned cylinder, the double-headed piston whose heads are hollow and have a tubular connection, a shaft provided with oppositely-running spiral grooves, sleeved ratchet-disks having internal spiral ribs to engage the shaft and sets of teeth on their opposite faces to engage corresponding sets of teeth on the piston-head, and a stop-block in each piston-head, having suitable connections and pointed projections, substantially as described.

11. The combination of the cylinder, a double-headed piston whose heads are hollow and are provided with slotted covers, said heads having likewise a tubular connection, a shaft provided with oppositely-running spiral grooves, the sleeved ratchet-disks having internal spiral ribs to engage the shaft, sets of teeth on their opposite faces to engage corresponding sets of teeth on the piston-heads, and beveled edges to engage inclines on the stop-blocks, together with a stop-block in each piston-head, having projections located within the slots of the piston-covers, substantially as described.

12. The combination of the cylinder, a double-headed piston whose heads are hollow and have a tubular connection, a spirally-grooved shaft running through the piston, the ratchet-disk having sets of ratchet-teeth, a stop-block arranged within each piston-head in connection with the ratchet-disk, said stop-blocks having inclined projections, and the reversing leverage adapted to operate in connection with the inclined projections of the stop-blocks, substantially as described.

13. The combination of the partitioned cylinder, a double-headed piston whose heads are hollow and have a tubular connection, a shaft provided with oppositely-running spiral grooves and located through the piston, sleeved ratchet-disks having internal spiral ribs to engage the shaft and sets of teeth on their opposite faces to engage corresponding sets of teeth on the interior of the piston-heads, a stop-block in each piston-head, having oppositely-located inclines and pointed projections, the reversing leverage in connection with which the pointed projections of the stop-block operate, the valve for supplying and cutting off the steam to the cylinder and the leverage, and gearing connections between said valve and the grooved shaft, all arranged so that during the reciprocations of the piston said shaft may be caused to revolve in the same direction, except when the engine is reversed, substantially as described.

14. The combination of the partitioned cylinder, the piston moving therein, the spirally-grooved shaft, a ratchet-disk and a stop-block within each piston-head, a valve for supplying steam, and connections between the valve and the shaft, consisting of a disk on one end of said shaft, an internally-cogged governor-wheel engaging said disk, a pitman-rod connected to the governor by a universal joint, a bell-crank pivoted to the other end of said rod, and a link connecting one end of said crank with arms on the valve-journals, substantially as described.

15. The combination of the cylinder, a double-headed piston whose heads are hollow and have tubular connection, a shaft provided with oppositely-running spiral grooves, sleeved ratchet-disks having internal spiral ribs to engage the shaft and sets of teeth on their opposite faces to engage corresponding sets of teeth on the piston-heads, a stop-block in each piston-head, a supply-valve for the steam, a pinion on one end of the grooved shaft, a governor for regulating the speed, said governor being geared to the aforesaid pinion, and leverage connections between the governor and supply-valve, substantially as described.

16. The combination of the cylinder, a double-headed piston whose heads are hollow

and have a tubular connection, a shaft having spiral grooves therein and located through the piston, ratchet-disks within each head, having internal spiral ribs to engage the shaft and sets of teeth on their opposite faces to engage corresponding sets of teeth on the piston-heads, a stop-block in each piston-head, which blocks have pointed projections, and the reversing leverage consisting of levers pivoted at each end of the cylinder and provided with pairs of inclined faces, in connection with which the stop-block connections operate, substantially as described.

17. The combination of a steam-cylinder having open ends and a central transverse partition, a piston having hollow heads which are connected by means of a tubular connection, said heads being situated on opposite sides of the central partition and the said tubular connection working through an opening in the central partition, a spirally-grooved shaft running through the tubular connection, and means for connecting the aforesaid piston-heads to this spiral shaft for the purpose of revolving it, together with a valve operated by said shaft to supply the steam, and a ratchet-disk and stop-block in each piston-head, substantially as described.

18. In an engine, the combination of a cylinder, a piston moving therein, a grooved rotary shaft passing through the piston, and a ratchet-disk which is internally ribbed to permanently engage the shaft and is intermittently connected to the piston, so that the reciprocations of the latter may rotate the shaft, substantially as described.

19. In an engine, the combination of a cylinder, a piston therein, a grooved rotary shaft passing through the piston, a ratchet device for intermittently making connection between the piston and the shaft, and a reversing stop-block, substantially as described.

20. The combination of a cylinder, a double-headed piston whose heads are hollow and have a tubular connection, a grooved rotary shaft passing axially through the piston, and a ratchet mechanism in each head for intermittently making connection between the piston and shaft.

21. The combination of a cylinder, a double-headed piston whose heads are hollow and have a tubular connection, a grooved rotary shaft passing through the piston, and ratchet-disks having internal ribs to engage the shaft and teeth to engage with corresponding teeth on the piston-heads.

22. The combination of a cylinder, a piston therein, a grooved rotary shaft passing axially through the piston, and a ratchet-disk engaging the shaft and having teeth that engage corresponding teeth on the piston.

In testimony whereof I affix my signature in presence of two witnesses.

JOHN V. RICE, JR.

Witnesses:
HENRY B. BOLTON,
WM. L. BOYDEN.