No. 657,384. Patented Sept. 4, 1900.

S. F. BEETZ.

EXPLOSIVE ENGINE.

(Application filed May 5, 1899.)

(No Model.) 4 Sheets—Sheet 1.

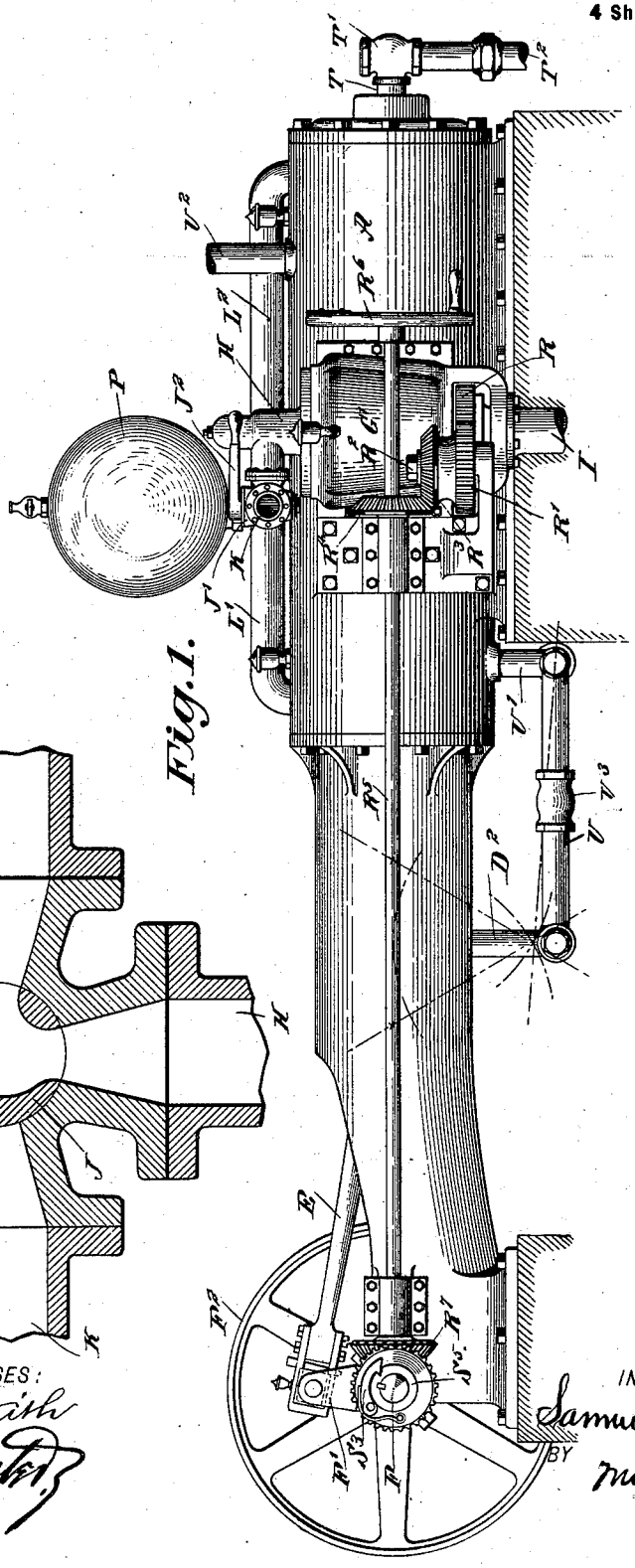

Fig. 1.

Fig. 12.

WITNESSES:

C. W. Smith

Geo. Gosterz

INVENTOR

Samuel F. Beetz

BY

Munn

ATTORNEYS

THE NORRIS PETERS CO., PHOTO-LITHO., WASHINGTON, D. C.

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S. F. BEETZ.

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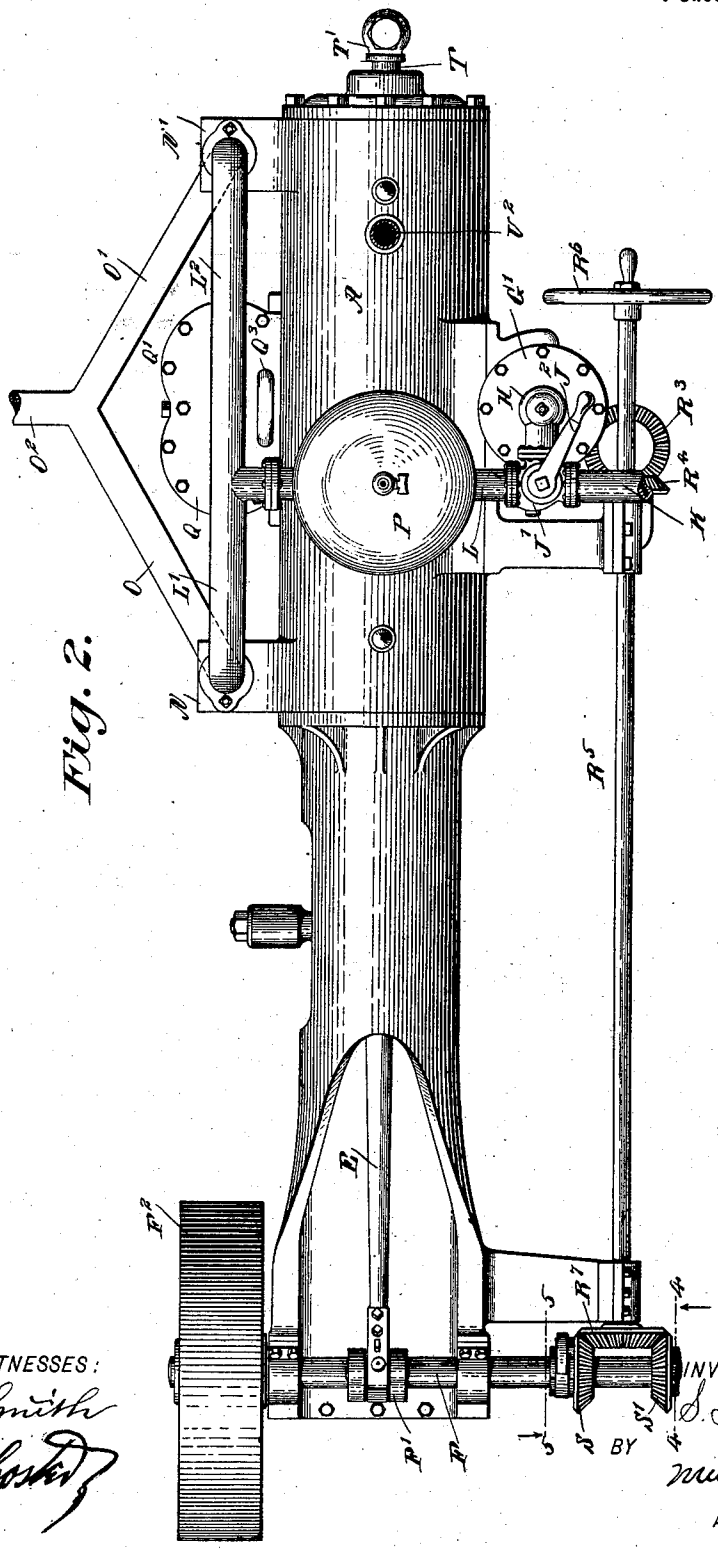

Fig. 2.

WITNESSES:

C. W. Smith

Wm. G. Hoster

INVENTOR

S. F. Beetz

BY

ATTORNEYS

THE NORRIS PETERS CO., PHOTO-LITHO., WASHINGTON, D. C.

No. 657,384. Patented Sept. 4, 1900.

S. F. BEETZ.

EXPLOSIVE ENGINE.

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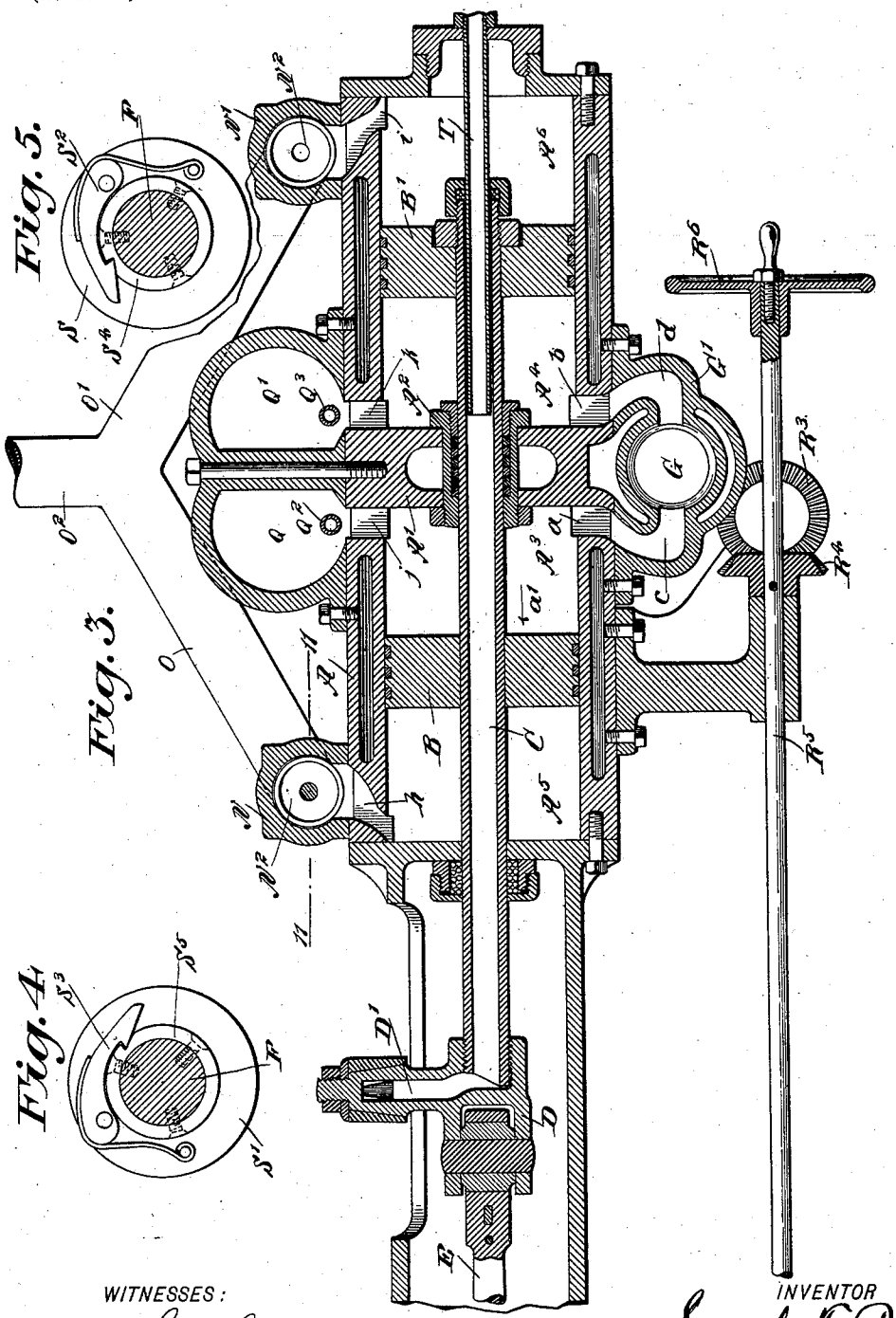

Fig. 5.

Fig. 3.

Fig. 4.

WITNESSES:

C. W. Smith

Wm. J. Hoskins

INVENTOR

Samuel F. Beetz

BY

Munn

ATTORNEYS

THE NORRIS PETERS CO., PHOTO-LITHO., WASHINGTON, D. C.

No. 657,384. Patented Sept. 4, 1900.

S. F. BEETZ.

EXPLOSIVE ENGINE.

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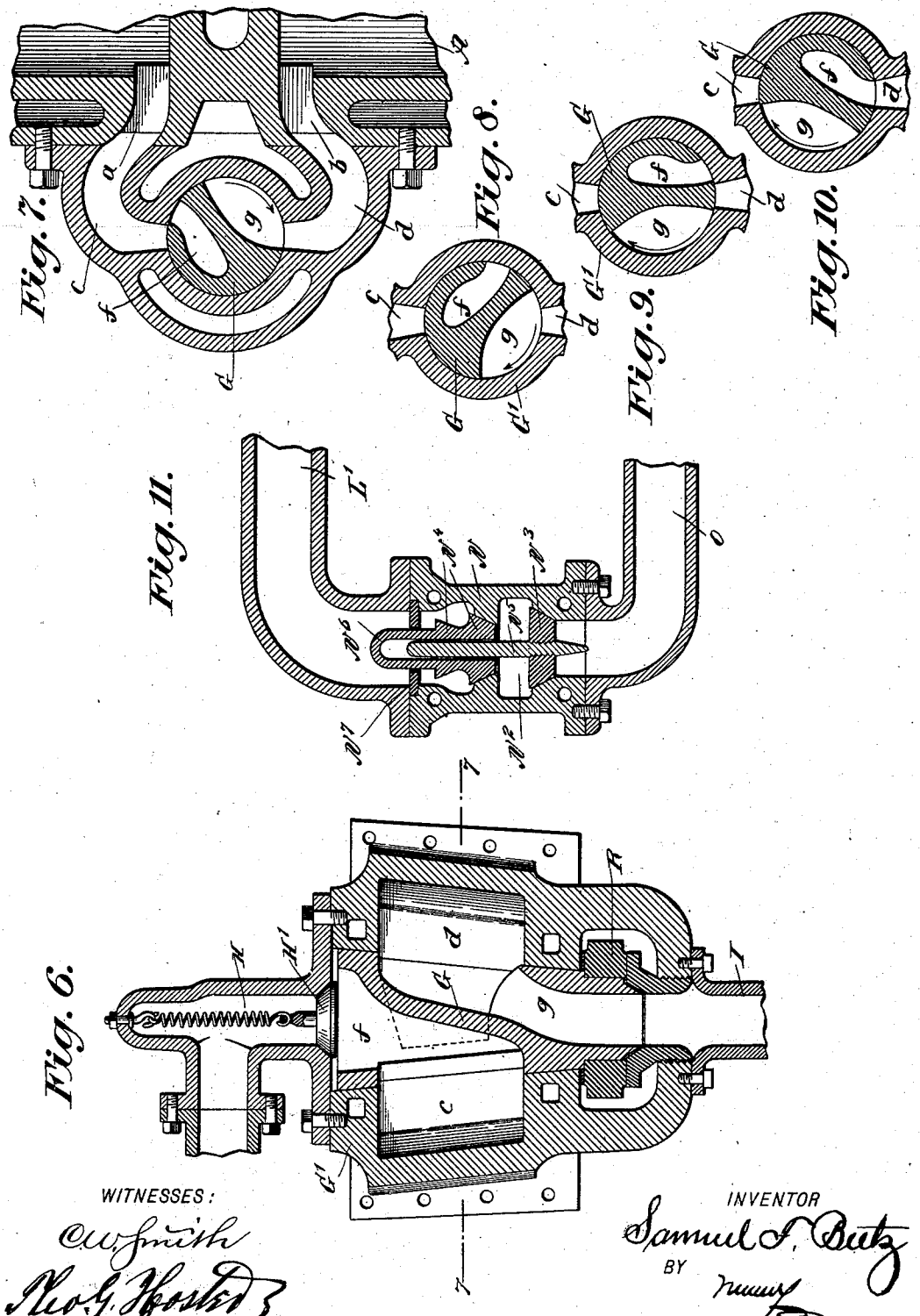

WITNESSES:

C. W. Smith

Rud. J. Hoster

INVENTOR

Samuel F. Beetz

BY

Munn & Co.

ATTORNEYS

THE NORRIS PETERS CO., PHOTO-LITHO., WASHINGTON, D. C.

UNITED STATES PATENT OFFICE.

SAMUEL FREDERIC BEETZ, OF MENDOTA, ILLINOIS.

EXPLOSIVE-ENGINE.

SPECIFICATION forming part of Letters Patent No. 657,384, dated September 4, 1900.

Application filed May 5, 1899. Serial No. 715,673. (No model.)

To all whom it may concern:

Be it known that I, SAMUEL FREDERIC BEETZ, of Mendota, in the county of La Salle and State of Illinois, have invented a new and Improved Explosive-Engine, of which the following is a full, clear, and exact description.

The object of the invention is to provide a new and improved explosive-engine which is simple and durable in construction, very effective in operation, arranged to utilize the motive agent to the fullest advantage, and to permit of instantly starting, stopping, and reversing the engine whenever desired.

The invention consists of novel features and parts and combinations of the same, as will be fully described hereinafter and then pointed out in the claims.

A practical embodiment of my invention is represented in the accompanying drawings, forming a part of this specification, in which similar characters of reference indicate corresponding parts in all the views.

Figure 1 is a side elevation of the improvement. Fig. 2 is a plan view of the same. Fig. 3 is an enlarged sectional plan view of the cylinder and adjacent parts. Fig. 4 is an enlarged sectional side elevation of part of the reversing mechanism, the section being on the line 4 4 in Fig. 2. Fig. 5 is an enlarged sectional rear elevation of the same on the line 5 5 in Fig. 2. Fig. 6 is an enlarged sectional side elevation of the rotary admission and exhaust valve. Fig. 7 is a sectional plan view of the same on the line 7 7 in Fig. 6. Figs. 8, 9, and 10 are similar views of the admission and exhaust valve in different positions. Fig. 11 is an enlarged sectional side elevation of the admission and discharge valves of the compression-chambers, the section being taken on the line 11 11 in Fig. 3; and Fig. 12 is an enlarged sectional plan view of the throttle-valve.

The improved explosive-engine is provided with a main cylinder A, provided at or near its middle with a transverse partition A′ for dividing the main cylinder into two cylinders, in which reciprocate the pistons B B′, secured on a hollow piston-rod C, passing through a suitable stuffing-box A^2 in said partition A′ and through the usual stuffing-box in the forward head of the main cylinder A. The outer end of the piston-rod C is connected with a cross-head D, pivotally connected by a pitman E with the crank-arm F′ of the main driving-shaft F, carrying a pulley F^2 for transmitting the rotary motion of the engine to other machinery. By the construction described the main cylinder A is provided with working chambers A^3 A^4 on opposite sides of the partition A′ and with compression-chambers A^5 A^6 at the outer ends of said cylinder. The working chambers A^3 A^4 are connected by ports *a* and *b* with ports *c* and *d*, respectively, formed in the body G′ of a rotary admission-valve G, disposed vertically and mounted to rotate continuously in the body G′, the valve being driven from the main driving-shaft F by gearing hereinafter more fully described.

The ports *c* and *d* are adapted to register alternately with an admission-port *f* and an exhaust-port *g* formed in the rotary valve G, the port *f* connecting at its upper end (see Fig. 6) with an admission-pipe H, containing a spring-pressed valve H′, to allow the explosive charge to pass from the pipe H into the port *f*; but to prevent a return movement of the charge by the spring-pressed valve H′ the exhaust-port *g* connects at its lower end with an exhaust-pipe I, bolted to the valve-body G′ and leading to a suitable place of discharge, said pipe serving to carry off the products of combustion, as hereinafter more fully described.

The rotary admission and exhaust valve G is preferably slightly conical in shape, the admission-port *f* being narrow and opening at the large end of the valve and the exhaust-port *g* being wide, as shown, and opening at the opposite end of the valve. The ports *c d* of the stationary valve-body leading to the working chambers are preferably diametrically opposite each other. The exhaust-port *g* of the valve is sufficiently wide to permit a flow of the exhaust-gases from the working chamber during the whole or greater part of the exhaust-stroke of the piston, although the valve continues uninterruptedly to rotate. The spring-controlled check-valve H′ for the admission of the compressed explosive fluid to the valve is arranged in the supply-pipe very close to the rotary valve, so as to leave the least practicable space between them. This valve H′, besides admitting the explo-

sive fluid to the rotary valve, prevents the fire from extending back into the feed-pipe and its connection, thereby consuming the explosive fluid intended for future explosions in the power-chamber. The rotary valve G is especially adapted for explosive-engines which feed the explosive fluid to the power or working chamber only after compression. It will be seen that the valve does the work of two ordinary valves for each and every power-chamber it works—namely, that of an inlet-valve and an outlet-valve.

The pipe H connects with the casing J′ of a throttle-valve J, provided with a handle J^2, under the control of the operator, to connect the pipe H with either a pipe K, leading to a storage-chamber, (not shown,) or with a conveyer-pipe L, connected by branch pipes L′ L^2 with discharge and admission valves N N′, bolted to the ends of the cylinder A and connected with the compression-chambers A^5 A^6 by ports *h* and *i*, as is plainly indicated in Fig. 3. The said chambers N N′ are also connected with branch pipes O O′, connected with a supply-pipe O^2, connected with a suitable source of gaseous-mixture supply. Each of the valves N N′ is provided with a central chamber N^2, leading to the ports *h* and *i* mentioned and normally closed at its bottom by a check-valve N^3 and at its top by a check-valve N^4, and the stem N^5 of the check-valve N^3 extends loosely into the hollow stem N^6 of the other check-valve N^4 to limit the movement of the check-valve N^3 and to guide the same on said stem N^6. The movement of the valve N^4 is limited by a spider N^7. (See Fig. 11.) Now when the piston B or B′ is on the inward stroke the corresponding check-valve N^3 opens and the explosive mixture from the supply-pipe O^2 is drawn into the compression-chamber A^5 or A^6 by way of the corresponding branch pipe O or O′, and when the pistons B and B′ are on the outward stroke the charges are compressed and finally forced into the chamber N^2 and through the valve N^4, which now opens into the corresponding branch pipe L′ or L^2 to pass to the conveyer-pipe L and by way of the throttle-valve J to the pipe H and to the valve G, which delivers at the port *f* the explosive charge to the corresponding ports *c* or *d* and by way of the ports *a* or *b* to the working chambers A^3 A^4 and to the explosion-chambers Q Q′, bolted to the cylinder A, preferably at the rear thereof, and connected with the interior of said working chambers by the ports *j* and *k*. (See Fig. 3.) It is understood that when the valve N^3 opens for admitting a charge the other valve N^4 remains closed, because pressure from above is greater than from below, and when the compressed charge is passed into the chamber N^2 the valve N^3 is seated and kept seated, while the force of the compressed charge opens the valve N^4 and allows the charge to pass to the corresponding branch pipe L′ or L^2. The explosion-chambers Q Q′ contain pipes Q^2 Q^3, heated from an external source, such as a flame, to cause ignition of the explosive charge at the proper moment, the explosive charge passing into the corresponding working chamber A^3 or A^4 to drive the corresponding piston B or B′ on its outward stroke. The chambers Q Q′ form transverse extensions of the cylinders, thus increasing the capacity of the working chambers without increasing the length of the cylinder A. It is evident from the foregoing that when one of the pistons B B′ is thus forced outward by an explosion in the corresponding working chamber the other piston moves inward, and vice versa, and during this inward stroke of a piston the products of combustion of the previous explosion are forced through the corresponding ports *b d g* or *a c g* to the exhaust-pipe I to carry off the said products. During this return or inward stroke of a piston a new charge is drawn into the compression-chamber A^6 or A^5 by way of the valves N′ or N, and when a piston is on the outward or working stroke such previously-drawn-in charge is compressed and finally forced into the working chamber of the other cylinder immediately after the exhaust-port *g* has moved out of register with the corresponding port *d* or *c*—that is, immediately previous to the returning piston B′ or B reaching the innermost end of its stroke. Ignition now takes place just at the time when the crank-arm F′ has left the dead-center position, so that the explosive force of the ignited charge forces the corresponding piston B or B′ outward in the manner above described.

The ports *g* and *f* in the admission-valve G are so disposed that for each revolution of said valve G the port *f* registers with the ports *c* and *d*, and in a like manner the port *g* registers with the ports *d c*, so that a charge is admitted to each working chamber during each revolution of the main shaft F, and an exhaust takes place from the said working chambers during each revolution.

In order to rotate the valve G in the manner described, I provide the lower end thereof with a spur-wheel R in mesh with a spur-wheel R′, mounted to rotate on a stud R^2, and on the hub of the spur-wheel R′ is secured a bevel gear-wheel R^3 in mesh with a bevel gear-wheel R^4, secured on a shaft R^5, arranged longitudinally and provided at one end with a hand-wheel R^6 under the control of the operator for reversing the engine, as hereinafter more fully described.

On the forward end of the shaft R^5 is secured a bevel gear-wheel R^7 in mesh at opposite sides with bevel gear-wheels S S′, both mounted to rotate loosely on the main driving-shaft F. On the bevel gear-wheels S S′ are fulcrumed spring-pressed pawls S^2 S^3, extending in opposite directions and adapted to engage and hook into shoulders on collars S^4 S^5, secured to the main driving-shaft F. Now the rotary motion of the shaft F is transmitted by either the collar S^4 or S^5 and the pawl S^2 or S^3, respectively, to the correspond-

ing gear-wheel S or S′ and by the latter to the gear-wheel R^7 on the shaft R^5. Now whichever pawl S^2 or S^3 engages its collar at the time causes a transmission of motion from the shaft F to the shaft R^5, but always in the same direction, and when it is desired to reverse the operator simply turns the hand-wheel R^6 to disengage the one pawl from the shoulder on its collar and to bring the other pawl into engagement with the shoulder on its collar to cause a further uninterrupted turning of the shaft R^5 in the same direction; but during the time the pawls are shifted the valve G has been reversed by the operator turning the shaft R^5 by hand, and consequently the subsequent turning of the shaft R^5 from the shaft F causes only a further turning of the valve G. When the valve G is turned by the operator turning the hand-wheel R^6, the explosive charge is then passed first into the chamber A^4 or A^3, and consequently a reversing of the engine takes place when this charge is ignited.

In order to keep the hollow piston-rod C and the cylinder A, as well as the valve-body G′ and the stuffing-box A^2 in the partition A′, cool, I prefer to force a cooling liquid, such as water, through the said piston-rod C and the water-jackets in the said cylinder A and valve-body G′, and for this purpose I provide a stationary pipe T, which extends through the outer cylinder-head and through a stuffing-box in the end of the piston-rod C within the latter to thus form a pump, of which the stationary pipe is the barrel and the piston-rod the plunger. The outer end of the pipe T is provided with a check-valve T′, from which extends a suction-pipe T^2, connected with a suitable water-supply. Now when the pistons B B′ and their piston-rod C are reciprocated water is drawn into the pipe T and piston-rod C and forced through the latter and a transverse channel D′, formed in the cross-head D, and then into and through a pipe D^2, pivotally connected with the cross-head extension, (see Fig. 1,) the lower end of the pipe being pivotally connected by a pipe U with a pipe U′ and opening into the water-jacket of the main cylinder at the forward end thereof. The said water-jacket is in communication with the water-jacket in the partition A′ and a water-jacket in the body G′, so that the water returns through all said water-jackets, finally passing through a pipe U^2 to a suitable place of discharge. Either of the pipes U or U′ contains a check-valve U^3 to prevent the return flow of the water on the inward stroke of the pistons B B′ and piston-rod C.

The operation is as follows: When the several parts are in the position shown in the drawings, then the piston B is on its outward stroke, owing to the explosion of the charge in the working chamber A^3, and the other piston B′ is on the inward stroke to discharge the products of combustion from a previous explosion in the working chamber A^4 through the registering ports *b*, *d*, and *g* to the pipe I and at the same time draw in a new charge of gaseous mixture into the compression-chamber A^6 by way of the supply-pipe O^2, branch pipe O′, and the valve N′, connecting by its chamber N^2 and port *i* with said compression-chamber A^6. During the outward stroke of the piston B the previously-drawn-in charge in the compression-chamber A^5 is compressed and forced through the port *h* into the chamber N^2 of the valve N to finally flow past the valve N^4 into the branch pipe L′, from the latter into the conveyer-pipe L, and by way of the throttle-valve J to the pipe H, from which the mixture passes into the port *f*, which will move into register with the port *d* shortly after the exhaust-port *g* has left the port *d*, so that the explosive and compressed charge passes by way of the ports *f*, *d*, and *b* into the working chamber A^4 at the time the piston B′ reaches the inner end of its stroke, the charge passing by way of the port *k* into the explosion-chamber Q′, in which the charge is ignited by coming in contact with the heated pipe Q^3 at the time the port *f* is again moved out of register with the port *d* and the crank-arm F′ has just passed the dead-center position, so that the force of the explosion is exerted against the inner face of the piston B′, and the latter is thereby driven outward in the inverse direction of the arrow *a*′, thus causing the piston B to make its inward stroke. When this takes place, the previously-drawn-in charge in the chamber A^6 is compressed by the outwardly-moving piston B′, and the products of combustion in the chamber A^3 are forced by the returning piston B through the ports *a*, *c*, and *g* into the exhaust-pipe I, it being understood that the port *g* is advanced sufficiently to register with the port *c* for receiving the products of combustion from the working chamber A^3. A new charge is now drawn into the chamber A^5 by the returning piston B, and when the latter nears the end of its inward stroke the port *g* moves out of register with the port *c* and then immediately after the port *f* moves into register with the port *c*, so that the charge compressed in the chamber A^6 is passed through the valve G into the working chamber A^3 to be exploded therein soon after the piston B′ has passed its next dead-center position. The above-described operation is then repeated.

From the foregoing it is understood that an impulse is given for each forward and backward stroke, and consequently a continuous and uniform rotary motion is obtained.

In order to equalize the pressure in the conveyer branch pipes L′ L^2 and the pipe L, I prefer to provide the latter with a cushioning-chamber P, so that the resistance to compression is not greater than the actual effective pressure in the explosion-chambers Q Q′ immediately previous to ignition.

For starting the engine I prefer to make use of the storage-chamber previously mentioned

and connected by the pipe K with the throttle-valve J, so that for starting the said chamber can be connected by the pipe K with the pipe H upon the operator turning the throttle-valve J to cut off the conveyer-pipe L and to connect the pipes K and H with each other. Now an explosive charge or even a charge of compressed air contained in the storage-chamber can pass through the properly-set valve G into the corresponding working chamber A^3 or A^4 to drive the corresponding piston on the outward stroke, thus starting the engine, and when this is done the operator again shifts the throttle-valve J to disconnect the pipe K and the storage-chamber and to again connect the conveyer-pipe L with the pipe H to allow the compressed explosive charges from the compartments A^5 A^6 to pass to the opposite working chambers A^4 and A^3 in the manner above explained. The pressure in the storage-chamber is somewhat reduced by starting the engine with the motive agent from the storage-chamber, and in order to replenish the latter with motive agent it is only necessary for the operator to somewhat throttle the connection between the pipes L and H, so that a part of the explosive and compressed charge can pass through the by-pass J^3, containing a spring-pressed valve J^4 from the pipe L to the pipe K and to the storage-chamber for the purpose mentioned. (See Fig. 12.)

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

1. An explosive-engine, comprising a main cylinder having a transverse partition for forming separate cylinders containing working chambers on opposite sides of the partition and compression-chambers at the outer ends of the main cylinder, pistons reciprocating in unison in said cylinders and connected with the main driving-shaft, a rotary valve driven in unison with said pistons and having an inlet and exhaust port arranged to alternately connect said working chambers with the motive-agent-supply pipe and the exhaust-pipe, and valve-casings located at the ends of the cylinder and each connected by a port with the corresponding compression-chamber, the said valve-casings being each provided with a chamber leading to the said port and connected through valve-controlled openings with the motive-agent supply and with said rotary admission-valve, so that the compressed charge from the compression-chamber of one cylinder can pass into the working chamber of the other cylinder, substantially as shown and described.

2. An explosive-engine, comprising a main cylinder having a transverse partition for forming separate cylinders containing working chambers on opposite sides of the partition and compression-chambers at the outer ends of the main cylinder, pistons reciprocating in unison in the said cylinders and connected with the main driving-shaft, a rotary valve driven in unison with said pistons and having an inlet and an exhaust port arranged to alternately connect said working chambers, with the motive-agent-supply pipe and the exhaust-pipe, valves arranged in casings located at said compression-chambers and arranged for connecting said chambers with the motive-agent supply and with said admission-valve so that the compressed charge from the compression-chamber of one cylinder can pass into the working chamber of the other cylinder, the connection between the compression-chambers and the admission-valve comprising a conveyer-pipe connected with the admission-pipe for the rotary valve, branch pipes leading from the valve-casings at the compression-chambers and connected with said conveyer-pipe and a cushioning-chamber for said conveyer-pipe substantially as shown and described.

3. An explosive-engine comprising a main cylinder having a transverse partition for forming separate cylinders containing working chambers on opposite sides of the partition, and compression-chambers on the outer ends of the main cylinder, pistons reciprocating in unison in said cylinders and connected with the main driving-shaft, a rotary valve driven in unison with said pistons and having an inlet and exhaust port arranged to alternately connect said working chambers with the motive-agent-supply pipe and the exhaust-pipe, valves at said compression-chambers and arranged for connecting said chambers with the motive-agent supply and with said admission-valve so that the compressed charge from the compression-chamber of one cylinder can pass into the working chamber of the other cylinder, explosion-chambers located at one side of the cylinder adjacent to the working chambers and each connected by a port with the corresponding working chamber and an igniting device in each explosion-chamber, substantially as shown and described.

4. An explosive-engine comprising a main cylinder having a central transverse partition for forming separate cylinders containing working chambers on opposite sides of the partition and compression-chambers at the outer ends of the main cylinder, pistons reciprocating in unison in said cylinders, a stationary valve-body located at one side of the cylinder and connected with the working chambers by ports located at opposite sides of the transverse partition, a rotary valve mounted to turn in said body and driven in unison with said pistons, the said valve having an inlet and exhaust port arranged to alternately connect said working chambers with the motive-agent-supply pipe and the exhaust-pipe, valves at said compression-chambers and arranged for connecting said chambers with the motive-agent supply and with said rotary admission-valve, a reversing-gear for said rotary admission-valve, combustion-chambers, located at the side of

the cylinder opposite the rotary valve, and communicating with the working chambers by ports located at opposite sides of the transverse partition, substantially as shown and described.

5. An explosive-engine, comprising alined working chambers, and compression-chambers, pistons mounted to reciprocate in unison, one piston for a compression-chamber and a working chamber, a valve-chamber connected with each compression-chamber and with the opposite working chamber, two valves in each of said valve-chambers one valve controlling the admission of the explosive mixture to the compression-chamber and the other controlling the discharge of the compressed explosive mixture from the compression-chamber to the opposite working chamber, and a rotary valve in the connection from the said valve-chamber to the working chamber for controlling the admission of the compressed charge to the said working chamber and for controlling the exhaust from said working chamber substantially as shown and described.

6. An explosive-engine comprising working chambers and compression-chambers, pistons reciprocating therein, a valve-chamber connected with each compression-chamber, a pipe leading from a suitable source of gaseous-mixture supply and connected by branch pipes with the respective valve-chambers, valves in each of said valve-chambers, one for controlling the admission of the motive agent to the compression-chamber, and the other for controlling the passage of the compressed charge therefrom, pipes leading from the valve-chambers for conveying the compressed charge, a rotary valve connected by a supply-pipe with said conveying-pipes and with an exhaust, the said valve having a single inlet-port and a single exhaust-port for connecting the working chambers alternately with the compressed motive-agent supply and said exhaust, and a driving and reversing gear for said valve, substantially as shown and described.

7. An explosion-cylinder, provided with separate working chambers pistons reciprocating therein, a stationary valve-body provided with a port for each of the working chambers, a rotary valve mounted to turn in said body and connected with a compressed motive-agent supply and with an exhaust, the said valve having both an inlet and an exhaust port adapted to register alternately with each of the ports in the stationary valve-body, to connect said working chambers alternately with said supply and exhaust, substantially as shown and described.

8. An explosion-cylinder, provided with separate working chambers, pistons reciprocating therein, a stationary valve-body provided with ports connected with the respective working chambers, a rotary valve mounted to turn in said body and connected with a compressed motive-agent supply and an exhaust, the said valve having a single inlet-port and a single exhaust-port adapted to register alternately with each port in the body of the valve to connect the working chambers with said supply and said exhaust, and a driving and reversing gear for said valve, substantially as shown and described.

9. In an explosive-engine, the combination with the working chambers of the engine, of a stationary valve-body having a port for each of the working chambers, and a valve mounted to rotate in said body and having a narrow feed-port for the admission of the charge to the working chamber, and a wide exhaust-port for the exhaust from said working chamber, the said ports being adapted to register alternately with each of the ports in the valve-body, substantially as described.

10. In an explosive-engine, the combination with a rotary admission and exhaust valve for said engine having an admission-port at one end thereof, of a feed-pipe connected with the admission-port, and a spring-pressed check-valve closing the opening between the said port and feed-pipe, the said valve opening inwardly in direction of the rotary valve, for the purpose set forth.

11. In an explosive-engine, a stationary valve-body provided with a port connected with a working chamber of the engine, a rotary valve mounted to turn in said body and having an admission-port and an exhaust-port adapted to register alternately with the said port in the body of the valve, an admission-pipe for the charge connected with the admission-port and a spring-pressed valve located in said pipe adjacent to the rotary valve, substantially as shown and described.

SAMUEL FREDERIC BEETZ.

Witnesses:
ROBERT N. CRAWFORD,
O. J. BUETTNER.