(No Model.)

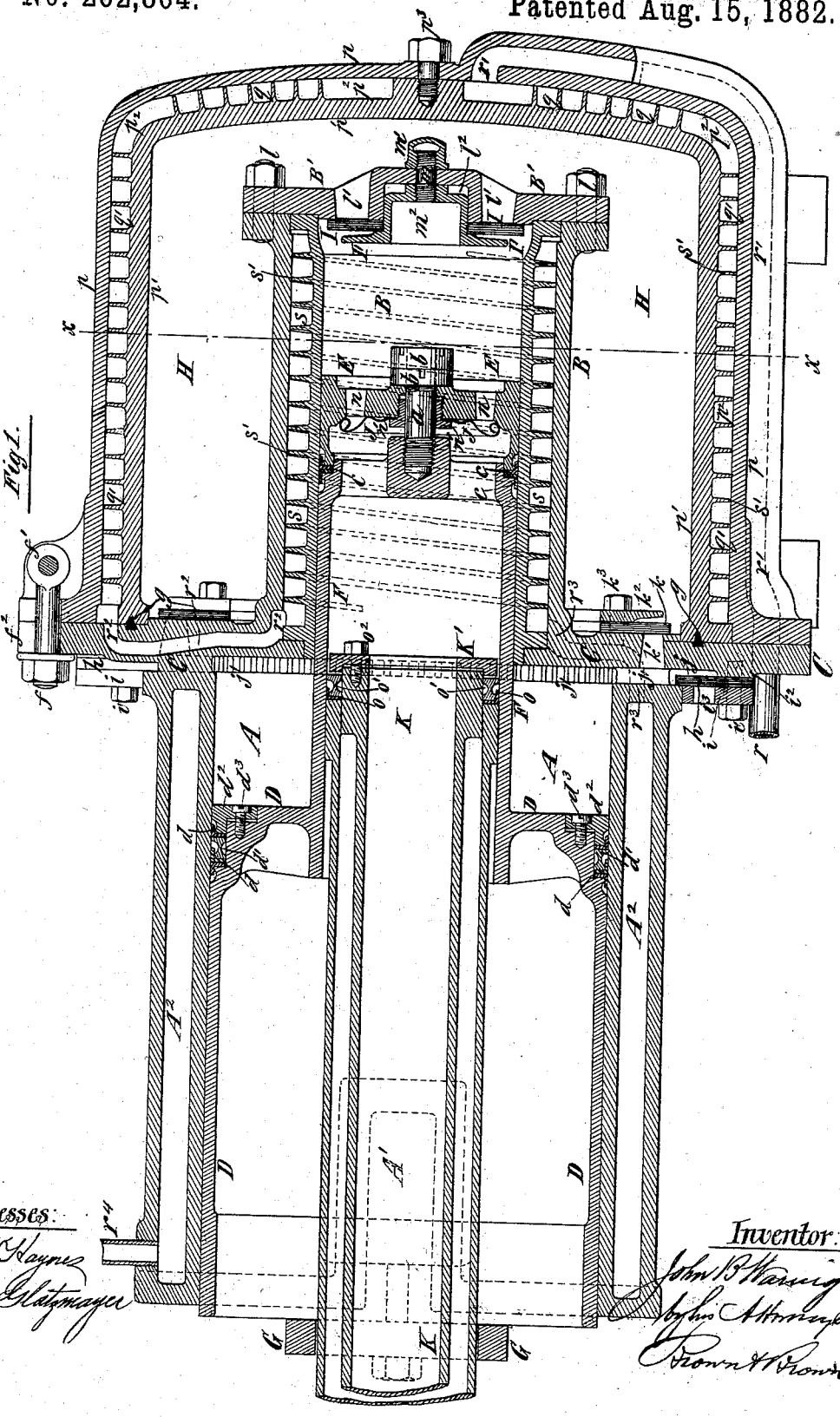
3 Sheets—Sheet 1.

J. B. WARING.

AIR COMPRESSOR.

No. 262,864. Patented Aug. 15, 1882.

Fig 1.



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(No Model.)

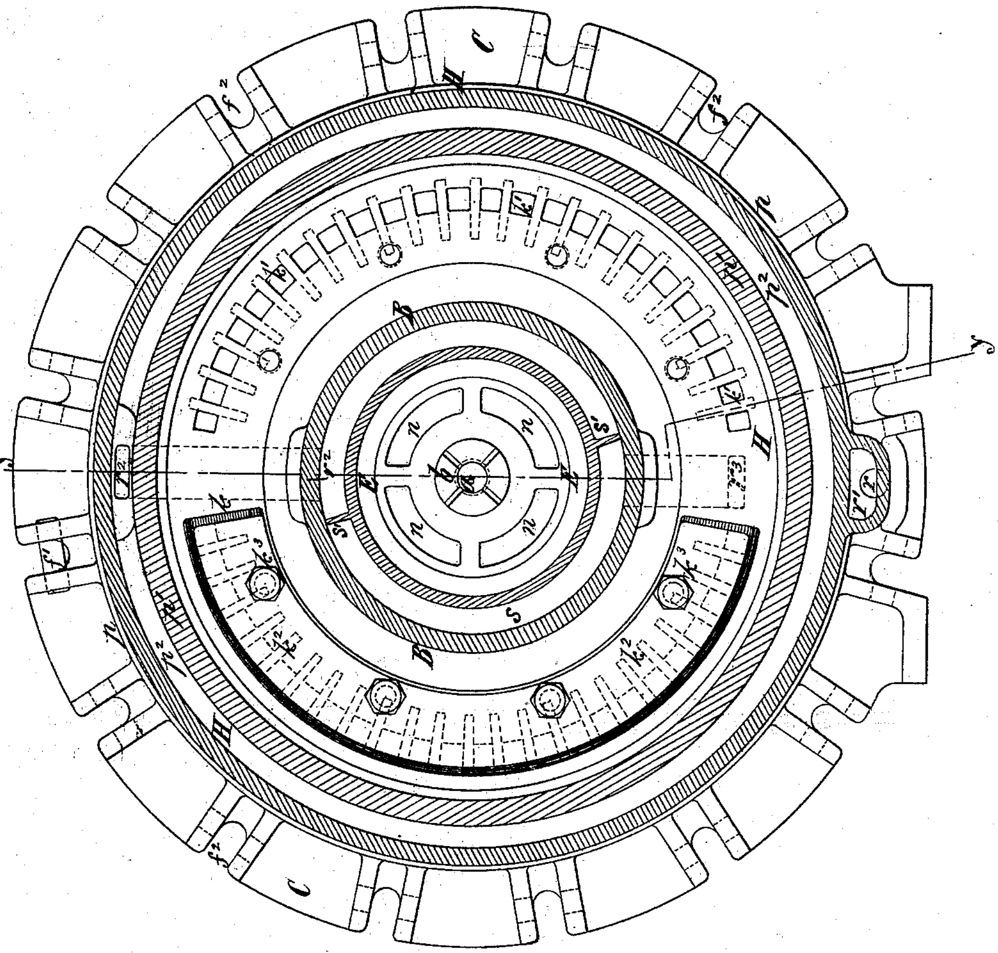
3 Sheets—Sheet 2.

J. B. WARING.

AIR COMPRESSOR.

No. 262,864. Patented Aug. 15, 1882.

Fig. 2.



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(No Model.)

3 Sheets—Sheet 3.

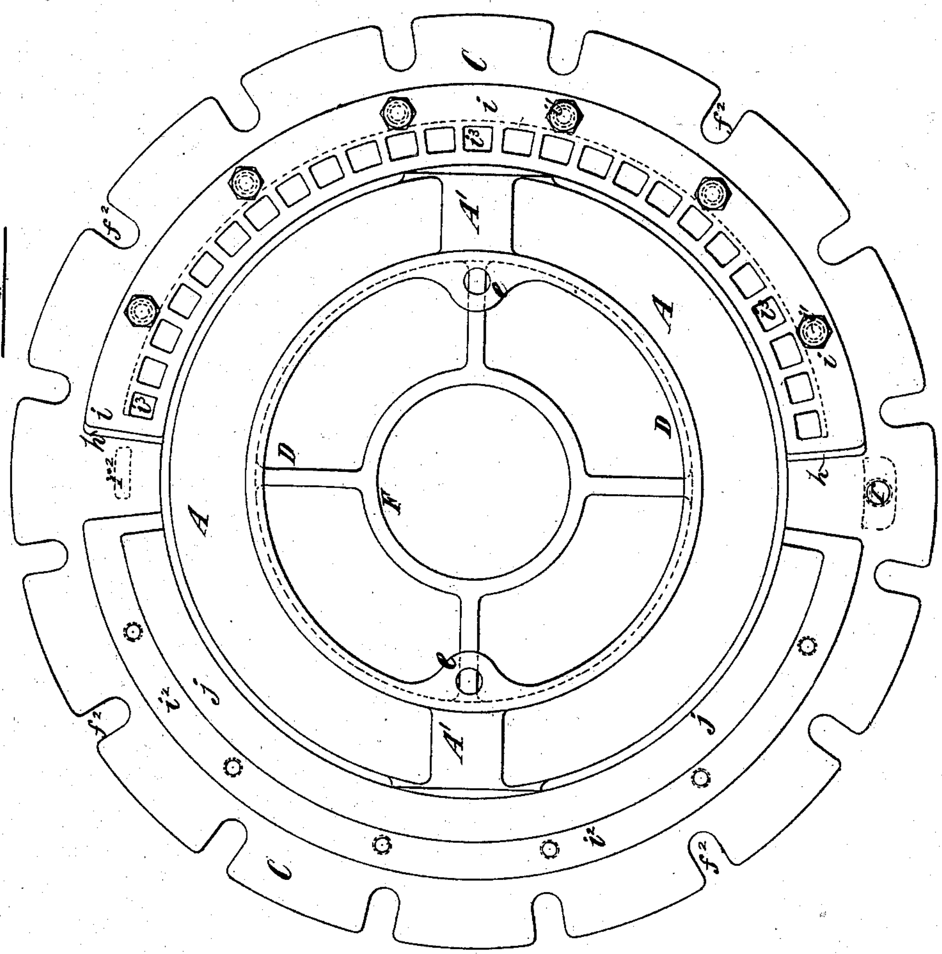
J. B. WARING.

AIR COMPRESSOR.

No. 262,864.

Patented Aug. 15, 1882.

Fig 3.



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UNITED STATES PATENT OFFICE.

JOHN B. WARING, OF NEW YORK, N. Y., ASSIGNOR OF ONE-HALF TO MILAN C. BULLOCK, OF CHICAGO, ILLINOIS.

AIR-COMPRESSOR.

SPECIFICATION forming part of Letters Patent No. 262,864, dated August 15, 1882.

Application filed January 14, 1882. (No model.)

To all whom it may concern:

Be it known that I, JOHN B. WARING, of the city and county of New York, in the State of New York, have invented certain new and useful Improvements in Air-Compressors, of which the following is a specification.

In air-compressors as usually constructed, in which air is drawn into the cylinder by one stroke of a piston and expelled therefrom into the reservoir or receiver by the return-stroke of the piston, much difficulty is experienced in working the compressors, owing to the variable resistance offered to the air-piston. The resistance to the movement of the piston at the beginning of the stroke, without considering friction, is nothing, while at the end of the stroke the resistance is greatest, and consequently an engine of sufficient power to overcome the terminal resistance offered to the air-piston would have a large surplus of power at the beginning of the stroke of said air-piston.

An important object of my invention is to produce a compressor in which the resistance offered to the movement of the piston shall be as nearly as possible uniform during the whole length of its stroke.

To this end my invention consists in the combination, in an air-compressor, of two cylinders of unequal diameter arranged in line, two pistons connected together and fitting said cylinders, suction-valves for admitting air to the larger cylinder upon the inner side of its piston, valves for passing air therefrom to the smaller cylinder upon the outer side of the smaller piston, a discharge valve or valves for said smaller cylinder, preferably arranged in its piston, and preferably also a pipe or conduit for admitting compressed air for acting upon the inner side of said smaller piston. The two pistons may be connected by means of a hollow trunk, which receives within it a stationary discharge-pipe fitted with a piston-head, and through which air passes to the reservoir or receiver.

The invention also consists in the combination, with the two cylinders, their connected pistons and valves, of a reservoir or receiver which surrounds the smaller cylinder, and into which the partly-compressed air is discharged from the larger cylinder and thence delivered into the smaller cylinder for further compression.

The invention also consists in the combination, with the two cylinders, their connected pistons, and the reservoir or receiver surrounding the smaller cylinder, of water-jackets surrounding said smaller cylinder and said reservoir or receiver, whereby the partly-compressed air contained in the reservoir and containing a large amount of heat is subjected to the action of both water-jackets. The larger cylinder is also preferably provided with a water-jacket, and I provide pipes or passages for supplying water to the jacket of the reservoir or receiver, thence to the jacket of the smaller cylinder, and finally through and out of the jacket of the larger cylinder.

The invention also consists in details of construction to be hereinafter explained.

In the accompanying drawings, Figure 1 represents a longitudinal irregular section of a compressor embodying my invention upon the dotted line *y y*, Fig. 2. Fig. 2 represents a transverse section thereof upon the dotted line *x x*, Fig. 1; and Fig. 3 represents an end view of the compressor, looking from the left toward the right, certain parts in Figs. 2 and 3 being removed to better illustrate the invention.

Similar letters of reference designate corresponding parts in all the figures.

A B designate respectively cylinders which are arranged in line and are of unequal diameter, the cylinder A in the present instance being double the diameter of the cylinder B. As here represented, the two cylinders are comprised in a single casting, and are separated by a common head, C, cast in one with the cylinders, as shown, or made separate from them, if desired.

D E designate respectively pistons, one of which, D, is fitted to the larger cylinder, A, while the other, E, is fitted to the smaller cylinder, B. The two pistons are rigidly connected, so that they move backward and forward in unison, and in the present example of my invention they are connected by a hollow trunk, F, formed in one casting with the piston D, and of a size to fit snugly within the smaller cylinder, B. The end of the trunk F is open, and the piston E is secured thereto by

means of a stud-bolt, *a*, fixed in the trunk, and circular jam-nuts *b b*, having notches in their faces for turning them upon the said bolt. The packing of the piston E is effected by two leather-cup packings, *c c*, which are clamped between the meeting faces of the piston E and the end of the trunk F. The piston D, as here shown, is packed tight by means of leather-cup packings *d*, a metal ring, *d'*, located between them, and a gland or packing-ring, d^2, which may be clamped and held on the piston by bolts d^3 to compress and tighten the packing.

The mechanism for operating the pistons D and E may be of any suitable character, none being here shown. In this instance I employ a cross-head or cross-bar, G, secured to the piston D on opposite sides by means of bolts passing through said cross-head or cross-bar, and also through lugs *e*, as shown in Fig. 3. The cross-head or piece G may have at each end a wrist, to which are secured connecting-rods, (not here shown,) and to prevent the vibration of said rods producing any injurious effect upon the cylinder or piston the cylinder and piston are made longer than is absolutely necessary, so as to have a long bearing. In order to obtain such long bearing without unduly increasing the length of the compressor, the end of the cylinder A has in it slots or recesses A', into which the cross-head or piece G moves as the pistons are moved forward.

H designates a reservoir or receiver, into which partly-compressed air is discharged from the cylinder A, and from which such air passes to the cylinder B to be finally compressed. This reservoir or receiver preferably surrounds and incloses the smaller cylinder, B, as here represented. As clearly shown, the common head C projects considerably beyond the cylinder A, and I connect the reservoir or receiver H and the common head by means of bolts *f*, hinged or pivoted at *f'* to one part—in this instance the reservoir or receiver H—and fitting in slots or notches f^2 in the other part—in this instance the common head C. By loosening the nuts of the bolts *f* all the bolts may be swung outward upon their pivots sufficiently to disengage them from the slots or notches f^2 to permit of the detachment of the reservoir or receiver.

In order to prevent leakage, I form in the meeting faces of the head C and reservoir or receiver H correspondingly-opposite angular grooves, and in such grooves I fit a packing-ring, *g*, one of the grooves being undercut or dovetailed, so as to retain the packing when the parts are separated.

The suction-valves for admitting air to the larger cylinder, A, upon the inner side of the piston D and the valves for discharging air partially compressed in the cylinder A into the reservoir or receiver H may be of any desirable construction; but I prefer to use a novel arrangement of valves, which I will now describe.

The suction-valves *h*, for admitting air into the cylinder A, are composed of segmental strips of rubber or similar flexible material, and they are held in place by segmental pieces *i*, which are secured by bolts *i'* to the head C, and constitute the valve-seats, the form of both valves and seats being clearly shown in Fig. 3, one side of said drawing showing the valve and seat in place, and the other side showing the valve and seat removed and the outline of a facing-piece, i^2, upon which the valve-seats and valves are bolted. The valve-seats *i* fit around the outside of the cylinder A, and are provided with a great number of openings, i^3, through which air is drawn, and which are closed by the valves *h*. Between the head C and the valve-seats *i* are formed segmental cavities or recesses *j*, which give room to allow the valves *h* to open inward when the piston D moves back or outward, and the said recesses or cavities communicate with the cylinder A by a number of radial ports, *j'*.

The discharge-valves *k* of the large cylinder A, through which the partially-compressed air enters the reservoir or receiver H, are composed of segmental strips of rubber or other suitable material similar to the valves *h*, and the form of which is shown in Fig. 2. The discharge-valves *k* are secured to the seat upon the opposite side of the head C from the valves *h*, and close a large number of openings, *k'*, in said seat, which communicate with the radial ports *j'*, through which air both enters and leaves the cylinder A. The valves *k* are held in place by segmental guards k^2, secured to the head C by bolts k^3, and the form of both valves and guards is shown clearly in Fig. 2, the left-hand side of which shows the guard and valve in place, while the right-hand side shows the guard and valve removed and a full view of the several openings, *k'*, in the valve-seat.

The valves whereby air is admitted from the reservoir or receiver H to the cylinder B upon the outside of the piston E may be of any suitable form; but a very desirable construction is here shown, which I will now describe.

The head B' of the cylinder B is secured thereto by bolts *l*, and forms the valve-seat, it being provided with openings *l'* for the passage of air.

The valve I, which is composed of an annular ring or disk of india-rubber, leather, or other suitable material, closes the openings *l'*, and is held in place by a valve-guard, I', secured in the head B' by a bolt, *m*, and cap-nut *m'*. In order to leave as little clearance as possible in the cylinder B, the valve-guard I' is constructed with a circular cavity, m^2, which receives the jam-nuts *b b*, whereby the piston E is secured to the trunk F, and in order to save space the guard I' itself fits in a recess or cavity, l^2, of corresponding form in the head B'.

The discharge-valve, which controls the discharge of air from the cylinder B, is composed of an annular corrugated disk or diaphragm, J, which covers openings *n* in the piston E, and is secured in place by an annular nut, *n'*, screwed into the piston E. The air, after pass-

ing the valve J, enters the trunk F, which connects the pistons D and E.

K designates a pipe or conduit, of which only a portion is shown. At its end, which fits within the trunk F, it is provided with a leather-cup packing, *o*, a metal ring, *o'*, and a gland or cap, K', which is tightened by bolts o^2, to compress the packing. The pipe or conduit, K, has a surrounding jacket, which provides for water-circulation to cool the air, and may be provided with suitable inlet and outlet pipes. (Not here shown.) The outer end of said pipe or conduit K (not here shown) abuts against or is fixed to a suitable support, whereby it is held stationary, and the air may be conducted from it by a branch pipe to a reservoir or receiver, in which the compressed air is stored for use.

I will now describe the means whereby the various parts of the compressor are kept cool for cooling the compressed air.

The reservoir or receiver H is composed of two parts or outer and inner shells, *p p'*, secured together by a bolt, p^3, leaving between them a space or jacket, p^2, at the sides and end. Upon one or the other of the shells—in this instance on the inner shell—is formed a spiral rib, *q*, at the end and a second spiral rib, *q'*, running round the jacket from the closed end toward the common head C. The cooling-water enters through a supply-pipe, *r*, and passes through a passage or duct, *r'*, which delivers it at the center of the jacket p^2, near the end of the reservoir or receiver H, from whence it passes outward in a spiral direction, following the convolutions of the spiral rib *q*, and thence along the body of the reservoir or receiver, following the convolutions of the spiral rib *q'* until it reaches the end thereof, where it enters a passage or duct, r^2. The smaller cylinder, B, has a removable lining held in place by the head B', which forms a water-jacket, *s*, and which has upon its exterior two spiral ribs, *s'*, forming a double thread. The water, entering the jacket *s* through the passage or duct r^2, passes toward the closed end of the cylinder B through the jacket, following the convolutions of one thread and then returns, following the convolutions of the other thread, and enters a passage or duct, r^3, in the common head C. (Shown in dotted outline in Fig. 1.) The larger cylinder, A, is constructed with a jacket, A^2, and the water passes from the passage or duct r^3 through this jacket, and thence out of a discharge-pipe, r^4.

In compressing air the first compression, which is effected in the cylinder A, generates a very large amount of heat, and as the reservoir or receiver H is much larger than the smaller cylinder, B—say seven times larger—the partially-compressed air passes slowly through the reservoir or receiver H, and is subjected to the action of the coldest water passing through the jacket of the reservoir or receiver H, and the water passing through the jacket of the smaller cylinder, B, and hence is greatly reduced in temperature before it enters the cylinder B.

Turning, now, to the operation of my compressor, we will suppose that both pistons are moving toward the left. The air is drawn in through the suction-valves *h* of the larger cylinder to fill the space between the inner side of the piston D and the end of the cylinder, while at the same time the air is drawn from the reservoir or receiver H through the suction-valve I of the smaller cylinder to fill said cylinder. On the return-stroke the air in the larger cylinder is forced through the valves *h* into the reservoir or receiver H, while the air in the smaller cylinder is forced through the valve J into the trunk F and pipe or conduit K, and, as said pipe or conduit communicates directly with the reservoir or receiver in which air is stored, the supply of compressed air is thereby augmented. Considering, now, the resistance offered to the movements of the pistons D and E, it will be readily understood that when the said pistons are moving toward the left the piston D will have no resistance save that due to friction, while the piston E will be resisted by the pressure of air in the reservoir in which the compressed air is stored, which may be supposed to be seventy-five pounds per square inch. The piston E has, however, the pressure of the partially-compressed air upon its opposite or right-hand side, which may be supposed to be thirty-five pounds per square inch, and hence the piston is balanced to that extent, and the unbalanced resistance offered by the air to the movement of both pistons will be only about forty pounds per square inch on the area of the piston E. In moving toward the right the initial resistance offered to the piston D is next to nothing, while the terminal resistance is thirty-five pounds, making an average of seventeen pounds per square inch. The resistance offered to the piston E is, say, thirty-five pounds; but this is more than balanced by the pressure of seventy-five pounds on the opposite side of said piston, and the excess of pressure on the piston E is opposed to the resistance on the piston D, and partially balances the same. It will therefore be seen that when moving toward the left the resistance at the termination of the stroke does not materially exceed the initial resistance, and that when moving toward the right the air-pressure on the piston E actually overbalances the resistance at the beginning of the stroke, and nearly balances the resistance at the end of the stroke. The work, therefore, being so nearly uniform throughout the stroke, it will be obvious that a smaller engine could be used than when the resistance is nothing at the beginning of the stroke and reaches its maximum at the end of the stroke; or, what is preferable, an engine of the same size could be used, cutting off much earlier in the stroke, and therefore effecting an economy of steam by its greater expansion.

Although I have shown the reservoir or receiver H as surrounding the smaller cylinder, B, and prefer to so arrange it, it might be differently arranged, and the construction and arrangement of the valves and other features of the compressor might be modified or changed without departing from my invention.

What I claim as my invention, and desire to secure by Letters Patent, is—

1. The combination, in an air-compressor, of two cylinders of unequal size arranged in line, two pistons connected together and fitting said cylinders, suction-valves for admitting air to the larger cylinder upon the inner side of its piston, valves for passing air therefrom to the smaller cylinder upon the outer side of the smaller piston, and a discharge valve or valves for said smaller cylinder, substantially as specified.

2. The combination, in an air-compressor, of two cylinders of unequal size arranged in line, two pistons connected together and fitting said cylinders, suction-valves for admitting air to the larger cylinder upon the inner side of its piston, valves for passing air therefrom to the smaller cylinder upon the outside of its piston, a discharge valve or valves for said smaller cylinder, and a pipe or conduit for admitting compressed air to act upon the inner side of said smaller piston, substantially as specified.

3. The combination, in an air-compressor, of two cylinders of unequal size arranged in line, two pistons connected together and fitting said cylinders, suction-valves for admitting air to the larger cylinder upon the inner side of its piston, valves for passing air therefrom to the smaller cylinder upon the outer side of its piston, and discharge-valves for said smaller piston, arranged in said piston, and providing for the discharge of air through said piston, substantially as specified.

4. The combination, in an air-compressor, of two cylinders of unequal size arranged in line, two pistons fitting said cylinders, a hollow trunk connecting said pistons and communicating with a reservoir, suction-valves for admitting air to the larger cylinder upon the inner side of its piston, valves for passing air therefrom to the smaller cylinder upon the outer side of its piston, and discharge-valves for passing air through said smaller piston into said trunk, substantially as specified.

5. The combination, in an air-compressor, of two cylinders of unequal size arranged in line, two pistons fitting said cylinders, a hollow trunk connecting said pistons, a stationary discharge-pipe fitting closely within said trunk, suction-valves for admitting air to the larger cylinder upon the inner side of said piston, valves for passing air therefrom to the smaller cylinder upon the outer side of its piston, and a discharge valve or valves for passing air through said smaller pistons into said trunk, substantially as specified.

6. The combination, in an air-compressor, of two cylinders of unequal size arranged in line, two pistons connected together and fitting said cylinders, a reservoir or receiver surrounding the smaller cylinder, suction-valves for admitting air to the larger cylinder upon the inner side of its piston, valves for discharging air therefrom to the reservoir or receiver, a valve or valves whereby air passes from said receiver or reservoir to said smaller cylinder upon the outer side of its piston, and a discharge valve or valves for said smaller cylinder, substantially as specified.

7. The combination, in an air-compressor, of two cylinders of unequal size arranged in line, two pistons connected together and fitting said cylinders, a head between said cylinders and common to both, a reservoir or receiver surrounding the smaller cylinder and secured to said common head, valves on opposite sides of said common head for admitting air to the larger cylinder upon the inner side of the piston and for discharging air therefrom into said reservoir or receiver, and valves for admitting air from said reservoir or receiver to the smaller cylinder upon the outside of its piston, and for discharging air from said smaller cylinder, substantially as specified.

8. The combination, in an air-compressor, of two cylinders of unequal size arranged in line, a water-jacket surrounding the smaller cylinder, two pistons connected together and fitting said cylinders, an air reservoir or receiver surrounding said smaller cylinder, and a water-jacket surrounding said reservoir or receiver, whereby the air in said reservoir or receiver is cooled by contact with both water-jackets, substantially as specified.

9. The combination, in an air-compressor, of two cylinders of unequal size arranged in line, a water-jacket around said smaller cylinder, an air-reservoir or receiver surrounding said smaller cylinder, a water-jacket around said reservoir or receiver, and pipes or passages for supplying water to the jacket of the reservoir or receiver, thence conducting said water to the jacket of said smaller cylinder, and finally discharging the water therefrom, substantially as specified.

10. The combination, in an air-compressor, of two cylinders of unequal size arranged in line, a reservoir or receiver surrounding the smaller cylinder, water-jackets for both said cylinders and for said reservoir or receiver, and pipes or passages for supplying water to the jacket of the reservoir or receiver, and for conducting water from said jacket to the jacket of the smaller cylinder, thence to the jacket of the larger cylinder, and finally for discharging the water from the jacket of said larger cylinder, substantially as specified.

11. The combination, in an air-compressor, of the two cylinders, and the reservoir or receiver H, composed of two parts fitting one within the other, and having a spiral passage along its side or cylindric portion and its closed end, substantially as specified.

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