(No Model.)

3 Sheets—Sheet 1.

E. HILL.

AIR COMPRESSOR.

No. 448,859.

Patented Mar. 24, 1891.

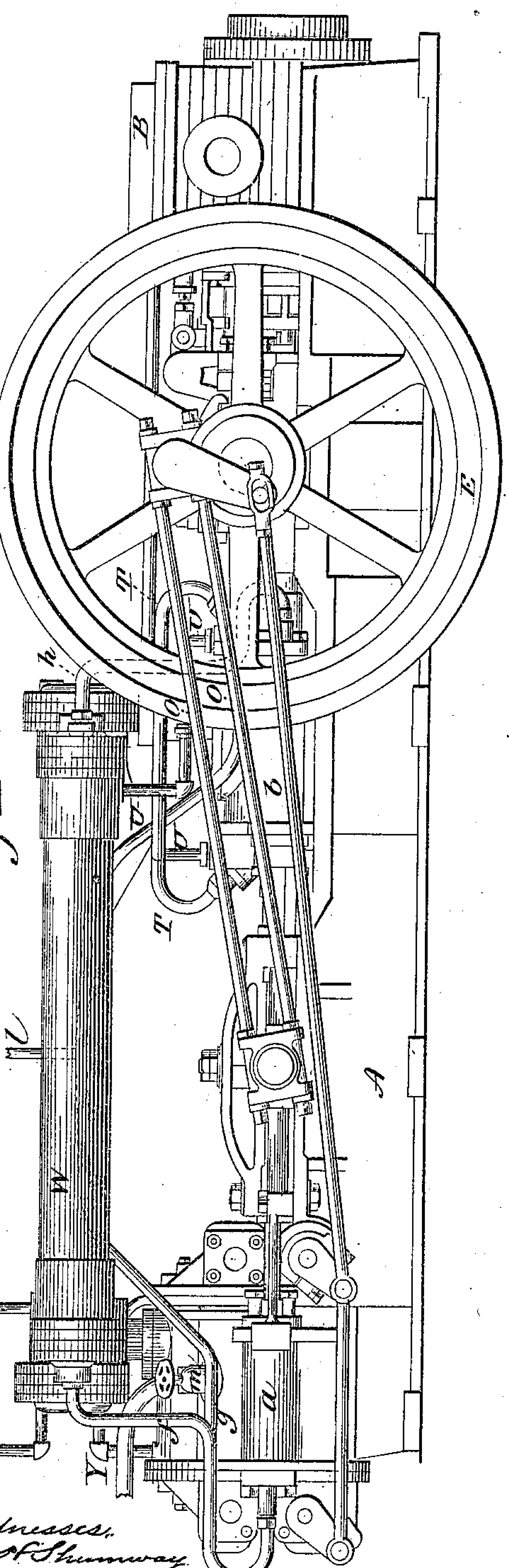

Fig. 1

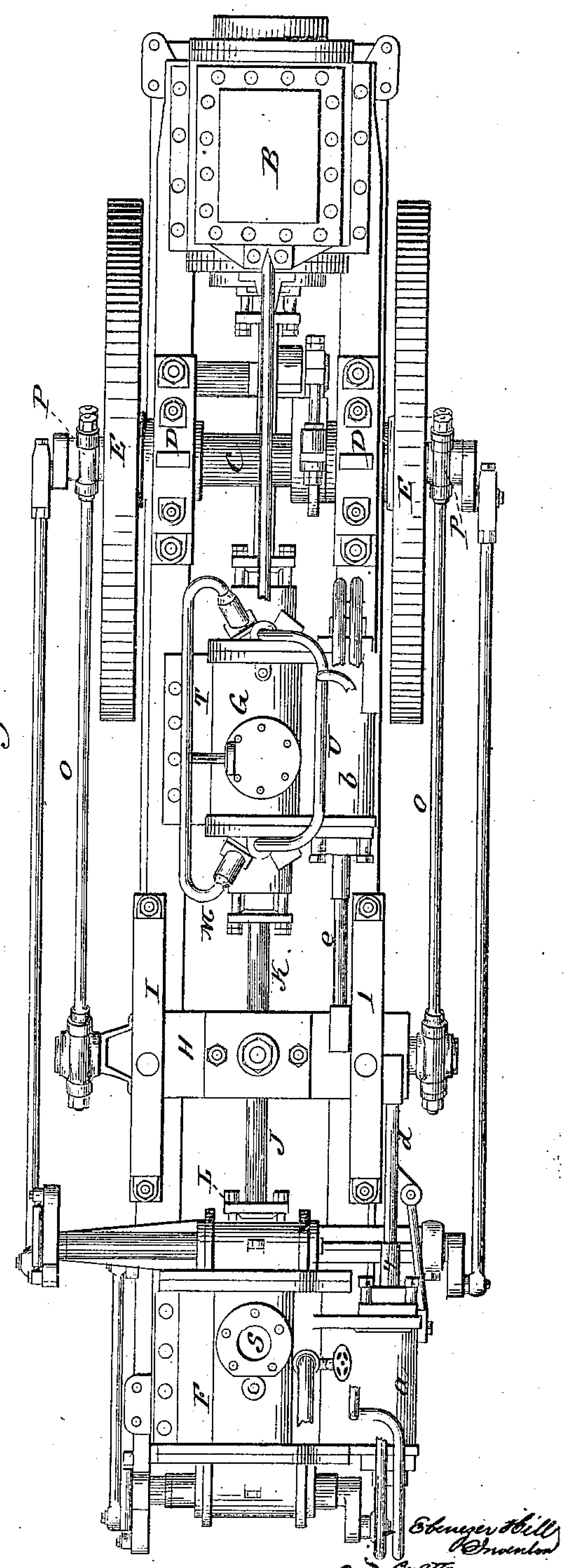

Fig. 2

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Fig. 3

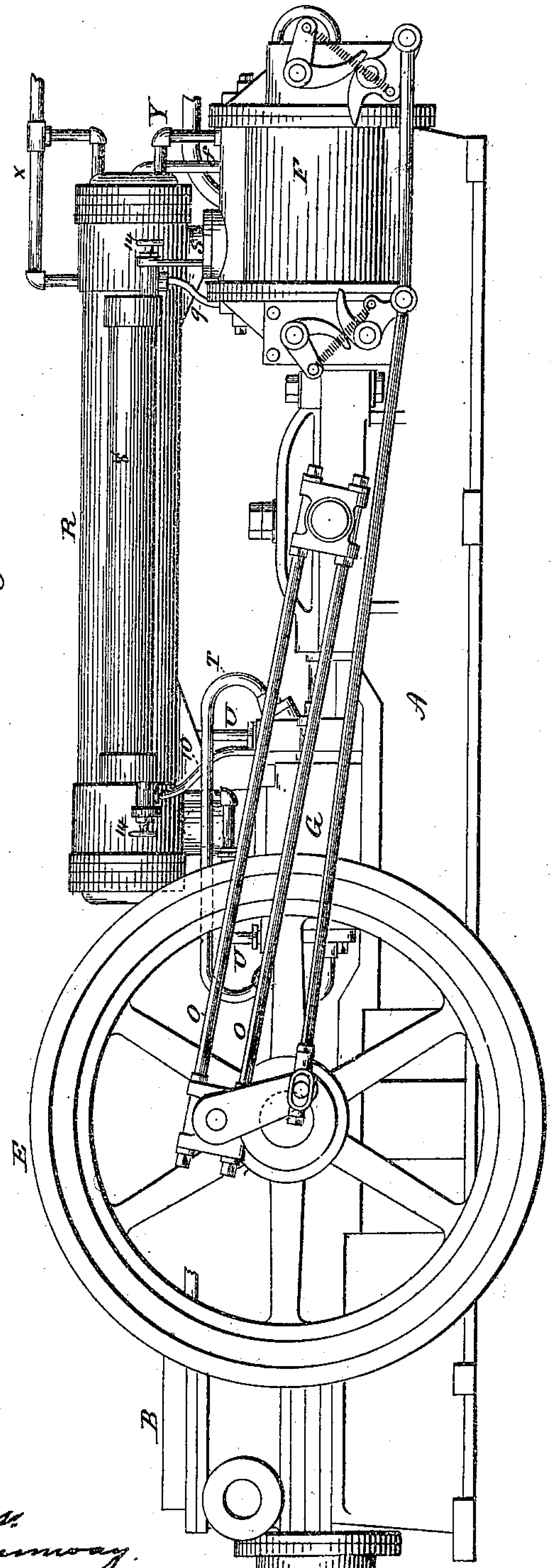

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Fig. 5

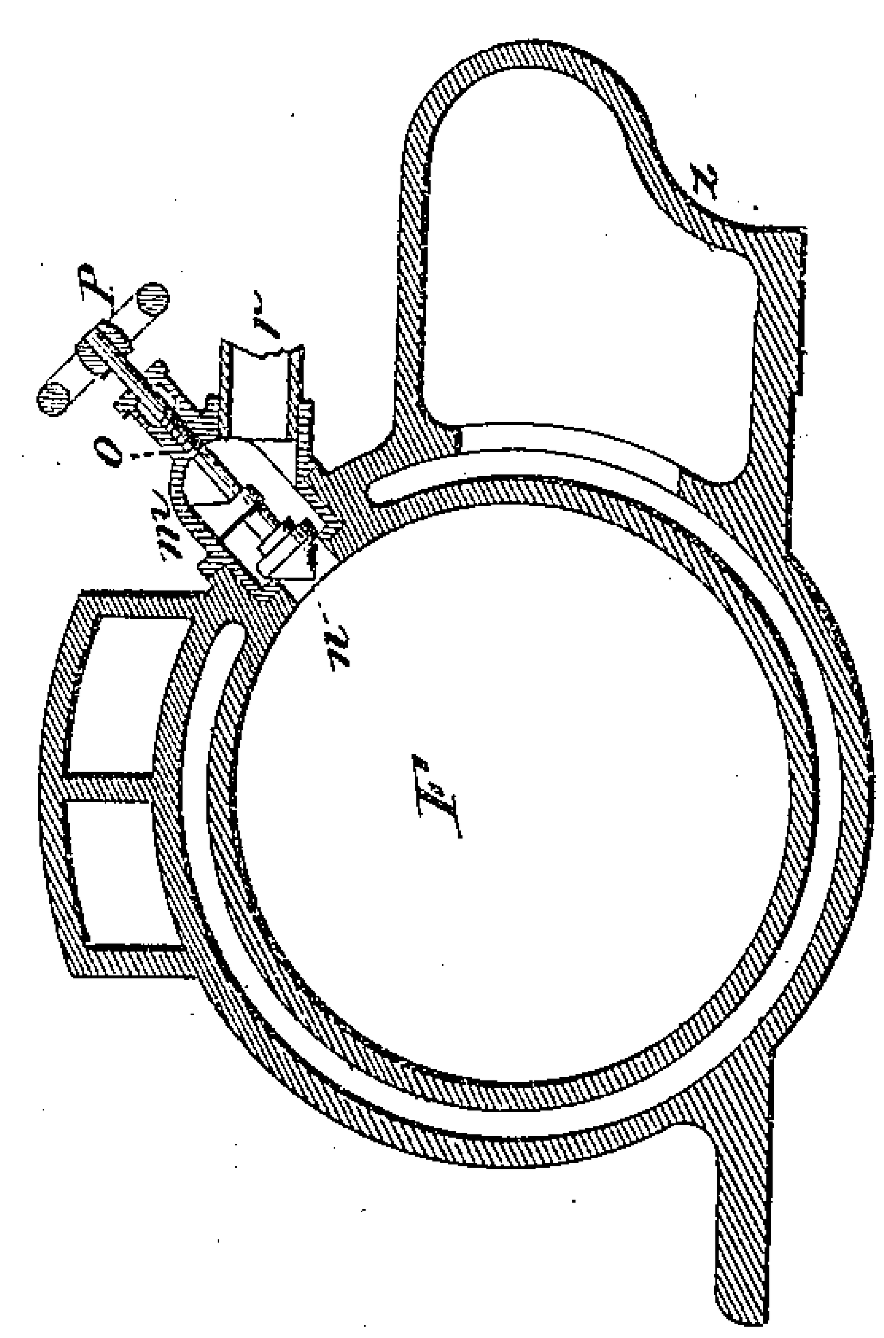


Fig. 6

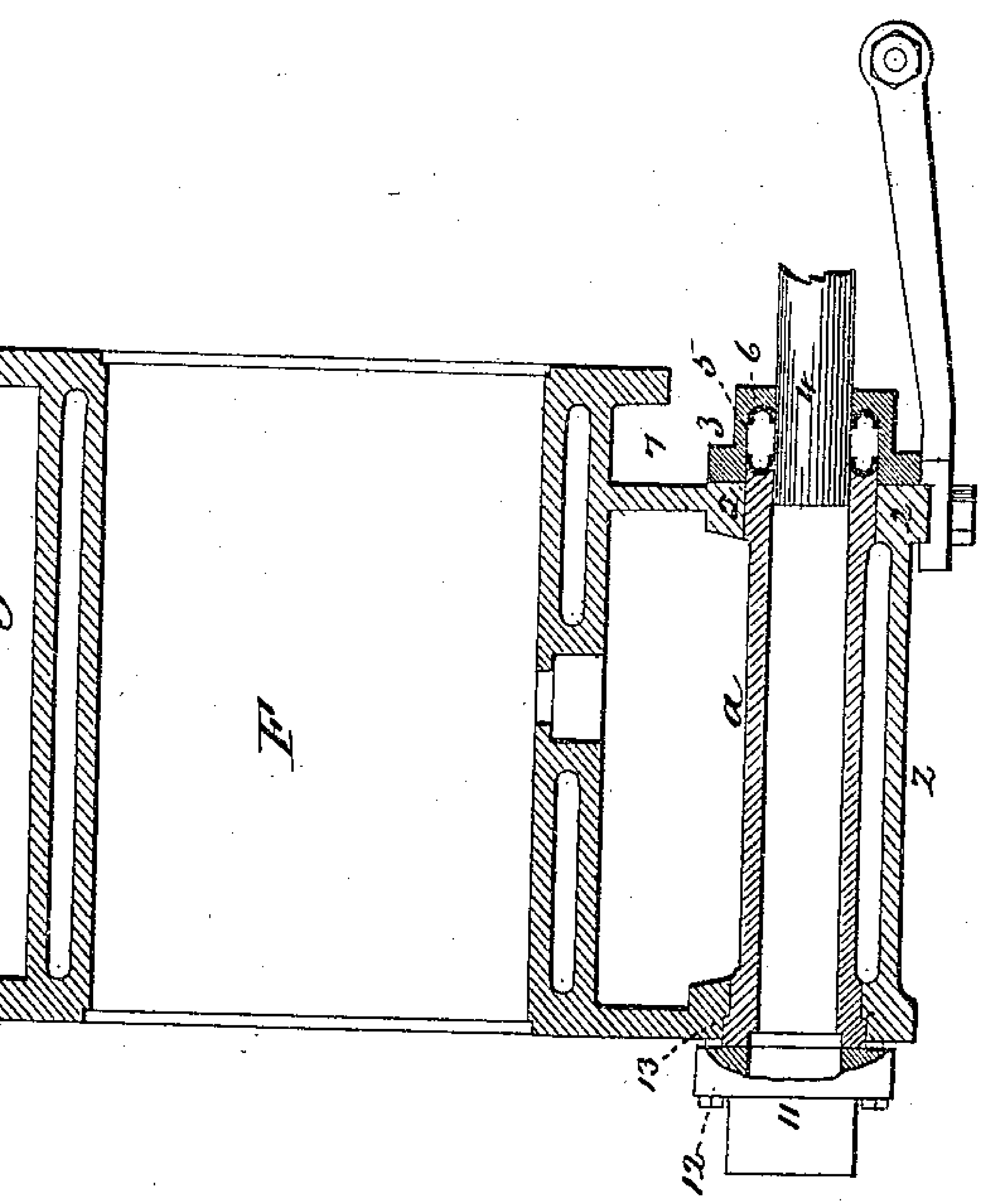
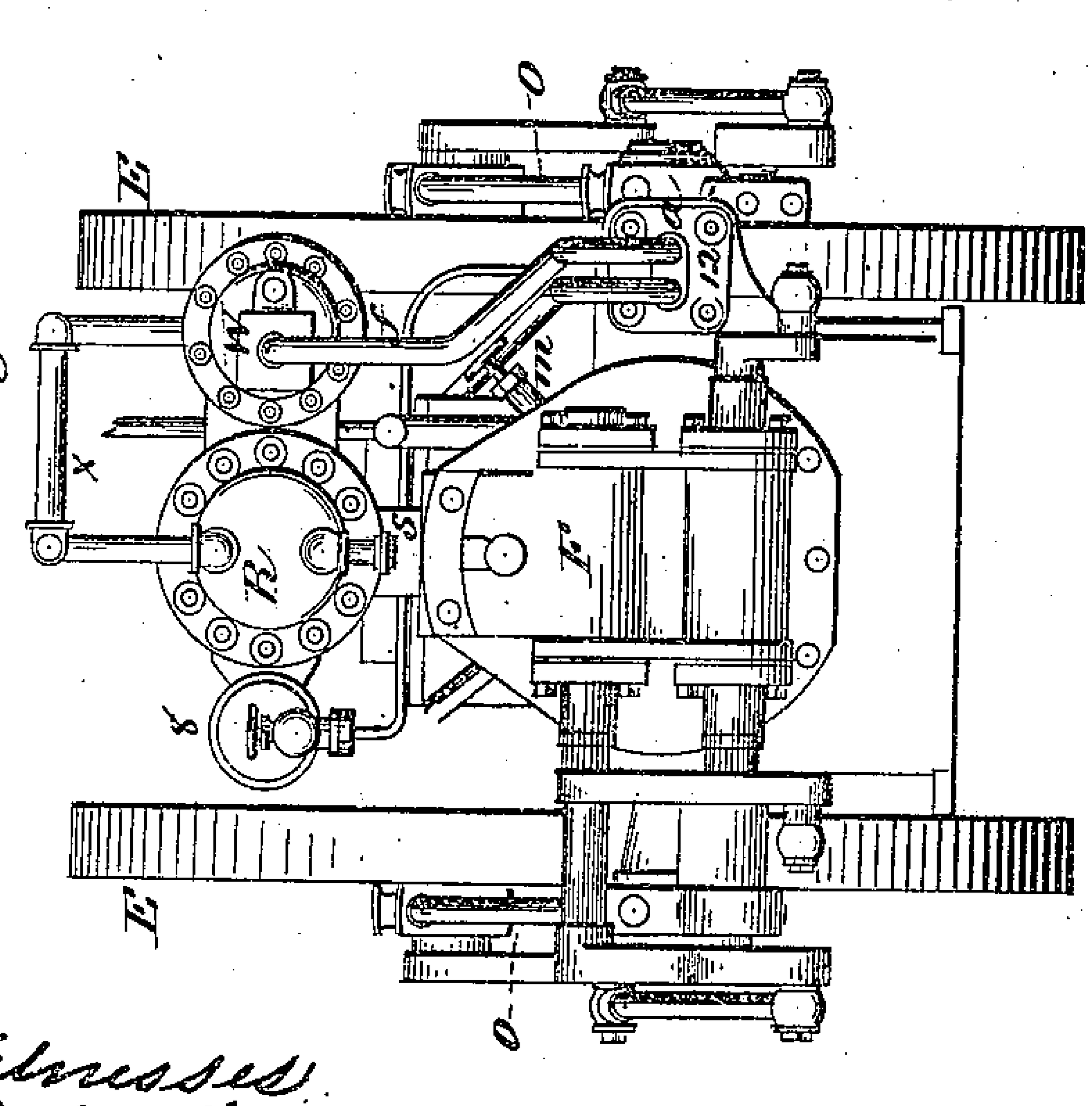


Fig. 4



Witnesses.
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UNITED STATES PATENT OFFICE.

EBENEZER HILL, OF SOUTH NORWALK, CONNECTICUT.

AIR-COMPRESSOR.

SPECIFICATION forming part of Letters Patent No. 448,859, dated March 24, 1891.

Application filed December 17, 1888. Serial No. 293,822. (No model.)

To all whom it may concern:

Be it known that I, EBENEZER HILL, of South Norwalk, in the county of Fairfield and State of Connecticut, have invented new Improvements in Air-Compressors; and I do hereby declare the following, when taken in connection with accompanying drawings and the letters of reference marked thereon, to be a full, clear, and exact description of the same, and which said drawings constitute part of this specification, and represent, in—

Figure 1, a side view looking from the right of Fig. 4; Fig. 2, a top or plan view, the air-receivers or intercoolers and reservoir removed to show the mechanism beneath; Fig. 3, a side view the reverse of Fig. 1; Fig. 4, an end view from the left of Fig. 1; Fig. 5, a transverse section of the principal cylinder cutting through the relief-valve; Fig. 6, a longitudinal section through the principal cylinder and the single-acting final compressor adjacent to it.

This invention relates to an improvement in that class of air-compressors which are designed to compress the air to a very great extent. Formerly air-compressors of this class were composed of two single-acting cylinders, a large cylinder, as the primary compressor, and a smaller cylinder, as the auxiliary compressor, the air from the first cylinder being led to the second cylinder directly or indirectly. During the first part of the operation—that is, when the machine first started and before the air in the reservoir had been compressed—the first cylinder would be doing its full share of the work, but the second or smaller cylinder would be doing practically nothing; hence the machine would "go heavy" on one side and light on the other. If, however, double-acting cylinders were used for both primary and auxiliary, the stroke would be the same in both directions, perfectly balanced; but for the smaller or auxiliary cylinder it is impracticable to make it double-acting, for the reason that it is extremely difficult and practically impossible to construct the piston for the auxiliary cylinder so that it will work perfectly tight in both directions. Hence in the attempt to employ a small double-acting auxiliary or final compressor the air will escape from one side of the piston to the other side, and thus materially retard or interfere with the proper action of the pump, and such leak cannot be readily ascertained. In the use of a single-acting cylinder, however, the packing for the piston may be made outside, where any escape or leak will be observed, and so applied as to be practically tight. Hence it is that in all practical air-compressors the auxiliary or final compressing-cylinder is made single-acting. In the operation of the single-acting cylinder the power is employed only in one direction, the piston running free in the opposite direction. Consequently there is a very considerable loss of power, as well as an irregular use of that which is employed, which produces undue strain upon the machinery.

The object of my invention is primarily to overcome this difficulty; and the invention consists in combining in an air-compressor double-acting cylinders, as the primary compressors with a pair of single acting cylinders oppositely-arranged, as the supplemental or final compressors, and whereby an even resistance is produced in all parts of the machine, and in details of construction fully hereinafter described, and particularly recited in the claims.

A represents the bed of the apparatus, and B the steam-cylinder arranged upon the bed; C, the driving-shaft supported in pillow-blocks D D, and to which the power from the steam-cylinder is applied in the usual manner and substantially as in steam-engines. The details of construction whereby the steam-power is imparted to the driving-shaft it is unnecessary to describe, as they do not differ materially from steam-engines in general use, and may be any suitable mechanism between the steam-cylinder and the driving-shaft whereby the reciprocating movement of the piston will be converted into the rotary movement of the shaft.

E E represent a pair of fly-wheels made fast to the driving-shaft, one upon each side of the bed.

F represents the first or principal compressing-cylinder, and G the second compressing-cylinder. These are arranged upon the bed, made fast thereto and in line with each other, as clearly seen in Figs. 1 and 2. Between the two cylinders F and G a cross-head H is arranged in suitable parallel longitudinal guides I, and in connection with which is a piston-rod J, extending from one side of the cross-head to the piston of the principal cylinder F, and upon the other side a like piston-rod K, which extends to the piston of the cylinder G, the respective rods working through stuffing-boxes L M on the cylinder in the usual manner for packing the rods of such cylinders. These cylinders are both double-acting, and are of common construction, so that the pistons, both working together, take air upon one side as they move in one direction and on the return force that air out of the cylinder and take air upon the other side of the piston, and so continuing, each movement of the piston taking and receiving air.

The cross-head H is connected by rods O on each side to cranks P on the driving-shaft, and so that each revolution of the driving-shaft will impart full reciprocating movement to the cross-head H and the respective pistons connected thereto.

Above the cylinders F G a receiver R is arranged and suitably supported, (here represented as of cylindrical shape,) and to which the principal cylinder F discharges through a connection-passage S. (See Figs. 2 and 3.) The second cylinder G draws from the receiver R through a pipe T, which leads directly from the receiver R to the respective ends of the cylinder G, as seen in Figs. 2 and and 3, and so that the air which has been forced into the receiver R from the cylinder F will be drawn therefrom by the cylinder G through the said pipe T. The cylinder G discharges from its respective ends through a pipe U, which leads into a second receiver W, arranged parallel with the receiver R. (See Figs. 1 and 2.)

The receivers R W are provided with a supply of water through pipes X in the usual manner, to reduce the temperature of the air forced into the respective receivers, and this water may circulate around the cylinder, as through a pipe Y, represented as leading into the principal cylinder, as seen in Fig. 1. This circulation of water, however, constitutes no part of my present invention, and is therefore only referred to to indicate the purpose of the pipes represented in the drawings.

In the illustration I have represented the mechanism for the valves of the principal cylinder as oscillating valves, the valve-gear being common and well known, operated directly from the driving-shaft, so that induction and eduction valves are opened and closed at the proper time, this mechanism being well known and for which any other known mechanism may be substituted, and as such mechanism constitutes no part of my present invention I do not particularly describe it.

In combination with two double-acting cylinders I employ two single-acting cylinders *a* and *b*. These are arranged at the side of the cylinders F G and parallel therewith, as seen in Fig. 2. The piston-rod *d* of the cylinder *a* is connected to the cross-head on one side, and the piston-rod *e* of the cylinder *b* is connected to the cross-head on the opposite side, so that under the reciprocating movement of the cross-head one piston enters its cylinder as the other is withdrawn from its cylinder; consequently each of the cylinders *a b* operate to force air in one direction only. The action of the one cylinder is opposite to the action of the other cylinder, and each takes air on the return-stroke. These cylinders *a b* are of like area, so that one substantially counterbalances the other. The cylinder *a* draws air from the receiver W through a pipe *f*, connecting directly to the cylinder *a*, and on the return-stroke, after having so drawn the air from the receiver W, the air is discharged through a pipe *g*. The cylinder *b* draws air from the same receiver W through a pipe H, connecting directly to the cylinder *b*, and discharges the air so drawn through a pipe *i*, the pipes *g* and *i* being connected to a common discharge *l*. (See Fig. 1.) Thus the four cylinders connected and operating present an equal resistance at all times when the machine is in operation, the one single-acting cylinder counterbalancing the other, so that there may be a perfect uniformity in the action of the machine, and this irrespective of the pressure—that is to say, on the first starting of the machine the resistance will be as regular as when the highest pressure is attained, thereby avoiding the wear and tear of the machine due to one single-acting cylinder.

It will be understood that the inlet or discharge check-valves are employed for the respective cylinders, as usual in air-compressing apparatus.

It sometimes occurs that the principal cylinder will deliver more air than is desirable—that is to say, the full capacity of the cylinder will be greater than desirable. To adapt the principal cylinder to deliver less air than it takes, I provide a relief-valve *m*. (See Fig. 5.) This valve consists of the movable valve *n*, attached to or made as a part of a screw-spindle *o*, working through a stuffing-box, the spindle provided with a hand-wheel *p* at its outer end, by which the spindle may be rotated to draw the valve from or force it to its seat. The opening through the valve-seat is into the principal cylinder, and from the chamber outside the valve an escape-pipe *r* conducts air, which may escape to any desirable point. This valve is arranged about midway of the length of the cylinder; but so that the piston may pass the valve-opening. Consequently if the valve be open air will escape during the first part of the advance of the piston and until the piston has passed the valve-opening. The quantity of air to be compressed by the piston will therefore be reduced according to the amount which is permitted to escape during the first part of the movement of the cylinder, and may be greater or less accordingly as the valve is adjusted.

If the valve be opened sufficiently to permit all the air in advance of the piston to escape, then the capacity of the cylinder will be but one-half its stroke in each direction, and as the escape-opening is reduced the quantity of air delivered by the piston will be correspondingly increased. The initial pressure thus being regulated, it necessarily follows that the regulation will be continued through all the cylinders to the reservoir, as the pressure of each cylinder succeeding the principal cylinder will vary according to the pressure produced by the first cylinder.

To produce a packing around the piston of the final compressing-cylinders *a b* and so that air cannot escape from the cylinders, the piston ends of the cylinders *a b* are arranged in a support 2, as seen in Fig. 6, this support being a part of the surrounding case Z, which forms the cooler for the cylinders, this figure representing only the cylinder *a*. The end of the cylinder projects beyond the face of the support 2, which surrounds that end of the cylinder.

The stuffing-box 3, which surrounds the piston 4, is secured directly to the face of the support 2 and outside the end of the cylinder, so that the stuffing-box practically covers or incloses the end of the cylinder. The stuffing-box is recessed to form a chamber 5 around the piston 4 and outside the end of the cylinder. The ends of the chamber 5, one of which is formed by the stuffing-box and the other by the end of the cylinder, are made concave in longitudinal section, as clearly seen in Fig. 6. Into these ends of the chambers, which form seats, the packings 6 7 are respectively arranged. These packings are made from leather or other flexible material, and are of ring shape, corresponding to the diameter of the piston and the chamber 5, and the packing-rings are concavo-convex shape in longitudinal section, corresponding to the concave shape of the respective ends of the chamber and so as to seat therein, as shown. The inner sides of these packing-rings therefore rest directly upon the piston, and they form the ends of the chamber. Consequently any pressure produced in this stuffing-box chamber 5 will tend to force the packing close upon the piston and against the outer wall of the chamber to completely pack the joint.

To produce pressure within the chamber, and so as to hold the packing-rings 6 7 in their proper position and at the same time lubricate the pistons, I provide a reservoir 8, which is in the form of a hollow cylinder, similar to but of smaller capacity than the air-receiver and arranged parallel therewith and above the cylinders *a b*, as seen in Figs. 3 and 4. From this reservoir a tube 9 leads to the stuffing-box chamber 5 of the cylinder *a*, and a like tube 10 leads to the stuffing-box chamber of the cylinder *b*. The reservoir 8 is supplied with lubricating material, which readily flows into the respective stuffing-box chambers, and so that those chambers are constantly filled with lubricating material, through which the respective pistons work. As the pistons of these final compressors operate, at first air will escape in small quantities around the piston into the stuffing-box chambers, thence, in accordance with nature's laws, the air will pass directly to the reservoir and so continue until the pressure is attained in the reservoir to substantially counterbalance the pressure of the air escaping around the piston, and this pressure will force the packing-rings upon the piston and prevent further escape of air. The outer ring 6 prevents the escape of the lubricating material outside the stuffing-box and also prevents the passage of air in that direction, all the air which escapes passing directly to the reservoir. Consequently there is no possible escape of air from the cylinder around the piston and at all times the piston is properly lubricated. As heretofore constructed, the head 11 for the closed end of these final compressing-cylinders has been fitted to the face of the support or chamber surrounding the cylinder; but a serious difficulty is experienced in properly packing the joint between the face and head so as to prevent the escape of air, the strain upon this head being so great that the joint is easily affected. To overcome this difficulty I make the end of the cylinder to be closed to an extent beyond the face of the surrounding surface, as at 12, Fig. 6, and construct the head to fit closely upon the end of the cylinder without contact with the surrounding surface and then bolt the head directly to the surrounding surface and outside the cylinder, as indicated in Figs. 4 and 6. The cylinder is constructed with a shoulder 13 near the closed end, so as to take a bearing in the surrounding casing as a resistance against the head, and so that the head may be drawn hard upon the end of the cylinder, and force the shoulder 13 to a solid bearing in the surrounding casing. Under this arrangement, I am enabled to make a metal packing close and tight, and one which is not affected by the strain brought upon the head under the action of the piston. Thus constructed and arranged, the cylinder is supported against longitudinal movement entirely at one end, the other end resting in its bearing free to slide therein, so that the expansion and contraction of the cylinder are provided for entirely at the stuffing-box end, where the packing adjusts itself to such longitudinal expansion and contraction of the cylinder. This arrangement adds materially to the efficacy of the complete fitting and stability of the joint at the closed end of the cylinder.

The lubricating-passages may be regulated, say as by screw-valves 14, (see Fig. 3,) or cut off completely should occasion require.

In some cases the intermediate or second compressing-cylinder may be dispensed with, the two oppositely, single-acting final compressors working in combination with that one cylinder the same as with the two, so also may the arrangement of the single-acting cylinder whereby it is supported rigidly at one end without longitudinal movement, but free at the other end for such longitudinal movement under expansion and contraction independent of its stuffing-box. It will be evident that in such case other known packing may be substituted for the peculiar packing which I have described.

I make no claim in this application on the peculiar packing of the stuffing-box and a reservoir-connection therewith, such being the subject of an independent application.

I claim—

1. In an air-compressor, the combination of a principal double-acting air-compressing cylinder, mechanism substantially such as described to impart reciprocating movement to the piston of said principal cylinder, a receiver into which the said double-acting cylinder discharges, a pair of single-acting cylinders of equal capacity, but arranged to operate in opposite directions and in connection with the mechanism by which the piston of the principal cylinder is operated, connection from the said receiver to each of the said single-acting cylinders, whereby one of said single-acting cylinders draws from the said receiver in one direction and the other single-acting cylinder draws from the receiver in the opposite direction, and the said two single-acting cylinders operating to deliver air on the return-strokes, but in the opposite direction, substantially as described.

2. In an air-compressor, the combination of a principal double-acting cylinder, and a second double-acting cylinder arranged in line with each other, a cross-head arranged between said two cylinders in longitudinal parallel guides, mechanism substantially such as described to impart reciprocating movement to said cross-head, the piston-rod of each of said cylinders in connection with said cross-head, and whereby the reciprocating movement of the cross-head imparts like reciprocating movement to the pistons of the respective cylinders, a receiver into which the said principal cylinder discharges, a connection from said receiver of the principal cylinder to the second cylinder, a second receiver into which the said second cylinder discharges, a pair of single-acting pumps arranged upon opposite sides of said cross-head and parallel with the double-acting cylinders, the pistons of said single-acting cylinders connected at opposite points to the said cross-head with connection from each of said single-acting cylinders with the second receiver, whereby each of said cylinders in its turn draws from the said second receiver and both discharge in opposite directions, substantially as described.

3. In a compressing-pump, the pump-cylinder rigidly supported at one end without longitudinal movement, its other end supported, but free for longitudinal movement, the free end of the pump extending beyond the face of its support, combined with a stuffing-box around the piston at the said free end of the cylinder, the said stuffing-box recessed corresponding to the said free end of the cylinder, and so that the said free end of the cylinder may enter the said stuffing-box, the box secured to the face of the support around the cylinder, the end of the said cylinder forming one end of the chamber in the stuffing-box, and the said chamber of the stuffing-box provided with a packing, substantially as described.

4. In a compressing-pump, the combination of the pump-cylinder supported rigidly at one end against longitudinal movement, that end of the cylinder extending beyond the face of its support, the head for that closed end of the cylinder arranged to bear directly upon the projecting end of the cylinder, but secured to the surrounding surface without contact therewith, the other end of said cylinder arranged in a support free for longitudinal movement, a stuffing-box at the said free end of the cylinder, and a packing within said box around the piston, substantially as described.

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