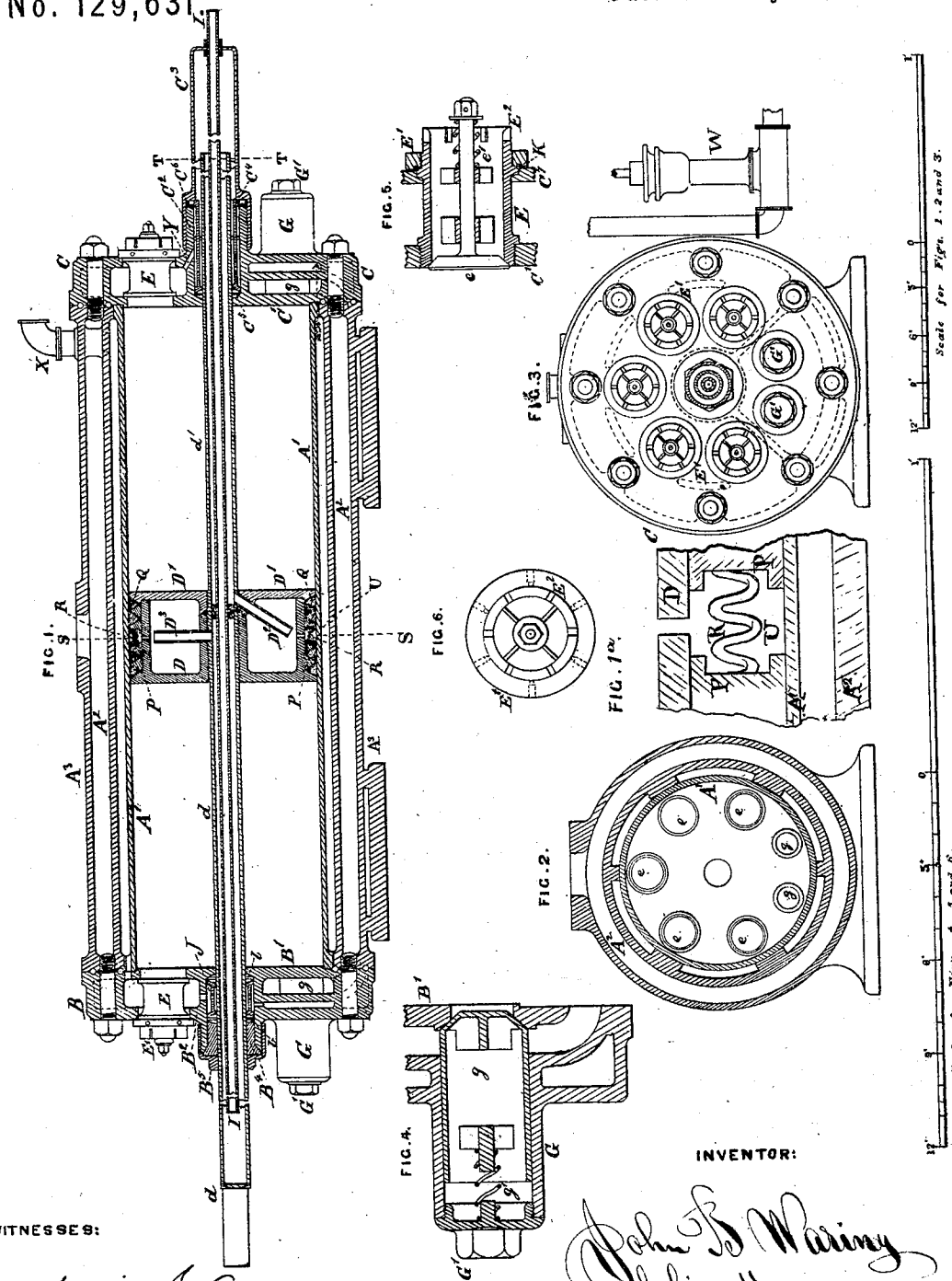
J. B. WARING.

Improvement in Air-Compressing Apparatus.

No. 129,631. Patented July 16, 1872.



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IMPROVEMENT IN AIR-COMPRESSING APPARATUS.

Specification forming part of Letters Patent No. 129,631, dated July 16, 1872.

Specification describing certain Improvements in Air-Compressing Machines, invented by JOHN B. WARING, of South Norwalk, Fairfield county and State of Connecticut.

In the use of machines for compressing air to any considerable density, the temperature of the air is found to rise, and it becomes an important consideration to dispose of the heat thus set free by the compressive action. The means heretofore provided for this purpose are open to objection. One of the best means formerly known consisted in introducing water with the air, which water would go through the pump and be afterward removed in a heated state, resulting from its great capacity of absorbing the caloric set free in the compressed air. The chief objection to this lay in the difficulty of effectually removing the water. The presence of water in minute globules or otherwise in the air becomes highly objectionable when, at a subsequent period, the compressed air, which has in the meantime become thoroughly cooled, is expanded. The refrigeratory effect due to the expansion causes ice to accumulate about the exhaust, and has often been known to completely close the exhaust-passage. I provide for the employment of water by circulating it in the vicinity of the air, but separated therefrom by metal intervening, and have invented several improvements in the means for accomplishing this. I also employ water to lubricate the rubbing surfaces. I also employ water to compress the packing. I employ the same water to effect all these ends. I give the water for these purposes a positive and definite intermittent motion, which thoroughly sends it into all the recesses.

The following is a description of what I consider the best means of carrying out the invention.

The accompanying drawing forms a part of this specification.

Figure 1 is a central longitudinal section through the cylinder and piston, and through the piston-rod and its appurtenances. Fig. 1ª represents a small portion of the same on a much larger scale. Fig. 2 is a cross-section on the line S S with the piston and piston-rod removed. Fig. 3 is a section on the line T T. The remaining figures represent certain details on a larger scale. Fig. 4 is a section through one of the eduction-valves and its appurtenances. Fig. 5 is a section through one of the induction-valves and its appurtenances. Fig. 6 is an end view of the latter.

Similar letters of reference indicate like parts in all the figures.

The pump body or cylinder is formed with channels or spaces around it peculiarly arranged for conveying water and air. The ends or heads are, as usual in such constructions, formed separately from the main body, and the main body is formed of two separate pieces or thicknesses, the outermost being a peculiarly-chambered casting and the innermost a thin and sufficiently-rigid hollow cylinder, of steel. The latter is formed in a separate piece from the other parts, but is drawn in very tightly and firmly to its place, so that it ever afterward serves as one piece with the casting exterior to it. I shall, with the proper qualifications, designate it by the same class of distinguishing letters.

The letter A, without any distinguishing marks affixed, will be used, when necessary, to indicate the entire main body, comprising the steel lining and the exterior casting. So the letter B will indicate the entire head on the left, and the letter C the entire head on the right. The marked letters A^1 A^2, &c., and B^1 C^1, and the like, indicate parts of the main body A or parts of the heads B and C. The steel lining is marked A^1. It is as thin as is consistent with its strength in order to allow the heat developed in the interior by the rapid compression of the air to be transmitted very freely to the water outside. The piston D and the connected moving parts will be described in detail further on. It may be sufficient here to say that it is a tight-fitting piston, having not only a piston-rod extending out through one head of the cylinder, through which the power is received, but also an opposite extension passing out through the opposite head. There is a hole in the center of each head B and C, with suitable provisions for packing tightly around the part which slides axially therein. The cylinder-head B is that through which passes the part corresponding to the piston-rod proper. Its inner surface, B^1, corresponds to the ordinary cylinder-head. Close around the piston-rod it is extended out-

ward, as shown by B^2, to form a deep and capacious stuffing-box. This box not only contains provisions for packing at two points with any ordinary or suitable material for the purpose of forming tight joints and compensating for wear around the piston-rod, but also provides for a free access of the water to the surface of the piston-rod between these packings. My invention provides for circulating a stream of water through the interior of the entire piston-rod and of the corresponding tubular construction, which projects outward through the entire mass of the piston, and through both the cylinder-ends and around the entire surface of the cylinder. It also provides for allowing such water to wet the surface of the piston-rod and of the corresponding tubular constructions, and to wet the inner surface of the cylinder. The deposit of a thin layer of water upon these surfaces contributes, I believe, in an important manner to the capacity of the metal to absorb caloric rapidly, and also obviously serves, by its well-known lubricating properties, to reduce the friction and wear on these surfaces. The entire piston will be designated by the letter D. The removable part, ordinarily termed a follower, is marked D^1, and, as it is necessary to distinguish other parts of the piston proper, they will be marked D^2, &c. The piston-rod proper is designated *d;* the tubular construction which extends in the opposite direction is marked *d'*. There are five induction-valves, by which I mean valves opening inward, to allow the entrance of air in each end. There are two delivery-valves, or valves opening outward, in each end. The induction-valves receive the air directly from the exterior atmosphere. The delivery-valves discharge the air into a chamber partitioned off for the purpose. The induction-valves are marked *e e*. They are mounted in housings or casings E, which are removable, to allow of convenient exchange and repairs. These casings E extend through the water-chamber, as will be apparent, and are fitted tightly in both the outer and inner laminæ or partitions which form the head at each end. The delivery-valves are marked *g*. They require no removable casings, but are capable of being drawn out separately from the housing or cage which surrounds them by simply removing a cap, G^1. These delivery-valves are hollow cases, the construction of one of which, with its springs and its adjuncts, which tend to force it home, is clearly shown in Fig. 4. The spring to force home a delivery-valve, *g*, is marked *g'*. The spring to force home an induction-valve, *e*, is marked *e'*. Any suitable power being applied to the piston-rod *d* to reciprocate it rapidly to the proper extent causes the piston D, by its motion in one direction, to induct the air through the valves *e*, and to compress it by its movement in the opposite direction, and in the latter part of its motion to force it out through the delivery-valves *g*. A smaller number of valves will serve to deliver the air than is required for its induction, by reason of its greatly-reduced volume consequent upon the severe compression to which it has been subjected. The air on being discharged through the delivery-valve *g* is confined within a small area on the cylinder-end, by reason of the radial partitions shown in dotted lines in Fig. 3. From this chamber or confined segmental space it moves through a passage, represented in dotted lines in Fig. 1, into an annular chamber which surrounds the entire cylinder, and thence is discharged through the orifice represented at the top of the structure into any suitable pipe or conducting-channel, (not represented,) which leads it to the point where it is wanted. This annular chamber surrounding the cylinder serves obviously to receive the air with equal freedom from either end of the cylinder, and, whether received from either source, exposes it for a considerable period to the cooling influence of the external air, which acts on the outer surface of the containing metal, and also to the cooling influence of the water moving within the thin chambers or passages represented between it and the steel. The machine is capable of serving for all purposes for which air is required to be compressed—as, for example, for supplying an air engine or drill in a distant portion of a mine, to which it must be led through a long hose, and to exert a very high pressure on the mechanism at the terminal point, in which case it requires to be compressed very greatly, or for supplying air to diving-bells or submarine armor at various depths, or analogous work where the pressure may be varied indefinitely; or it may be used for inducing very moderate pressures—as, for example, for blowing the fires in blast-furnaces, or even in ordinary forges and fanning and analogous operations. Its chief use, however, being for transmitting power, I will consider it always as inducing what may be called a high pressure, from five to ten atmospheres. When working under such pressures it is very important to cool the air as much as possible, and to free it from moisture before its discharge from the compressor. The exposure of the compressed air to the great extent of cooling-surface in this annular chamber around the entire cylinder effects this end, and causes the water contained in the air to gather mainly upon the inner surface, which, by reason of the water, may be assumed to be coldest and to trickle down. When any quantity is gathered in the lower portion of the chamber it may be discharged through a cock, (not represented,) which may be opened from time to time by the attendant, or it may be allowed to escape automatically through a device analogous to what is known as a steam-trap. The cooling-water must be supplied in liberal quantities from as cold a source as is available. It is introduced by means of a pump or otherwise through a suitable pipe, X, into the space immediately exterior to the

steel lining A^1. It is represented here as coming in at the top, in order to make it plainly visible, but I prefer to put it in near the bottom. Fig. 2 shows the interior lining bearing against the exterior lining at six points in its circumference. In practice these bearings at the extreme top and bottom are made continuous throughout the whole length of the cylinder, but the side bearings are only at intervals. The side bearings allow the water to circulate freely upward and downward past them. The water entering at one side circulates along that side of the cylinder to a point near the opposite end, where it is allowed to pass across into the hollow head B. It circulates through this head B, and, passing around the receiving valve-chambers E and through the thin water-chamber exterior to the air-delivering chamber in the lower part of that cylinder-head, thence it enters through a suitable passage into the hollow main body A^2 of the cylinder on the opposite side thereof to that which it has previously cooled. It circulates back along the cylinder, cooling the whole side, until it has reached the opposite head C, the hollow interior of which it enters and cools, as before described for the head B. The passages through which the air passes from the main body of the cylinder into the heads are shown in dotted lines in Fig. 3. The water has now a further important function to perform in circulating within the piston. To effect this it flows through several small channels, one of which is indicated by Y in Fig. 1, into a space around the tubular extension *d'*. An inclosed space, extending out sufficiently far to allow reciprocations of the rod *d'*, is provided by means of a long hollow casing, C^3, screwed upon the exterior of the stuffing-box C^2. The long casing C^3 serves, by screwing it home gradually, to drive down the perforated gland C^4 upon the single mass or ring of packings C^5. The cool water moves inward through the perforations in this gland C^4, and thence circulates freely throughout the interior of the long case C^3, and enters the open end of the tube *d'*. Through this tube *d'* it moves inward to the piston, after cooling and lubricating which it moves outward through the hollow piston-rod *d* to a certain point, where it turns and enters the open end of a fixed tube mounted concentrically within the piston and piston-rod, marked I. This tube I extends out through the end of the fixed casing C^3, and serves as the means of the final discharge of the water. Returning now a little, in the body of the piston, where the tubular constructions *d d'* abut against each other, is formed a small stuffing-box, in which I apply a ring of soft rubber, which serves to form a sufficiently tight packing to deflect the water, and cause it to circulate properly through the piston for an indefinite period. The water moving inward in the pipe *d'* is arrested by the central stuffing-box just referred to, and caused to move outward into the body of the piston through the inclined pipe D^2. It next circulates not only through the whole interior of the piston, but also flows outward through small holes into the space U within the piston-packing, where it exerts a pressure to distend the packing, and also wets the interior of the cylinder as the piston reciprocates backward and forward with the beneficial effects above referred to. Having performed these functions, it enters the open end of the pipe D^3, and thus enters the hollow piston-rod *d*, to be thence discharged through the contained pipe I, as before described. In the passage of the cooling-water through the head B it circulates freely through several small openings in the wall B^2 of the stuffing-box, and thence obtains access to the perforated lantern-brass, marked J, which stands between the two masses of packing *b b*.

It will be understood, with regard to the peculiar provisions for packing and for wetting the piston-rod at this end, that the adjusting of the gland B^4 inward by means of the inclosing screw-cap pipe B^5 compresses both the masses of packing *b b* to about an equal extent, the perforated brass J being movable to allow the force to be transmitted. The perforations in the hollow brass J and the perforations in the exterior wall B^2 opposite thereto allow the cooling-water to circulate with tolerable freedom through the entire construction, and obtain ample access to the exterior of the piston-rod *d*.

A ring, C^6, shown as close to the screw-threads of the casing C^3, serves to guard against the escape of any water which might otherwise flow along the threads of the screw. It is held outward tightly by the pressure. The casing E, which incloses the induction-valve *e*, is bridged across by steadiments, which support the stem of the valve *e* in the obvious manner. The outermost forms an abutment for the spring *e'*. The force of this spring may be adjusted with great delicacy by means of a nut and collar, represented on the outer end of the stem. There may be a nut and jam-nut tightly driven against each other to maintain their places, if preferred. The outer edge of the removable valve-casing E is recessed, as indicated by E^1, to allow it to be acted on by a suitable wrench for its removal and insertion. This casing E is threaded tightly home in the inner surface of the cylinder-end. I will describe this as being the right-hand cylinder-end C, and having the inner wall C and the outer wall C^7; but it will be understood that a precisely similar construction to that shown in Fig. 5 is used not only for each of the five induction-valves at this end of the cylinder, but also for the five at the other end. In each place the casing E is tapped securely into the inner wall of the cylinder-head, and is fitted loosely in the outer wall. In each case there is a recess provided for a ring of soft rubber, K, which is compressed by an exterior ring, E^2, which is threaded around the valve-casing

E, as will be obvious. This ring E^2 may be taken off and put on by a suitable hook-wrench applied in the holes in its periphery.

The delivery-valves *g* and their mountings are less complex for obvious reasons. It is not necessary with these, as with the induction-valves, to remove the casing which surrounds them in order to get at the valves. The surrounding casings are marked G, but they are not removable like the induction-valve casings. They form parts of the cylinder-ends. The springs *g'* should be carefully made so as to possess the proper degree of tension, and the confining-cap G' should be screwed home tightly with a thin ring of rubber packing or other means to make the joints tight.

I employ a plunger-pump, represented in outline by W in Fig. 3, to circulate the water through its entire round of duties in cooling, lubricating, and setting out the packing in my compressor. The use of a pump for this purpose gives a control of the action which is not attainable by any self-acting flow. There may be a provision, by means of an escape valve analogous to a safety-valve, for guarding against the pressure in the water-passages ever much exceeding a certain fixed limit, and with such provision it may be relied on to give a reliable and gradually determinable pressure, admirably adapted for setting out and holding the packing. The employment of a plunger-pump causes the motion to possess an intermittent character, which, while it does not relax the pressure for any sufficient period to allow the packing to become loosened, causes the water to flow in an irregular manner, alternately stopping or partially stopping and again jumping forward, which causes it to circulate in all the corners and recesses of the several irregular chambers through which it passes. The packing of the piston is formed with loose metallic rings of a V-shaped section, standing between corresponding rings formed of a composition of rubber and plumbago.

All the rings of the packing are movable. The rings P, which simply perform the functions of supporting the other rings Q and holding them out properly to their work, are acted on by springs R, represented as spiral, but which may be of any other suitable form, which will allow the free circulation of water past and through them. These springs R exert a constant force, tending to separate the innermost series of rings P, and thus to crowd them into closer union with the follower D^1 on one side, and with the corresponding inclined flange of the piston on the other side. The result is a gentle forcing out of the rings Q, so as to keep them always firmly but gently pressed up against the inner surface of the cylinder.

Much difficulty is experienced in the construction and adjustment of the packing for compressing air under rapid motion and high pressures and temperatures.

My experiments with the packing provisions here described indicate that the circulation of water through the space thus provided to moisten the surfaces at each motion will overcome all the difficulties.

Although the valves *e* are here represented as receiving air directly from the free atmosphere external to the cylinder-ends, I propose in some situations to incase the entire exterior of the cylinder-heads with a thin metallic or other casing, or connecting them to a pipe or other suitable inducting-passage of thin metal or other suitable material, which shall cause all the air inducted to be led from a predetermined point at a distance from the engine.

The apparatus may thus serve to compress other gases than air, or the apparatus may be made to assist in ventilating any mine or other structure in which it may be employed, or which may be in the vicinity thereof.

I claim as my invention—

1. In combination with the reciprocating piston D and suitable valves and connections for receiving air and delivering it in a compressed condition, the thin-lining cylinder A^1, made in a separate piece from the supporting-cylinder A^2, with provisions for circulating water in the space between them, substantially as and for the purposes herein specified.

2. In connection with the above, I claim the within-described arrangement of the circulating-passages for the cooling-water, so that said cooling medium shall circulate in contact with the entire sides and both ends of the cylinder in which the air is received and compressed.

3. Packing-rings of plumbago, combined with a suitable cementing material, and arranged, as shown, relatively to the water in the piston, and to passages for allowing the water to obtain access to the plumbago packing, as and for the purposes specified.

4. The water-space U, arranged between two series of packing-rings in the piston, in combination with suitable provisions for admitting water thereto, so that the water is presented directly against the inner surface of the cylinder while confined against escape by the packing on either side, all substantially as herein set forth.

5. The perforated lantern-brass J around the piston-rod, arranged, as shown, relatively to the current of cooling-water, so that the water shall have access to and circulate actively around in contact with the piston, as and for the purposes herein specified.

6. The casing C^3 and tube I, arranged substantially as shown relatively to the hollow piston D and tubular construction or rods *d d'*, with provisions for leading the water to and through the same, as herein specified.

7. The valve-chambers E G, extending through the water-chambers in the cylinder-ends, and arranged relatively to the cylinder

and piston, and to the valves and circulating currents of water and air, as specified.

8. In combination with the water-chambers on the cylinder-ends, I claim the removable valve-cases E, extending through such chambers, and adapted to be readily removed with their contents and applied again without disturbing the other parts, as herein set forth.

In testimony whereof I have hereunto set my hand this 25th day of March, 1872, in the presence of two subscribing witnesses.

J. B. WARING.

Witnesses:

THOMAS D. STETSON,

WM. C. DEY.