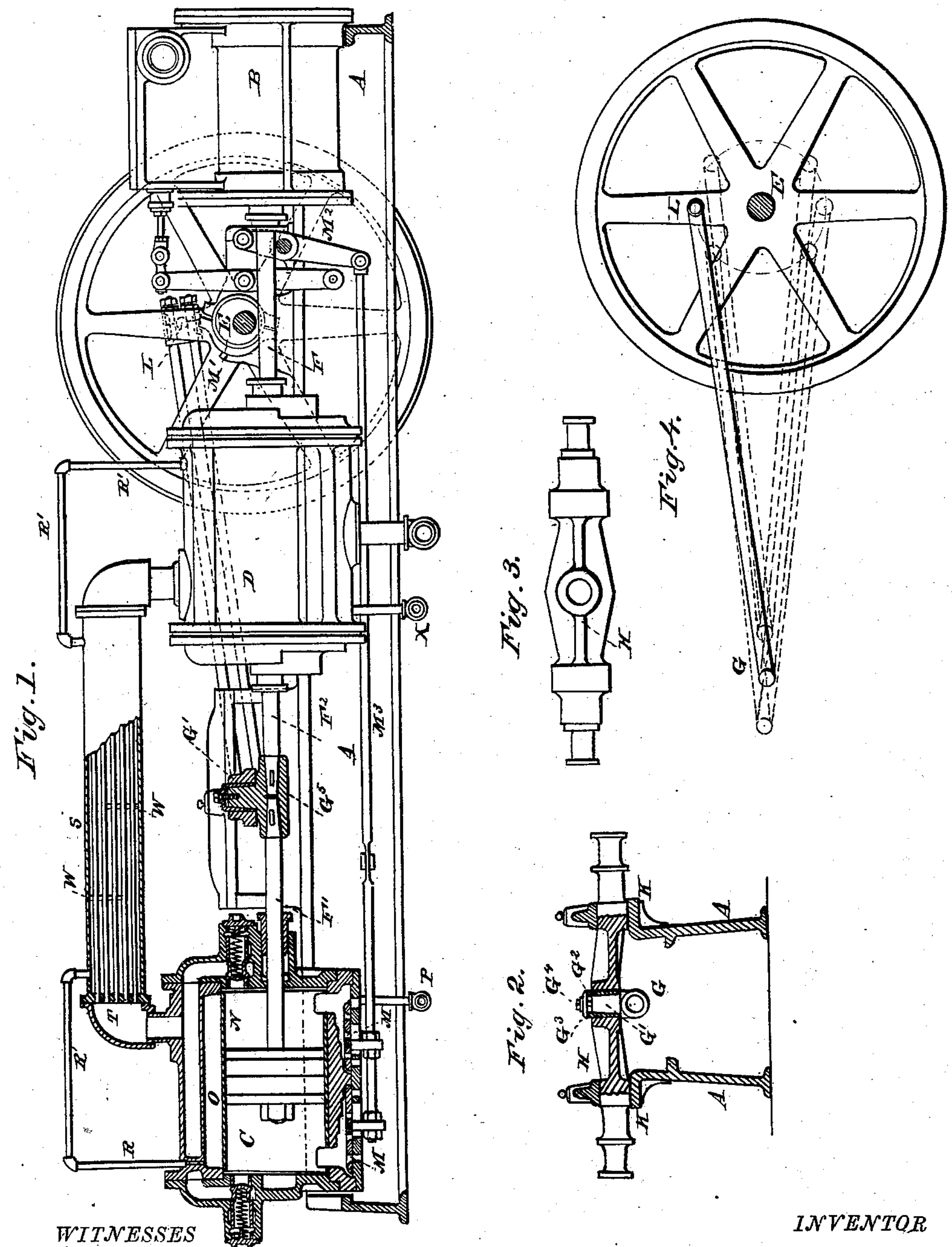
(No Model.)

E. HILL.

COMPOUND AIR COMPRESSOR.

No. 261,606. Patented July 25, 1882.



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COMPOUND AIR-COMPRESSOR.

SPECIFICATION forming part of Letters Patent No. 261,606, dated July 25, 1882.

Application filed December 16, 1880. (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 and useful Improvements in Compound Air-Compressors, of which the following is a specification.

This invention pertains to certain improvements in compound air-compressors in which two or more compressing-cylinders are used and are driven by a steam-engine.

The invention consists, first, in combining two or more air or gas compression pumps with a steam-engine and a fly-wheel shaft in such a manner that the piston-rod of the steam-engine will be in line with the piston-rods of the compression-pumps and either below or above the fly-wheel shaft, and said shaft will be in line with the center of the cross-head wrists that drive the said fly-wheel shaft, as will hereinafter appear.

Second. This invention also consists in combining with an air-compressing engine having two or more compressing pumps or cylinders a slide-valve or its equivalent, as an inlet-valve to the first cylinder and operated by positive mechanism from the main shaft of the engine, as will hereinafter appear.

Third. The invention also consists in combining a cooling or water-circulating apparatus with two or more compression cylinders or pumps in such a manner that the water or cooling agent begins to circulate around the first compression-cylinder, and thence through conduits leading to the second cylinder, and thence around the second cylinder or pump, and so on from the prior to the secondary pump in the entire system, as will hereinafter appear.

In the drawings, Figure 1 is a partial section and elevation of an air or gas compression engine having two compression-cylinders and a steam-engine with piston-rods in line with each other and a circulating apparatus for a cooling agent between the compression-cylinders. Fig. 2 is a section of the slides with the cross-head in elevation. Fig. 3 is a plan of the cross-head as seen from above it. Fig. 4 is a diagram to illustrate the relative positions of the cross-head with the crank and main shaft.

At A is represented the bed or frame of the machine, upon which is mounted the steam-engine, as at B, and two compressor-pumps, as at C and D, the one at C being the first or inlet-pump for the first compression.

The fly-wheel shaft is at E located between the steam-engine and one of the compressors, so that the entire mechanism may be combined in a small and compact form upon the same bed or frame. The cylinders of the engine and the compressors are all so located that their piston-rods are in line, as represented at F F′ F², and in this case are located below the fly-wheel shaft, but may be above, if desired. The piston-rod of the second compressor is in fact an extension of the rod of the engine, as shown at Fig. 1, and extends through the cylinder and connects to a horn, as at G, or a depending projection from the cross-head, which is shown at H, and which is mounted on slides, as at K, in such a position that its wrists are in the same plane with the fly-wheel shaft, and therefore the crank-pins, as at L, on the fly-wheels will have equal velocities in equal spaces in any portion of their revolution, or as illustrated in the diagram at Fig. 4, where E is the main shaft, and L the crank-pin, and G the cross-head. Now, when the crank is turned up, as shown in full lines, a certain angle is made at L, and when the crank is turned down to the opposite point, as shown in dotted lines, the same is produced, and so throughout the entire range of motion, the result being to make the forward and back stroke of the piston in the same time. In such an arrangement of the parts the power of this engine is direct acting to the pumps, instead of through cranks, as usually done, and the cross-head is only required to regulate the speed by first imparting motion to the fly wheel or wheels, as the case may be, and in turn from them to the piston-rods. Said horn G, which connects the piston-rods to the cross-head, is made cone-shaped, as at G′, and fits into a corresponding box, as at G², which is fitted into the cross-head, and is held in position by a cap and screw-bolt, as at G³ and G⁴, so that said horn may be rotated in said box, if desired.

Upon the lower end of the horn G is a horizontal sleeve, as at G⁵, that receives the ends of the piston-rods F′ and F², with conical ends, as shown, and that are fastened in the sleeve by keys in the ordinary manner. By such an arrangement it is evident that if from any cause the connecting-rods on one side should be a little longer or shorter than on the other there would be no cramping of the parts, as the cross-head could vibrate on the conical-shaped horn at G, and it also serves as an easy means of adjustment.

Concerning the second part of my invention, which pertains to the use of a slide-valve in combination with compound air-compressors, it may be here remarked that the inlet-valve here shown at M is of the form known as the "grid-iron slide-valve," and it is operated by an eccentric, as at M′, on the main shaft, through a lever, M^2, and a connecting-rod, M^3, which engages with the valve by lugs which extend through the cover of the valve-chest, and thereby causes regular reciprocations, according to the revolution of the main shaft; but I do not wish to limit myself to slide-valves and eccentrics, but wish to use any of the positively-operated valves common to engines and pumps. The qualities, however, desired in a slide air-inlet valve are large port-area and a proper time for opening; but in making a large port-area a large clearance-space is unavoidable, and said space is objectionable from the fact that air at each stroke of the piston is compressed, but not discharged, and hence a loss of efficiency in the machine; but if the inlet-valve be kept closed for a time after the piston recedes on its return stroke, then the air which has been left behind in a compressed state will expand until it reaches atmospheric pressure, and while so expanding will return its pressure upon the piston. When the air so expanded has reached atmospheric pressure, then is the proper time for opening the inlet-valve; but if opened before, then some pressure would be lost, and if not till afterward, then a partial vacuum is formed behind the piston. Now, if it were possible to preserve a constant pressure against which the piston is working, then a valve could be easily constructed and set to work properly under such conditions; but if there is any change in said pressures—as, for example, where a single cylinder is working into a reservoir from which varying pressures are required—then it is evident a corresponding change must be made in the time of opening the inlet-valve; but such a capacity or adaptation of the parts would require very complicated mechanism, and therefore to determine the exact time at which said valve may be opened and closed a second compression-pump is employed, of smaller diameter than the first, and into which the air from the inlet-cylinder is forced. This second cylinder encounters the varying pressures in the air-reservoir, and is provided with the ordinary automatic puppet-valves, and hence the first pump only forces into the second and smaller pump, and the pressure in the first never rises beyond a known point predetermined by the relative proportions of the two cylinders, and which is of course determined when the engines are constructed, and which could not be the case if a second cylinder were not used. Again, the pressure in the inlet pump or cylinder is much less than the pressure of the reservoir, and hence the friction of the slide-valve is much lighter than it would be were the large cylinder to discharge directly into the reservoir, or without any compound cylinders or pumps, and therefore by such a combination all the heretofore-troublesome objections to the use of slide-valves in air-compressors are overcome without loss of power or costly attachments, and all the advantages of the serial and compounding pressures are at the same time secured.

The third part of the invention relates to the cooling devices, in which thin linings are used for the compression-pumps, as already described in a previous application for a patent, one of said linings being shown at N in the large or inlet compressor at C, and which forms a water-chamber, as at O, into which water is admitted through a pipe, as at P, and after circulating around said thin lining in the first cylinder passes out through a pipe, as at R, to a cooling apparatus, as at S, which is intermediate between the compressors C and D. This cooling apparatus may be of any desired form, but, as here shown, is cylindrical, and contains thin tubes, as at T, through which the air from the first pump passes to the second, and the water circulates around them in the outer case, S.

Deflecting-plates, as at W, may also be introduced to more thoroughly circulate the water from side to side in the outer casing, and then the water is conducted by pipe R′ to the water-chamber in the second cylinder, where a thin lining is used, as in the first, and around this the water circulates and finally passes off through an outlet-pipe, as at X. As already described, the water begins its circulation in the first cylinder, and thence on through the cooling apparatus, and then through the second. This direction of the passage of the water is very important, as the coldest water comes in contact with the inlet-air cylinder, where the first part of the total compression is effected, and it is known to engineers that the increment of heat from compression is greatest during its early stages, and hence it is desirable to have the cooling process most efficient at that time. As the air during compression passes through the machine the water follows, and by reason of the successive compressions the temperature of the air is continually above that of the water, and the water continues to receive heat until finally discharged, and thus a given amount of water becomes hotter and carries away more heat by circulating in the direction of the compression than in any other way.

It is evident that in carrying out this part of my invention the cylinders may be arranged in a different position from that shown, and that the air-cylinders may be attached to different engines; also, that more than two compressors may be used, if desired.

I therefore claim—

1. The combination, with the cross-head, of the horn G and its sleeve for connecting the piston-rods of air-compressing pumps, as hereinbefore set forth.

2. The combination of a positive-movement air-inlet valve with compound cylinders in which serial compression is produced, whereby the working pressure of the inlet-cylinder is rendered practically uniform by the proportionate sizes of the several cylinders, as hereinbefore set forth.

3. In compound air-compressors, the combination of water-spaces in the cylinders and intermediate cooling apparatus with suitable inlet and outlet pipes, whereby the water will be caused to circulate in the direction of the air during the operation of compression, as hereinbefore set forth.

In testimony whereof I have hereunto set my hand and seal in the presence of two subscribing witnesses.

EBENEZER HILL. [L. S.]

Witnesses:
EUGENE N. ELIOT,
CHAS. BARTRAM.