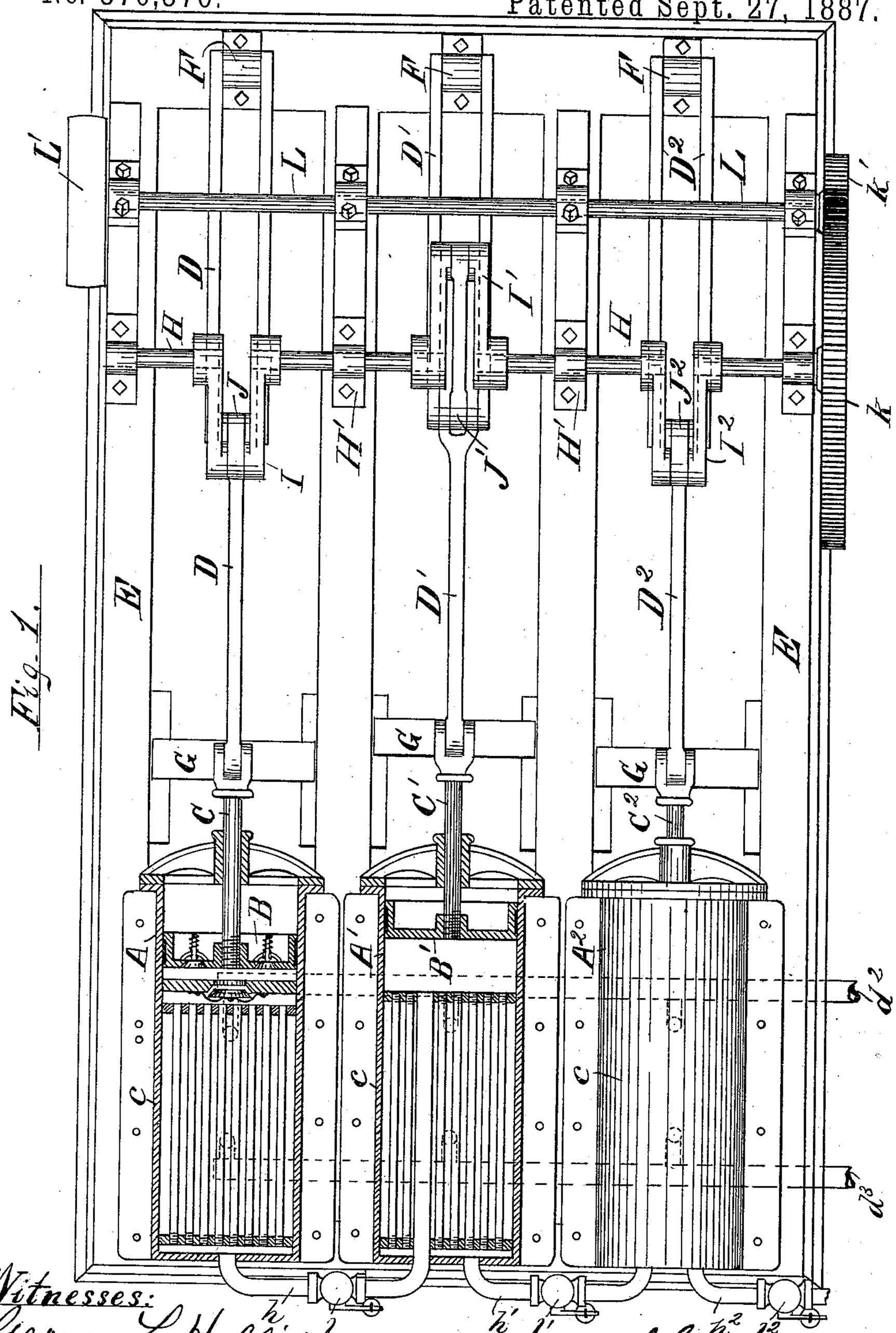
(No Model.)

3 Sheets—Sheet 1.

L. S. CHICHESTER.

AIR COMPRESSING APPARATUS.

No. 370,376. Patented Sept. 27, 1887.



Witnesses:
George L. Halliday
Henry J. Thebeath

Inventor: L. S. Chichester,
per Brand & Miller Attys.

(No Model.)

3 Sheets—Sheet 2.

L. S. CHICHESTER.

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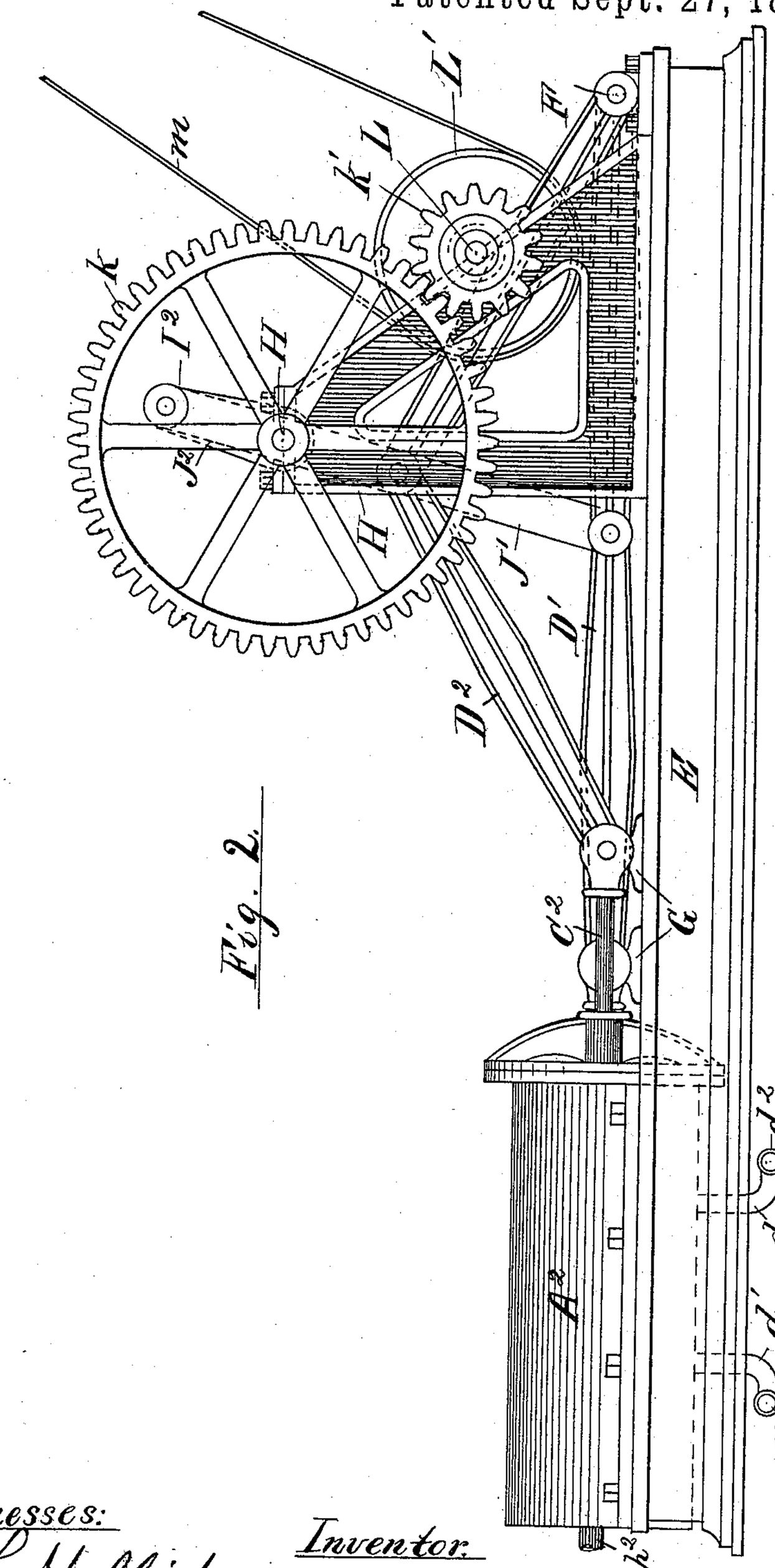

Fig. 2.

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(No Model.) 3 Sheets—Sheet 3.

L. S. CHICHESTER.

AIR COMPRESSING APPARATUS.

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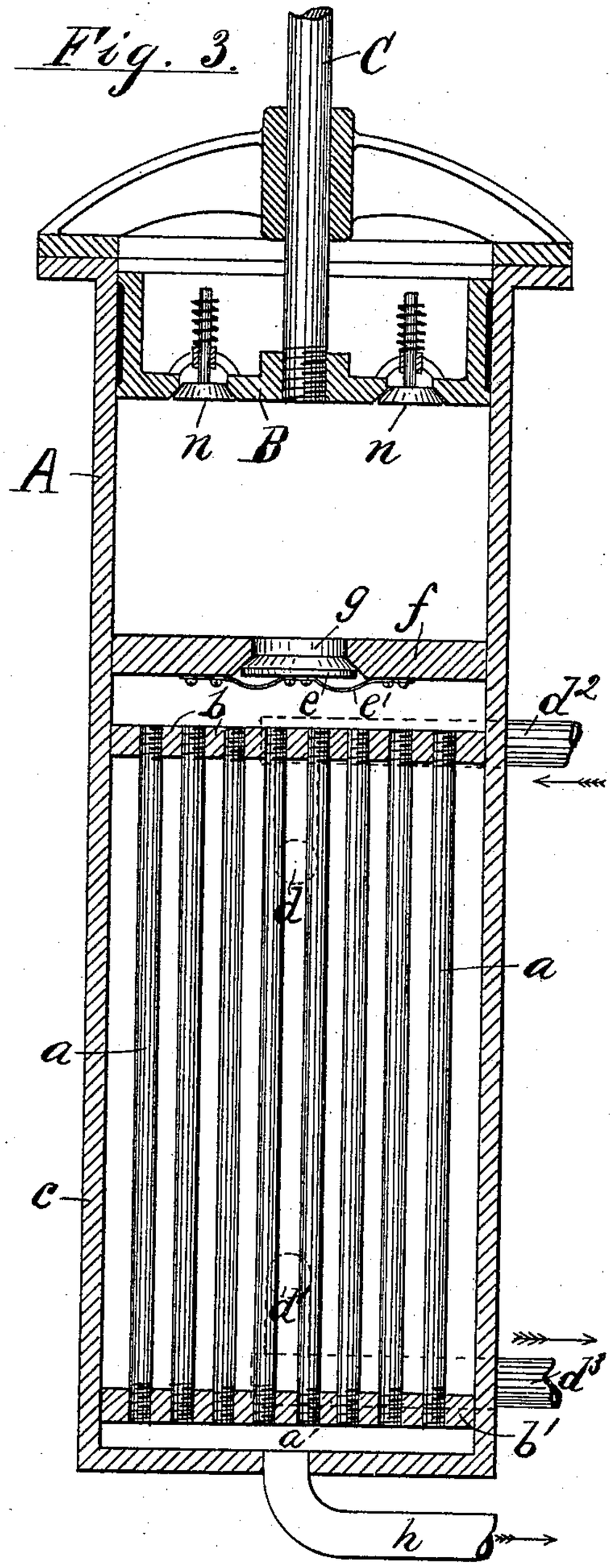
Fig. 3.



Witnesses:
George L. Holliday
Henry J. Theberath

Inventor:
L. S. Chichester,
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UNITED STATES PATENT OFFICE.

LEWIS S. CHICHESTER, OF NEWARK, NEW JERSEY, ASSIGNOR TO ANDREW LEMASSENA, OF SAME PLACE.

AIR-COMPRESSING APPARATUS.

SPECIFICATION forming part of Letters Patent No. 370,376, dated September 27, 1887.

Application filed November 1, 1886. Serial No. 217,645. (No model.)

To all whom it may concern:

Be it known that I, LEWIS S. CHICHESTER, a citizen of the United States, residing at Newark, Essex county, New Jersey, have invented certain new and useful improvements in Air-Compressing Apparatus, fully described and represented in the following specification and the accompanying drawings, forming a part of the same.

The object of this invention is to facilitate the cooling of the air in the process of compression, to facilitate the cooling of the compressing-cylinders, and to facilitate the construction of the compressing and refrigerating apparatus.

Heretofore it has been common to cool the cylinder by circulating water in a jacket around a compressing-cylinder, and it has also been common to employ combinations of refrigerating-tubes variously connected with the outlet-pipe from the compressing-cylinders.

It has also been common, as in British Patent No. 4,184 of 1880, to combine a tubular cooler with one side of a compressing-cylinder; but such construction involves the formation of ducts and passages from the cylinder to the cooler, which it is the object of my invention to avoid, that the construction may be simplified and cheapened, while its efficiency is maintained.

In my invention the cylinder itself is provided at one end with a series of air-conducting tubes cooled by a continuous current of water or other suitable means.

The tube-heads and the casing of the entire cooling device are constructed in direct continuous metallic connection with the cylinder, so that the heat generated in the latter by the compression of the air is rapidly conducted away and absorbed by the water circulating in the cooling device. As the air in the cylinder passes directly into such tubes during the compressing operation, there is an open communication between the interiors of the tubes and the cylinder, and the air within the latter is thereby more or less cooled before it enters the cooling device.

My invention includes a series of such cylinders, each provided in one end with a movable piston and in the other end with a series of cooling-tubes, the cylinders being connected by means of weighted or adjustable valves, and the first cylinder of the series having a plate and valve inserted between the piston and the open ends of the cooling-tubes. In the first cylinder provided with such a transverse plate the air is distributed to the different tubes by a narrow space between the plate and the ends of the tubes, the valve being opened by the air and forming an open communication between the cylinder and the tubes during the compressing movement of the piston. By this construction the cooling devices operate directly upon the air and upon the cylinder during the compressing operation, thus cooling both in a very effective manner without the use of separate means for cooling the shell of the cylinder and the air which is compressed therein.

My invention also includes means for alternately operating the several pistons of such a series of cylinders.

My improvements are shown in the annexed drawings in a horizontal compressing apparatus provided with three cylinders, to subject the air to a triple compression.

Figure 1 of the drawings is a plan of the apparatus, showing three compressing-cylinders mounted upon a bed-plate, with a crank-shaft and toggle mechanism for actuating the cylinder-pistons alternately. In this view two of the cylinders are shown in section through their horizontal axes. Fig. 2 is a side elevation of the same apparatus; and Fig. 3 is a section of the cylinder A upon a larger scale, to show the valves and tubes more plainly.

A A′ A^2 are the three compressing-cylinders, the cylinder A being arranged to receive its charge from the atmosphere and to deliver it under pressure to the cylinder A′, the air being further compressed in the said cylinder and delivered under such increased pressure to the cylinder A^2, where it is further compressed and discharged, ready for use in any desired manner, as for operating machinery or for refrigerating purposes. Each cylinder is provided with a piston, as B B′, and rods C, C′, and C^2, actuated by toggles D, D′, and D^2. The compressing-cylinder is formed entirely open at one end, thus admitting a free circulation of the atmosphere within the same when

the piston is forced in, to dissipate the heat absorbed by the metal. The cylinders are attached to a bed, E, to the farther end of which one link of each toggle is pivoted at F, and the ends of the piston-rods which are connected with the other toggle-links are supported upon the bed by guides G, which resist the lateral thrust of the toggles when bent.

A crank-shaft, H, is mounted in bracket H′ upon the bed by the side of the toggles, and is provided with separate cranks I, I′, and I², jointed to the hinges of the toggles by connecting-rods J, J′, and J².

The cranks are arranged in such relation to one another that the toggles are actuated alternately and the piston of the first compressing-cylinder is forced inward while that in the second is drawn outward, so that the latter is adapted to receive the air which is being discharged from the first under compression.

Gear-wheels *k k′* connect the crank-shaft with a driving-shaft, L, provided with a pulley, L′, to which a moving belt, *m*, may be attached to furnish the power for driving the entire apparatus.

Each cylinder is provided with a separate cooling device or cooler, which consists in a series of air conducting and refrigerating tubes, *a*, arranged at one end of the cylinder, and in tube-plates *b b′*, and in a casing, *c*, arranged in a line with and in direct metallic connection with the cylinder. The casing is thus practically a continuation of the cylinder and the cylinder a part of the casing, and the conduction of heat from the cylinder to the colder metal in the casing is so direct and rapid that the necessity for circulating water around the shell of the cylinder is entirely avoided. Such effect is further enhanced by the direct metallic connection with the cylinder of the tube-plates *b b′*, the tubes themselves, and the water circulating within the cooler, and the free circulation of air in the front end of each cylinder.

The cylinder and casing of the cooler are designated in the drawings by different letters to facilitate reference to such parts and to avoid confusion in describing them, and because their functions are different, although they are shown in the drawings constructed integrally of a continuous cylindrical casting. In the first cylinder of the series the air is admitted through valves *n* in the pistons at atmospheric pressure, while the air in each succeeding cylinder of the series is supplied at a higher pressure from the outlet of the preceding cylinder.

The casing is shown provided with water inlet *d* and outlet *d′* to circulate water within the casing around the tubes *a*, and the several inlets may be connected with a common supply-pipe, *d²*, and the several outlets with a common discharge-pipe, *d³*, through which the cold and heated water would be respectively conducted. In operating a series of such cylinders as A, A′, and A² to compress air in successive stages, the first cylinder would be provided with the partition and valve to prevent the reflux of air from the tubes upon the retraction of the piston. This construction is shown in the enlarged section in Fig. 3, in which *f* is the partition-plate; *g*, the aperture, provided with valve *e*, opening toward the ends of the tubes and affixed to a leaf-spring, *e′*, by which it is held in place. The air is collected from the outer ends of the several tubes in each cooler in a chamber, *a′*, formed at the outer end of the casing, and pipes, as *h h′*, connect such chamber with the interior of the succeeding cylinder, as A′ A². The air after its compression in the first cylinder is thus delivered into the second, and from that, after additional compression, into the third, the pistons of the first and third cylinders being moved inward by the toggle mechanism and the cranks I I² while the piston of the cylinder A′ is moving outward.

Check-valves *l l′ l²* are applied to the air-outlets from each of the coolers to regulate the pressure at which the respective pistons operate, and the air may thus be delivered at any required pressure from the last cylinder of the series and be subjected to the proper intermediate pressure in each preceding cylinder.

In the first cylinder the space between the plate *f* and the inner ends of the tubes serves to distribute the air to all of the latter when the valve *e* is opened, which occurs during each compressing-stroke of the apparatus. The insertion of such partition does not impair in any degree the cooling effect of the casing *c* upon the metal of the cylinder, but may be made to increase such effect by furnishing a heavy mass of metal of conducting properties to absorb the heat of the compressed air and transmit it by conduction to the cooling device to which it is so closely attached.

The tubes *a* may be secured in the inner tube-plates, *b*, or outer plates, *b′*, by any suitable means.

Inlet-valves *n* are shown applied to apertures in the piston B, with springs holding them to their seats when not opened by atmospheric pressure.

I am fully aware that toggle mechanism in many forms has been used to concentrate mechanical power for various purposes, and that it is not new to compress air in a series of cylinders, whether of the same size or of gradually-increasing capacity, and that a shaft with cranks placed in different positions has been used to actuate the pistons of such compressing-cylinders, as in British Patent No. 5,721 of 1875. I do not therefore claim the use of such cranks or toggles independently, but consider the essential feature of my arrangement is the fixing of the cylinders to one end of the bed E and the toggles to the other end, as at F, while the crank-shaft H is sustained above the same upon brackets H′, which are also attached to the bed, to support the crank-shaft under the thrust transverse to the bed. By combining such crank-shaft with the bed and

with the toggle mechanism I am enabled to obtain a great concentration of power at the close of each stroke, when the compressed air causes the greatest resistance to the movement of the pistons.

In practice I make the cubical capacity of the cooling-tubes one-half that of the cylinder with which they communicate, and they therefore contain, when the cylinder is filled, one-third the total volume of their joint capacity.

In the cylinders unprovided with a partition plate or valve it is obvious that such portion of the air as is compressed in the cooling-tubes and is not expelled from the outlet-pipe and check-valve leading from the same during the compressing-stroke will react when the piston is retracted, and by its expansion serve to actuate the piston and the crank-shaft, and thus aid in rotating the same.

It is also obvious that such air is materially cooled before its reaction and moves through the tubes when it expands upon the return-stroke of the piston, and carries its cooling influence into the cylinder; and as it is subsequently forced through the tubes again it moves past their cooling-surfaces for the third time, and the heat developed by compression is thus most effectively abstracted.

I wholly disclaim the compression of air in stages by the delivery of the partially-compressed air from one pump to another operating in a series, as well as the use of tubular coolers for refrigerating the air, except in the particular construction and arrangement described herein.

Having thus set forth the nature of my invention, what I claim herein is—

In an air-compressing apparatus, the combination, with a series of compressing-cylinders each formed entirely open at one end to permit the circulation of the atmosphere therein, of a piston with its piston-rod extending from the open end of the cylinder, a cooler-casing, *c*, extending from the opposite end of the cylinder and in continuous metallic connection therewith, and provided with the tube-plates *b b'*, tubes *d*, chamber *a'*, and outlet-pipe *h*, the first cylinder of the series being provided between the piston and the inner ends of the cooling-tubes with a partition and cooling plate, *f*, having an aperture and valve, *g*, opening toward the ends of the tubes, and the pipes *h*, being connected, respectively, with the inlets of the succeeding cylinders and being provided with weighted or adjustable check-valves, as *l l'*, and the whole being arranged and operated as and for the purpose set forth.

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

LEWIS S. CHICHESTER.

Witnesses:

THEO. F. LEMASSENA,

HENRY J. MILLER.