No. 661,575. Patented Nov. 13, 1900.

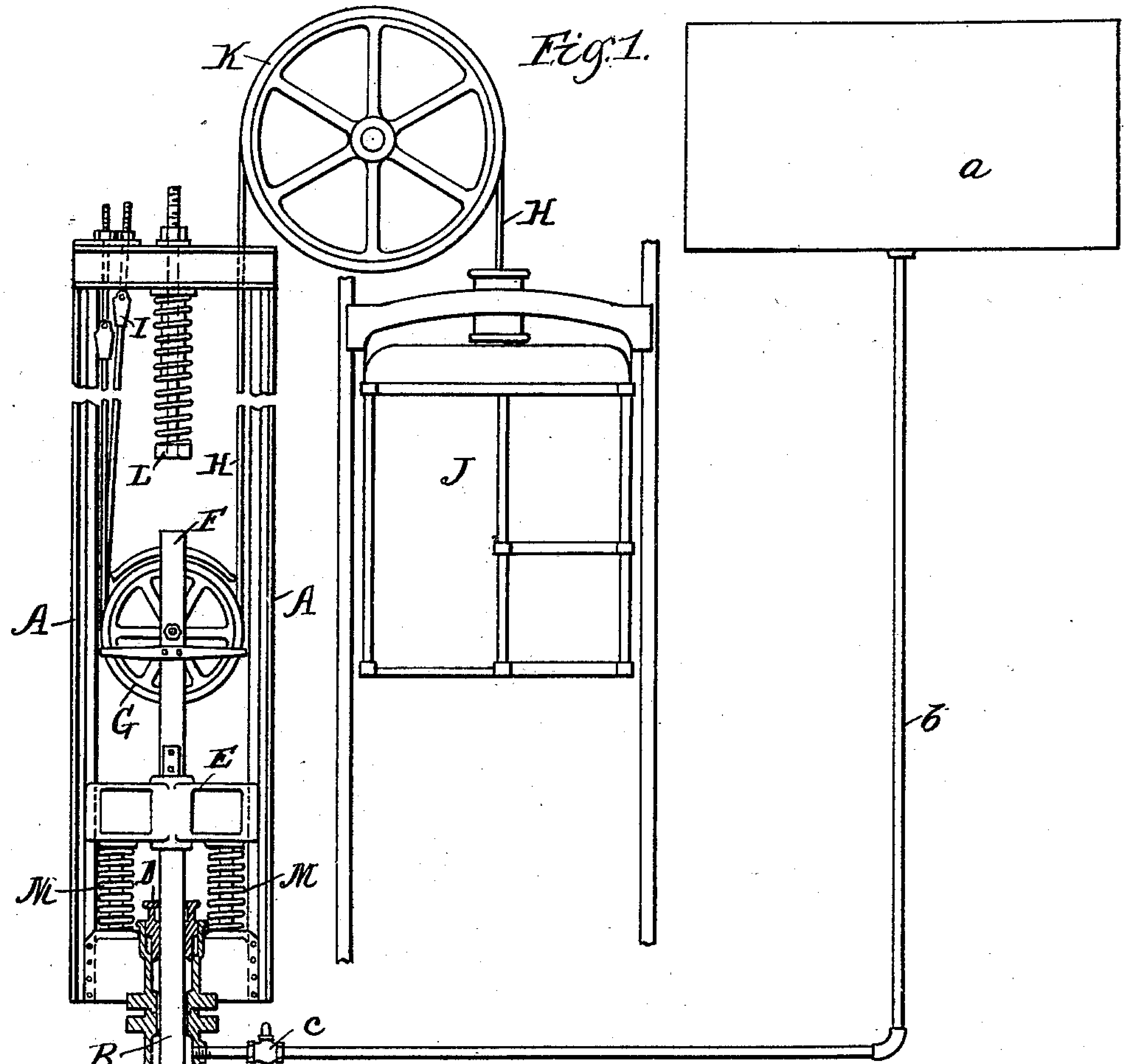
R. T. CRANE.

HYDRAULIC ELEVATOR.

(Application filed Dec. 26, 1896.)

(No Model.) 3 Sheets—Sheet 1.

Fig. 1.



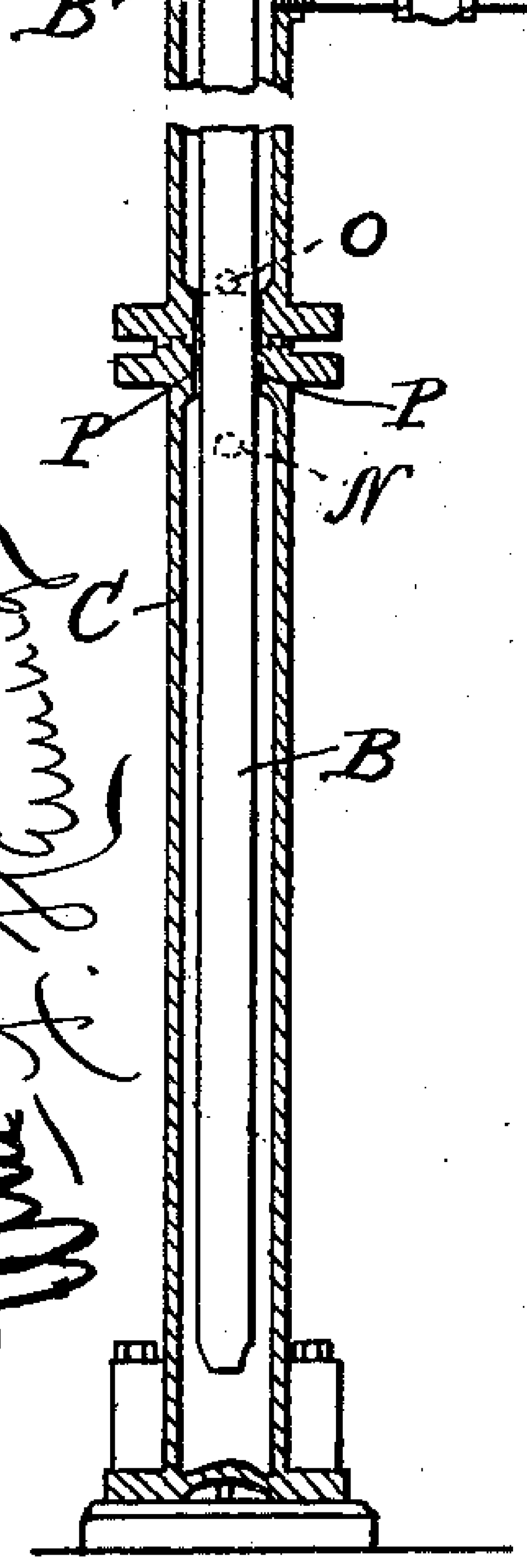
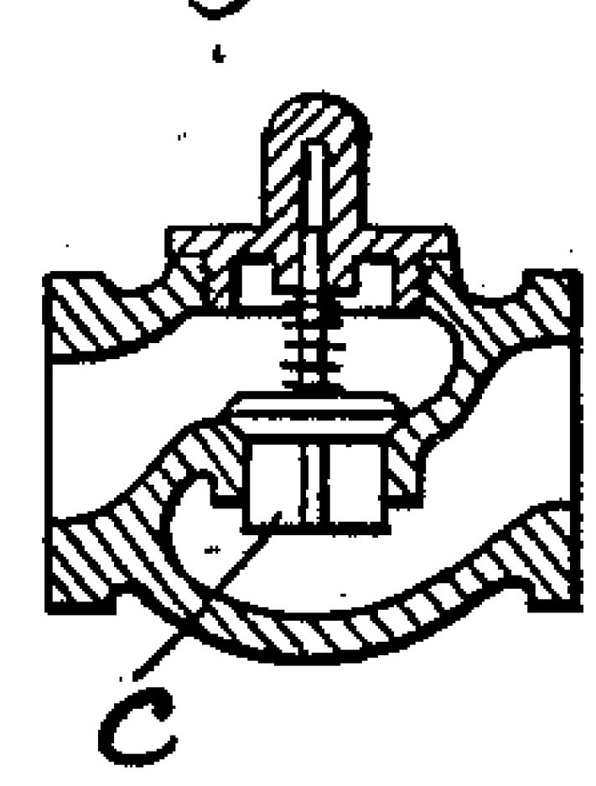


Fig. 2.



Witnesses.
Wm. M. Rheem.
Wm. F. Henning

Inventor
Richard T. Crane
by
Raymond & Ouschundt
Att'ys.

THE NORRIS PETERS CO., PHOTO-LITHO., WASHINGTON, D. C.

No. 661,575. Patented Nov. 13, 1900.

R. T. CRANE.

HYDRAULIC ELEVATOR.

(Application filed Dec. 26, 1896.)

(No Model.) 3 Sheets—Sheet 2.

Fig. 5.

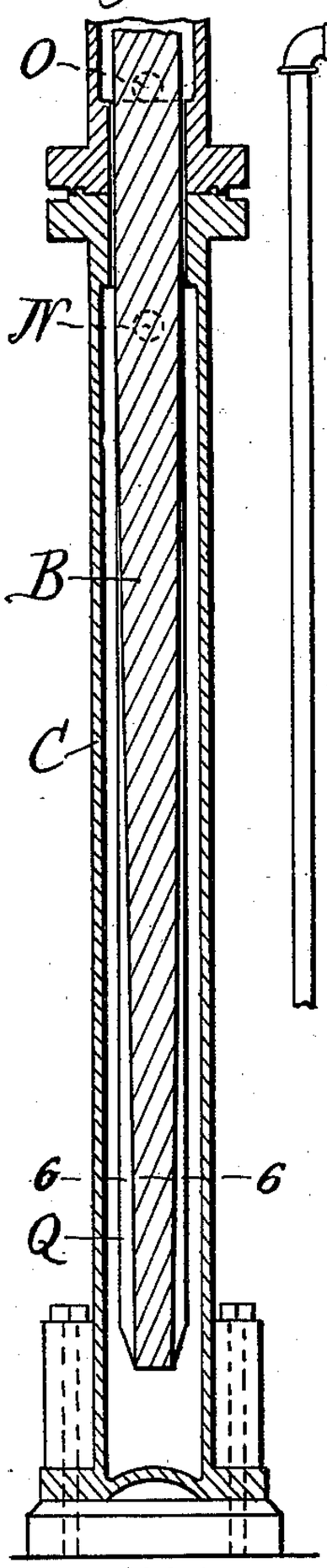


Fig. 6.

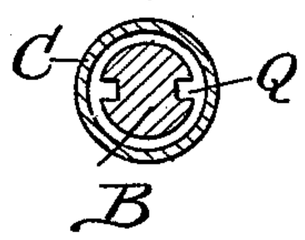
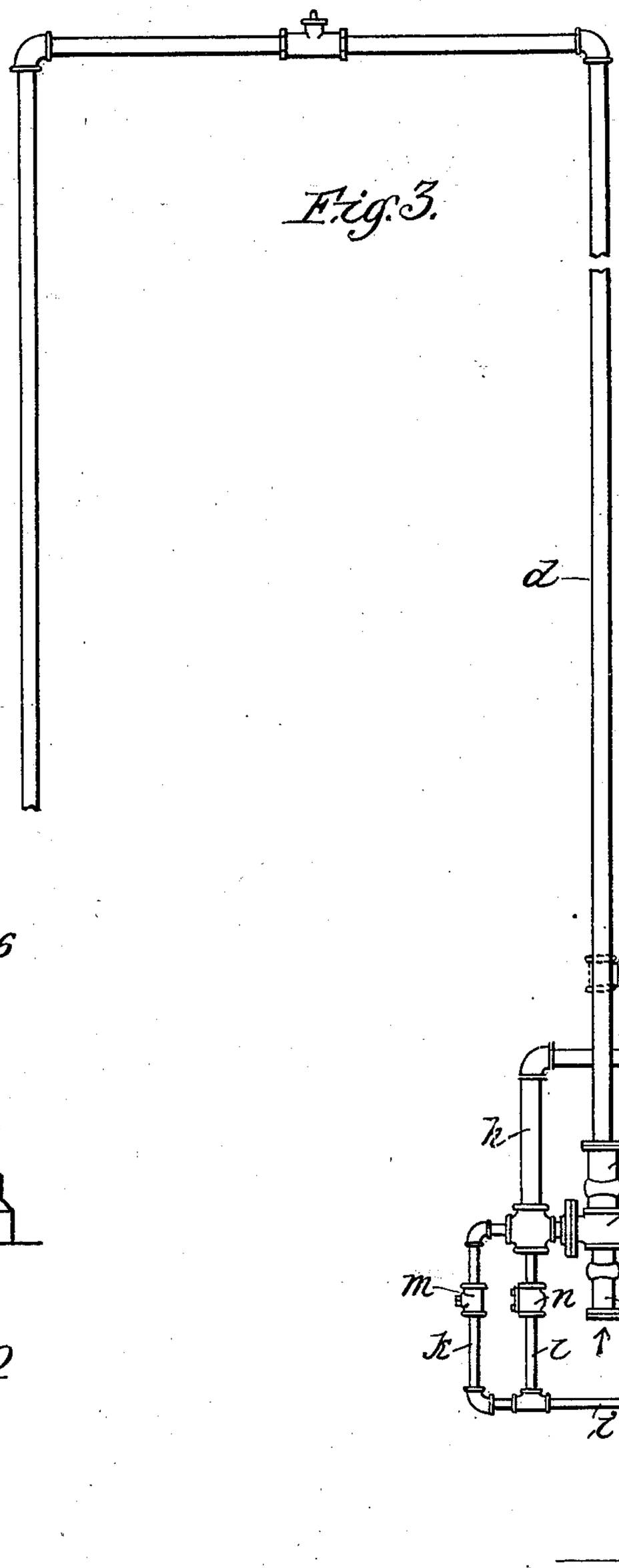
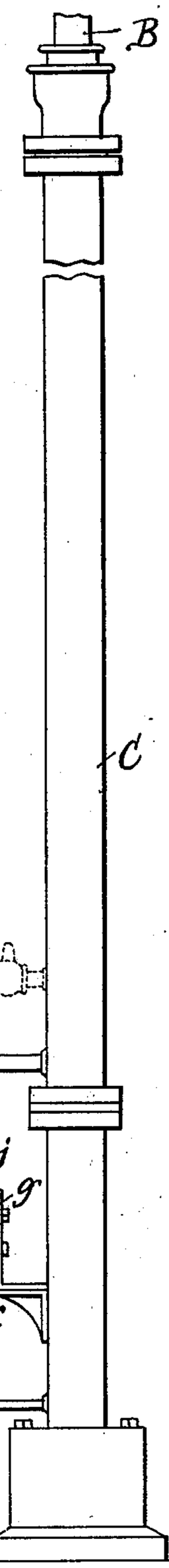
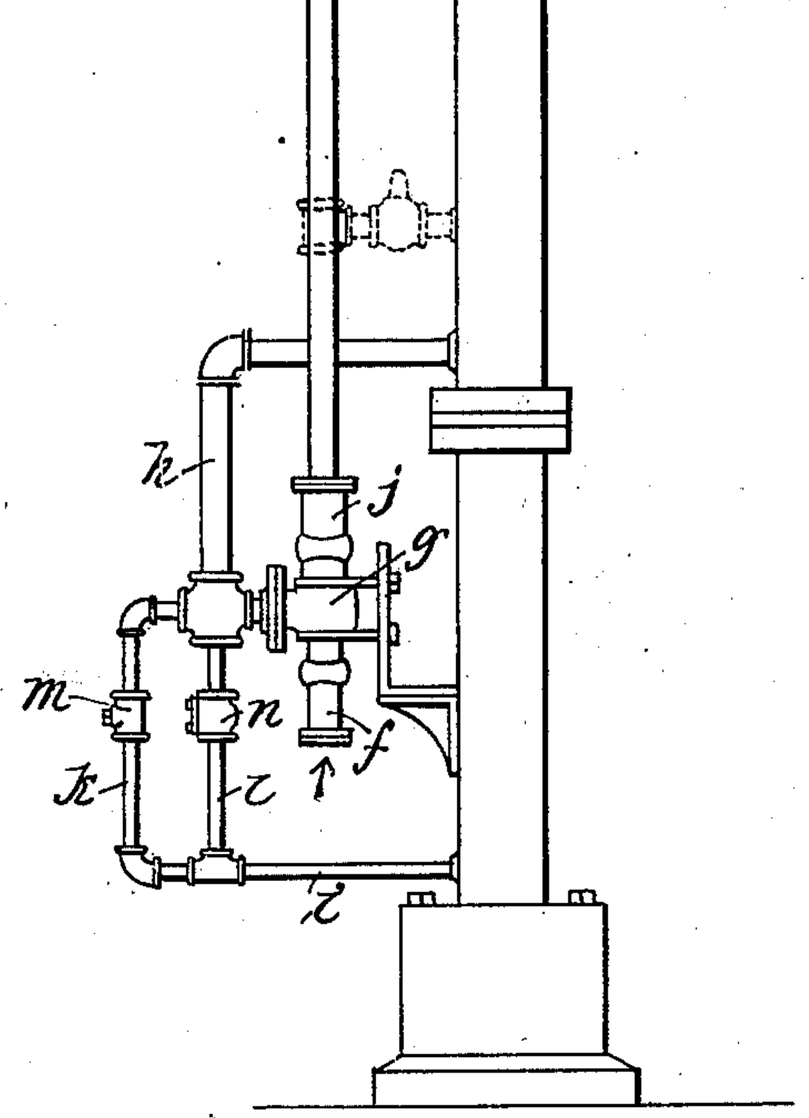


Fig. 3.







Witnesses.
Wm. M. Rheem.
Wm. T. Fleming.

Inventor
Richard T. Crane
by Raymond Pat Ouchmundro
Atty's.

No. 661,575. Patented Nov. 13, 1900.

R. T. CRANE.

HYDRAULIC ELEVATOR.

(Application filed Dec. 26, 1896.)

(No Model.) 3 Sheets—Sheet 3.

Fig. 7.

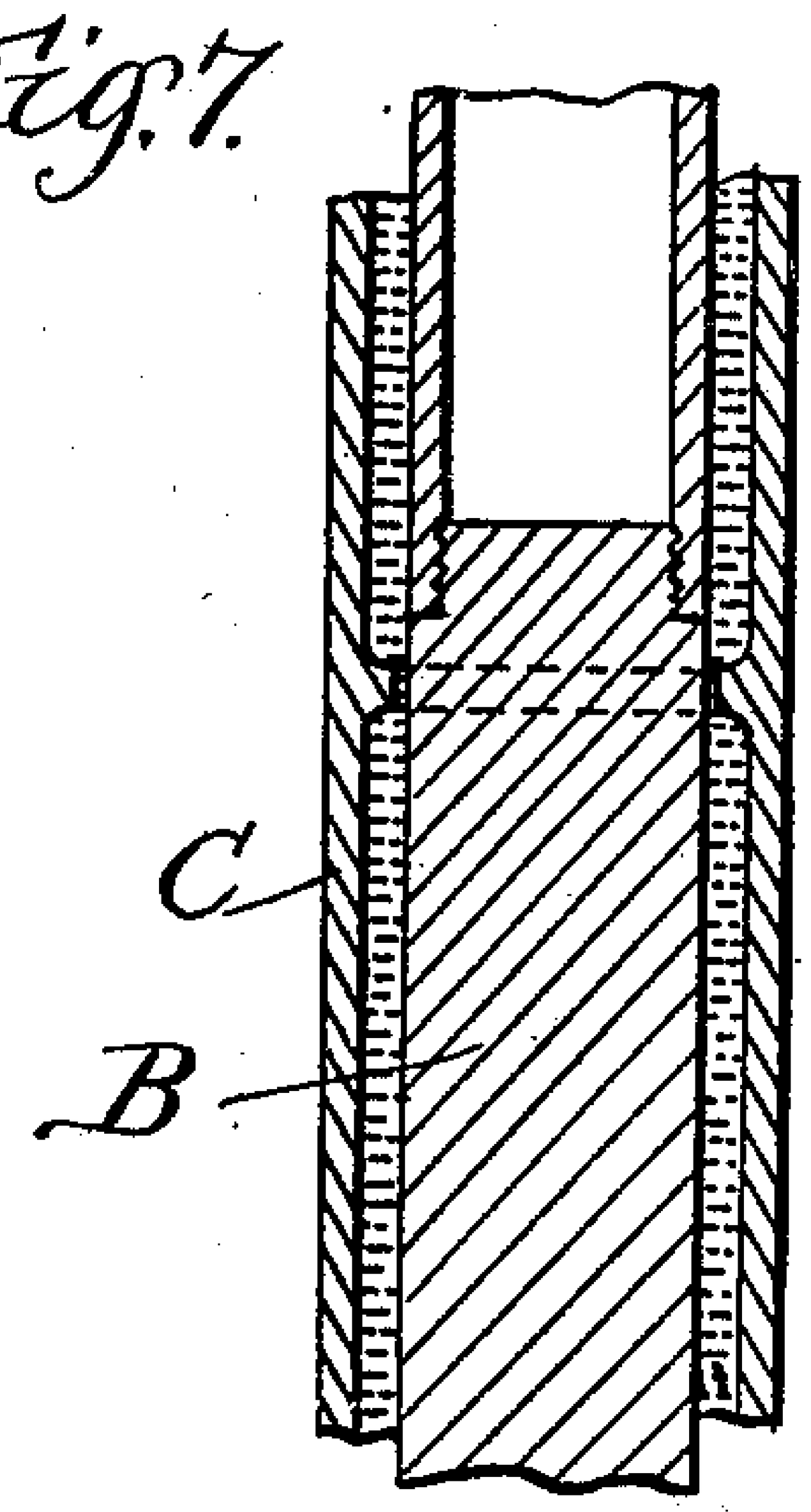
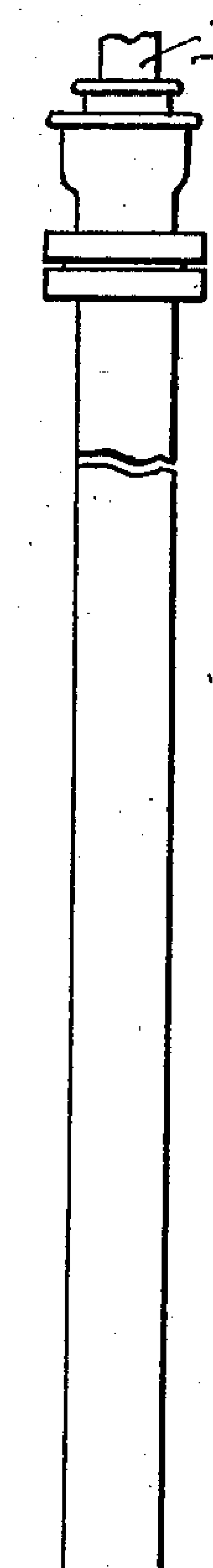
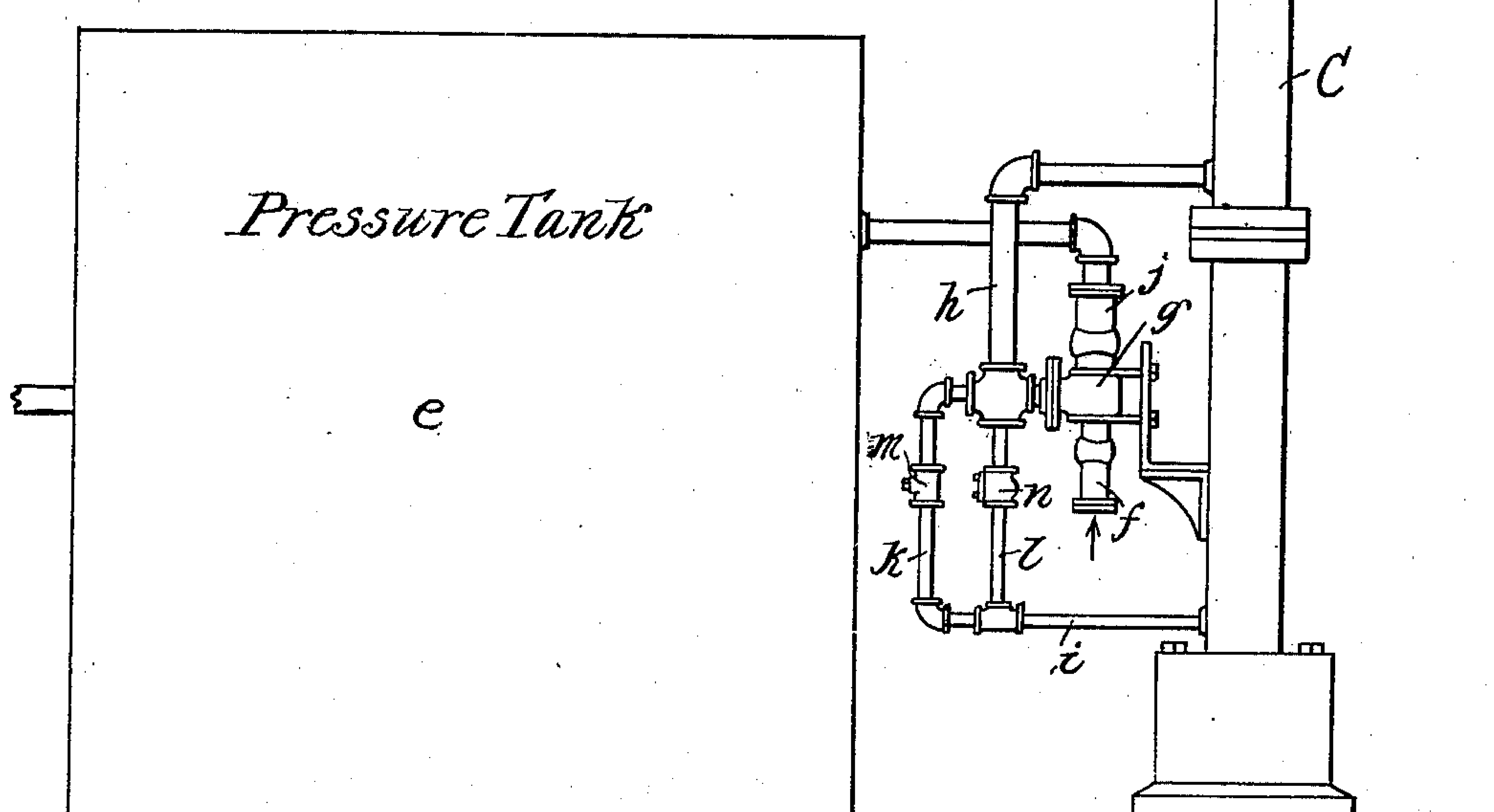


Fig. 4.





Witnesses.
Wm. M. Rheem.
Wm. J. Henning

Inventor:
Richard T. Crane
by
Raymond & Oeshlander
Atty's

THE NORRIS PETERS CO., PHOTO-LITHO., WASHINGTON, D. C.

UNITED STATES PATENT OFFICE.

RICHARD T. CRANE, OF CHICAGO, ILLINOIS, ASSIGNOR TO THE OTIS ELEVATOR COMPANY, OF NEW JERSEY.

HYDRAULIC ELEVATOR.

SPECIFICATION forming part of Letters Patent No. 661,575, dated November 13, 1900.

Application filed December 26, 1896. Serial No. 617,036. (No model.)

To all whom it may concern:

Be it known that I, RICHARD T. CRANE, a citizen of the United States, residing at Chicago, in the county of Cook and State of Illinois, have invented certain new and useful Improvements in Hydraulic Elevators, of which the following is a full, clear, and exact description, reference being had to the accompanying drawings, forming a part of this specification.

This invention relates to certain new and useful improvements in hydraulic elevators of the vertical type, and more particularly to hydrogravity-elevators in which the car or cage is lifted by the gravity of a falling weight and lowered by hydraulic pressure directed against, so as to lift, the weight.

The object of the invention is to provide a construction wherein are secured all the advantages and economical results as to cost of installation, maintenance, operation, and space occupied incident to the use of an elevator of the type above referred to and at the same time to dispense with a piston, a piston fit in the cylinder, and an independent counterweight for the lifting-cables, and to provide certain novel details in the construction and arrangement of the parts, all as illustrated in the accompanying drawings, in which—

Figure 1 represents a diagrammatic elevation of an elevator apparatus embodying my invention, showing the cylinder for the ram or plunger in section. Fig. 2 represents a detail section through the check-valve casing. Fig. 3 represents a modified form of operating mechanism. Fig. 4 represents another modified form of operating mechanism. Fig. 5 is a detail longitudinal section through the lower end of the ram and cylinder. Fig. 6 represents a horizontal section on the line 6 6 of Fig. 5, and Fig. 7 a detail longitudinal section through a modified form of ram in the cylinder.

Similar letters of reference denote corresponding parts in all the figures of the drawings.

In elevators of the class to which my invention belongs to perform the service for buildings of considerable or even ordinary height a heavy weight is necessary, and as the space in which it may be used is invariably valuable and restricted it is of course desirable that the weight shall be of such character as to occupy but little space and yet be sufficient for the desired purposes.

I have found by practical demonstration in the use of a number of elevators embodying my invention that the best results are attained by the use of a ram or plunger of substantially half the length of the lift or of the height of the building with but a single multiplying-sheave, this arrangement being most economical and advantageous from every point of view, as all of the apparatus is contained within the elevator-shaft, occupies the minimum space, requires the oiling and maintenance of but two sheaves, and involves the use of but one set of cables, and that only the length of the height of the building.

In carrying out my invention I employ a guide-frame A of any desirable or suitable construction, which should be of a length equal to about one-half of the height of the building and located in the upper part of the building, and a plunger or ram B, which should be of a length equal to about one-half of the height of the building and arranged to work in a cylinder C, which should be of a length equal to about one-half of the height of the building and located in the lower part of the building. This cylinder may be of any desired and suitable construction and may be supported in position in a manner that will be obvious to one skilled in the art, according to the requirements of the particular building in which the apparatus is located. I prefer, however, to have the cylinder C made up of a number of sections, as illustrated in the drawings, such sections being bolted or otherwise fastened together end for end and provided with bearings near the ends thereof, which serve only as guides for the ram or plunger, so as to avoid the necessity for a long bearing of the ram or plunger throughout its length and the excessive friction resulting therefrom. It will be borne in mind, however, that the ram should not have a piston fit in the cylinder, but, on the contrary, a sufficiently loose fit to permit the free passage of water between the ram and cylinder, which condition is greatly promoted by having

the series of guide-bearings in the cylinder, with the remainder of the walls of the cylinder well separated from the ram instead of simply a loose ram in a plain cylinder.

The purpose of the loose or free fit of the ram in the cylinder is to enable the cylinder to be kept full of water at all times, whether the ram is wholly or partly within the same, the maintenance of a hydrostatic column of water in the cylinder being of the utmost importance, as will appear farther on. Obviously various other means may be adopted for providing this hydrostatic column in the cylinder—such, for instance, as by grooving the cylinder or by having the ram fit loosely in a uniformly-bored cylinder and provided with a cross-head or guide of any suitable character; but all such modifications or any other construction that enables the maintenance at all times of the hydrostatic column in the cylinder are within the purview of my invention.

It is necessary, of course, in order to maintain the hydrostatic column that the upper end of the cylinder through which the ram works should be closed, and to accomplish this I prefer to use a simple stuffing-box D, closing the end of the cylinder and through which the ram works, which box may be readily removed and repacked when necessary without removing the ram or disturbing any other parts of the apparatus.

The upper end of the ram or plunger projects beyond the cylinder when the ram is in its lowest position in the cylinder, and it carries at its upper end a cross-head E, which engages the guide-frame A and serves to guide and steady the upper end of the plunger after it leaves the cylinder, the detailed construction of the cross-head being obviously immaterial to my present invention. Supported upon the cross-head is a frame F, in which is loosely journaled a multiplying-sheave G, around which are trained the ilfting cables H, one end of which latter is anchored at I to the upper end of the guide-frame A or any other suitably-fixed part, the other ends of the cables being anchored to the frame of the car J in any well-known and convenient manner. The lifting-cables, as usual in elevator constructions, are trained over the idler-pulley or main sheave K at the top of the elevator-shaft.

At the top of the guide-frame A may be located a spring-buffer L, against which the frame F impacts just before the frame reaches the limit of its upper travel, and consequently just before the car or cage reaches the limit of its lower travel, while at the lower end of the guide-frame may be arranged a pair of spring-buffers M, against which the cross-head impacts just before reaching the limit of its downward travel, and consequently just before the car or cage reaches the limit of its upper travel. These buffers serve as spring-stops for the elevator at both limits of its travel and prevent violent or dangerous shocks to the car and its operating and accessory mechanism in stopping at either limit of its movement.

For the application of hydraulic pressure to the cylinder to lift the ram or plunger I prefer to have the water-inlets located above the lower end of the cylinder, preferably at N and O, respectively, one being below and the other above the lowest bearing P for the ram or plunger in the cylinder. Any suitable apparatus may be employed for forcing the water into the cylinder and for controlling the supply to and discharge thereof from the cylinder, the particular construction and arrangement of such apparatus forming no part of the present invention.

The supply of water through the water inlets or ports N and O is simultaneous, while the lifting effect of the water admitted at the upper port is somewhat throttled by the interposition of the lowermost bearing in the cylinder until the end of the ram passes the same, after which time the water admitted at both ports operates with full and unrestricted force. The principal advantage, however, of providing this succession of ports through which the water is admitted to and discharged from the cylinder occurs in the discharge of the water from the cylinder, when the water may be utilized as an automatic stop for the ram or plunger.

So far as relates to the broad idea of my invention it is immaterial whether one or more inlet and discharge openings be employed or whether the water is admitted and discharged through the same inlet or inlets. The location of the supply and discharge ports above the lower end of the cylinder prevents the complete discharge of the water from the cylinder, and the water thus retained in the cylinder may be utilized as a gradual stop for the plunger by tapering the lower end of the plunger below the upper supply-port O or by providing tapering grooves on the sides of the plungers, so that as the plunger passes beyond the lowermost bearing P in the cylinder the escape of the water in the lower end of the cylinder through the port O will be gradually throttled, the resistance of the water to the downward movement of the plunger materially resisting the travel of the plunger to its lowermost position.

The effect of locating the lower port N above the lower end of the plunger may be obtained by having a relatively free passage through the port O and a restricted or contracted passage through the port N, which latter may in this instance be located at any point along the cylinder and but slightly above the bottom, if desired, the purpose being to afford increased resistance to the discharge of the water from the cylinder after the end of the plunger passes the lowermost bearing. Devices for accomplishing this result are illustrated in Figs. 3 and 4 and will be described farther on.

As between a weighted piston for lifting the

car, which I am aware is old, and a ram or plunger such as I have herein described, working freely in the cylinder, by which I mean in such manner as to permit of the maintenance of a hydrostatic column in the cylinder through which the ram falls, there is a wide difference mechanically as well as in the results produced. In the first place a weighted piston must have a piston fit in the cylinder to be operative, and such a piston fit in a cylinder of the length required in practice it is practically impossible to maintain, and if possible to maintain would involve great waste of power to overcome friction and binding as compared with my freely-working ram. Furthermore, the packing of the piston must be frequently renewed, and this can only be done by completely withdrawing the piston from the cylinder, an operation involving great waste of time, both in the packing and in the enforced idleness of the elevator. The packing for my ram is in a stuffing-box at the upper end of the cylinder, through which the ram works with the minimum friction, as reliance need not be placed upon the stuffing-box as a guide for the ram, and the renewal of the packing is a very simple manner and can be accomplished without the removal of the ram from the cylinder, as is perfectly obvious.

In practical operation a weighted piston, if operative at all, in a cylinder of practical length, would soon cut the cylinder so as to necessitate the removal of the cylinder from the building for reboring or the substitution of a new cylinder, besides involving the enforced idleness of the elevator in the meantime. In the use of my ram all danger of cutting the cylinder is avoided, because no piston is employed. In addition to all of these practical advantages of the ram over the weighted piston there are the further important advantages incident to its use in the provision of means for maintaining a hydrostatic column through which the ram falls, thereby enabling the utilization of the changing displacement of the ram to counterbalance the changing weight of the lifting-cables. This cannot be done with a weighted piston; but, on the contrary, an independent counterbalance, such as the well-known counterbalance-chain suspended from the car, must be employed as a counterbalance for the changing or shifting weight of the lifting-cables.

Another important advantage is the capability of use of the ram in connection with a succession of supply and discharge ports along the cylinder as an automatic stop for the ram at the limit of its downward travel, whereby are avoided dangerous shocks and jars, which would otherwise occur. By having the ram work freely in the cylinder instead of with a piston fit, like a piston, the cylinder is maintained full of water, so as to provide a hydrostatic column therein at all times and under all conditions, which may be taken advantage of to provide an automatic counterbalance for the running cables, and thus dispense with the usual counterbalance-chain attached to the car or other independent counterbalance, with its necessarily-accompanying cables. Another important and desirable result attained by maintaining a hydrostatic column in the cylinder at all times is that it prevents the possibility of air getting into the cylinder, with the accompanying evils resulting therefrom. It is immaterial to the broad idea of my invention how or by what means the hydrostatic column is maintained under all conditions; but for the purpose of illustration I have shown in the drawings three arrangements by which this most desirable result may be accomplished.

In Fig. 1 I have shown the application of a tank *a*, located on the roof or in the upper part of a building, which tank or some other suitable source of constant hydraulic pressure is connected by a pipe *b* with the cylinder C, preferably near the upper end thereof, and has a check-valve *c* located therein, which valve may be of any suitable construction so long as it is arranged to open toward the cylinder, but will close so as to prevent the outflow of water from the cylinder. In this construction the hydraulic lifting-column directed against the end of the ram is obtained from any suitable source and admitted through the openings N and O, or either of them, near the lower end of the cylinder, and by reason of the loose fit of the ram in the cylinder or the passages provided for the free run of the water past the ram the water thus forced into the cylinder at the bottom will fill the cylinder to the top, and sufficient pressure should at all times be maintained to keep the cylinder full of water, such pressure obviously being not sufficient to lift the ram. In any event should the pressure fall sufficiently to temporarily lower the head of the column of water in the cylinder the loss will be instantly supplied by water from the tank *a*, which is free to flow into the cylinder, but cannot flow back therefrom to the tank. In the same way should the pressure in the cylinder be instantly cut off while the ram is rising, or should the latter, by reason of inertia, continue to rise, thereby tending to produce a vacuum at the end of the ram, such vacuum will be instantly dispelled by the supply of water which will be thereby drawn into the cylinder from the tank *a*. This action serves to prevent the falling back of the ram after the force of inertia is overcome, which would result in serious and damaging shocks to the elevator-car and the accessory parts. This action also serves to prevent the drawing in of air which would follow but for the free inlet of water to the cylinder from the tank, so that under any conditions the possibility of air getting into the cylinder is avoided. Should it for any reason be undesirable to maintain sufficient pressure from the source of hydraulic supply to keep the cylinder at all times full

of water, this service can be performed by the tank *a*, which, as before stated, may be located at any suitable point and can be supplied with water from any source.

In Fig. 3 I have shown another mechanism for keeping the cylinder full of water at all times, which, though contemplated by the broad idea of my invention, is not specifically of my invention, but is herein illustrated as being one of the forms in which my invention has been practically embodied in elevator apparatus now in daily service. In this apparatus I provide a stand-pipe *d*, through which the water from the cylinder is discharged, a suitable arrangement of control-valves being used in connection therewith, (which it is not necessary to illustrate or describe in detail herein,) whereby the water may be admitted to the openings N and O, or either of them, while the stand-pipe is cut off from communication with the cylinder, but which will establish communication between the stand-pipe and the cylinder whenever the discharge of the water is desirable. Obviously the head of the column in the cylinder can never fall below the head of the column in the stand-pipe, and as the latter is extended up to a point substantially even with the top of the cylinder the cylinder will be at all times kept full.

In Fig. 4 I have shown still another apparatus for keeping the cylinder full of water, in which the pressure-tank *e* is substituted for the stand-pipe, the pressure-tank normally containing sufficient air or other pressure to sustain the column of water the height of the cylinder. This tank may form a portion of the usual circulating pumping system from which the pump-supply is drawn.

In all forms of my invention the changing displacement of the ram or plunger may be utilized to counterbalance the changing weight of the lifting-cables in their run to opposite sides of the main sheaves. I may here state, however, that the invention involving the utilization of the changing displacement of the ram to counterbalance the changing weight of the lifting-cables by proper proportion of the displacement caused by the ram to the weight of the lifting-cables is not my invention, but is that of George H. Reynolds, whose application for patent for said invention was filed March 27, 1895, Serial No. 543,381, and I therefore do not desire to herein claim the invention by which that useful and desirable result is attained. It is well understood that the ram when immersed in the hydrostatic column theoretically loses a certain portion of its weight per foot, depending upon the displacement caused thereby, and that, conversely, as the ram emerges from the hydrostatic column it theoretically acquires weight, or, in other words, regains the weight lost by immersion. This principle holds good whether the ram is solid or hollow (if closed) throughout its length or partially solid and partially hollow, as illustrated in Fig. 7, and also regardless of the shape or configuration of the ram, and so long as the ram has sufficient weight to lift the car and its accessory parts its shape or construction would fall within my invention; but to take advantage of this displacement for the purposes of a counterbalance for the changing weight of the lifting-cables a certain proportion must exist between the displacement caused by the ram and the weight of the cables, so that the weight of the water displaced by the ram in any position will correspond with so much of the weight of the lifting-cables as has run from one side to the other of the main sheave. This is Mr. Reynolds's invention, for so far as relates to the broad idea of my invention a counterbalance-chain might be employed without destroying any of the other advantages hereinbefore set forth.

Assuming an apparatus having a single multiplying-sheave or a movement of two to one as between the car and the ram, by having the displacement of the ram so proportioned that the weight of the water displaced by it per foot will equal the weight of two feet of the lifting-cables, it will be readily seen that as the ram falls each foot it will lose in weight the amount gained by the weight of the two feet of the lifting-cables running to its side of the main sheave, and, on the other hand, when the ram is rising it gains in weight each foot an amount equal to the loss of weight from the running of two feet of the lifting-cables to the car side of the main sheave. Hence the weight of the ram practically remains the same throughout its movements up and down, and the same power will move it in all positions.

The detail mechanism illustrated in Figs. 3 and 4 does not form a specific part of my invention; but I may state generally that in both *f* is a supply-pipe from the pump or other source of pressure, *g* is the change-valve, *h* is a pipe leading from the change-valve to the opening O in the cylinder, *i* is another pipe leading from the change-valve to the opening N in the cylinder, *j* is the discharge-pipe, leading to the stand-pipe *d* or the pressure-tank *e*, and *k* and *l* are branches of the pipe *i*, in the former of which is located a throttling-valve *m* and in the latter of which is located a check-valve *n*. The throttling-valve *m* is adjustable, so as to render the passage of water through the pipe *k* in either direction more or less restricted, as desired. The check-valve *n* opens upon movement of the water toward the pipe *i* and closes against a return movement of the water.

The pipe *h* is several times the capacity of the pipe *i*, thereby permitting a comparatively free flow of water to and from the cylinder through said pipe. This relation of size, however, is not essential, and the pipes may be of the same capacity or reverse, the principal point being to have the two passages for the escape of water from the lower end of the cylinder through the pipe *i* to the

discharge-pipe in order to utilize the retardation of the water as a stop for the ram. It will thus be seen that the pipe *h* is practically cut off by the ram when the pipe *i* comes most actively into play, although both pipes operate simultaneously in forcing water into the cylinder. As the water is being discharged from the cylinder the comparatively free discharge afforded by the pipe *l* branching from the pipe *i* will be closed by the check-valve *n* and the water will be compelled to pass through the restricted passage *m*.

Of course it will be understood that the elevator-car, with its accessory parts, must be of a weight more than sufficient to counterbalance the lifting-cables between the main sheave and the ram when the ram is in its lowest position, so that the car will start promptly when the ram is lifted, thus allowing the car to fall.

An elevator apparatus constructed in accordance with my invention is simple, durable, and economical in the maximum degree, and is of such construction that it will not easily get out of working order and may be easily and quickly repaired if it does, besides which my invention possesses the maximum advantage in the cost of installation, maintenance, operation, and space occupied.

Having thus fully described my invention, what I claim, and desire to secure by Letters Patent, is—

1. In an elevator, the combination of a car, a ram, cable connections therebetween, a closed cylinder in which said ram works, and having an internal diameter greater than the diameter of the ram, a series of guide-bearings for said ram at intervals in the cylinder through which the ram freely works, means for permitting the passage of the operating medium through said guides and about said ram, a hydraulic pressure operating to maintain said cylinder constantly filled with water, means for controlling the supply of said water, whereby the ram is raised by said pressure to lower the car, and means for controlling the exhaust of said water from the cylinder, whereby the car is raised and the weight of the hoisting-chain is compensated by the fall of the ram in the cylinder, as and for the purpose set forth.

2. In an elevator, the combination of a car, a ram, cable connections therebetween, a closed cylinder in which said ram works, having an internal diameter greater than the diameter of the ram, a series of guide-bearings for said ram at intervals in the cylinder through which the ram freely works, said ram being externally tapered to permit of the passage of the operating medium about said ram, supply and exhaust openings for said cylinder adjacent to the lower end thereof but somewhat removed therefrom, and means for controlling the supply of water to and exhaust thereof from said cylinder, whereby said cylinder is constantly maintained filled and the ram is raised and lowered, as and for the purpose set forth.

RICHARD T. CRANE.

Witnesses:
W. R. OMOHUNDRO,
C. L. WOOD.