No. 745,373. PATENTED DEC. 1, 1903.

R. NUTTY.

UTILIZATION OF COMPRESSED AIR.

APPLICATION FILED DEC. 17, 1898.

NO MODEL. 3 SHEETS—SHEET 1.

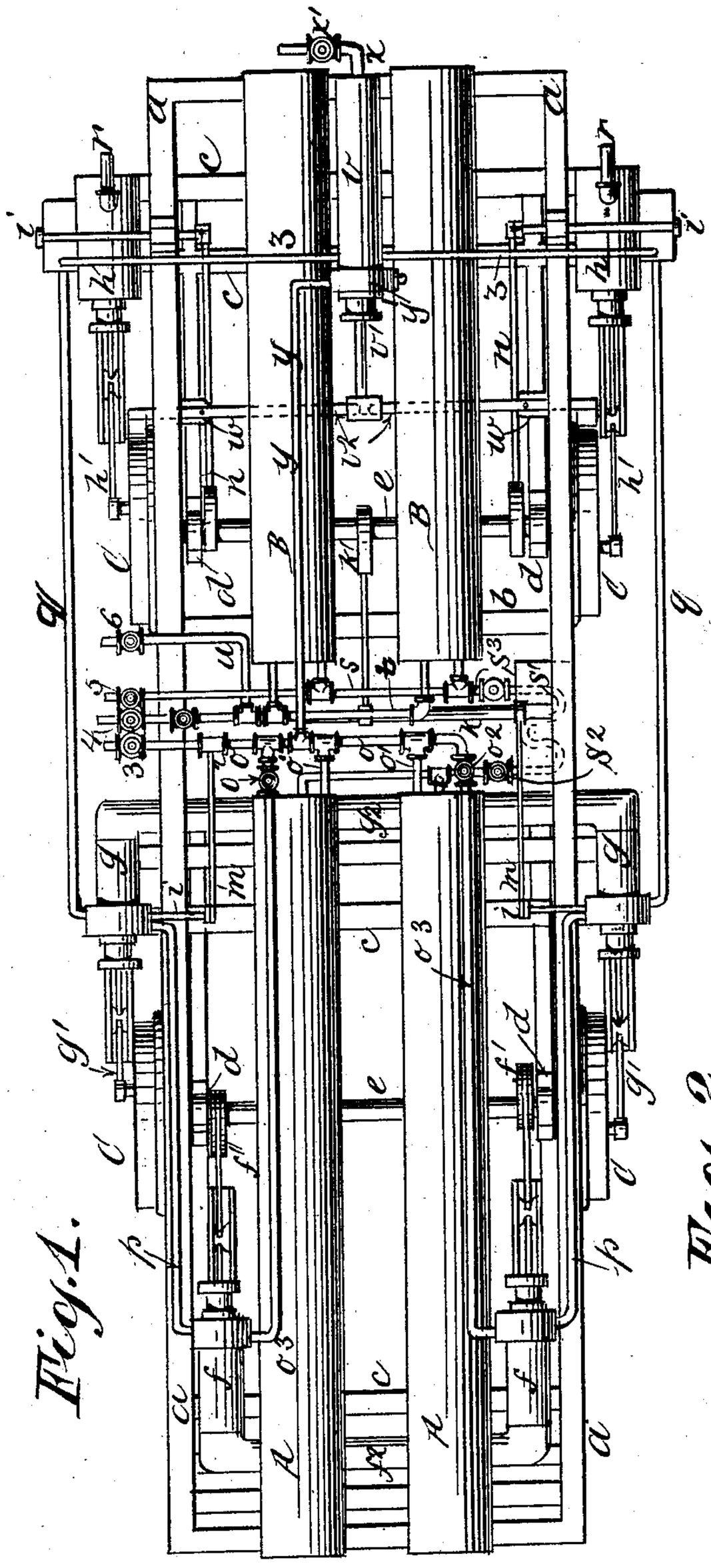

Fig. 1.

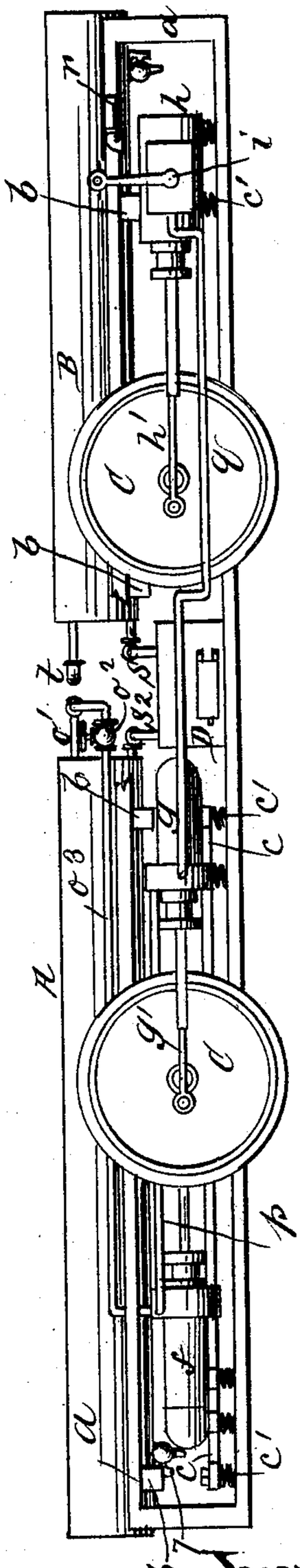

Fig. 2.

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NO MODEL. 3 SHEETS—SHEET 2.

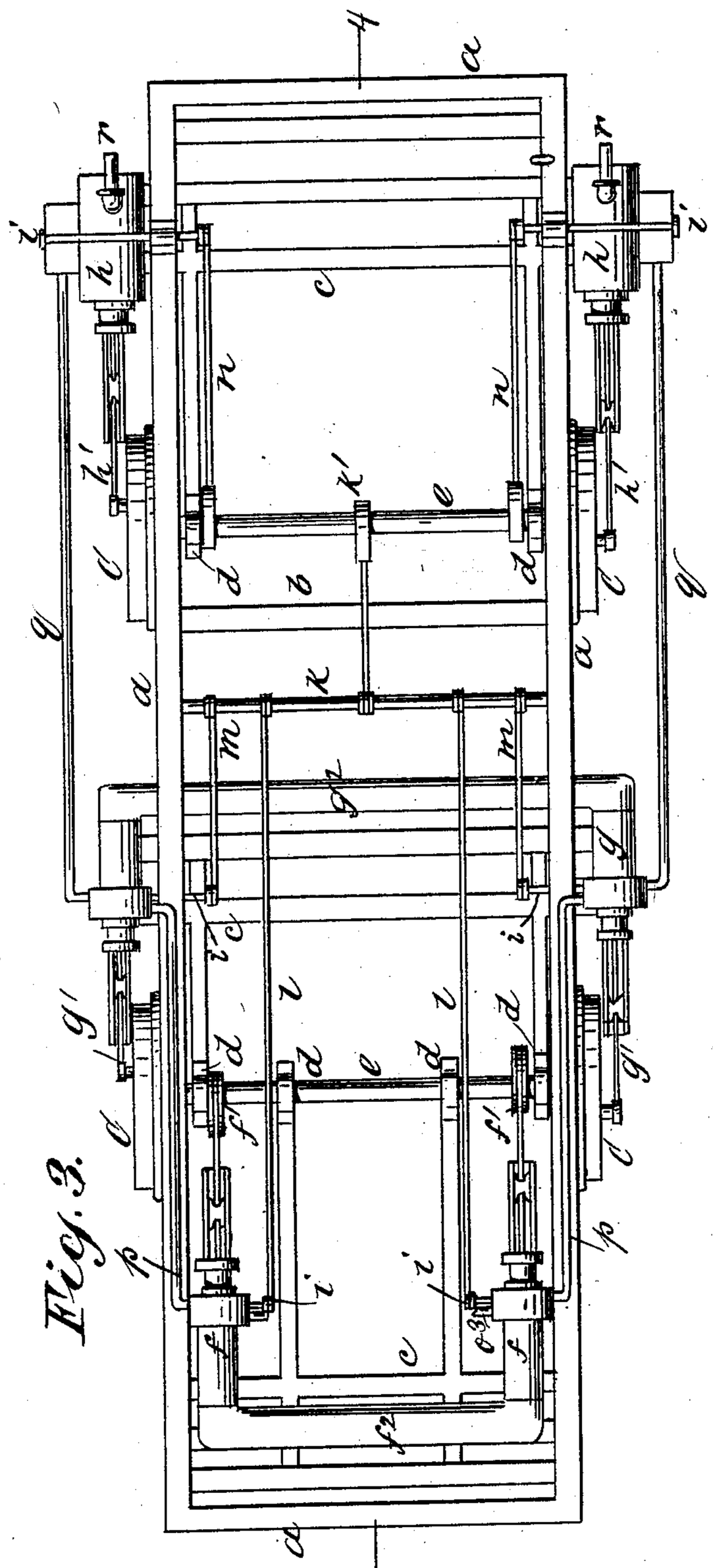

Fig. 3.

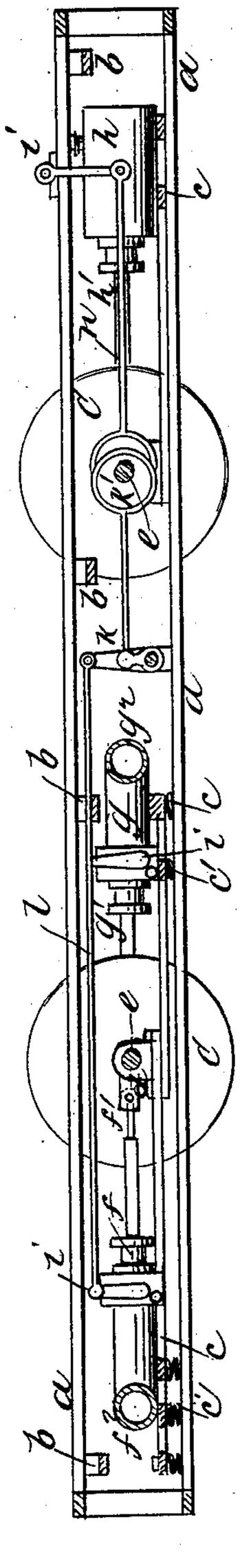

Fig. 4.

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NO MODEL. 3 SHEETS—SHEET 3.

Fig. 5.

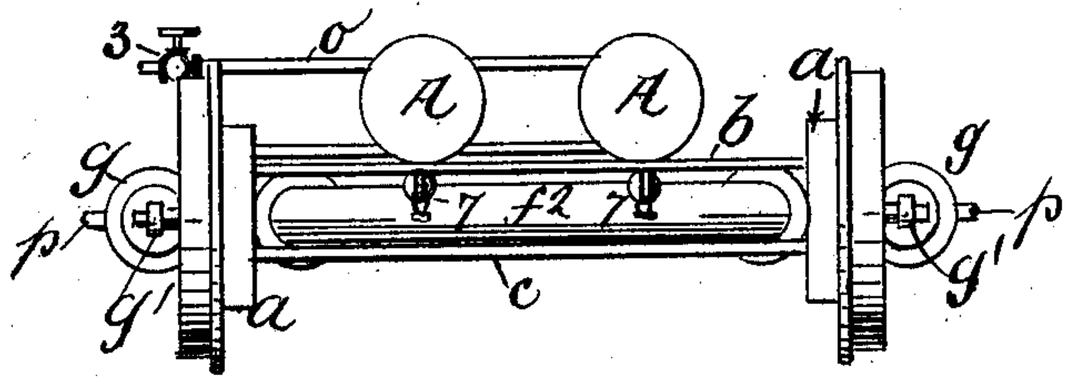


Fig. 6.

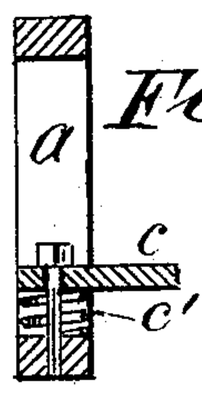
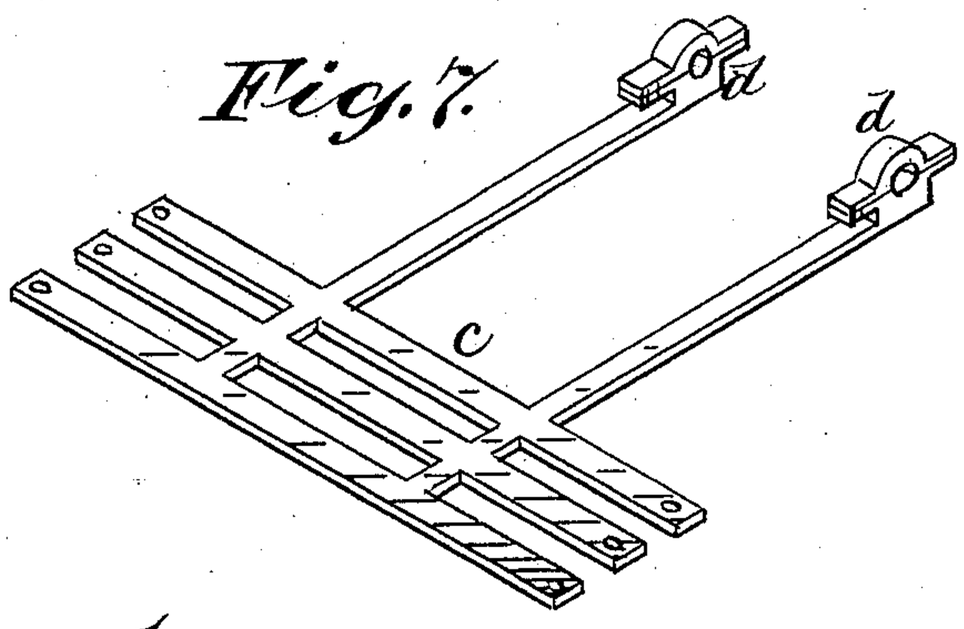


Fig. 7.



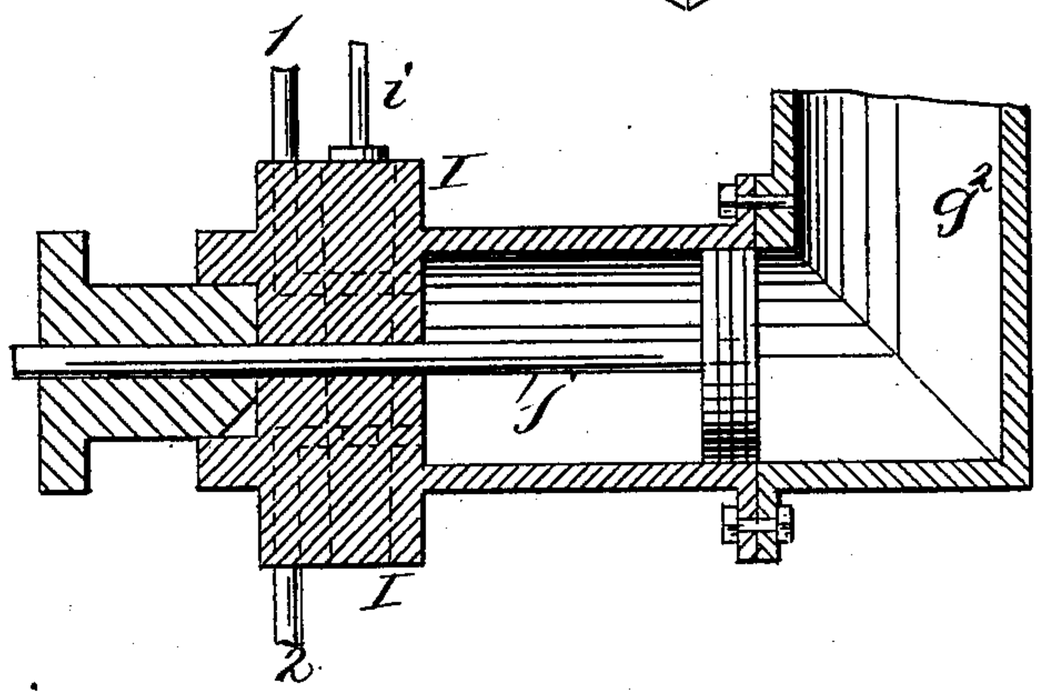


Fig. 8.

Witnesses:

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No. 745,373. Patented December 1, 1903.

UNITED STATES PATENT OFFICE.

ROBERT NUTTY, OF NEW YORK, N. Y.

UTILIZATION OF COMPRESSED AIR.

SPECIFICATION forming part of Letters Patent No. 745,373, dated December 1, 1903.

Application filed December 17, 1898. Serial No. 699,600. (No model.)

To all whom it may concern:

Be it known that I, ROBERT NUTTY, of No. 44 Seventh street, in the borough of Manhattan and city of New York, in the State of New York, claim to have made new and valuable improvements in machinery for the use of compressed air and steam, compressed air to be used in the propulsion of railroad-cars, such as are used on city railroads, and on elevated railroads and in tunnels and in mines, and also in the propulsion of marine torpedoes and submarine boats for war or other purposes where steam cannot be used, also for reducing or lessening the consumption of steam in locomotive and other steam-engines; and I do hereby declare that the following is a full, clear, and exact description of the invention, which will enable others skilled in the art to which it appertains to make and use the same.

This invention relates to certain new and useful improvements in the utilization of compressed air or other gaseous or fluid pressures, and has for its object the production of mechanism whereby the pressure of the propulsive gas or fluid to be carried may be reduced to the minimum and in which such pressure shall be kept constant, uniform, and undiminished and in which the entire force of such power may be used.

To these ends, therefore, my said invention consists in the novel features, as well as in the arrangement and combination of parts and the details of construction, all as hereinafter more fully described, and pointed out in the claims.

Referring to the accompanying drawings, illustrating my invention and in the several figures of which like parts are similarly designated, Figure 1 is a top plan view of said invention mounted upon the wheels of a surface car. Fig. 2 is a side elevation thereof. Fig. 3 is a top plan view with the tanks and their connections omitted. Fig. 4 is a longitudinal section of the line 4 4 of Fig. 3. Fig. 5 is an end view. Fig. 6 is an enlarged detail in section of Fig. 4, showing springs intended to relieve jar of cylinders. Fig. 7 is a perspective view of the independent spring-frames for the engines, and Fig. 8 is an enlarged fragmentary view, in central longitudinal section, of one of the engines.

Briefly stated, I use a suitable number of tanks, here shown as four, arranged in sets and with appropriate connections. One set, the operating-tanks, are filled with compressed air at a comparatively low pressure, and the other set are first about half filled with hot water, the remainder of the space therein being filled with compressed air at a much higher pressure than that in the operating-tanks. When air is drawn from the latter to operate the engines, the place of the air withdrawn is at once taken by hot water forced into the operating-tanks by the higher pressure of the air in the other set, thus keeping the air-pressure in the operating-tanks always equal and uniform until the air therein has been entirely exhausted. I also use three sets of engines similar to a triple-expansion engine, the air from the operating-tanks first operating the small or primary engines, being thence exhausted into the larger or intermediate engines, and being thence exhausted into the largest or low-pressure engines. I also have a separate brake-engine and so arrange the exhaust therefrom that it will serve to start the car.

a is a double frame having rigidly secured below its upper portion the transverse bars *b*, upon which are mounted the operating-tanks A and the feed or auxiliary tanks B.

c, Fig. 7, represents independent spring-frames, of which three are used, one for each set of engines, the lateral portions of which are supported upon coil-springs *c'* to compensate for jar and oscillation, and the longitudinal portions of said frames are provided with journals *d*, in which turn the car-axles *e*, Figs. 3, 4, and 6. The engines are of the simple direct-acting type and in each the piston area is approximately one-third greater than that of the next smaller engine.

f represents the small or primary engines, arranged to rotate the car-axle *e* by means of crank connections *f'*.

g g are the intermediate or secondary engines, the piston-rods *g'* of which act as driving-rods upon the car-wheels *c*, and *h h* are the large or low-pressure engines, the piston-rods *h'* of which are also arranged to act as driving-rods upon the other set of car-wheels C. As shown in Fig. 8, the engines consist, preferably, of tubular piping, having

the head I provided with the inlet-port 1 and the exhaust-port 2, a plug-valve *i*, adapted to alternately open and close said inlet and exhaust ports, and the piston *j*.

In the preceding paragraph I say that I construct my engines of tubular piping. I do this that they may be able to bear with safety the comparatively high pressures I use as compared with the pressures used in engines of the ordinary construction, and desiring to retain all the heat possible in the charge of air (say at six hundred pounds per square inch which I use in the primary engines) to operate the intermediate engines I follow the pistons of the said primary engines to the end of the stroke and allow of no expansion. I cannot have a cushion on the other side of the piston, as in the said engines of ordinary construction and in the absence of this cushion the connecting-rod straps would inevitably be broken before the piston could be started in the opposite direction. To prevent this, I prefer to connect the two primary engines, as well as the two intermediate engines, by the transverse pipes f^2 g^2, which form an open connection between the piston-heads of the two engines, and I preferably fill said connections f^2 g^2 between said piston-heads with compressed air, water, or oil to aid in the exhaust of the pressure charge, the engines in each set being arranged to work alternately. When the piston in one engine is on the upstroke, it will force the oil, &c., in the pipe connections f^2 g^2 against the piston-head of the other engine and drive out the air which has been used on the upstroke of the latter. I use the open connection filled with water, oil, &c., between the two engines, as I have said, and the crank connections are preserved intact and violent shocks to the engines are avoided. If this open communication were not provided upon the completion of the stroke of one engine, the inlet would be closed, the exhaust opened, and the inlet of the opposite engine opened to continue the rotation of the shaft or axle and the piston of the first engine would have to be returned against the remaining pressure in its cylinder solely by the rotation of the shaft or axle. By using the body of oil, &c., however, the upstroke of the second engine, as I have said, actuates the said fluid directly against the opposite side of the first piston-head and drives it back to complete its exhaust without undue strain upon its crank connections, driving the still-heated air in its cylinder into the cylinder of the intermediate engine, and in the same manner the pistons of the intermediate engines drive the exhaust air into the low-pressure engines.

k, Fig. 3, is a rock-shaft operated by an eccentric *k'* on the rear axle *e*, from which extend the levers *l l m m*, connected with the valve-stems *i* of the primary and intermediate engines and adapted to operate the same to alternately open and close the inlet and exhaust ports thereof. The valves of the low-pressure engines *h h* are similarly operated by the eccentric-rods *n n*, also operated by the rear axle *e*.

The operating-tanks A are filled with compressed air at a comparatively low pressure—say six hundred or seven hundred pounds per square inch—through the pipe *o* and branches *o'*, the former being adapted to communicate through valve 3 with a compressor, tank, or other suitable source of compressed air, the valves o^2 in said pipe being closed.

The auxiliary or feed tanks B are about half filled with hot water through pipe *t* and valve 4, connected for the purpose to a suitable source of hot water. The remaining space in said tanks B is then filled with compressed air at a much higher pressure than that in the tanks A through pipe *s* and valve 5. The pipe *s* is continued in a coil *s'*, arranged in any suitable heater D, and communicates with the operating-tanks A through the stop-valve s^3 and the regulating-valve s^2. This pressure of the air in the water-tanks may be regulated to suit the length of the trip.

Upon opening the valves o^2 (the valves 3, 4, 5, and 6 being of course closed) air passes from the tanks A through branches *o'*, pipe *o*, through valves o^2, and by pipes o^3 to the primary engine *f f*, operating the same and starting the car. The exhaust from said engines is carried by pipes *p p* to operate the intermediate engines *g g*, and the exhaust therefrom is conducted through pipes *q q* to operate the low-pressure engines *h h*, the small remaining pressure being exhausted through ports *r r* to the atmosphere. As the air is thus drawn from the tanks A its place is immediately taken by hot water forced by the higher air-pressure in tanks B through the pipe *s*, in which pipe *s* is placed, as before said, the stop-valve s^3, which stop-valve s^3 is controlled by the motorman by any suitable connection. When the hot water has passed through said valve s^3, it continues through coil *s'* in heater D, where the water is further heated, and through the regulating-valve s^2 into said tanks A, heating, expanding, and moistening the remainder of the air therein and uniformly maintaining the pressure thereof at the same point as before any air was withdrawn. By these means not only may a much lower pressure than heretofore commonly used be carried in the operating-tanks, obviating the use of heavy and expensive tanks or "bottles" and the danger from explosion or bursting, but the initial pressure in said operating-tanks is constantly maintained.

At the end of each trip the water in the tanks A is drawn off through the stop-cocks 7, and the compressed air remaining in tanks B flows through the pipe *s*, &c., into the tanks A until the pressure in both sets of tanks A and B is equal. The valve s^2 is then closed, and a suitable connection being made between the end of pipe *u*, tapped into pipe *t*, and the tank

or reservoir in the power-house the valve 6 is opened and the air allowed to flow back to said tank or reservoir from the tanks B until the pressure therein is sufficiently reduced to permit a new charge of hot water to be forced in, as previously described, while the pressure of the air still remaining in said tanks will be sufficient to prevent vaporization of the water, and consequent loss of heat.

The brake mechanism comprises the cylinder v, having a piston-rod v', to the outer end of which are pivoted the brake beams or levers v^2, fulcrumed in brackets W, secured to frame a. x is a pipe provided with the valve x', and through said pipe a charge of compressed air but slightly higher than that of the exhaust from the intermediate engines g g is forced into the said brake-cylinder v below its piston-head whenever required. This charge of compressed air is intended as a cushion to the said piston in the said brake-cylinder v and also as a spring, as hereinafter described. y is a pipe provided with a valve y' and being in direct communication with the operating-tanks A through pipe o and branches o'. The valve y' is normally closed; but when it is desired to apply the brakes said valve is opened, permitting the ingress of air at the comparatively high pressure of the operating-tanks A into the cylinder v above its piston-head, driving the latter inwardly against the low pressure in the cylinder v below its piston-head and applying the brakes by the described connections between the piston-rod and the brake beams or levers v^2. At the same time the low-pressure charge in the cylinder v is compressed by the inward movement of the piston and its pressure is increased. Upon turning the valve y' the inlet-port from the pipe y to the cylinder v is closed and exhaust-ports are opened, communicating with the transverse pipes z, leading to the low-pressure engines h h, and the air which has been drawn from the operating-tanks A to apply the brake, passes through said pipes z and operates the said low-pressure engines to start the car, a complete exhaust being made by the expansion of the original charge in the cylinder v.

Many changes and alterations may be made in the devices and arrangements herein shown and described without departing from the principle and scope of my invention. Modifications, additions, and omissions may also be made to adapt my invention to particular cases or to meet certain exigencies, and steam and other pressures may be used instead of compressed air. All such changes, however, may be made by a mechanic skilled in the art and still be within the scope and purview of this invention.

What I claim as new, and desire to secure by Letters Patent, is—

1. An engine, one or more operating-tanks connected directly to said engine, and adapted to contain propulsive gas or fluid under pressure, in combination with one or more auxiliary or feed tanks adapted to contain a similar gas or fluid under a higher initial pressure than that in the operating-tanks, and a body of water contained in the said auxiliary tanks; a valved pipe connecting the operating and the feed tanks; whereby the gas or fluid withdrawn from said operating-tanks to run said engine is replaced by water from said feed-tanks; and means for heating said water during its passage through said pipe; substantially as described.

2. An engine comprising a cylinder, a piston, a valve-controlled pressure inlet and exhaust at the crank end of the cylinder, in combination with a similarly-constructed and alternately-operating engine; an open connection between the head ends of the two engine-cylinders, and a body of gas or fluid contained in said connection and extending from one piston-head to the other; substantially as and for the purposes set forth.

3. A plurality of engines arranged in pairs of increasing area, the engines of each pair being arranged to work in alternation and each engine comprising a cylinder, a piston, a valve-controlled pressure inlet and exhaust at the crank end of the cylinder, the latter being connected by a pipe to the inlet of the next larger engine; an open connection between the head ends of the cylinder of each pair of engines and a body of gas or fluid contained in said connection and extending from one piston-head to the other in each pair, and a suitable source of power connected to the smallest pair of engines; substantially as described.

4. A plurality of engines arranged in pairs of increasing area, each engine comprising a cylinder, a piston, a valve-controlled pressure inlet and exhaust, the latter being connected to the inlet of the next larger engine; a suitable number of operating-tanks mounted on a frame and connected to the smallest pair of engines in combination with a brake-engine comprising a cylinder and a piston, the former containing a pressure behind said piston greater than the pressure entering the largest pair of engines, and having a valve-controlled inlet from the operating-tanks, and an exhaust leading to the inlet to said largest pair of engines ahead of said piston (by means of which connection the exhaust from said brake-engine is used to start the car) and brake beams or levers connected to and adapted to be operated by said piston, substantially as described.

5. An engine; one or more operating-tanks, adapted to contain gas or fluid under pressure, connected to said engine and provided with a valved charging connection in combination with a suitable number of auxiliary or feed tanks, adapted to contain a similar gas or fluid under a higher initial pressure than that in the operating-tanks, and a body of hot water; a valved connection between the operating and the feed tanks, whereby the gas or fluid withdrawn from said operating-tanks to operate said engine is replaced by wa-

ter from the feed-tanks; valved connections for charging said feed-tanks with air and with hot water; and a valved air-outlet for reducing the pressure in said tanks to permit the recharging with hot water, and means, consisting of the remaining pressure in said feed-tanks, for preventing said water from vaporizing and losing its heat; substantially as described.

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