(No Model.) 5 Sheets—Sheet 1.

R. MIDDLETON.

HYDRAULIC APPARATUS FOR MOVING LOADS.

No. 475,588. Patented May 24, 1892.

FIG. 2.

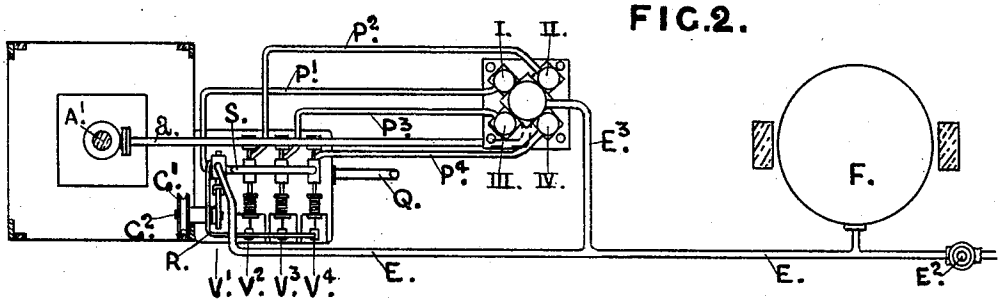
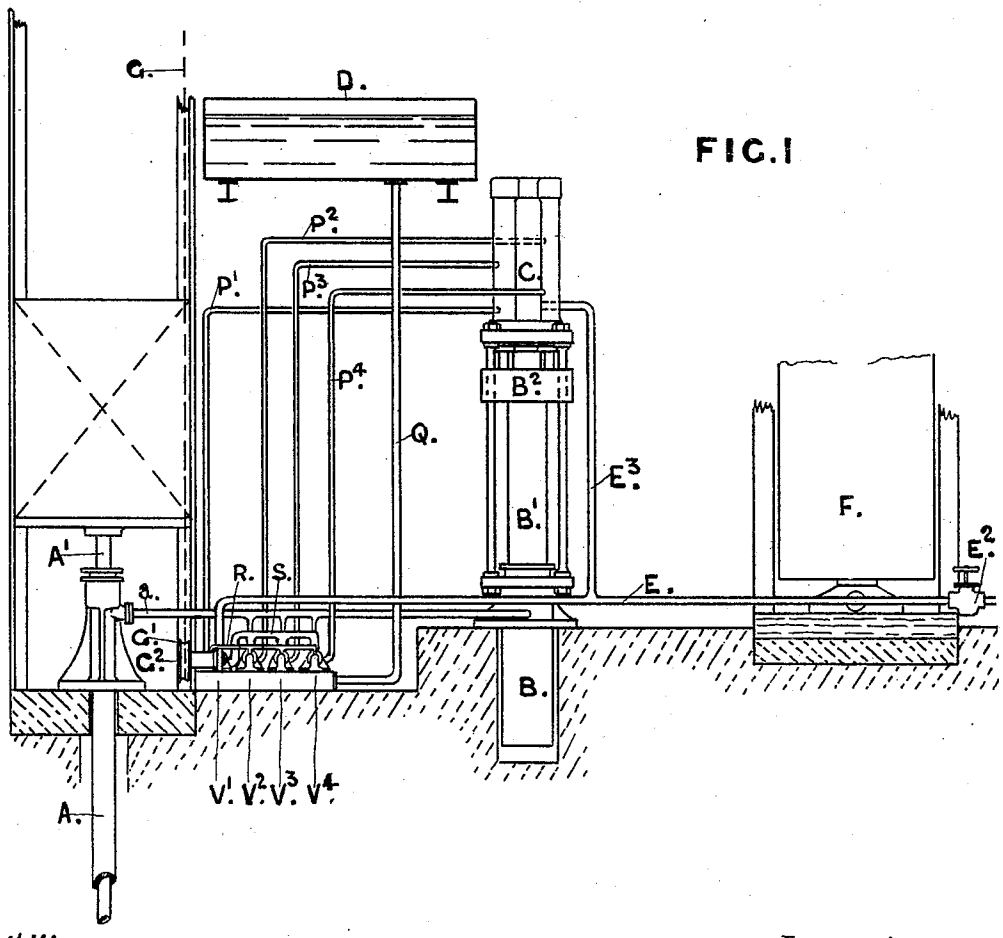


FIG. 1



Witnesses:
E. C. Barker.
C. E. Bott

Inventor
Robert Middleton
per Fairfax & Wetter
Attorneys.

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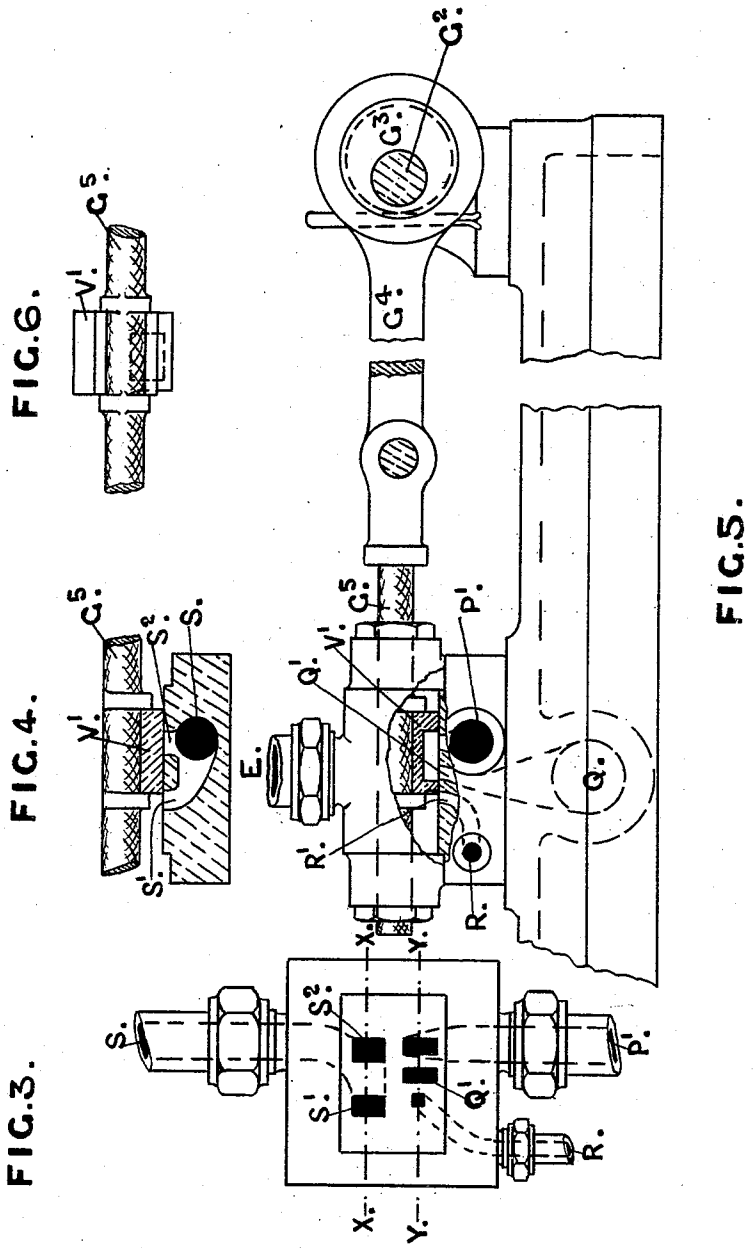

FIG. 6.

FIG. 5.

FIG. 4.

FIG. 3.

Witnesses:
E. C. Barker.
C. E. Bott

Inventor
Robert Middleton
per Fairfax & Wetter
Attorneys.

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

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R. MIDDLETON.

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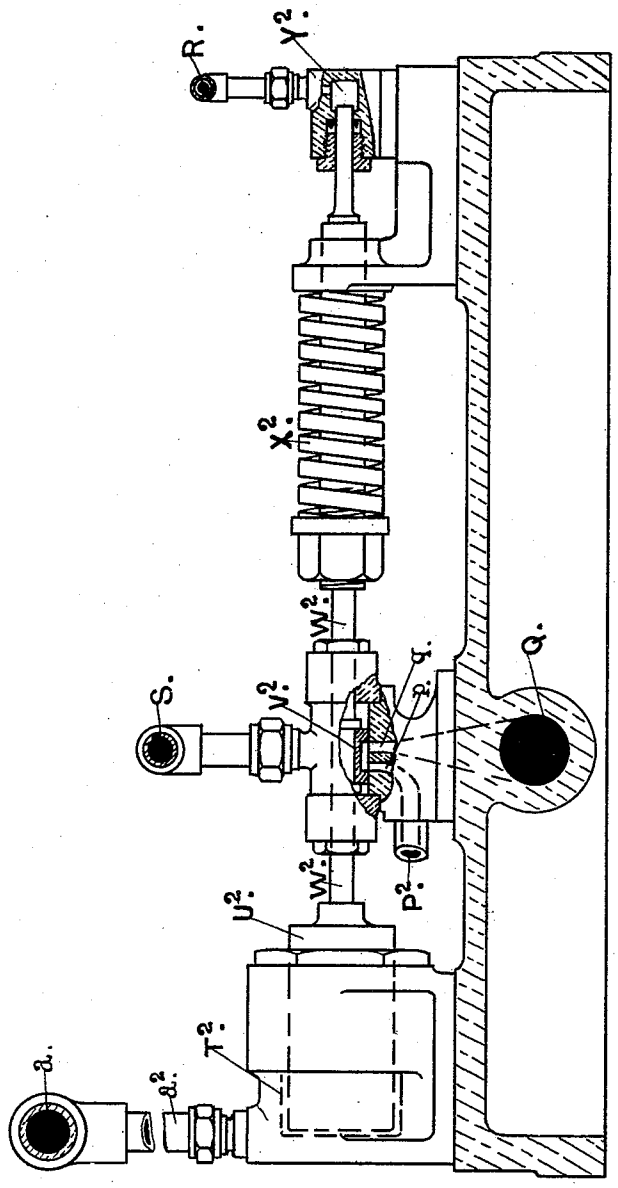

FIG. 7.

Witnesses:
E. C. Barker.
C. L. Bott

Inventor
Robert Middleton
per Fairfax & Wetter
Attorneys.

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R. MIDDLETON.

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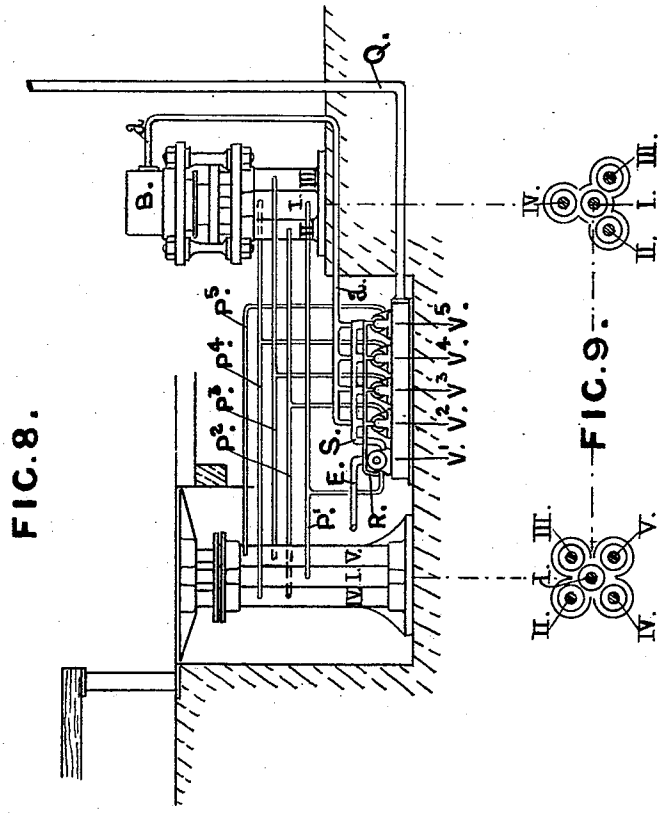

FIG. 8.

FIG. 9.

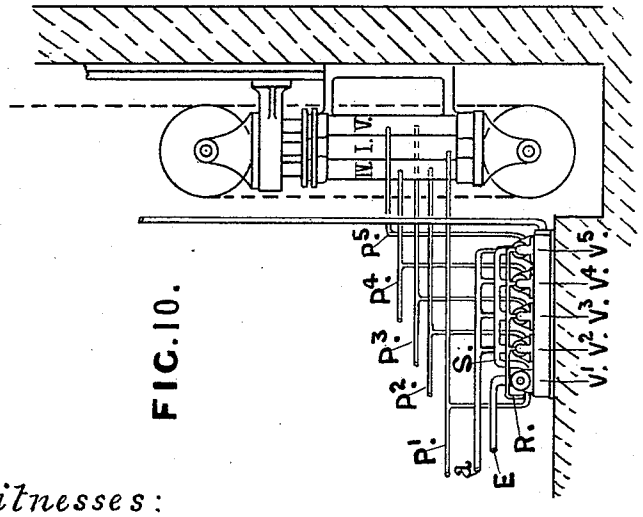

FIG. 10.

Witnesses:
E. C. Barker.
C. E. Bott

Inventor
Robert Middleton
per Fairfax & Metter
Attorneys.

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

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R. MIDDLETON.

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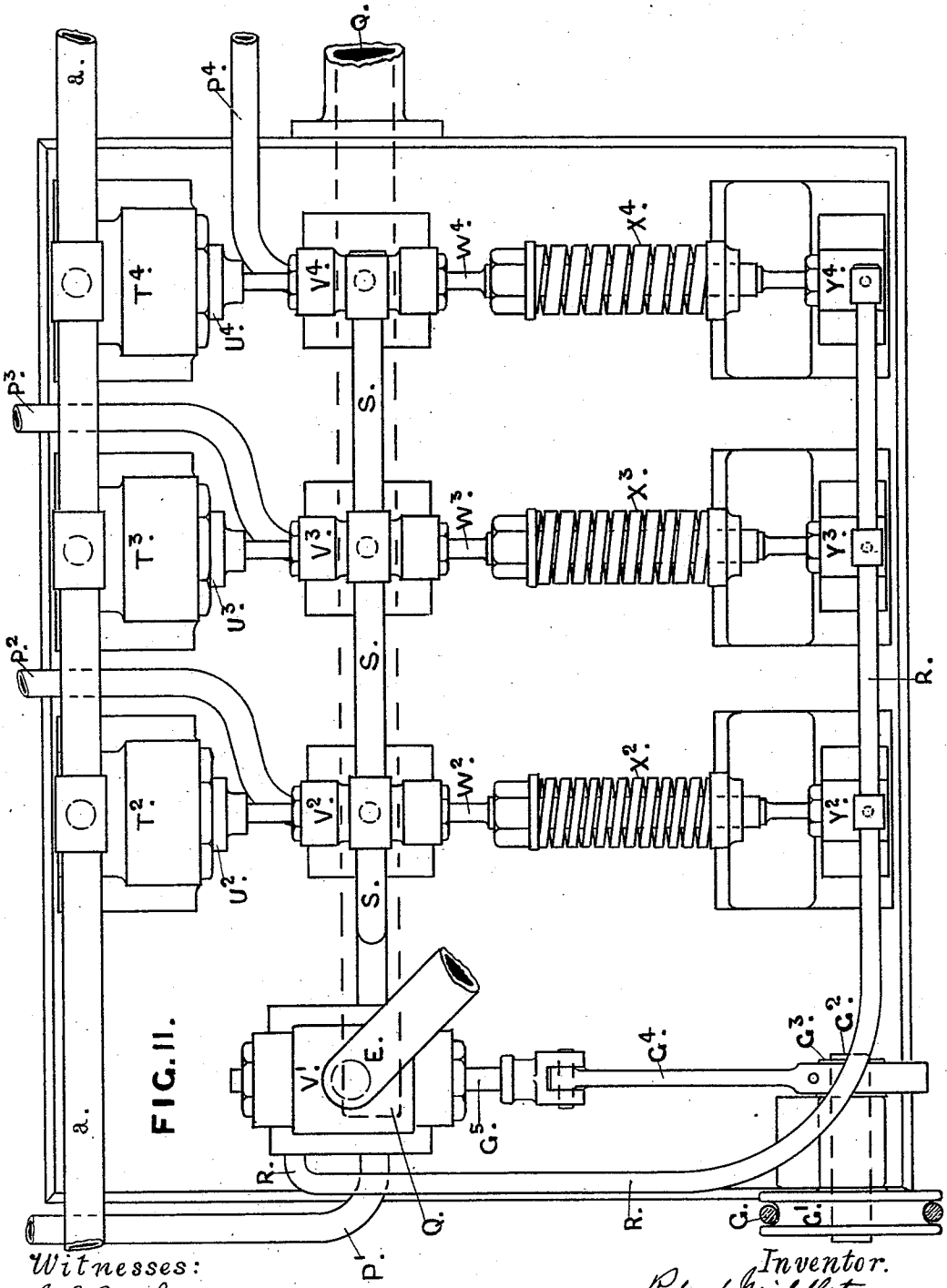

FIG. 11.

Witnesses:
E. C. Barker.
C. E. Butt.

Inventor.
Robert Middleton
per Fairfax & Wetter
Attorneys.

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

UNITED STATES PATENT OFFICE.

ROBERT MIDDLETON, OF LEEDS, ENGLAND.

HYDRAULIC APPARATUS FOR MOVING LOADS.

SPECIFICATION forming part of Letters Patent No. 475,588, dated May 24, 1892.

Application filed June 9, 1891. Serial No. 395,718. (No model.) Patented in England October 3, 1888, No. 14,200.

To all whom it may concern:

Be it known that I, ROBERT MIDDLETON, a subject of the Queen of England, residing at Leeds, in the county of York, England, have invented certain new and useful Improvements in Hydraulic Apparatus for Moving Varying Loads, (for which I have obtained Letters Patent for the United Kingdom of Great Britain and Ireland, No. 14,200, dated October 3, 1888,) of which the following is a specification.

The object of this invention is to produce economy in the use of hydraulic power or water under pressure, and it refers to the subdivision of the said power for moving varying loads or to loads receiving power and capable of returning a part thereof. Whenever the load is the maximum and is moved without a return load, or if none of the power exerted is given back, then there is no advantage accruing from the use of this invention. The peculiarities of the system adopted are those of subdividing the lifting-power into sections, (the more numerous the greater the prospect of economy,) the using such only as are necessary for raising the load, the running to the waste-tank (when lowering) of such sections only as are required to reverse the motion and lower the load, and the return of as much water as possible to the accumulator or supply-pipes.

The apparatus may be designed to suit either high or low pressure or long or short strokes.

In the accompanying drawings, Figure 1 is is a general elevation of a hydraulic elevator and the apparatus employed for working it. Fig. 2 is a plan of the same. Figs. 3, 4, 5, and 6 are enlarged details of the main valve and adjacent parts, of which Fig. 3 is a plan showing the ports and exits in the lower portion of the valve-box, Fig. 4 is a sectional elevation through the valve and one set of ports on the line X X, Fig. 5 is a general side elevation, partly in section, to show the valve and ports, on the line Y Y, and Fig. 6 is a plan of the valve. Fig. 7 is a side elevation of one of a series of automatic valves and gear connected therewith, the valve, distributing-ports, and a small auxiliary counterbalancing-cylinder being in section. Fig. 8 is an elevation of a short-stroke hydraulic elevator and its apparatus suitable for a freight-lift, and Fig. 9 is a plan section through the cylinders of the same. Fig. 10 is an elevation of a short-stroke hydraulic apparatus carrying multiplying-pulleys at the ends suitable for cranes, and Fig. 11 is a detailed view of the relative position of the valves and other automatic gear with their pipe connections.

My invention is applied as follows with reference to Figs. 1 and 2: A long-stroke lifting-cylinder A (shown broken off to save space) is connected with a short-stroke cylinder B, of equal cubical capacity, by a pipe *a*, which allows the water to flow from one cylinder to the other. A ram B′, working in the cylinder B, is prolonged upward to work in a third cylinder C, mounted above, the diameter of the latter being proportioned to the pressure in the accumulator to nearly balance the ram of the cylinder A, leaving, however, a sufficient margin of weight unbalanced to insure its gradual descent in a manner well known. The ram B′ carries a cross-head B^2 between the cylinders B and C, in which are mounted four rams working in corresponding small cylinders (called "actuating-cylinders") clustered around the balancing-cylinder C and of equal stroke thereto. The collective power of the four cylinders (respectively marked I II III IV) must overcome the maximum weight in the car of the elevator and all friction of the apparatus in lifting the car to the top of its stroke. When the car on the ram A′ is raised empty to bring down a load, then, for example, only one of the cluster of small cylinders need to be used for the purpose of such lifting. If the load is greater than the minimum, then two or more of the clusters of cylinders may be used to lift the elevator, according to the character of the load. An open overhead tank D is adapted with suitable pipe connections (not shown) to supply the cluster of actuating-cylinders when they are not supplied direct from the pressure-mains, and this tank is high enough to insure the water flowing freely therefrom. Suppose, for example, that the actuating-cylinder marked I has raised the elevator empty to a given height by water under pressure and the water remaining

in the said cylinder. The other actuating-cylinders of the group II III IV are also full of water, for they fill up from the tank D as their rams move with the cross-head B^2 in common with the ram of cylinder I. If a maximum load is now put on the elevator to be lowered, the load (disregarding friction) imposes a pressure within the four cylinders equal to that required to balance the said load. Therefore if cylinders II III IV are opened to the accumulator and cylinder I allowed to discharge into the tank D the power-water generated in cylinders II III IV will pass into the accumulator F for subsequent use. If a lighter load than the maximum is to be lowered, two or more cylinders must discharge into the tank.

The tank should be large, and if the principal work done is lifting it must have an overflow; but if the reverse is the case then a supply-pipe is required, as water will be drawn off and passed into the accumulator. Economy results, while lifting, in filling with power-water only those actuating-cylinders of the group required by the load, leaving the others to take their water from the tank, and while lowering discharging into the tank from such cylinders only as will allow the load to descend and causing the others to discharge into the accumulator. Any required number of actuating-cylinders may be used and the cylinders otherwise arranged without departing from the nature of the invention.

When lifting, controlling-valves are employed to admit power-water to the actuating-cylinders in a series, one after another, until the requisite power is obtained, and in lowering the valves pass as much water as possible to the accumulator, discharging into the tank only sufficient to allow the elevator to descend. This is done automatically.

In Figs. 1 and 2 a pipe E is shown, which conveys power-water either from pressure-mains or from an accumulator F to the chest of the main valve V′, and the said pipe is fitted with a back-pressure and stop valve E^2. A branch pipe E^3 from the main pipe E keeps the cylinder C constantly in communication with the accumulator F to partly balance the ram of the lifting-cylinder A. Each actuating-cylinder has its own controlling-valve; but V′ is the main valve, directly connected with the starting-rope G, working over the pulley G′, fixed on the shaft G^2, and when the rope is pulled by the attendant the valve V′ is operated as the first of the series, while the others are automatically put into action, as required, by the weight of the different loads. In lowering the valves are likewise automatically regulated to discharge water into the tank from the one or more cylinders employed, according to the nature of the load, as aforesaid. The valve V′, working in its valve-chest, which receives power-water from the pipe E, controls the supply for two sets of ports, as shown in detail in Figs. 3, 4, and 5, and is actuated by an eccentric G^3 on the shaft G^2, through the intervention of eccentric and valve rods G^4 and G^5, respectively. A pipe P′ communicates between the actuating-cylinder I and the exhaust-space under main valve V′ to pass water, as shown in Fig. 5, from the cylinder to the tank D, through the pipe Q and exhaust-port Q′ and indicates that the elevator is coming down. Another pipe R leads from the port R′ to communicate with a series of auxiliary cylinders Y^2, Y^3, and Y^4, attached to the ends of the automatic valve-rods, for a purpose described hereinafter. When the valve V′ is in mid-gear, all these ports are covered and the power-water cut off; but when thrown quite over the valve connects R′ to Q′ and opens P′ to the power-water in the valve-chest, and the elevator would then rise.

The valve V′ not only controls the ports R′, Q′, and P′ on the line Y Y, but also controls the ports S′ S^2 on the line X X within the same valve-chest, as shown by the plan, Fig. 3, the latter-named ports being shown, with the other half of the controlling-valve V′, by the section, Fig. 4. The ports S′ and S^2 both lead to the pipe S, and one of them is open when the valve is at the end of its stroke in either direction; but when in its mid-position the valve covers both these ports.

The pipe S conveys power-water to each successive valve V^2 V^3 V^4, and thence to the corresponding actuating-cylinder by pipes P^2, P^3, and P^4, respectively. Automatic apparatus (shown in elevation in Fig. 7 and in plan in Fig. 11) is applied to the valves V^2, V^3, and V^4 to regulate their respective actuating-cylinders. Assuming Fig. 7 to refer to the automatic gear of actuating-cylinder II, a pipe a^2 connects lifting-cylinder A to a cylinder T^2, used for balancing the pressure upon the valve-rod of V^2, which pipe establishes the same pressure upon the ram U^2 of cylinder T^2 that obtains in the cylinders A and B. The pressure upon U^2 is transferred through the prolonged valve-rod W^2 to the surrounding spiral spring X^2, the extreme end of the rod being reduced to receive a few pounds pressure within its surrounding auxiliary cylinder Y^2 whenever power-water is admitted therein. The strength of spring X^2 is regulated to keep the valve V^2 in the position shown in Fig. 7, so that the pipe P^2 is in communication with the exhaust-pipe Q (to the tank) through the ports p and q.

When the pressure in the pipe a (from the lifting-cylinder A) causes the ram U^2 to advance and compress the spring X^2 by means of the valve-rod W^2, the valve V^2 is made to uncover the port p, putting the pipes P^2 and S in communication, and thus through valve V^2 connecting S to the actuating-cylinder II. Similarly the automatic gear shown in Fig. 7 is adapted to the successive valves V^3 and V^4 and their actuating-cylinders, and each corresponding and successive spring to X^2 is regulated by an adjusting-nut to an increased

strain, so that as pressure rises in the lifting-cylinder A the ram U^2, having the weakest spring X^2, will be forced back first and the rams U^3 and U^4, (in cylinders T^3 and T^4, respectively,) with their springs X^3 and X^4 in succession as the pressure rises, while the reverse action takes place as the pressure falls. The relative arrangement of these parts are shown in Fig. 11. Supposing, for example, actuating-cylinder I, with its valve V′, exerts a pressure of two hundred pounds per square inch in the lifting-cylinder A with a maximum load, then the spring X^2 of actuating-cylinder II is forced back, and by its valve V^2 brings the said cylinder into action, the two exerting, say, four hundred pounds per square inch on the lifting-cylinder, and this not being sufficient spring X^3 is compressed, actuating-cylinder III is brought into action to assist in lifting the load, and so with the remaining actuating cylinder or cylinders (according to the number that may be employed) until the load is lifted. In the example given it is assumed that the elevator starts from the bottom with a full load; but it may start empty therefrom and gather loads as it rises from floor to floor, automatically bringing into action one after another of the series of actuating-cylinders. In coming to rest at any desired point the valve V′ would be closed automatically or by the attendant in any known manner, and this, by closing the ports S′ and S^2, cuts off the supply of power-water from the valve-chests of all the other valves of the series of actuating-cylinders.

In lowering a maximum load the attendant moves the valve V′ by the actuating-rope G into the position shown in Fig. 5, so that its actuating-cylinder I discharges into the tank. In doing so communication is made between the accumulator and the valve-boxes of V^2, V^3, and V^4 in order to return the contents of their respective actuating-cylinders to the accumulators, thereby producing economy. This is more clearly shown by considering how the actuating-cylinder IV discharges. The pipe P^4, corresponding to P^2 in Fig. 7, leads power-water into the valve-chamber of V^4, when the valve is pushed back to the end of its stroke by pressure within the balancing-cylinder T^4, corresponding to T^2, and travels thence through the pipe S and port S′, Figs. 3 and 4, to valve-chamber of V′, where it directly communicates with the accumulator F. When sufficient of the load has been removed to lower the pressure in the lifting-cylinder A, so that the last and strongest of the series spring X^4 has resumed its normal position and reversed its valve V^4, as in Fig. 7, the contents of its actuating-cylinder IV will be discharged into the tank D. This takes place when the descending load cannot overcome the accumulator-pressure. If other portions of the load are removed, the other valves one by one will be reversed in like manner, and when all the weight is removed the valves V^2, V^3, and V^4 would leave their waste-ports open to the tank, as in Fig. 7. In this position their respective actuating-cylinders are ready to take their water from the tank.

When valve V′ is moved into position (shown in Fig. 5) for lowering, its actuating-cylinder I exhausts into the tank through the port Q′, and power-water will pass through the port R′ and pipe R into the series of counterbalancing-cylinders Y^2, Y^3, and Y^4. Thus if ten-pound pressure per square inch be put on and it took, say, five hundred and ninety-five pounds pressure per square inch in the cylinder A to force back the spring X^4, the latter will resume the normal position and reverse the valve at, say, six hundred and five pounds pressure. Thus assuming the mean pressure per square inch required in the respective actuating-cylinders II, III, and IV as two hundred pounds, four hundred pounds, and six hundred pounds to bring them into action, the springs automatically reverse the valves V^2, V^3, and V^4 at, say, one hundred and ninety-five pounds, three hundred and ninety-five pounds, and five hundred and ninety-five pounds; but with the pressures given by the auxiliary cylinders Y^2, Y^3, and Y^4 the actuating-cylinders automatically come into action (when lowering) as the pressure falls from six hundred and five pounds to four hundred and five pounds and two hundred and five pounds, respectively.

In the event of a short lift only being required, as in Fig. 8, or in crane-work, as in Fig. 10, the actuating-cylinders may be grouped together and fixed close to their work. In such cases the short-stroked cylinder B with a cluster of actuating-cylinders and their rams, together with the pressure-pipe *a*, may be arranged on one side at a convenient distance, as in Fig. 10. The other cylinders and arrangements are shown in the general view, Fig. 8, all acting in the manner already described. To avoid unnecessary drawing, the cylinder B and its rams are omitted in Fig. 10.

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

1. In hydraulic apparatus for varying loads, the combination of a controlling main valve with one or more automatic valves acting in serial succession therewith, actuating-cylinders corresponding in number to the said main and automatic valves, a lifting-cylinder, and communicating pipe connections between the said valves and the said cylinders, substantially as and for the purpose described.

2. In hydraulic apparatus for varying loads, the combination of a series of actuating hydraulic cylinders operated by a controlling main valve and automatic valves in series therewith, with an open tank, water-pressure mains, or hydraulic accumulator, a lifting-cylinder A, equal-capacity cylinder B, balancing-cylinder C, and pipe connections, substantially as and for the purpose described.

3. In hydraulic apparatus for varying loads, the combination of a controlling main valve

with a series of automatic valves having corresponding balancing-cylinders and pressure-springs tensioned to act upon said automatic valves in serial succession, an equal number of actuating hydraulic cylinders to said valves correspondingly operated in serial succession by the said automatic valves, a main lifting-cylinder, and pipe connections between the said valves and the said cylinders, substantially as and for the purpose described.

4. In hydraulic apparatus for varying loads, the combination of a controlling main valve with one or more automatic valves acting in serial succession therewith, the said main valve consisting, essentially, of a valve-seat having two separate lines of ports, one line of two ports S′ and S² leading to the said automatic valves, the other line of three ports R′, Q′, and P′ leading to a counterbalancing-cylinder, to the tank, and to the actuating-cylinder, respectively, a valve-rod and valve operating over and controlling said lines of ports during each full stroke, an outer casing having a suitable stuffing-box for said valve-rod, and pipe connections, substantially as and for the purpose described.

5. In hydraulic apparatus for varying loads, the combination of a controlling main valve with a series of automatic valves having pressure-springs tensioned to act in serial succession, actuating-cylinders corresponding in number to said valves and controlled thereby, counterbalancing-cylinders acting upon said pressure-springs, a main lifting-cylinder, waste-tank, and pipe connections, substantially as and for the purpose described.

6. In hydraulic apparatus for varying loads, the combination of a controlling main valve with one or more automatic valves acting in serial succession therewith, an elevator-actuating cylinder corresponding to each valve, a waste-tank situated above said actuating-cylinders, and pipe connections between said cylinders and said automatic valves, between the tank and the main valve, and between said main valve and water-pressure mains, substantially as and for the purpose herein described.

7. In hydraulic apparatus for varying loads, an automatic valve-gear comprising the combination of a balancing-cylinder and ram connected to and operated by the pressure within the main lifting-cylinder, a valve-chest and seat with ports to an actuating-cylinder and to a tank, respectively, an actuating valve-rod extending through each end of said valve-chest and connected at one end to said ram and at the other end prolonged and reduced to serve as a ram, an auxiliary cylinder for said reduced end of the valve-rod, a pressure-spring acting upon said valve-rod, and pipe connections, substantially as and for the purpose herein described.

8. In hydraulic apparatus for varying loads, the combination of a controlling main valve with an automatic valve-gear comprising a balancing-cylinder, an auxiliary cylinder, distributing-valve, pipe connections, and pressure-spring, an elevator-actuating cylinder, a main lifting-cylinder, a tank, and pipe connections, substantially as and for the purpose herein described.

9. In hydraulic apparatus for varying loads, the combination of a series of actuating-cylinders with a main and a corresponding series of automatic control-valves, a lifting-cylinder A, an equal-capacity cylinder B, a balancing-cylinder C, and pipe connections, substantially as and for the purpose set forth.

10. In hydraulic apparatus for varying loads, the combination of a main lifting-cylinder A with a series of actuating-cylinders I II III IV, a main and automatic controlling valves equal in number to the said series of actuating-cylinders, balancing-cylinders T², cylinder B, equal in capacity to A, cylinder C, a tank D, situated above said actuating-cylinders, and pipe connections, substantially as and for the purpose herein described.

In testimony whereof I have signed this specification in the presence of two subscribing witnesses.

ROBT. MIDDLETON.

Witnesses:
HENRY CAWOOD EMBLETON,
WILLIAM LUSENDON.