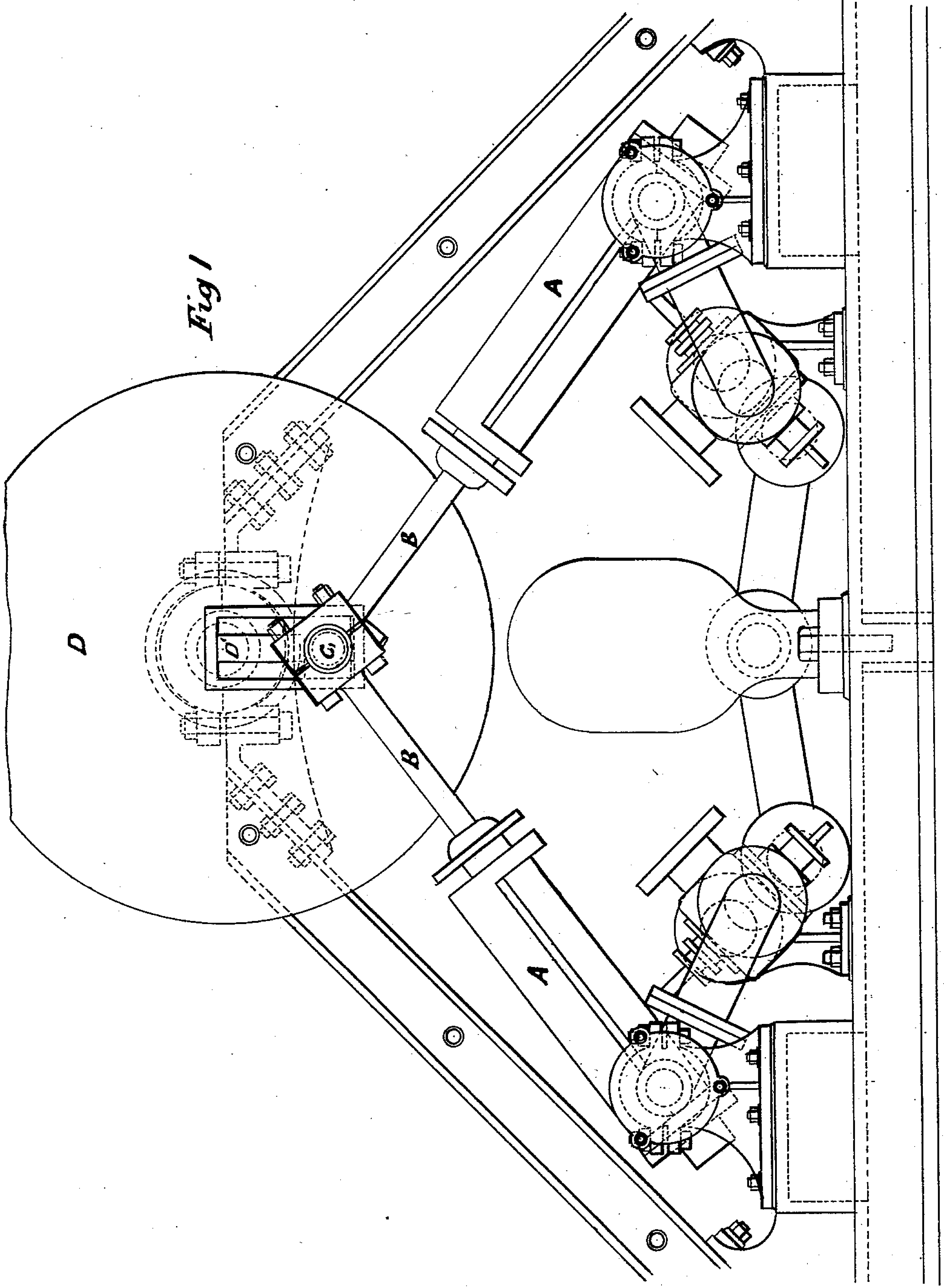
(No Model.)

8 Sheets—Sheet 1.

A. E. CUTLER & R. DONKIN.

HYDRAULIC COMPENSATING PUMP OR ENGINE.

No. 569,091. Patented Oct. 6, 1896.



Witnesses.
Thos. A. Green
Robert Everett.

Inventors.
Arthur E. Cutler
Reginald Donkin.
By James L. Norris.
Atty.

(No Model.)

8 Sheets—Sheet 2.

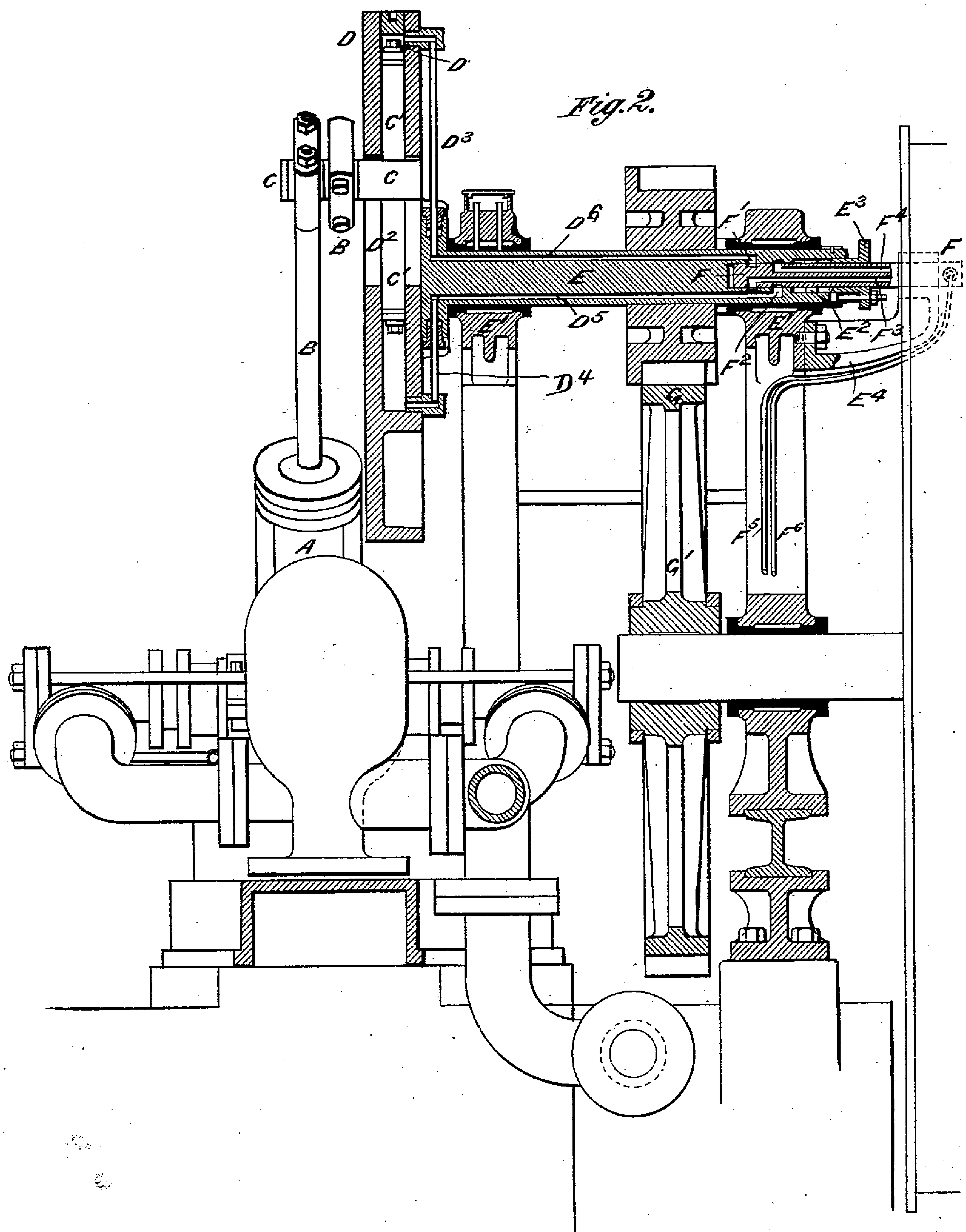
A. E. CUTLER & R. DONKIN.

HYDRAULIC COMPENSATING PUMP OR ENGINE.

No. 569,091.

Patented Oct. 6, 1896.

Fig. 2.



Witnesses.
Thos. A. Green
Robert Everett.

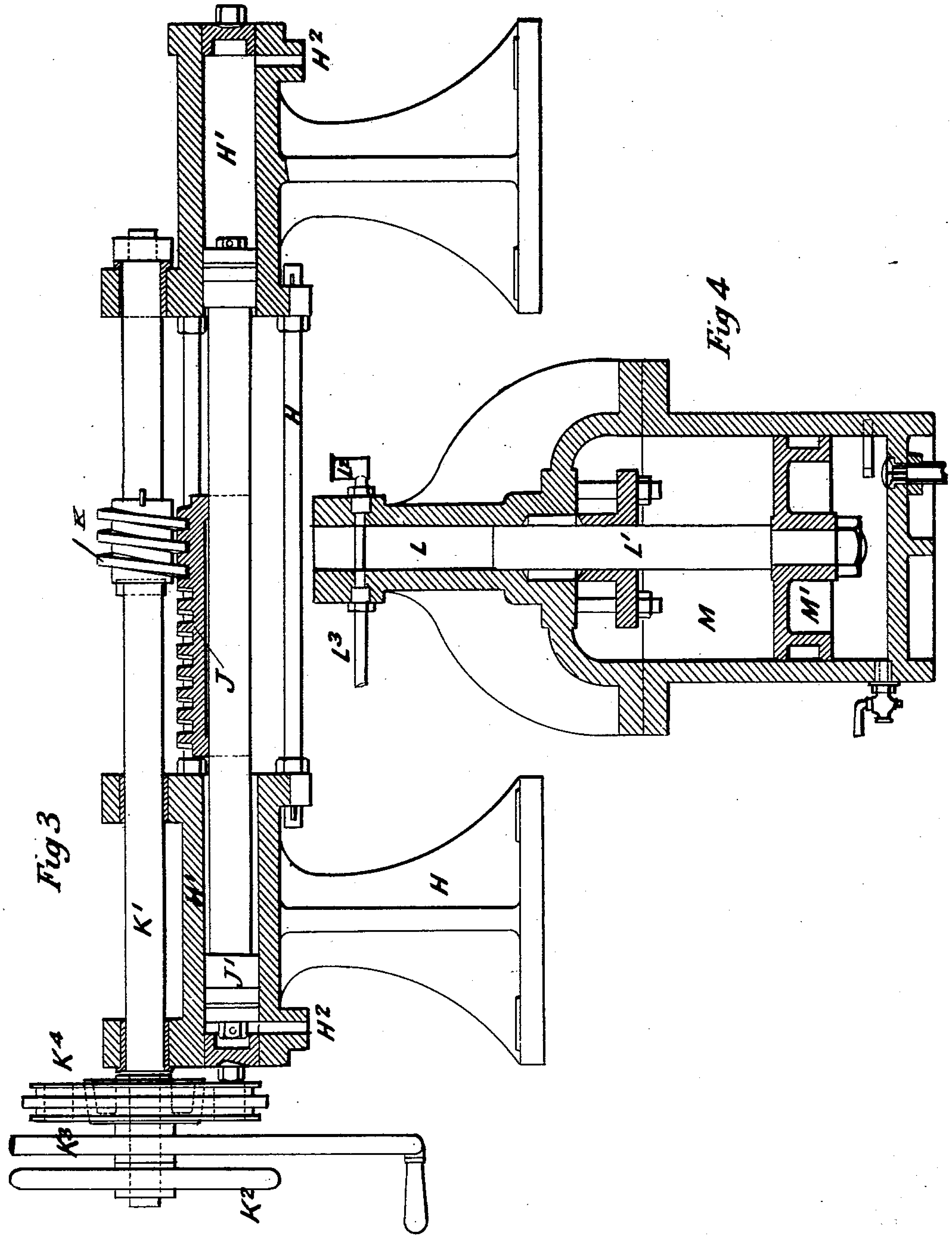
Inventors.
Arthur E. Cutler.
Reginald Donkin.
By James L. Norris.
Atty.

(No Model.) 8 Sheets—Sheet 3.

A. E. CUTLER & R. DONKIN.

HYDRAULIC COMPENSATING PUMP OR ENGINE.

No. 569,091. Patented Oct. 6, 1896.



Witnesses.
Thos. A. Green
Robert Everett

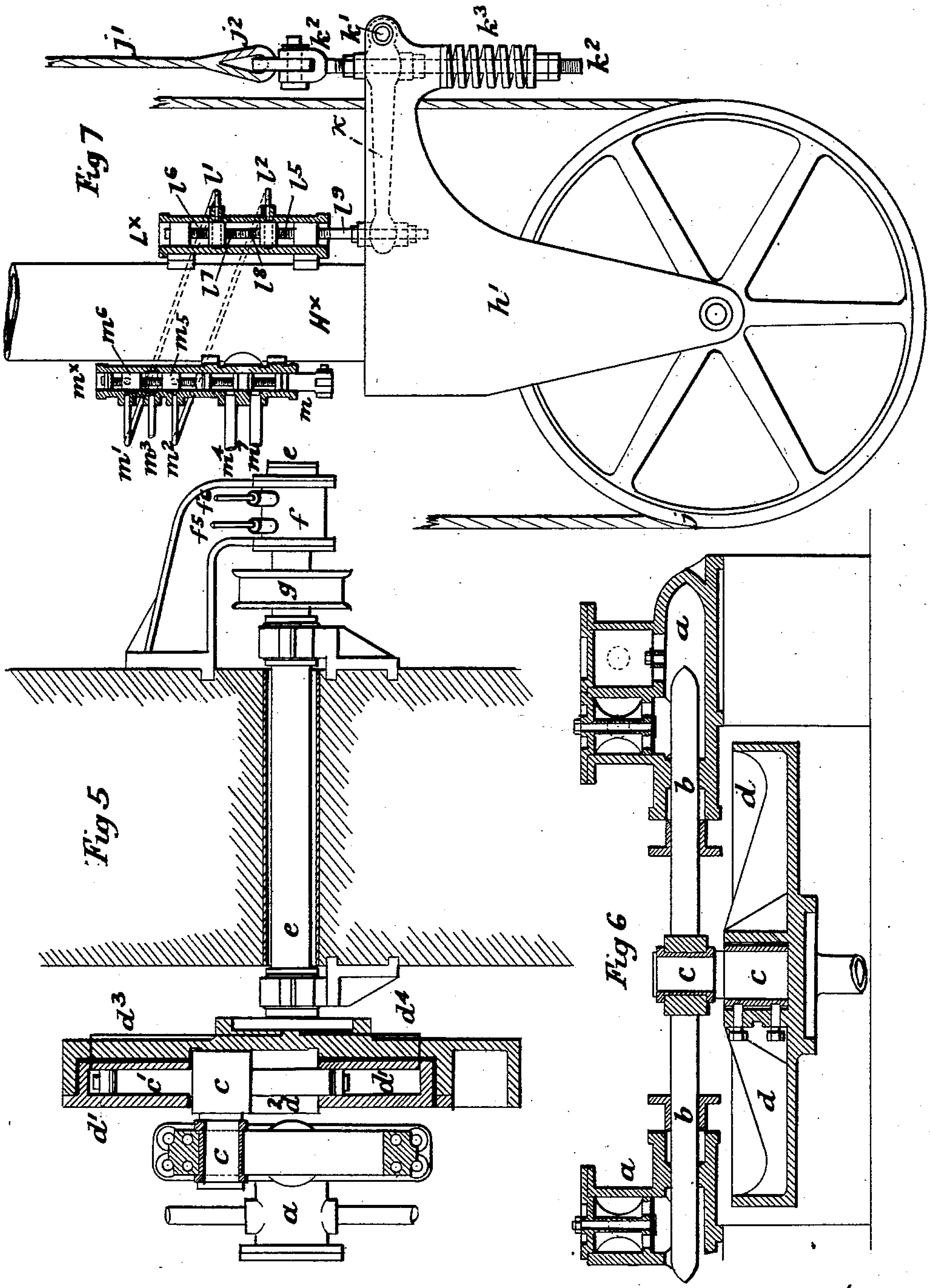
Inventors.
Arthur E. Cutler.
Reginald Donkin.
By James L. Norris.
Atty.

(No Model.) 8 Sheets—Sheet 4.

A. E. CUTLER & R. DONKIN.

HYDRAULIC COMPENSATING PUMP OR ENGINE.

No. 569,091. Patented Oct. 6, 1896.



Witnesses.
Thos. A. Green
Robert Everett

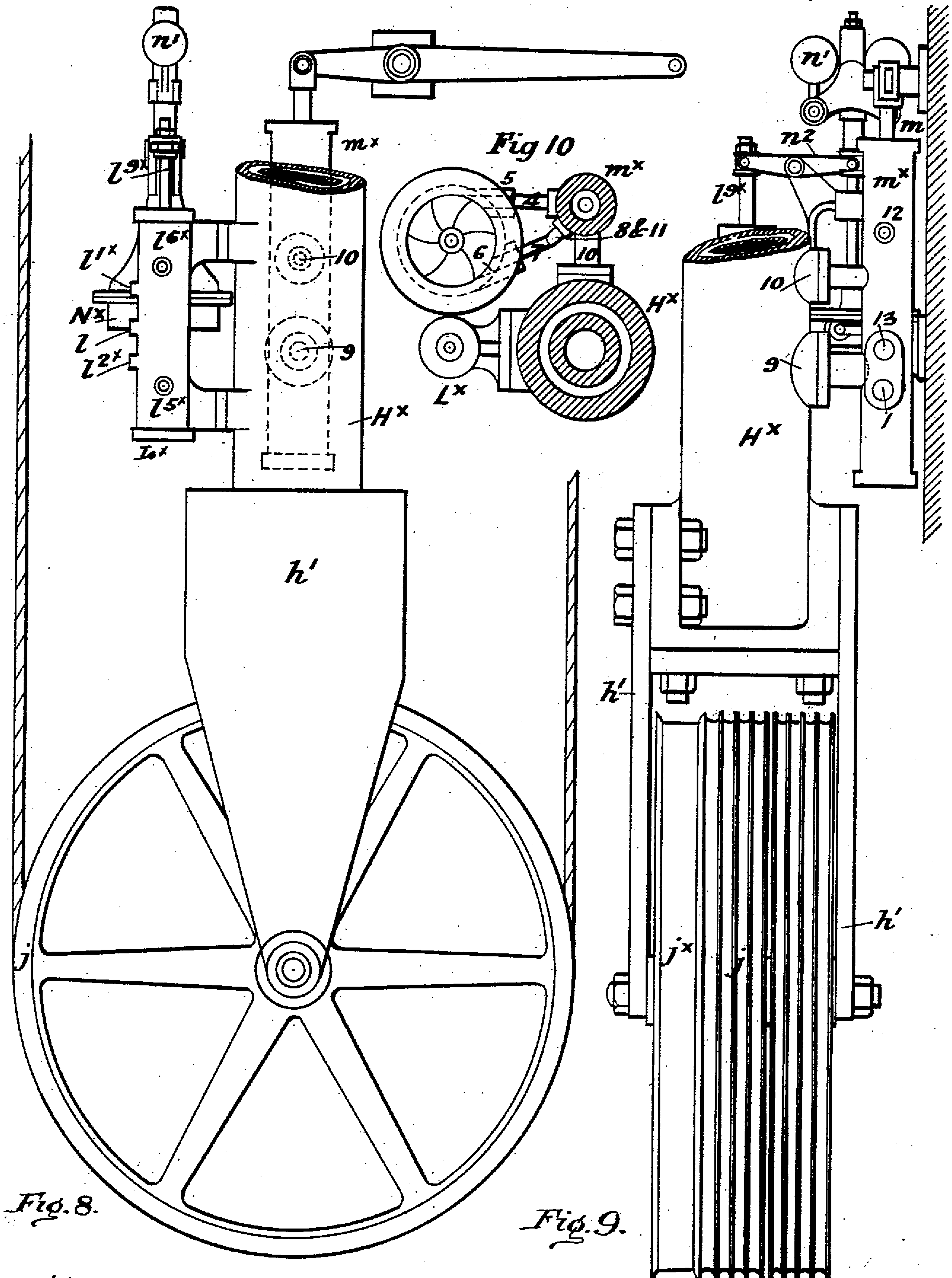
Inventors.
Arthur E. Cutler.
Reginald Donkin.
By James L. Norris.
Atty.

(No Model.) 8 Sheets—Sheet 5.

A. E. CUTLER & R. DONKIN.

HYDRAULIC COMPENSATING PUMP OR ENGINE.

No. 569,091. Patented Oct. 6, 1896.



Witnesses,
Thos. A. Green
Robert Everett.

Inventors
Arthur E. Cutler
Reginald Donkin.
By James L. Norris.
Atty.

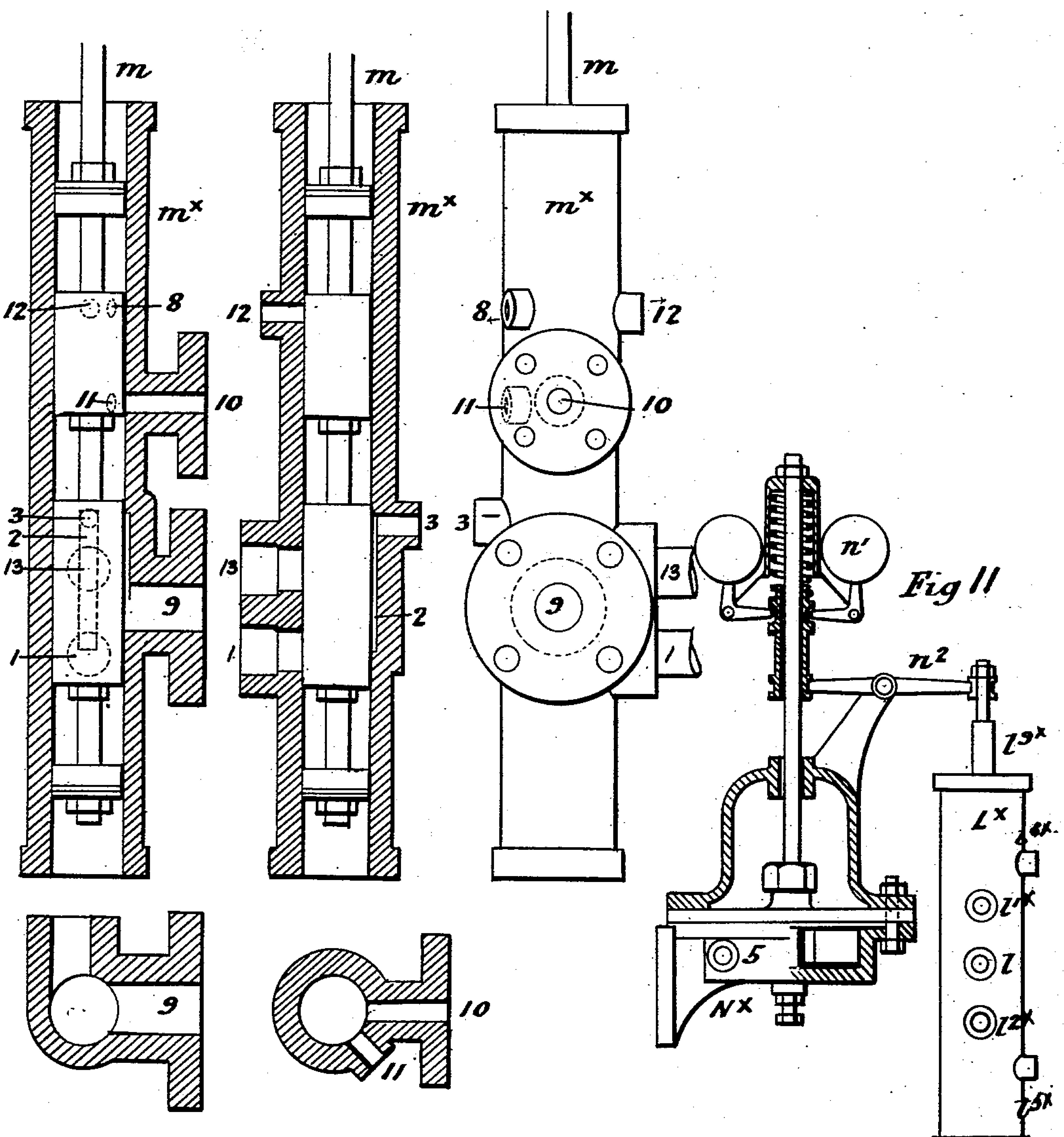
(No Model.) 8 Sheets—Sheet 6.

A. E. CUTLER & R. DONKIN.

HYDRAULIC COMPENSATING PUMP OR ENGINE.

No. 569,091. Patented Oct. 6, 1896.

Fig 12 *Fig 13* *Fig 14* *Fig 11*



Witnesses,
Thomas A. Green
Robert Everett,

Inventors
Arthur E. Cutler.
Reginald Donkin,
By James L. Norris.
Atty.

(No Model.) 8 Sheets—Sheet 7.

A. E. CUTLER & R. DONKIN.

HYDRAULIC COMPENSATING PUMP OR ENGINE.

No. 569,091. Patented Oct. 6, 1896.

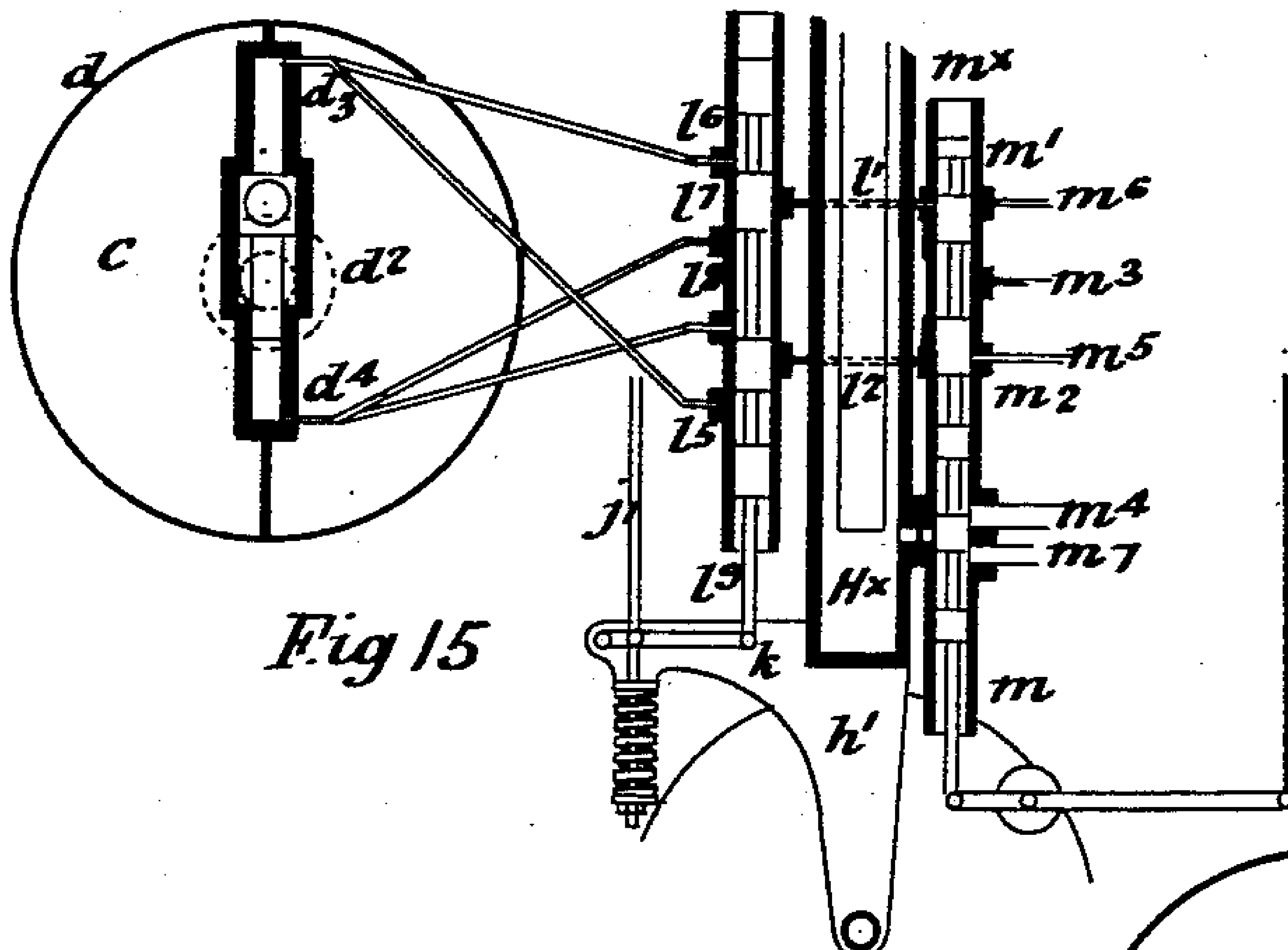
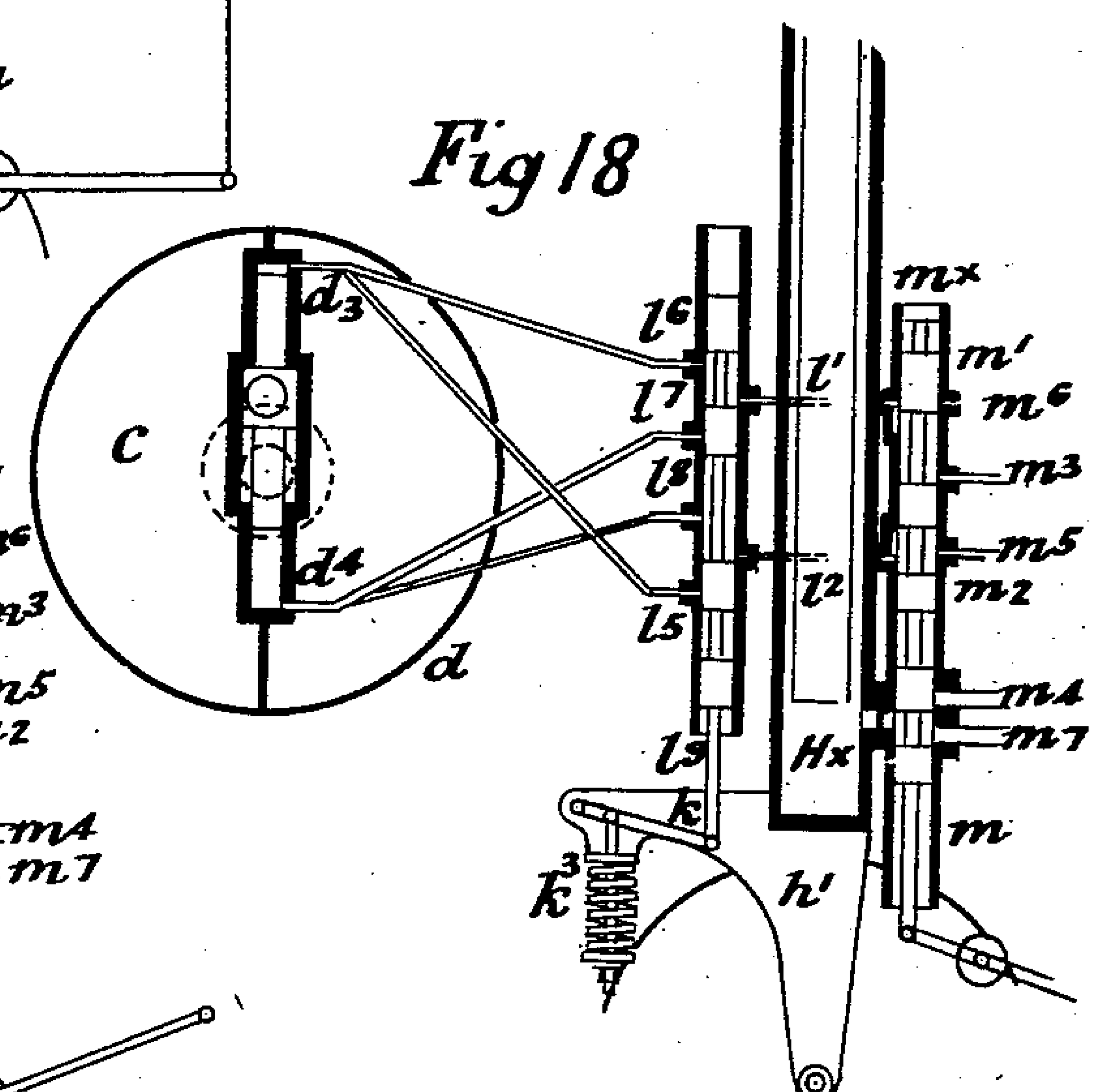


Fig 15

Fig 18



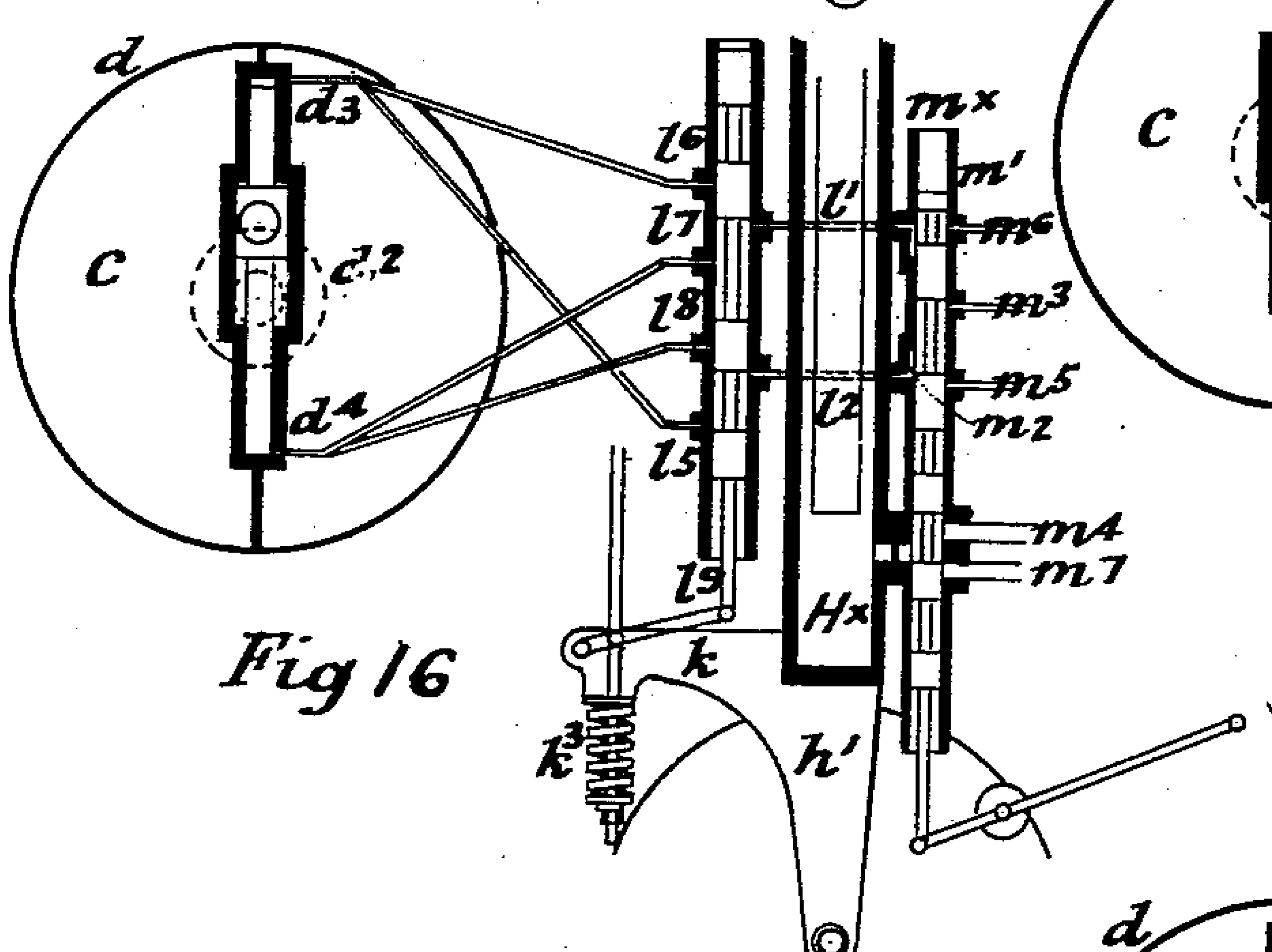


Fig 16

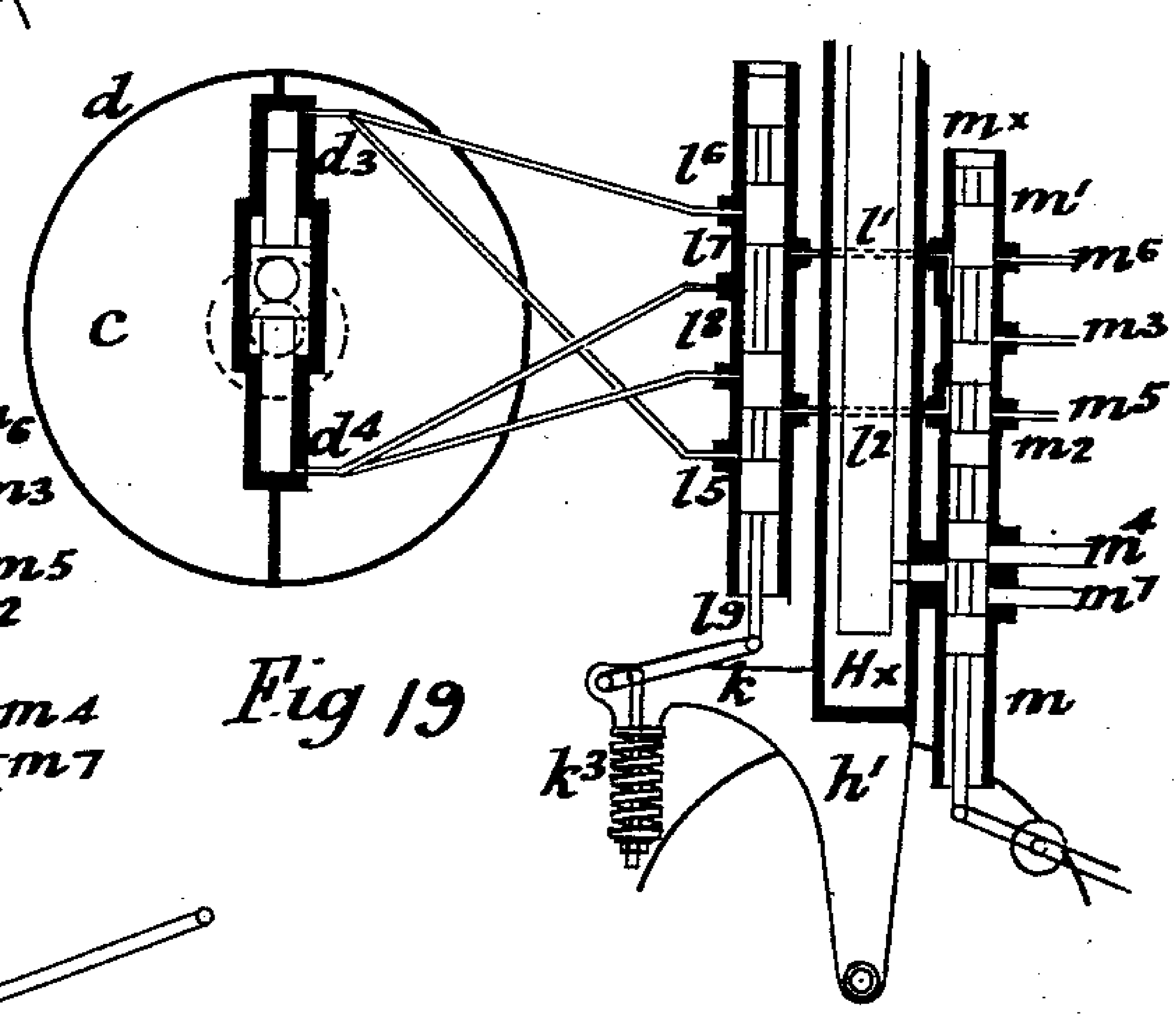


Fig 19

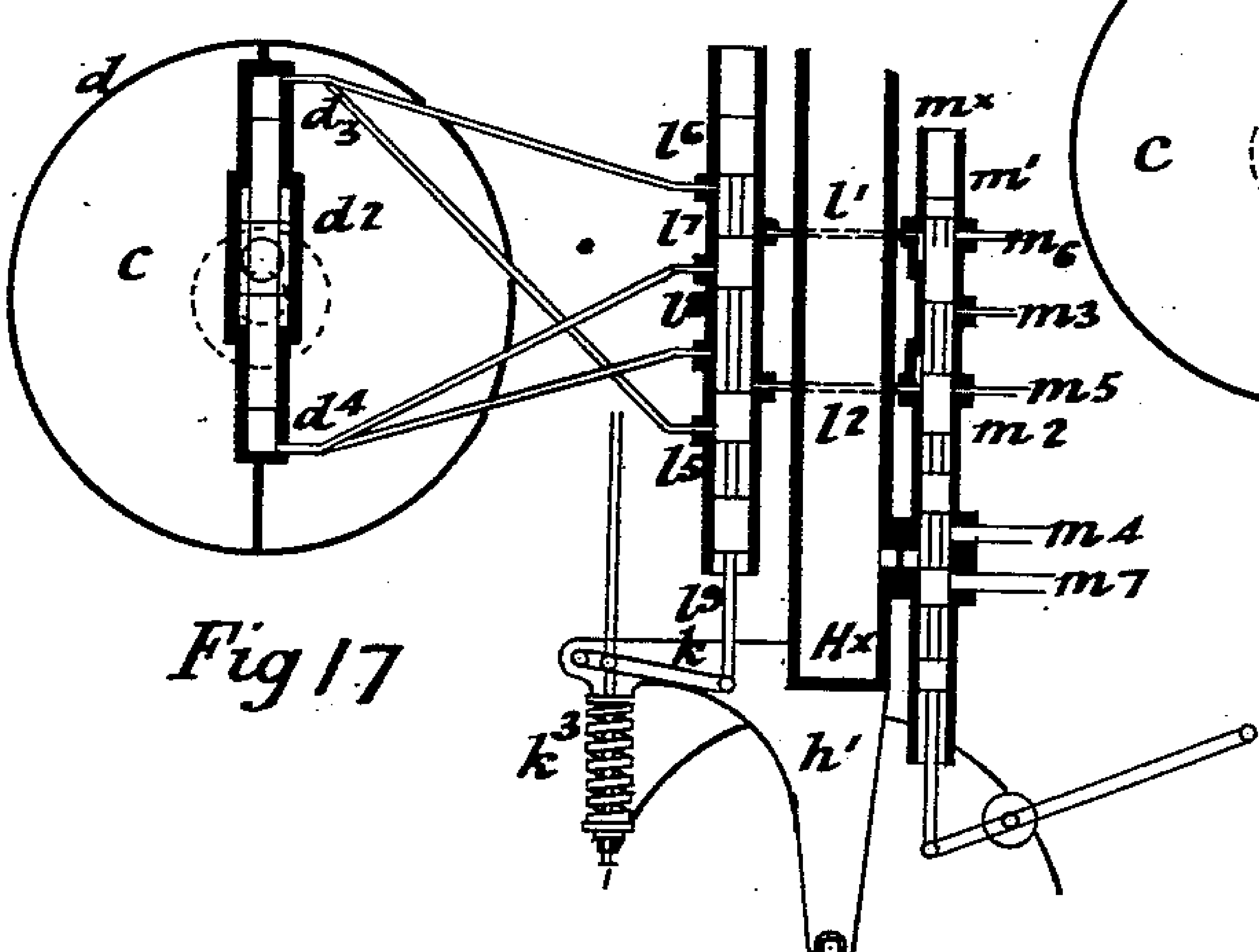


Fig 17

Witnesses.
Thos. A. Green
Robert Everett.

Inventors.
Arthur E. Cutler
Reginald Donkin.
By James L. Norris.
Atty.

(No Model.) 8 Sheets—Sheet 8.

A. E. CUTLER & R. DONKIN.

HYDRAULIC COMPENSATING PUMP OR ENGINE.

No. 569,091. Patented Oct. 6, 1896.

Fig 20

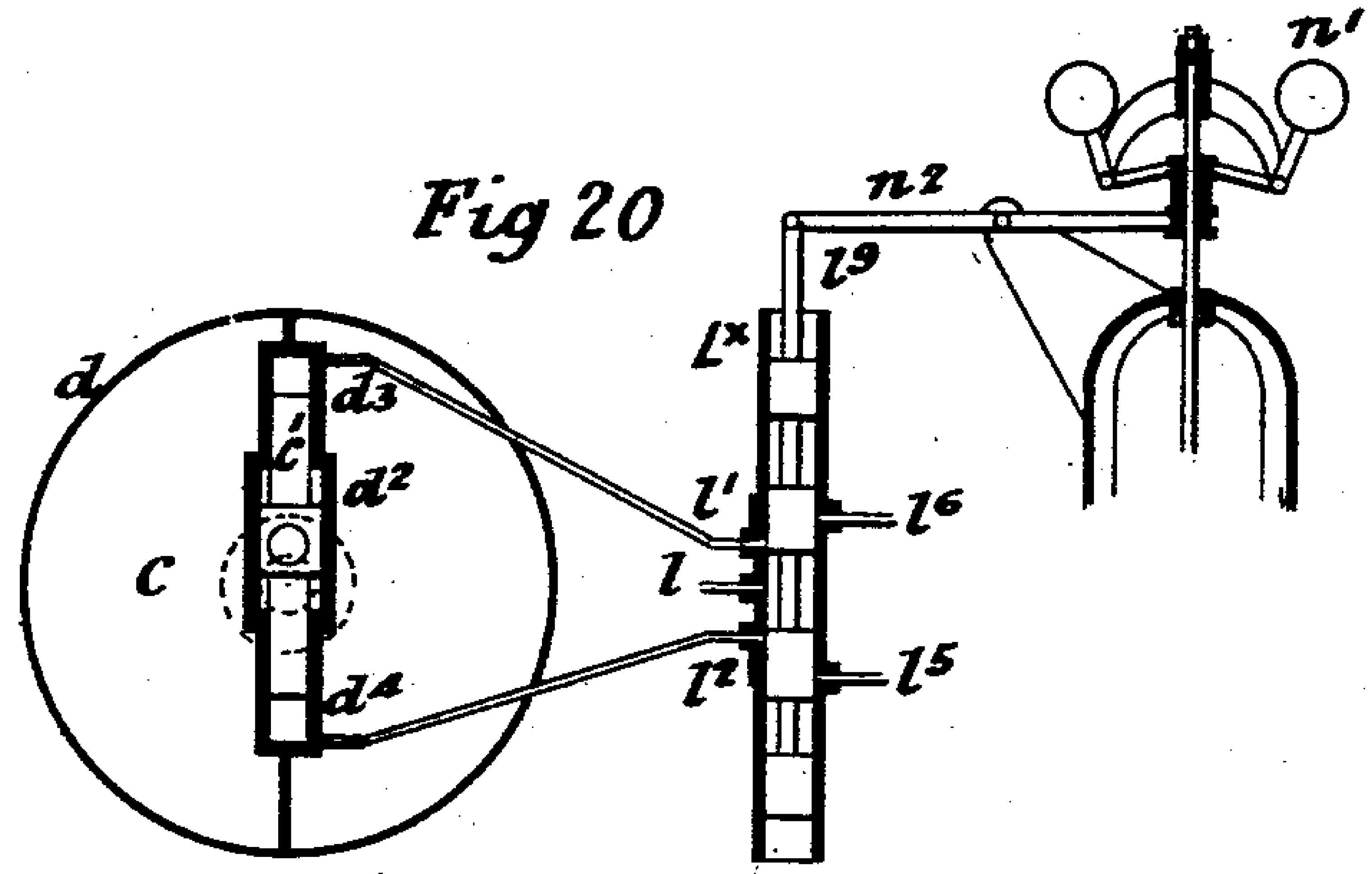


Fig 21

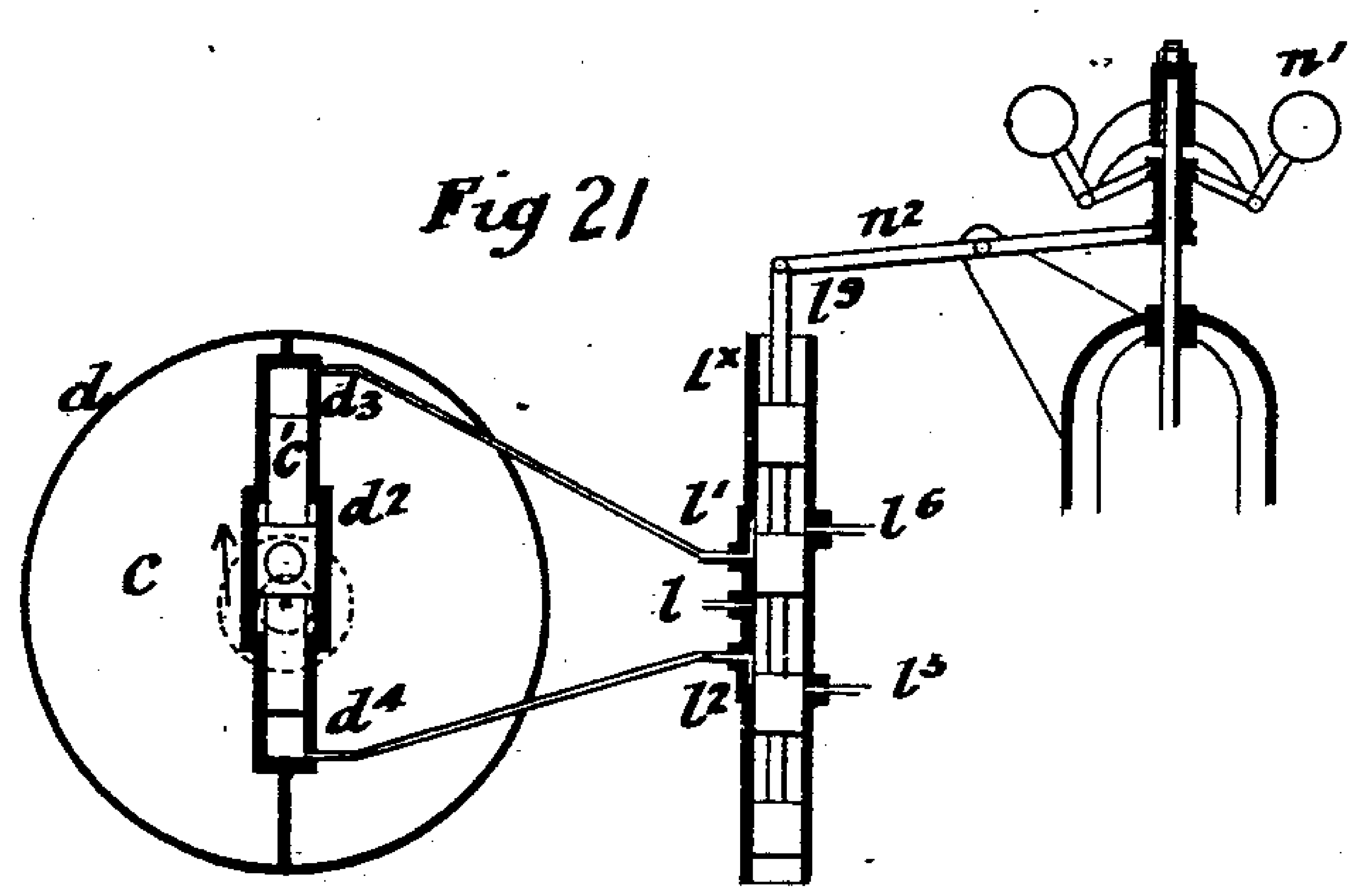
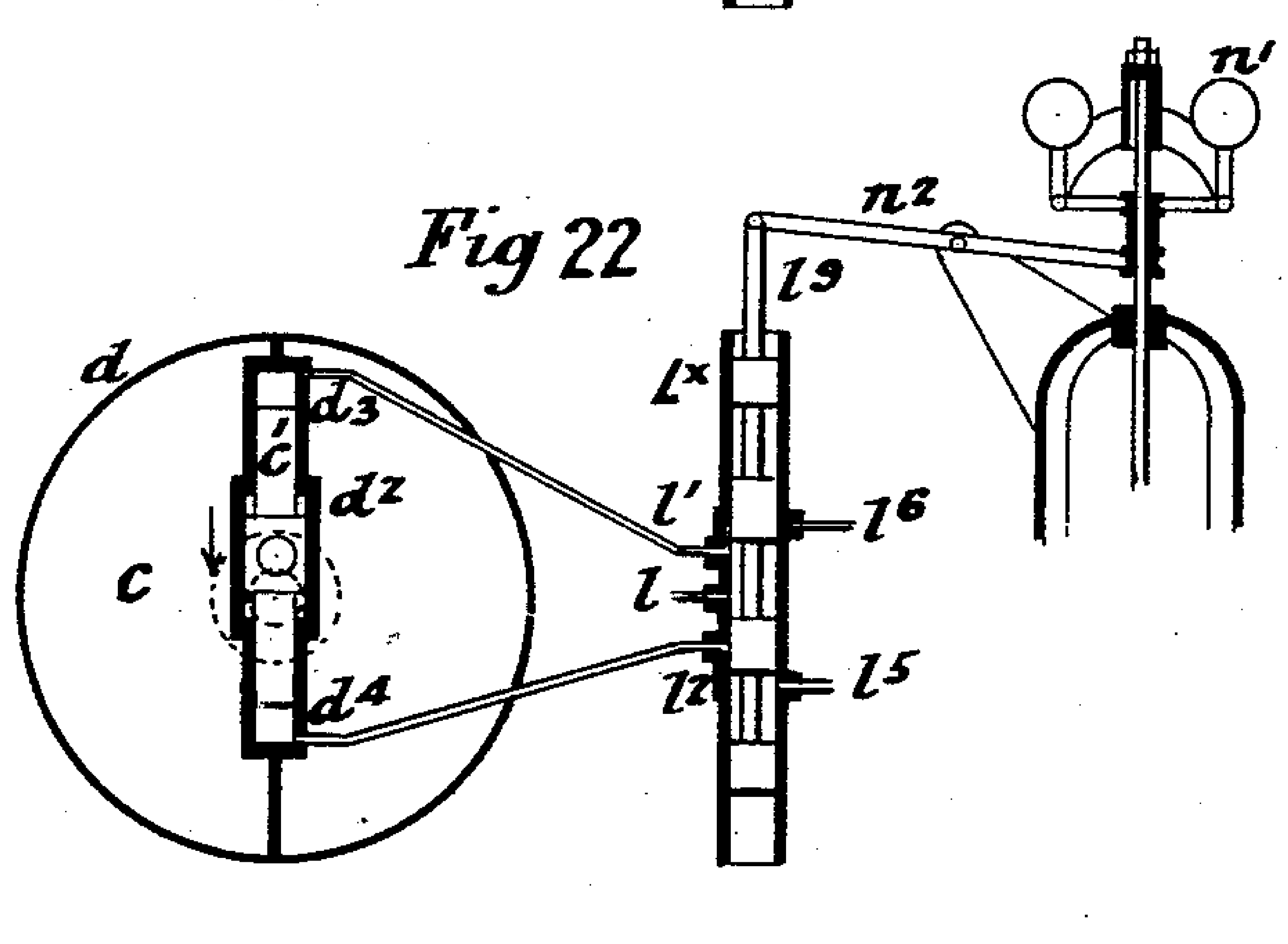


Fig 22



Witnesses.
Thos. A. Green
Robert Everett.

Inventors.
Arthur E. Cutler
Reginald Donkin.
By James L. Norris.
Atty.

UNITED STATES PATENT OFFICE.

ARTHUR EDWARD CUTLER AND REGINALD DONKIN, OF MOSMAN, NEW SOUTH WALES.

HYDRAULIC COMPENSATING PUMP OR ENGINE.

SPECIFICATION forming part of Letters Patent No. 569,091, dated October 6, 1896.

Application filed January 26, 1895. Serial No. 536,261. (No model.)

To all whom it may concern:

Be it known that we, ARTHUR EDWARD CUTLER and REGINALD DONKIN, engineers, subjects of the Queen of Great Britain, residing at Mosman, near Sydney, in the British Colony of New South Wales, have invented new and useful Improvements in Hydraulic Compensating Pumps or Engines and in Devices for Regulating Same, of which the following is a specification.

This invention relates to improvements in hydraulic compensating pumps and engines and in devices for regulating same, whereby the amount of power expended in such a pump or engine in performing work of varying extent or degree will be "compensated" or regulated by the requirements of the work to be done, or, in other words, the expenditure of power in raising loads of varying weights will be compensated or regulated in the ratio of said weights, and, further, where the work done is of a negative quantity, as where a load is lowered, the reservoir of power will be augmented in the ratio of the weight of said lowering load. This invention is specially serviceable for regulating the quantity of water used in hydraulic rotary engines, cranes, hoists, elevators, inclined tramways, and the like, according to the amount of work to be done in raising and lowering varying loads.

An improved hydraulic compensating engine or pump constructed according to this invention has a crank-pin which is held in the compensatory position in a radial slot in a disk or crank by means of hydraulic pressure acting upon a non-compressible fluid in a double-ended cylinder set radially in or forming part of the crank or crank-disk and whose ram is a double-ended extension of the crank-pin. The ends of this double-ended ram-cylinder are connected through the crank-shaft and a stationary plug in the end of said crank-shaft to regulating devices, which are adapted to be operated by hand or automatically, according to the work to be done or the varying resistance of the "load." The position of the crank-pin being thus alterable in the radial slot of the crank-disk or crank, either manually or automatically, the leverage of the crank is adjusted to the load. The regulating devices for the supply and exhaust of power from the double-ended ram-cylinder of the crank or crank-disk may take the form of a cataract or other hydraulic governor, by means of which a variation of pressure in the main cylinder will cause the desired alteration of crank-leverage, though, preferably, these devices would be of one or other of the improved constructions hereinafter described.

In order that this invention may be clearly understood, reference will now be made to the drawings herewith, in which—

Figure 1 is an elevation of a hydraulic engine (usable also as a hydraulic pump) constructed according to this invention, and Fig. 2 is a central sectional elevation of same. Fig. 3 is a central sectional elevation of regulating device or governor for an engine or pump such as that shown in Figs. 1 and 2, and Fig. 4 is a sectional elevation of a fluid-supply vessel or intensifier for use in connection with such regulating devices. Figs. 5 and 6 are elevations, partly in section and plan, respectively, of a hydraulic pump having an adjustable crank-pin which is automatically controlled by devices in connection with the ram of a multiplying hydraulic lift. Fig. 7 is a partial sectional elevation of the cylinder end of a multiplying hydraulic lift or hoist or crane having attached thereto devices for regulating a hydraulic compensating pump from same. Figs. 8 and 9 are front elevation and side elevation of a modified construction of Fig. 7; and Fig. 10 is a section through the turbine, the valve $m^{\times}$, and the ram above the head of the valve $L^{\times}$; and Fig. 11 is an enlarged detail, partly in section, of parts of Figs. 8 and 9. Figs. 12, 13, and 14 are sections and elevation of an auxiliary valve used in the regulating devices, and Figs. 15 to 22 are diagrammatic views of combination and arrangements of elevator-regulating devices and compensating hydraulic pump.

Referring to Figs. 1 and 2, A are the hydraulic cylinders with necessary valves, &c., as well understood, and B are the connecting-rods to the crank-pin C in or on disk D on end of crank-shaft E, running in bearings E', the whole having an appropriate framing. The crank-pin C extends radially in reference to crank-disk D outwardly and inwardly and takes the form of rams C′, working in cylinders D′ in or on disk D, in which at the front ends of said cylinders is a slot D^2. To the back ends of cylinders D′ the pipes D^3 and D^4 communicate from separate ports or passages D^5 and D^6, that extend longitudinally through the shaft E. These ports or passages communicate with ports or grooves F′ and F^2 in or on stationary plug F, which is held on the end of the shaft E by stuffing-box E^2 and gland E^3 and is supported by a bracket-arm E^4, to the outside of which are led the feed and exhaust pipes F^5 and F^6, which are continued in the plug F as ports or passages F^3 and F^4. The pipe F^6, passage F^4, port F^2, passage D^5, and pipe D^4 always constitute a through passage, while at the same time do also pipe D^3, passage D^6, port F′, passage F^3, and pipe F^5, the one end of such communications being the back of one of the disk cylinders D′ and the other end being the ends of regulating-cylinders, as in a cataract or other regulating devices or ports of such devices. The pinion G on the shaft E (shown in gear with wheel G′) is for transmitting the power to a hoist, &c., as well understood.

The crank-cylinders D′ and the passages and pipes connecting with same are filled completely with some incompressible fluid, preferably with heavy oil, so that pressure exerted in the regulating cylinders or devices will be transmitted to the rams C′ and the crank-pin C adjusted at any point in its possible movement in slot D^2.

The regulating device (shown in Fig. 3) consists of cylinders H′, connected firmly together by appropriate framing H. In these cylinders H′ are rams or pistons S′ on ends of one stem, which carries in its center a helical rack J. Working in rack J is a worm or endless screw K on spindle K′, having also thereon hand-wheels K^2 and K^3 and a friction-wheel or driving-wheel K^4, the cylinders H′ having sockets H^2 at their back ends connected by the pipes F^5 and F^6 to crank-cylinders D′, as before described, and they also are filled with the incompressible fluid. It is preferable, though not essential, in order to make up for any possible leakage in the plungers or passages to use an intensifier (see Fig. 4) consisting of a cylinder L with inlet L^2 and having therein a ram L′ and always communicating by pipe L^3 with one or other of the pipes F^5 and F^6. This ram is worked by piston M′ in cylinder M, whose end is in communication with the source of hydraulic power, so that, cylinder L being kept filled with non-compressible fluid, leakage, if any, will be constantly replaced and the rams C′ in crank-cylinders D′ kept effective in action.

Any motion given to the spindle K′, either by hand-wheels K^2 or K^3 or by the gearing-wheel K^4, which is driven by some automatic regulating devices actuated by the lift or by the spindle around which the load is hoisted, is by worm K and rack J transmitted to the rams J′ and by means of the connecting-pipes F^5 and F^6, as before described, to the crank-cylinders D′, where, the rams C′ being actuated, the position of the crank C is altered radially and its leverage made to suit the load to be lifted. Thus the amount of water consumed in and by the cylinders A, Figs. 1 and 2, is made proportional to the load. Further, when the engine is used where power may be conserved, as where a load is lowering, it (the engine) is converted into a pump drawing from the exhaust the amount of water commensurate with the work of the falling load and forcing it back into the accumulator or the pressure-main.

Referring to Figs. 5 and 6, the pump-cylinders a have plungers b connected to crank c, which has ram extensions c' in cylinders d' in crank-disk d. The ends of cylinders d' are connected by pipes d^3 d^4 and passages and ports through shaft e, stationary annulus f, and pipes f^5 f^6 to the controlling or regulating devices similar to those described and shown in reference to the engine of Figs. 1 and 2. The motion of the motive power-shaft is communicated to shaft e, and according to the force exerted is the position of the crank-pin c in radial slot d^2 adjusted, giving it more or less leverage and making the pump do more or less work. The motion may be communicated to the pump-shaft by belt or chain, or, say, preferably, friction-gearing, onto friction-pinion g.

A hydraulic compensating pump such as that shown in Figs. 5 and 6 in use with a hydraulic multiplying lift would have (see Fig. 7) a tension device at the end of the lift cylinders or ram $H^{\times}$, a friction or other gearing between the pulley-shaft and the pump-shaft, and a supply and exhaust valve worked by a tension device. The sheave-bracket h' holds, as well as sheaves j, an additional sheave, such as that marked $j^{\times}$ in Fig. 9, or a sprocket-wheel or a friction-wheel in gearing with the shaft of the pump, say by means of pinion g, (see Fig. 5,) so that such pump would work according to the power communicated from said sheave-pulley or friction-wheel. The adjustability of the crank of the pump is controlled by the tension on the rope or chain of the lift. In the sheave-bracket h' is the fulcrum k' of lever k, fixed to end bolt k^2 of the fixed end j^2 of hoisting-rope j'. This end bolt slides in bracket h' and terminates under said bracket, with spring or elastic buffer k^3 interposed. The end of lever k takes in adjusted position onto the spindle l^9, of an auxiliary valve $L^{\times}$, having ports l' and l^2 connected with ports m' and m^2 of the controlling-valve of the lift, whose spindle m is worked, as well understood, by cord through the elevator or lift car. This controlling-valve has a pressure-supply port m^3, so arranged that when port m' is in through communication with it then m^2 is in through communication with port m^5, and when port m^2 is in communication with it port m' is in communication with port m^6, these ports m^5 and m^6 being exhaust-ports. The ports l^5 and l^6 of the auxiliary valve are connected up by pipe f^6 and ports l^7 l^8 by pipe f^5 to the through-passages of the crank-shaft of a compensating hydraulic pump, as before described, thence to the crank-pin rams or cylinders of same by pipes d^3 d^4, respectively—that is, l^5 and l^6 connect to d^3 and l^7 and l^8 to d^4.

The attendant regulates the controlling-valve $m^{\times}$ by moving spindle m up or down, while the pull or tension on the rope j' by compressing or slackening spring k^3 moves lever k and regulates the auxiliary valve $L^{\times}$, the normal position of this latter valve $L^{\times}$ being shown in the drawings. Now in raising a heavy load the spring k^3 would be compressed and lever k be moved upwardly by the tension on the rope, (see Fig. 16,) valve-stem l^9 would move the valves thereon, and pressure enter the elevator ram-cylinder through port m^4, the port m^7 being the exhaust-passage from said ram-cylinder. Pressure-water would also pass to the crank-pin cylinders through pipes and ports m^3 m^2 l^5 and f^6 d^3 to the outer cylinder d', Fig. 5, while the other or inner cylinder d' would be open to through pipe d^4, pipe f^5, the through passage of the shaft-pipe l^7, and ports l', m', and m^6. This causes the crank-pin to move inwardly until lever k resumes its normal position with supply cut off to port l^5. The amount of water pumped back into the accumulator or pressure-main is therefore increased or decreased by means of the tension on the rope, and by this means when the car is ascending with a partial load the water which would be otherwise wasted is pumped back into main or accumulator, as also if the car is descending the water equivalent to the load is so returned to power reservoir.

Figs. 8 to 14 illustrate modifications of the regulating devices of a hydraulic compensating pump such as that shown in Fig. 5 when used in connection with a multiplying hydraulic lift. In this case the tension device is dispensed with and a speed-governor performs the function of regulating. The cylinder or ram $H^{\times}$ has bracket h', carrying actuating-sheave j' and additional friction-sheave $j^{\times}$ for working the pump. The controlling-valve $m^{\times}$ is worked by the attendant, while a speed-governor worked by turbine $N^{\times}$ actuates auxiliary valve $L^{\times}$ similar to that shown in Fig. 7, save that the ports l^7 and l^8 are dispensed with. Ports $l^{5\times}$ and $l^{6\times}$ are exhaust-passages to waste-water tank, and a supply-port l is made between the ports $l'^{\times}$ and $l^{2\times}$, which latter are connected to pipes f^5 and f^6, respectively, of hydraulic compensating pump.

The operations of the mechanisms shown in Figs. 8 to 11 will be more clearly understood on reference to the details of the valve shown in Figs. 12, 13, and 14. In raising a light load the spindle m of the valve $m^{\times}$ is moved upwardly, opening the port 1 to the pressure-water, which passes upwardly in groove port or passage 2 to port 3, whence, passing through pipe 4, it enters by way of port 5 the turbine $N^{\times}$, which it causes to revolve with a velocity proportional to the excess of pressure over the load to be raised. Flowing from the turbine, the water passes through pipe 7, having branches to both ports 8 and 11 of the valve, the former port 8 being closed through port 10 to the main ram or cylinder $H^{\times}$. The turbine $N^{\times}$ is at the same time revolving the governor-balls n', which lift and lower, as the case may be, the lever n^2 and move spindle $l^{9\times}$ of the auxiliary valve. When balls n' fly outwardly, owing to increase of speed, the valve-spindle is depressed and supply-port l communicates through port $l^{2\times}$, pipe f^5, through passage in shaft e, and pipe d^4 to inner crank-pin ram-cylinder d', while at the same time exhaust is open from the outer crank-cylinder d' through pipes d^3, through passage in shaft e, pipe f^6, port $l'^{\times}$, and exhaust-passage $l^{6\times}$ to waste-water tank. This action moves rams C' and forces crank-pin c outwardly from the center of shaft e, Fig. 5, and so increases the radial leverage or stroke of the pump, and therefore the quantity of water per stroke which it draws from the waste-water tank and forces into the accumulator or back into the main, which quantity corresponds to the excess of power exerted over the load lifted. When the valve $m^{\times}$ has been (by the attendant) placed in its highest possible position, as it is required for elevating loads, the supply-port 1 and port 9 freely communicate and a full volume of pressure will pass to the main ram $H^{\times}$, as well as the pressure-supply, by way of the turbine $N^{\times}$ through port 1, passage 2, pipe 3, ports 4 and 5, pipe 7, branch 8, port 11, and port 10.

In lowering a heavy load valve-spindle m is depressed and the water from the main ram $H^{\times}$ passes by way of passage 9, passage 2, port 3, pipe 4, and port 5 to the turbine $N^{\times}$, which it revolves similarly as before described with a velocity proportional to the excess of load over the normal load. Extra speed depressing the lever $l^{9\times}$, the pressure-water from port l passes, as before described, through port $l^{2\times}$, pipe f^5, and pipe d^4 to the inner crank ram-cylinder and leaves the outer crank ram-cylinder open per exhaust-passage $l^{6\times}$ to waste-water tank, thus causing the crank-pin c to move outwardly or increase its leverage, the exhaust-water of the main ram leaving the turbine $N^{\times}$ per port 6, pipe 7, and port 8, (branch 11 being closed,) and port 12 to the waste-water tank. When valve $m^{\times}$ is in its lowermost position, as in lowering loads, the passage 9 is open to port 13 and the exhaust from the ram-cylinder passes in volume to the waste-water tank.

From the foregoing descriptions and by the aid of the letters of reference to which such descriptions refer and which are placed upon the diagrams, it will not be necessary to state anything further in relation to Figs. 15 to 22, except to point out in general terms what each figure represents. Fig. 15 is a diagram of a hydraulic-lift-regulating devices and a hydraulic compensating pump driven from the gearing of said lift, and the arrangement is shown as when the mechanism is at rest—that is, neither lifting or lowering a load. Fig. 16 is a diagram of similar gearing with the mechanism as it would appear when a heavy load was being elevated, and Fig. 17 is the same when a light load is being elevated. Fig. 18 is a diagram showing the mechanism when a light load is being lowered, and Fig. 19 is the same when a heavy load is descending. Figs. 20, 21, and 22 are similar diagrams to the above with the modification of regulating devices in which a turbine and governor-balls take the place of a tension device, Fig. 20 showing the position of the mechanism when at rest, Fig. 21 the same when a light load is being raised or a heavy load is being lowered, and Fig. 22 the same when a heavy load is being lifted or a light load is being lowered.

Having now particularly described and explained the nature of our said invention and in what manner the same is to be performed, we declare that what we claim is—

In a hydraulic compensating pump or engine, the combination of a shaft geared for the transmission of power and having on one end a crank-disk provided with ram-cylinders and a radial slot communicating therewith, the said shaft and crank-disk having through-passages communicating with the ends of said ram-cylinders, the hydraulic cylinders and their plungers, a crank-pin connected with said plungers and provided with rams working in the ram cylinders of the crank-disk, automatic pressure-regulating mechanism communicating with the through-passages of the shaft and crank-disk for supply of fluid to and exhaust from the ram-cylinders to automatically adjust the crank-pin, and an intensifier adapted to communicate with said through passages intermediate the ram-cylinders and pressure-regulating mechanism substantially as described.

Dated this 21st day of December, 1894.

ARTHUR EDWARD CUTLER.
REGINALD DONKIN.

Witnesses:
THOMAS JAMES WARD,
MICHAEL JOSEPH CANDRICK.