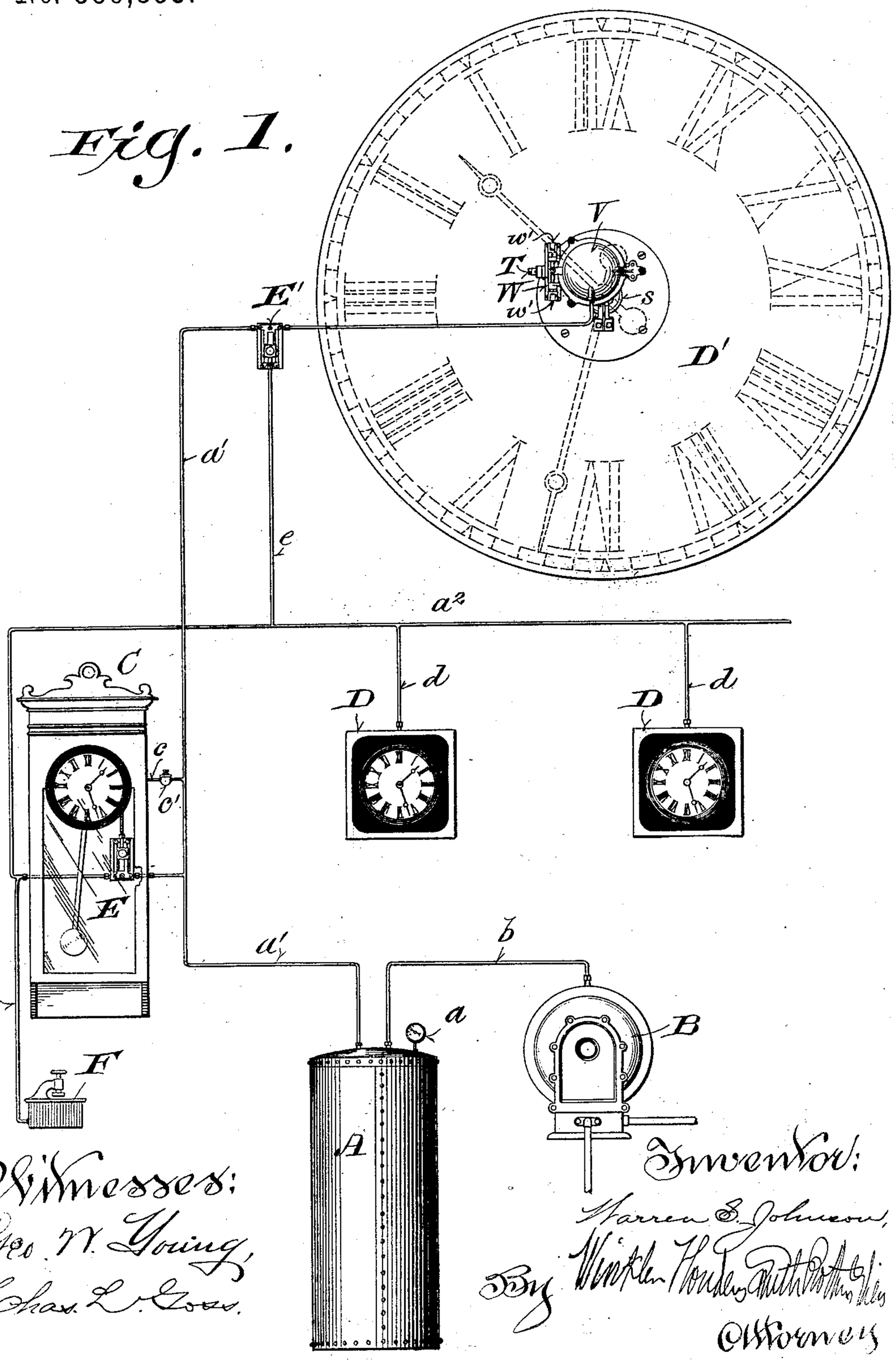
(No Model.) 4 Sheets—Sheet 1.

W. S. JOHNSON.

PNEUMATIC CLOCK SYSTEM.

No. 559,853. Patented May 12, 1896.

Fig. 1.



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(No Model.)

4 Sheets—Sheet 2.

W. S. JOHNSON.

PNEUMATIC CLOCK SYSTEM.

No. 559,853. Patented May 12, 1896.

Fig. 2.

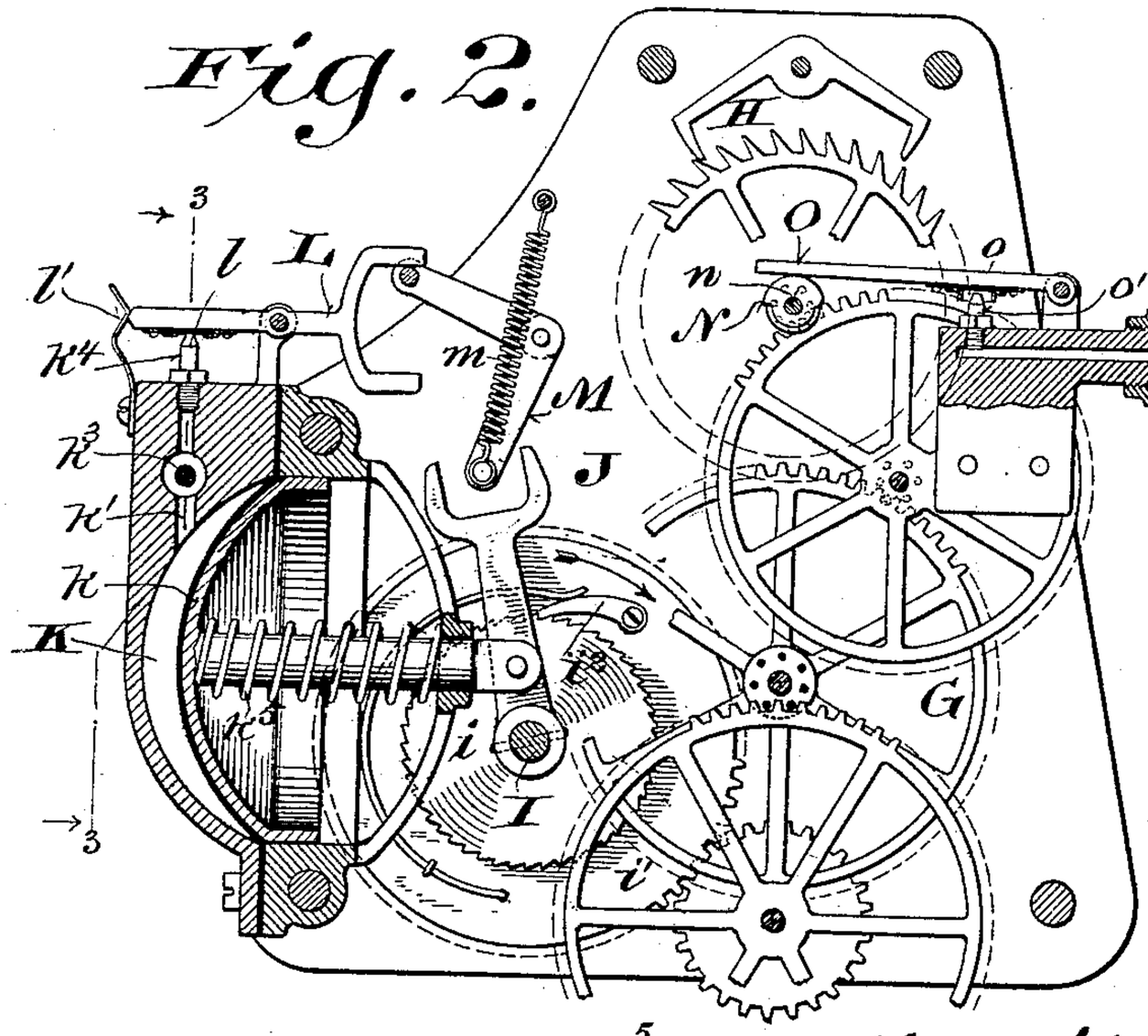

Fig. 4.

Fig. 3.

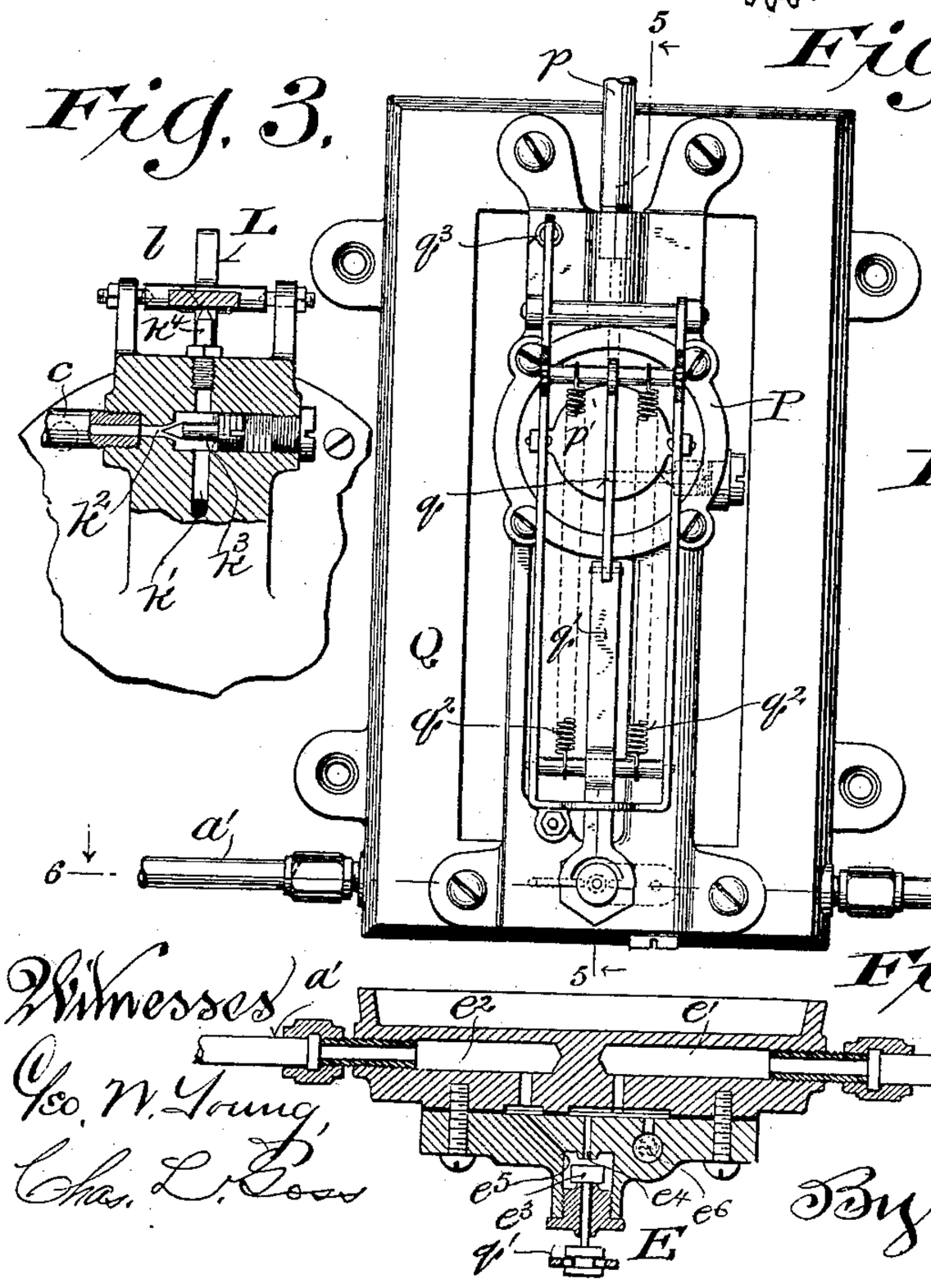

Fig. 5.

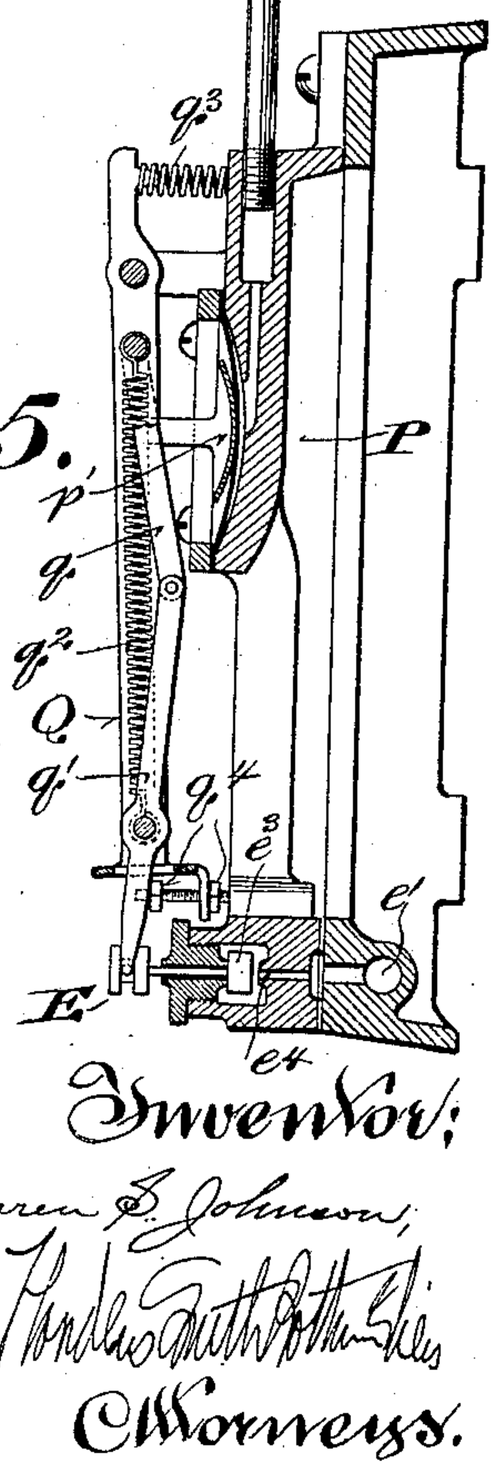

Fig. 6.

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4 Sheets—Sheet 3.

W. S. JOHNSON.

PNEUMATIC CLOCK SYSTEM.

No. 559,853. Patented May 12, 1896.

Fig. 9.

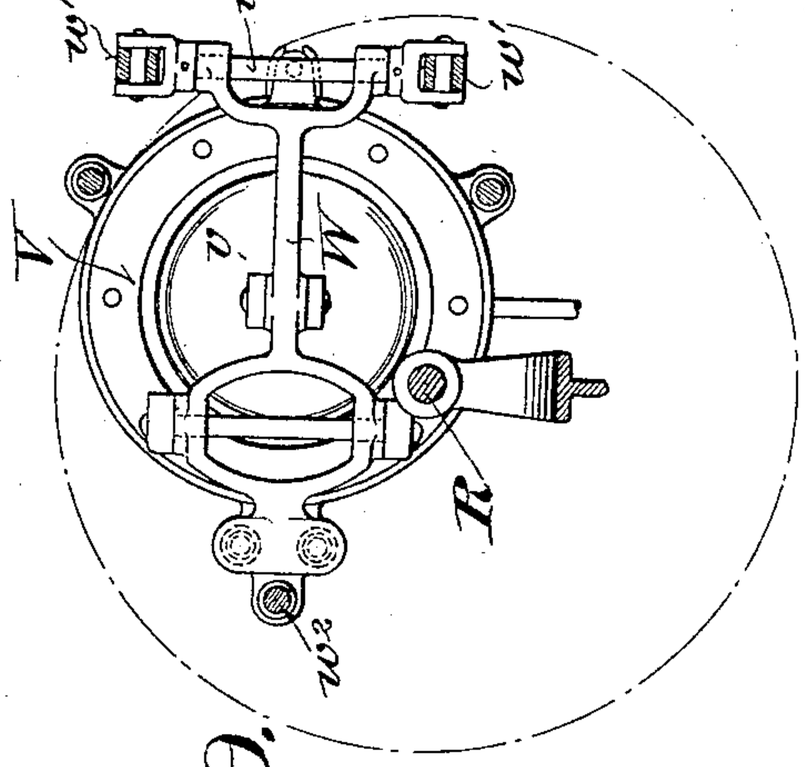


Fig. 10.

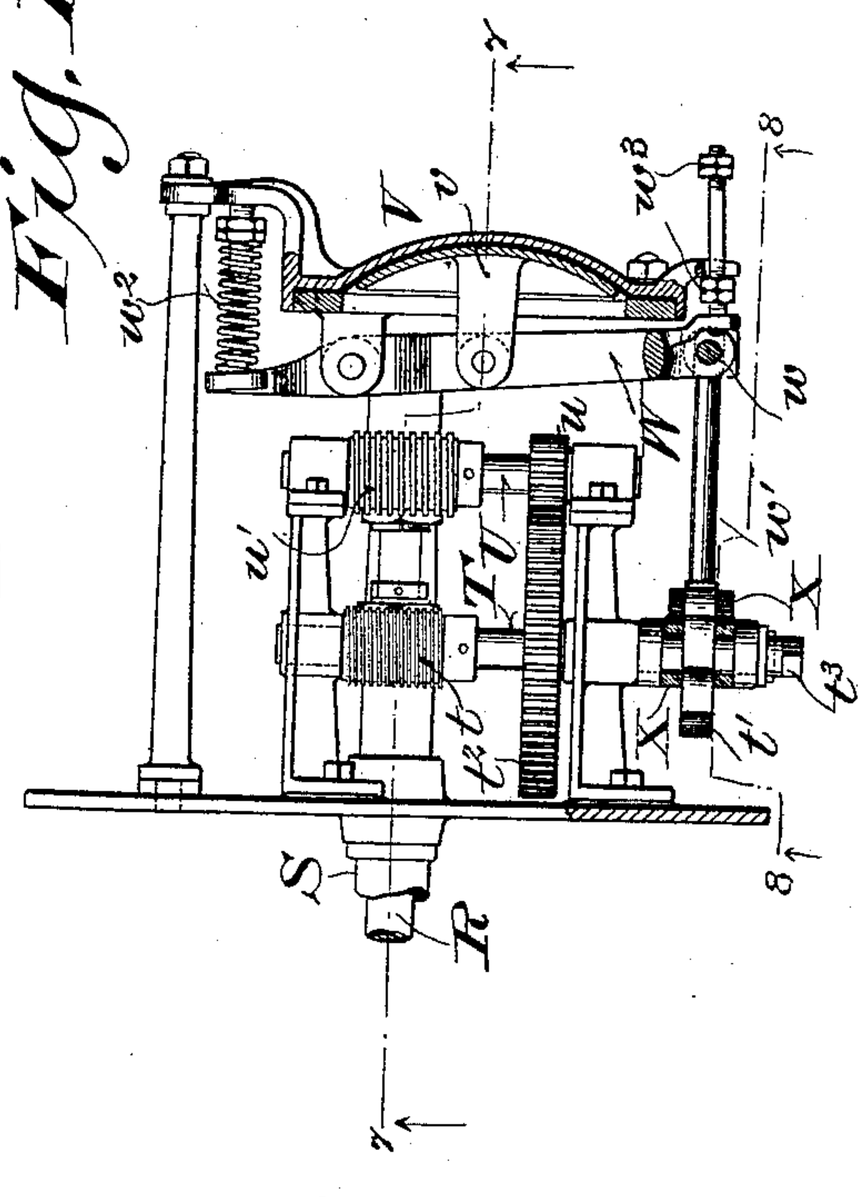


Fig. 7.

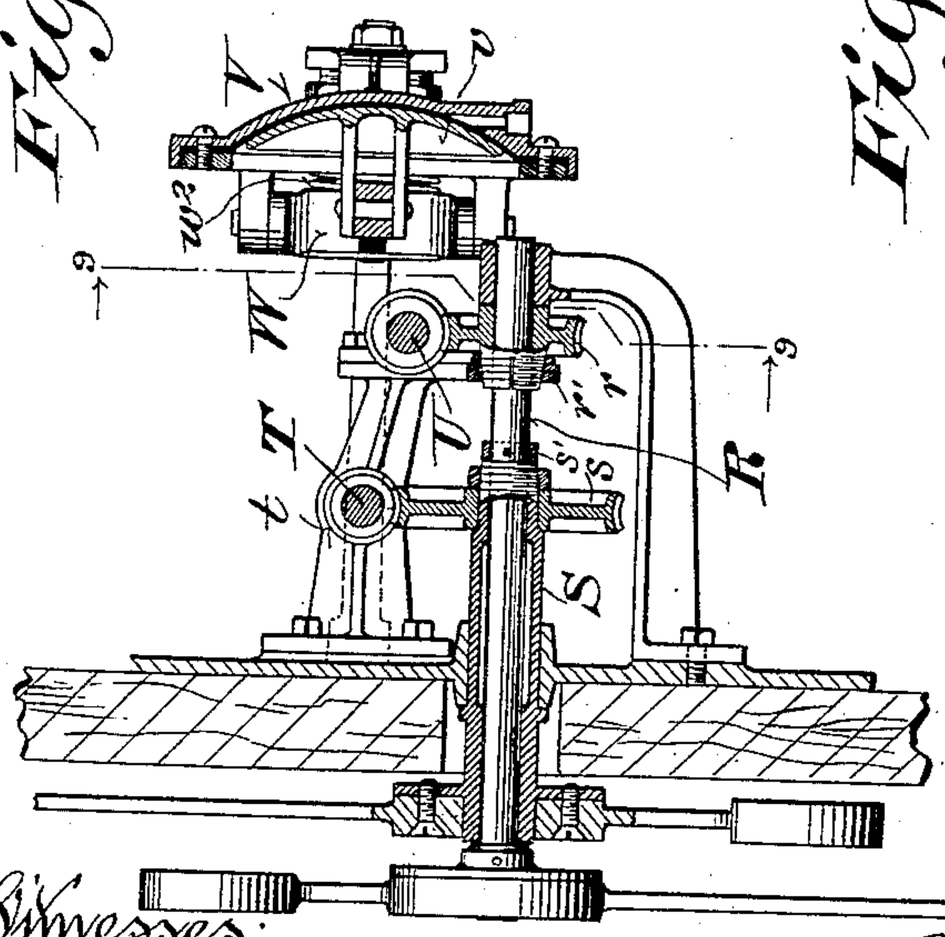
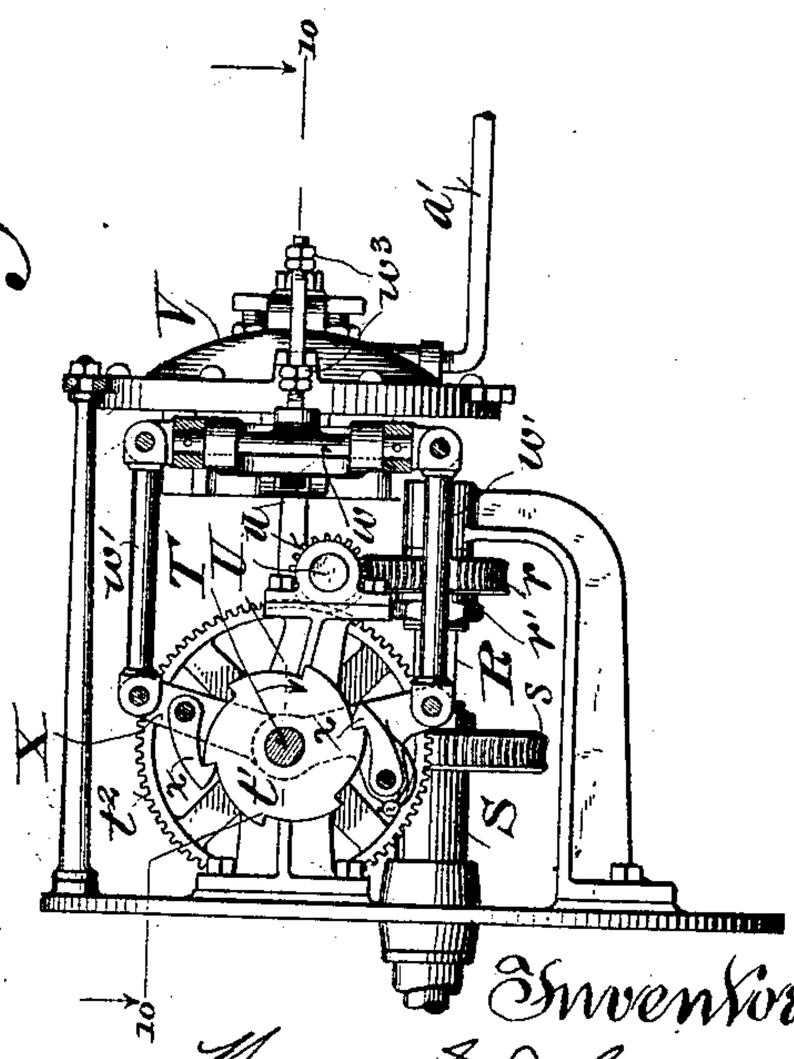


Fig. 8.



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(No Model.) 4 Sheets—Sheet 4.

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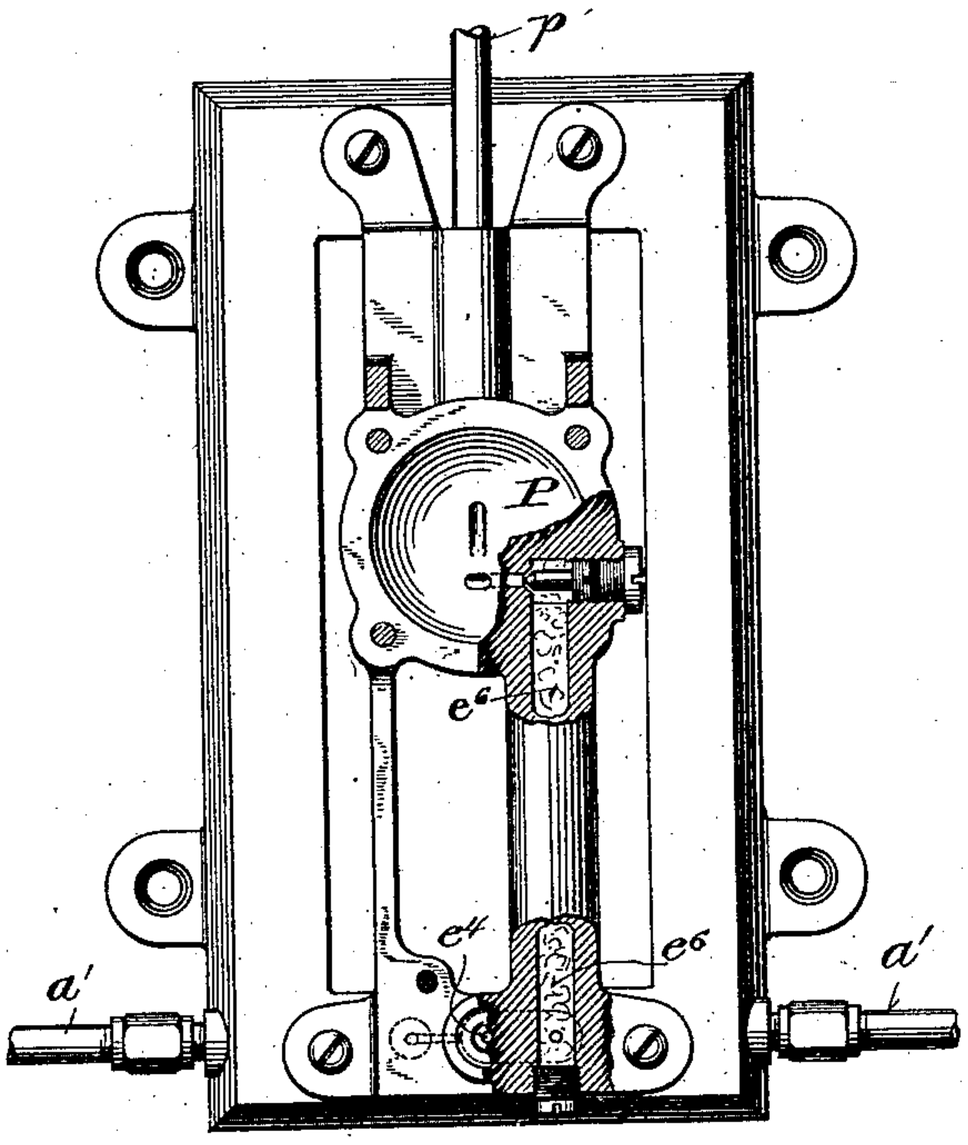
PNEUMATIC CLOCK SYSTEM.

No. 559,853. Patented May 12, 1896.

Fig. 11.



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UNITED STATES PATENT OFFICE.

WARREN S. JOHNSON, OF MILWAUKEE, WISCONSIN.

PNEUMATIC CLOCK SYSTEM.

SPECIFICATION forming part of Letters Patent No. 559,853, dated May 12, 1896.

Application filed October 15, 1895. Serial No. 565,707. (No model.)

To all whom it may concern:

Be it known that I, WARREN S. JOHNSON, of Milwaukee, in the county of Milwaukee and State of Wisconsin, have invented certain new and useful Improvements in Pneumatic Clock Systems; 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 pertains to make and use the same, reference being had to the accompanying drawings, and to the letters of reference marked thereon, which form a part of this specification.

My improvements relate to that class of time or clock systems in which one or more (usually a number of) time indicating or recording devices are actuated by air-pressure controlled by a chronometer or master-clock.

The main objects of my invention are to simplify and render more effective and certain mechanism for actuating the secondary clocks or time indicating or recording devices by pneumatic impulses and for controlling such impulses through the medium of a master-clock or chronometer; to operate the entire system, including the master-clock, by fluid-pressure, and thus dispense with the use of electricity; to dispense with the employment of weights or springs and winding and setting devices in the operation of the secondary clocks; to actuate the master-clock directly by substantially constant fluid-pressure without the intervention of springs or weights, thereby simplifying its mechanism and causing it to run more accurately; to subject the master-clock to as little work as possible in controlling the fluid-pressure impulses to the secondary clocks, and to enable the master-clock to directly control the fluid-pressure impulses to the secondary clocks by providing a sensitive secondary valve to be actuated by a part of the clock mechanism for controlling the supply of fluid-pressure in a motor that in turn operates the main supply and waste valve.

It consists of certain novel features in the construction and arrangement of component parts of the system, as hereinafter particularly described, and pointed out in the claims.

In the accompanying drawings like letters designate the same parts in the several figures.

Figure 1 is a general view of a complete system embodying my improvements. Fig. 2 is a partial section and elevation of the works of the master-clock. Fig. 3 is a sectional detail on the line 3 3, Fig. 2. Figs. 4, 5, and 6 are views on an enlarged scale of the main supply and waste valve, the motor associated therewith, and their connections, Fig. 4 being a front elevation, Fig. 5 a longitudinal section on the line 5 5, and Fig. 6 a cross-section on the line 6 6, Fig. 4. Figs. 7 to 10, inclusive, are views on an enlarged scale of the works of a secondary clock, Fig. 7 being a section on the line 7 7; Fig. 8, a section on the line 8 8, Fig. 10; Fig. 9, a section on the line 9 9, Fig. 7, and Fig. 10 a section on the line 10 10, Fig. 8; and Fig. 11 is a front elevation of a part of the device shown in Fig. 4, portions thereof being broken away to show the air-supply passage to the motor.

I am aware that pneumatic clock systems are not new and that various apparatus and devices have been patented in which secondary clocks are operated by air-pressure or vacuum produced or controlled by a master-clock. In some of these systems the fluid-pressure impulses are produced by the master-clock, and in others the fluid-pressure or vacuum is produced independently of the master-clock which controls the communication of the fluid-pressure impulses from their source to the secondary clocks. In the systems first mentioned the master-clock is required to do too much work. In those systems in which a source of fluid-pressure is provided outside of the master-clock, so far as I am aware, the master-clock has been made to operate a single supply and waste valve controlling communication between the source of fluid-pressure and the secondary clocks, or it has been made to trip a valve which is actuated by a motor independent of the clock mechanism to either directly or indirectly through another supply and waste valve and motor admit and release the fluid-pressure to and from the secondary clocks. In the first case the operation of the single direct-acting supply and waste valve requires more power for its operation than can be practicably furnished by a delicately-adjusted accurately-running timepiece. In the second case, where the master-clock simply trips

either a primary or secondary valve, which is operated by a motor independent of the clock, the valve-actuating connections are unnecessarily complicated and generally lack the delicacy and sensitiveness necessary for keeping accurate time.

In many of the systems heretofore proposed the fluid-pressure impulses are supplied at infrequent intervals to the secondary clocks, which consequently must be provided with springs or weights for storing the force thus supplied and continuously applying it during the intervals between the impulses to drive the clock mechanism and with winding and setting devices. In those systems in which winding and setting devices are dispensed with in the secondary clocks the fluid-pressure impulses must be supplied thereto at frequent intervals, and it is to this class that my improvements primarily relate. The fluid-pressure impulses in this case are necessarily controlled by one of the faster-running parts of the master-clock, and it is obviously impracticable to subject such parts to any work or resistance that would impede or affect their regular movement. It is therefore of prime importance that the part of the fluid-pressure-controlling mechanism which is immediately actuated by the clock should be extremely delicate and sensitive in operation, so as not to affect the accuracy of the master-clock and at the same time to produce the fluid-pressure impulses with absolute certainty and regularity.

Referring to Fig. 1 of the accompanying drawings, A designates a tank or reservoir for holding compressed air. It is provided with a pressure-gage *a* and connected by a pipe *b* with an automatic hydraulic air-compressor B or other source of fluid-pressure. C designates a master-clock, which may be directly actuated by fluid-pressure and for that purpose connected by a branch *c*, provided with a reducing-valve *c'* or pressure-regulating device, with the tank A or supply-pipe *a'*, leading therefrom to one or more of the secondary clocks. D D and D' are secondary clocks, any desired number of which may be connected by branch pipes *d d* with a common supply-pipe a^2, leading from the tank A or main supply-pipe *a'* and provided in or adjacent to the master-clock C with a supply and waste valve E. D' designates a tower or large clock connected with the compressed-air tank A by the main supply-pipe *a'* or a branch independent of the branch which supplies the smaller clocks, and provided with a pneumatic relay which consists of a supply and waste valve E', like or similar to the valve E in the pipe a^2, and of a motor connected by a branch *e* with the pipe a^2 and with the motors of the clocks D D and controlled in operation by the main supply and waste valve E. In connection with the secondary clocks I may operate one or more pneumatic dating-stamps, as F, which may be connected with the supply-pipe a^2 by branch pipe *f* and controlled in operation by the master-clock through the main supply and waste valve E. A separate supply-pipe and relay is provided for the larger clock, the operation of which requires more power than the smaller secondary clocks, to prevent its consumption of power at the expense of the smaller clocks and also to prevent condensation by reason of great variation in the temperature to which the supply-pipe is exposed, the tower or large secondary clock being usually located at a considerable distance from the master-clock and exposed to greater variations in temperature.

Referring to Fig. 2, showing the works of the master-clock, G designates the time-train of gearing, comprising an escapement H, through which the running of the train is regulated by a pendulum or balance (not shown) in the usual manner. I is the main driving-arbor of the train, provided with a ratchet-wheel *i*, fixed thereon, and a driving-gear *i'*, loosely mounted thereon and carrying a dog i^2, which engages with said ratchet-wheel, causing it to turn said gear in the direction indicated by the arrow. J is a forked arm also fixed upon the driving-arbor and pivoted to the plunger or movable part *k* of an expansion-chamber K. The chamber K has a fluid supply and waste connection through the passage *k'*, which communicates with the supply-pipe *c* through a port k^2, controlled by a valve k^3, as shown in Fig. 3. The passage *k'* terminates in a nipple k^4, the opening in which is controlled by a valve *l*, mounted on a forked lever L. The area of the inlet-port k^2 is made, by means of the valve k^3, smaller than the area of the exhaust-port in the nipple k^4 and the passage *k'*, so that the supply connection being constantly open the opening of the exhaust-port by the waste-valve *l* will quickly deplete or exhaust said expansion-chamber. M is a bell-crank lever, one arm of which projects into the fork of the arm J, while the other arm projects into the fork of lever L. It is connected by a spring *m* with the frame at such a point as will cause it to pass the fulcrum of said lever when the arm J reaches the limit of its advance movement, and thus instantly open the waste-valve *l* by engagement with the fork of lever L. k^5 is a spring arranged on the stem of the movable part *k* and acting thereon in opposition to the fluid-pressure. When the actuating fluid is released from the expansion-chamber, this spring returns the movable part of the motor to its starting-point and withdraws the arm J, which at or near the limit of its return movement engages the lever M, carrying the spring *m* back past its fulcrum, thus causing it to instantly shift the lever L and close the waste-valve *l*. A light spring *l'* is arranged to hold said lever L in either position. The supply and waste connections of the motor K are so proportioned and adjusted and the waste-valve and its connections so constructed and arranged that while the advance

movement of the arm J is slow its return movement is so quick that the movement of the clock-train is not affected. *n* designates the seconds-hand arbor of the clock-train. It has a cam or projection N, in engagement with a gravitating arm or lever O, provided with a valve *o*, which controls the port in a nipple *o'* at the end of a waste-passage *p*, leading out of the expansion-chamber of a motor P, which operates the main supply and waste valve E, hereinbefore mentioned.

Referring to Figs. 4, 5, and 6, showing said supply and waste valve in connection with its motor, *e'* designates the induction and e^2 the eduction passages, which communicate with the chamber of the valve proper, e^3, through ports e^4 and e^5, respectively, said valve-chamber having a waste opening or passage around the valve-stem. The induction-passage *e'* communicates through a passage e^6 with the expansion-chamber of motor P, as shown in Figs. 6 and 11. The passage e^6 is provided, as shown in Fig. 11, with a regulating-valve similar to the valve k^2, (shown in Fig. 3,) by means of which the area of the supply port or passage of said motor is restricted and made smaller than the area of the waste port or passage, so that the supply-passage being constantly open the opening and closing of the waste-passage will cause the expansion-chamber of the motor to be filled or exhausted. The movable member *p'* of said motor is connected with a swinging frame Q, pivoted to the base of the motor. *q q'* are the members of a toggle-joint carried by said frame, one member, *q*, having a sliding pivot connection and the other member, *q'*, a simple pivot connection with said frame. The cross-pins by which the toggle-joint is pivoted to said frame are connected by springs q^2, tending to move and hold the members of said joint out of line with each other. A spring q^3 acts upon said frame in opposition to the motor, and its swinging movement is limited by adjustable stops q^4. The member *q'* of the toggle-joint next to the free end of said frame Q is extended beyond its pivot connection therewith and connected with the stem of valve e^3.

By means of the mechanism just described the gradual movement of the motor P does not affect the valve e^3 until the swinging frame Q has been moved in either direction far enough to carry the pivot between the members of the toggle-joint in the same direction past a straight line between its pivot connections with said frame, whereupon the springs q^2 will instantly complete the deflection of the toggle-joint in that direction and shift the valve in the opposite direction.

By means of the above-described construction and arrangement of the main supply and waste valve and its actuating-motor it can be practicably controlled by the direct action of the master-clock movement through the gravitating lever O and valve *o*, which may be made very light and delicate so as not to perceptibly resist or affect the operation of the clock mechanism, and at the same time admit and release at frequent and regular intervals sufficient fluid to operate any desired number of secondary clocks, large or small, synchronously with the master-clock.

To prevent any dust or impurities which may be carried by the air or other fluid pressure medium from stopping the restricted supply-opening into the motor P, I provide the passage e^6 with cotton or other suitable filtering material.

Referring to Figs. 7 to 10, inclusive, showing the preferred movement for the secondary clocks, R designates the minute-hand arbor provided with a worm-gear *r*, and S the hour-hand arbor provided with a worm-gear *s*. T is a shaft arranged at one side and transversely to said arbors. It is provided with a worm *t*, as shown in Figs. 7 and 10, which meshes with the worm-gear *s* on the hour-hand arbor. It is also provided with a ratchet-wheel *t'* and a gear t^2, which meshes with a pinion *u* on a parallel shaft U. The shaft U is provided with a worm *u'*, which meshes with the worm-gear *r* on the minute-hand arbor. V is a fluid-pressure motor, the movable part *v* of which is connected with the lever W, forked at the ends, one of which is fulcrumed to the frame of the motor and the other provided with a cross-shaft *w*, connected by links *w' w'* with swinging arms X, loosely mounted upon and projecting in opposite directions from the shaft T next to the ratchet-wheel *t'*. These arms are provided with oppositely-turned pawls *x x*, which engage with opposite sides of said ratchet-wheel. A spring w^2 acts upon lever W in opposition to motor V, and the movement of said lever is limited and adjusted by stops w^3 to produce the proper movements of the clock-hands. The worm-gears *r* and *s* are formed with split tapered hubs externally threaded, and are secured on their arbors by means of nuts *r'* and *s'*, as shown in Fig. 7, so that either hand may be set independently of the other by loosening the hub of the worm-gear on its arbor. Both hands of the clock may be set simultaneously independently of the motor by turning the shaft T, which is squared at one end, as at t^3, Fig. 10, the pawls *x x* being thrown out of engagement with the ratchet-wheel *t'* if the hands are to be turned backward. By the use of worms and worm-gears, which can be readily made to work with ease without play or lost motion, arranged as shown and described, I am enabled to keep the hands of the secondary clocks in exact correspondence with the hands of the master-clock and to prevent their displacement by wind-pressure, as in the case of tower-clocks, or by other causes, without the use of extra locking devices applied to the actuating mechanism. Whatever play there may be between the gear t^2 and the pinion *u* is taken up when the clock is first started, and may be provided for in the adjustment of the hands of the clock,

since both the hour and minute hands are prevented from turning backward by the worms t and u engaging the worm-gears s and r, respectively, on their arbors.

My improved system operates as follows: The tank A being supplied with compressed air, or other suitable fluid-pressure medium, by an automatic hydraulic compressor B, or from any other suitable source of power, and the hands of all the clocks being set to correspond with each other, the actuating fluid passes through pipe a', branch c, and the reducing-valve c', and enters and gradually inflates the expansion-chamber of motor K. The arm J of the master-clock is thus moved slowly forward by the constant fluid-pressure in the direction indicated by the arrow and imparts its movement to the clock-train G through the medium of the driving-shaft I, its ratchet-wheel i, the gear i', and its dog i^2. As the arm J approaches the limit of its advance movement, the rear branch of its forked end engages the lower arm of lever M and moves it to the right. As soon as the spring m passes the fulcrum on which said lever turns it instantly throws the upper arm of said lever into engagement with the lower branch of the forked end of lever L, thus moving the waste-valve l away from the port in nipple k^4. The expansion-chamber of the motor is thus quickly exhausted owing to the greater area of the exhaust port or passage in comparison with the restricted area of the constantly-open supply port or passage, and the movable part k of the motor is returned to the starting-point and the arm J swung backward by the spring k^5. The other branch of the forked end of said arm J, as it returns to its starting-point, engages with the lower arm of lever M and swings it to the left. As soon as the spring m passes the fulcrum of said lever it instantly throws its upper arm into engagement with the upper branch of the forked lever L and closes the valve l against the nipple k^4, in which position it is retained by the spring l'. The expansion-chamber is again gradually inflated and the operations above explained are repeated as long as the required fluid-pressure is maintained and supplied to the motor. The cam N on the second-hand arbor n, making one revolution every minute, raises the lever O, lifting the valve o from its seat, as shown in Fig. 2, thus releasing the fluid medium from the expansion-chamber of motor P and permitting it to collapse, as shown in Fig. 5. The cam N and the lever O with its valve o are constructed and arranged to open and close the waste-port in the nipple o' alternately at frequent intervals, in the present instance every half-minute, which answers the purpose of all ordinary requirements. In the position of the parts of the supply and waste valve E and its motor P, as shown in Fig. 5, the waste port or passage around the stem of valve e^3 is closed and communication is established between the ports e^4 and e^5, thus admitting the fluid-pressure medium from the main supply-pipe a', through the pipe a^2, to the motors of the several secondary clocks D D and of the relay E', which controls the clock D'. The construction and operation of the relay E' and its motor are like or similar to those of the main supply and waste valve E and its associated motor P, except that the motor has a common supply and waste connection through the pipe e. Since the works of the several secondary clocks are or may be substantially the same, it will be sufficient to explain the operation of one of them by reference to Figs. 7 to 10, inclusive. Every time the actuating medium is admitted by the valve E into the pipe a^2 it enters and inflates the expansion-chamber of each motor V, the movable part v of which, acting through lever W and its connections, turns the pawl-carrying arms X simultaneously in opposite directions. One of the pawls is thus caused to turn the ratchet-wheel t' by engagement with one of its teeth a certain interval, while the other pawl rides loosely over its periphery into engagement with another tooth. The hour-hand is thus advanced an interval equal to one fourteen hundred and fortieth of a complete revolution through the medium of the worm t and worm-gear s, while the minute-hand is advanced one-half minute or one one hundred and twentieth of a complete revolution through the medium of the speed-multiplying gears t^2 and u, and of the worm u and worm-gear r.

When the main supply and waste valve E is shifted so as to close the port e^4 and open the waste passage or port, the fluid actuating medium will be released from the motors V and the movable part v of each motor will be returned to its starting-point by the spring w^2. The other pawl x will now turn the ratchet-wheel t' a like interval. Thus the motor of each secondary clock will be inflated and depleted alternately every minute, advancing the hands every half-minute the intervals or distances above specified. Thus all the secondary clocks will within a half-minute indicate exactly the same time as the master-clock.

Although I prefer to employ as a part of my system the pneumatic master-clock shown and described, as it makes the system automatic throughout and keeps more accurate time when observatory-time is not obtainable at frequent intervals for setting the master-clock, I do not wish to be understood as confining myself to the use of any particular kind of master-clock, as it is perfectly practicable to employ any of the well-known makes of chronometers in connection with my improved means for controlling the fluid-pressure impulses by which the secondary clocks are operated.

I claim—

1. In a pneumatic clock or time system, the combination with one or more time indicating or recording devices, of a fluid-pressure

motor for actuating the same, a source of fluid-pressure connected with said motor, a valve controlling the admission and release of the actuating fluid to and from said motor, a secondary fluid-pressure motor for actuating said valve, a sensitive secondary valve controlling the supply of actuating fluid in the secondary motor, and a master-clock arranged to directly actuate said secondary valve at stated intervals whereby the said time indicating or recording devices are operated synchronously with said master-clock, substantially as and for the purposes set forth.

2. In a pneumatic clock or time system, the combination with one or more time indicating or recording devices, of a fluid-pressure motor arranged to directly actuate the same, a source of fluid-pressure connected with said motor, a valve controlling the admission and release of the actuating fluid to and from said motor, a secondary fluid-pressure motor for actuating said valve, a connection between said valve and secondary motor constructed and arranged to instantly shift said valve at a certain point in the gradual movement of the motor, a sensitive secondary valve for controlling the supply of actuating fluid in the secondary motor, and a master-clock or chronometer constructed and arranged to directly actuate said secondary valve at stated intervals, substantially as and for the purposes set forth.

3. In a pneumatic clock or time system, the combination with one or more time indicating or recording devices, of a fluid-pressure motor for actuating the same, a source of fluid-pressure connected with said motor, a valve controlling the admission and release of the actuating fluid to and from said motor, a secondary fluid-pressure motor for actuating said valve, having a constantly open fluid-supply connection and a relief-opening of greater area than the supply-passage, a sensitive valve controlling said relief-opening, and a chronometer or master-clock arranged to directly actuate said valve periodically, substantially as and for the purposes set forth.

4. In a pneumatic clock or time system, the combination with one or more time indicating or recording devices, of a fluid-pressure motor for actuating the same, a source of fluid-pressure connected with said motor, a valve controlling the admission and release of the actuating fluid to and from said motor, a secondary fluid-pressure motor for actuating said valve, a sensitive gravity-valve controlling the supply of the actuating fluid in said secondary motor, and a chronometer or master-clock having a rotary projection arranged to lift said valve at stated intervals, substantially as and for the purposes set forth.

5. In a pneumatic clock or time system, the combination with a time indicating or recording device, of a primary fluid-pressure motor for actuating the same, a source of fluid-pressure connected with said motor, a pneumatic relay consisting of a three-way valve in the supply and waste connection of said motor and a fluid-pressure motor connected with said valve, a valve controlling the admission and release of the actuating fluid to said relay-motor, a secondary fluid-pressure motor for actuating said valve, a secondary valve controlling the supply of the actuating fluid in the secondary motor, and a chronometer or master-clock having a rotary projection arranged to actuate said secondary valve periodically, substantially as and for the purposes set forth.

6. In a pneumatic clock or time system, the combination of a secondary clock, a fluid-pressure motor for actuating the same, a source of fluid-pressure connected with said motor, a relay consisting of a three-way valve in the supply and waste connection of said motor and a fluid-pressure motor for actuating said valve, a valve controlling the admission and release of the actuating fluid from said relay-motor, a secondary motor for actuating said valve, a sensitive secondary valve controlling the supply of actuating fluid in said secondary motor, and a chronometer or master-clock arranged to shift the secondary valve at intervals, substantially as and for the purposes set forth.

7. In a pneumatic clock or time system, the combination of a tower or large clock and one or more smaller clocks or time indicating or recording devices, fluid-pressure motors for actuating said clocks, a source of fluid-pressure connected with said motors, a relay consisting of a three-way valve in the supply and waste connection of the larger clock and a fluid-pressure motor connected therewith, a valve controlling the admission and release of the actuating fluid to and from the motors of said relay and smaller clock or clocks, a secondary fluid-pressure motor for actuating said valve, a sensitive secondary valve controlling the supply of the actuating fluid in said secondary motor, and a chronometer or master-clock having a part arranged to shift said secondary valve at stated intervals, substantially as and for the purposes set forth.

8. In a clock, the combination of a time-train comprising a regulator, a substantially constantly-acting fluid-pressure motor arranged to actuate said train by the direct pressure of the fluid, a source of fluid-pressure connected with said motor and a pressure-regulating device whereby the actuating force that operates the motor is made constant, substantially as and for the purposes set forth.

9. In a clock, the combination of a time-train including a regulator, a fluid-pressure motor arranged to actuate said train by the direct pressure of the fluid, a source of fluid-pressure connected with said motor, a valve controlling the supply of the actuating fluid in said motor and a connection between said valve and the movable part of the motor arranged to instantly shift said valve, substantially as and for the purposes set forth.

10. In a clock, the combination of a time-train including a regulator, a fluid-pressure motor arranged to actuate the same by the direct pressure of the fluid and having a constantly open fluid-supply connection and a relief-opening of larger area, a valve controlling said opening, a connection between said valve and the movable part of said motor arranged to instantly shift said valve when said movable part reaches the limits of its movement, substantially as and for the purposes set forth.

11. In a clock, the combination with the hand-arbors of a worm-gear mounted on one of them, which is connected by suitable gearing with the other, a worm meshing with said gear, a ratchet or toothed wheel on the worm-shaft and a fluid-pressure motor the movable part of which is connected with one or more pawls adapted to turn said ratchet-wheel, substantially as and for the purposes set forth.

12. In a clock or time system, the combination of one or more secondary clocks each comprising hand-arbors, a worm-gear mounted on one of said arbors which is connected by suitable gearing with the other, a worm meshing with said gear, a ratchet-wheel mounted on the worm-shaft, one or more movable pawls adapted to turn said ratchet-wheel and a fluid-pressure motor connected with and arranged to actuate said pawl or pawls; a source of fluid-pressure connected with said motor, a valve controlling the admission and release of fluid-pressure to and from said motor, a secondary fluid-pressure motor arranged to actuate said valve, a secondary valve controlling the supply of the actuating fluid in the secondary motor, and a master-clock arranged to actuate said secondary valve at regular intervals, substantially as and for the purposes set forth.

13. In a clock or time system, the combination of one or more secondary clocks, a fluid-pressure motor or motors arranged to actuate the same, a source of fluid-pressure connected with said motor or motors, a valve controlling the admission and release of the actuating fluid to and from said motor or motors, a secondary fluid-pressure motor arranged to actuate said valve, a secondary valve controlling the supply of the actuating fluid in said secondary motor, and a master-clock arranged to actuate said secondary valve at stated intervals and having a time-train including a regulating device, a fluid-pressure motor arranged to directly actuate said time-train, a valve controlling the supply of fluid-pressure in said motor, and a connection between the movable part of the motor and said valve constructed and arranged to instantly shift the latter when said movable part arrives at the limits of its movement, substantially as and for the purposes set forth.

14. In a pneumatic time system, the combination with one or more secondary clocks D, each comprising a fluid-pressure motor V, a fluid-pressure reservoir A, and a supply-pipe as a^2, connecting the motor of each secondary clock with said reservoir, of a main supply and waste valve E controlling the admission and release of the actuating fluid to and from each motor through said supply-pipe, a fluid-pressure motor P for operating said valve having a constantly open restricted fluid-supply passage c^6 and a waste passage or part of greater area than the supply-passage, a pivoted arm or lever O provided with a valve *o* normally closing said waste part, and a waste-clock C provided with a cam N constructed and arranged by engagement with said arm or lever O to open said valve at frequent and regular intervals, substantially as and for the purposes set forth.

In testimony that I claim the foregoing as my own I affix my signature in presence of two witnesses.

WARREN S. JOHNSON.

Witnesses:
H. G. DUNN,
P. F. JOHNSON.