(No Model.) 4 Sheets—Sheet 1.

P. G. PUTTEMANS.

AUTO-PNEUMATIC CLOCK MECHANISM.

No. 360,481. Patented Apr. 5, 1887.

Fig. 1.

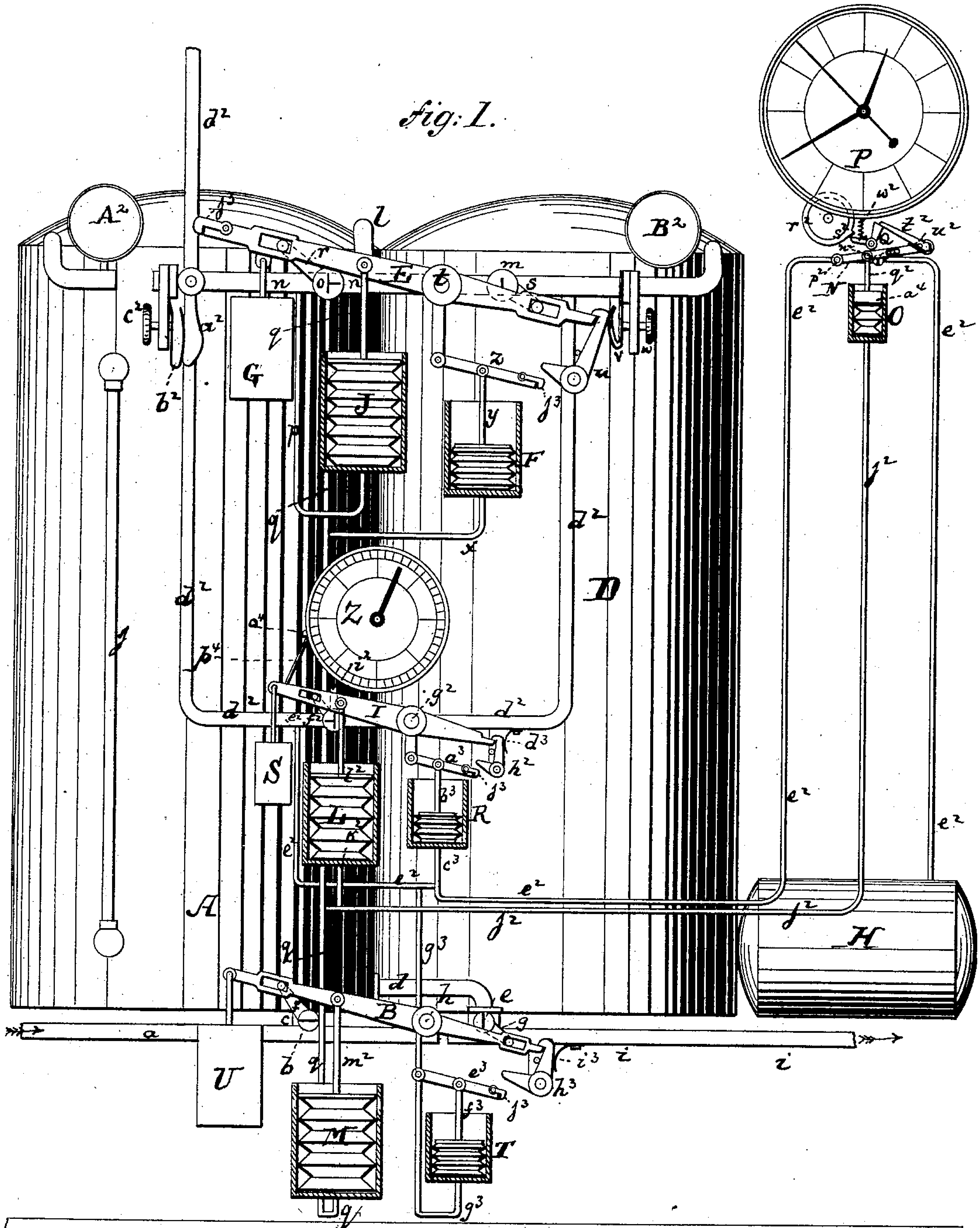

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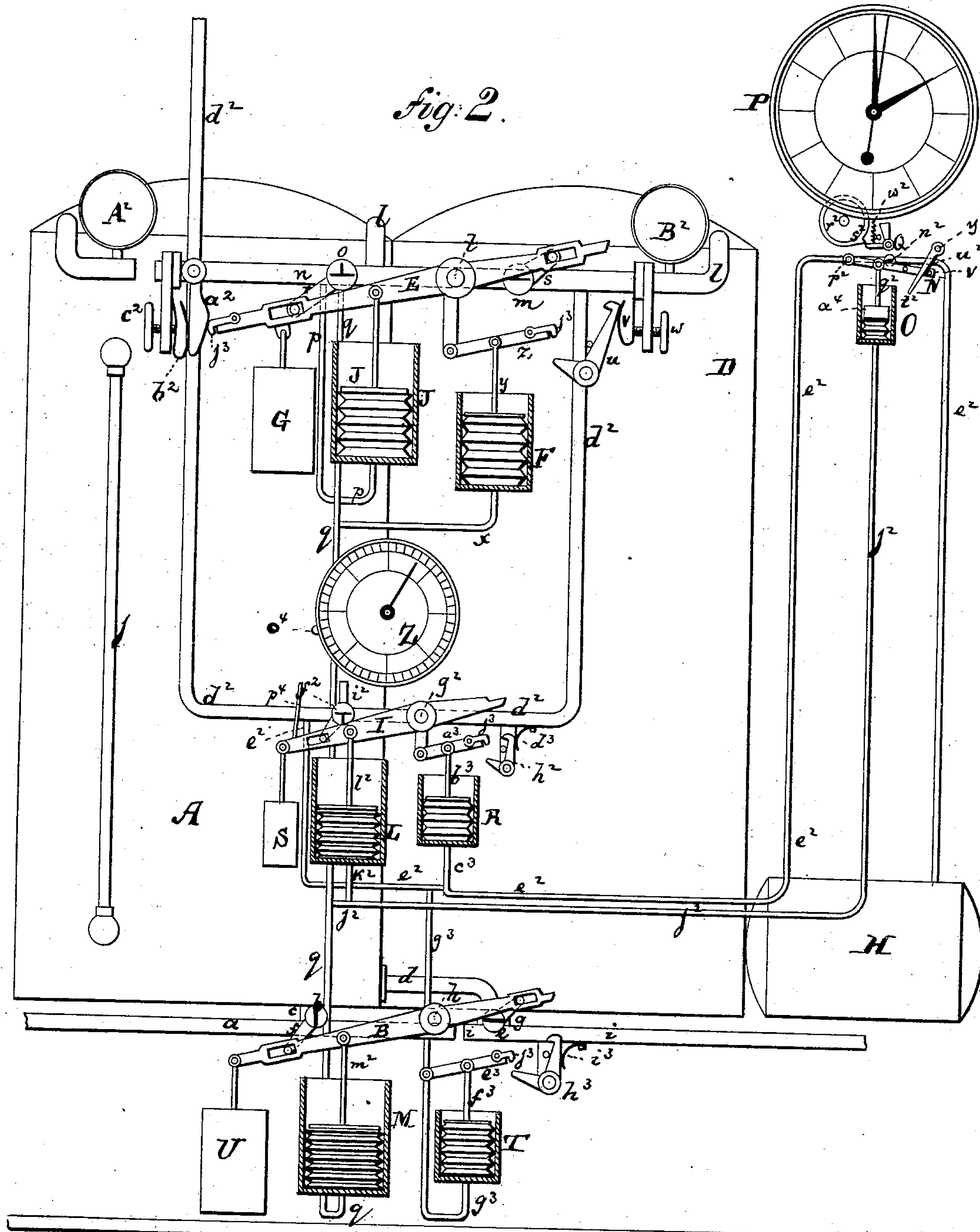
Fig: 2.



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AUTO-PNEUMATIC CLOCK MECHANISM.

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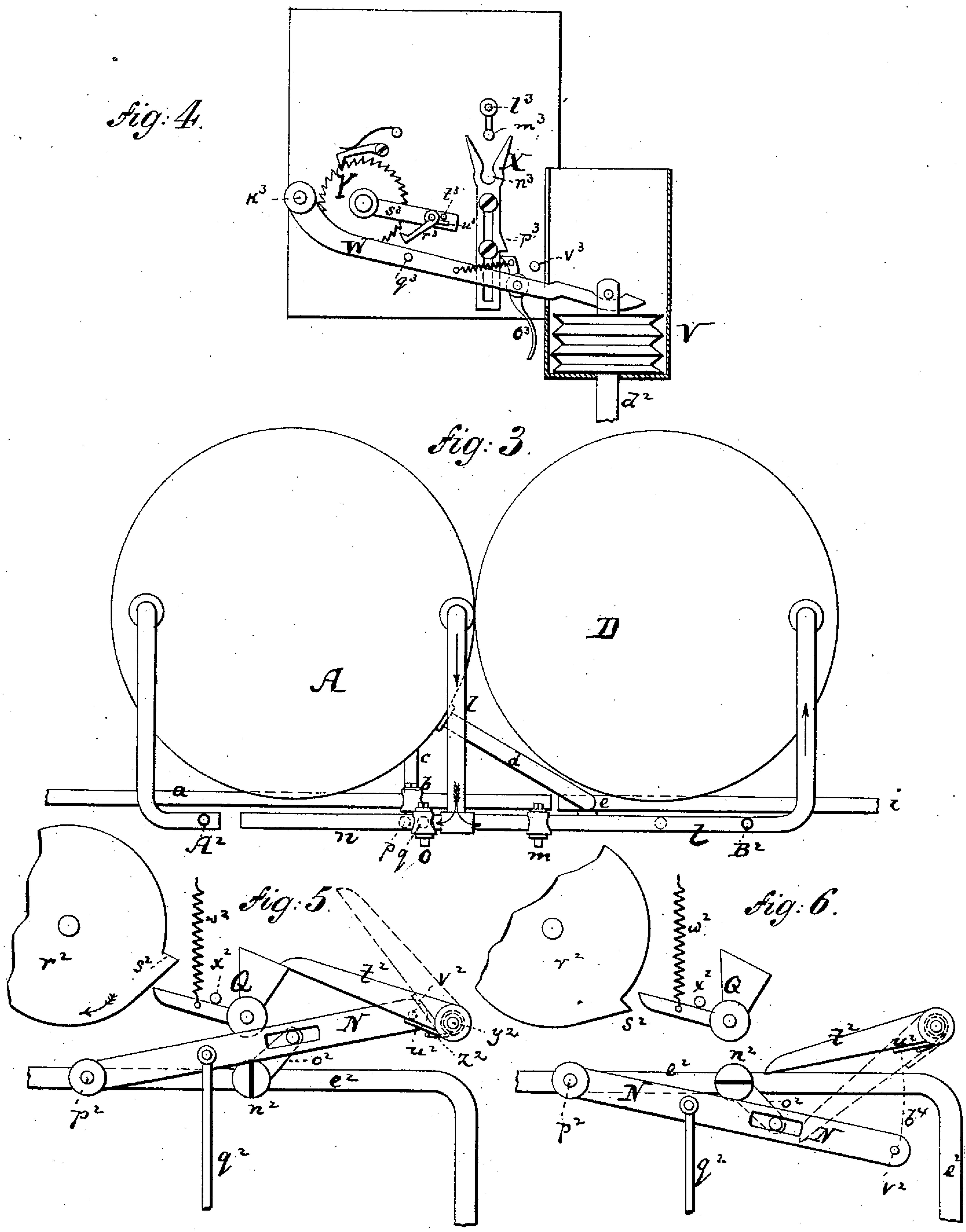

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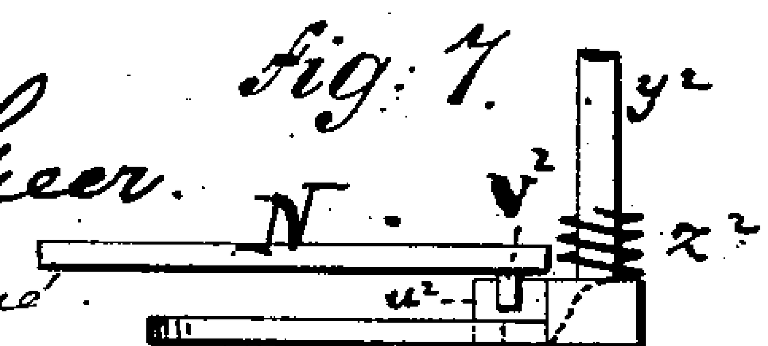
Fig: 7.



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(No Model.) 4 Sheets—Sheet 4.

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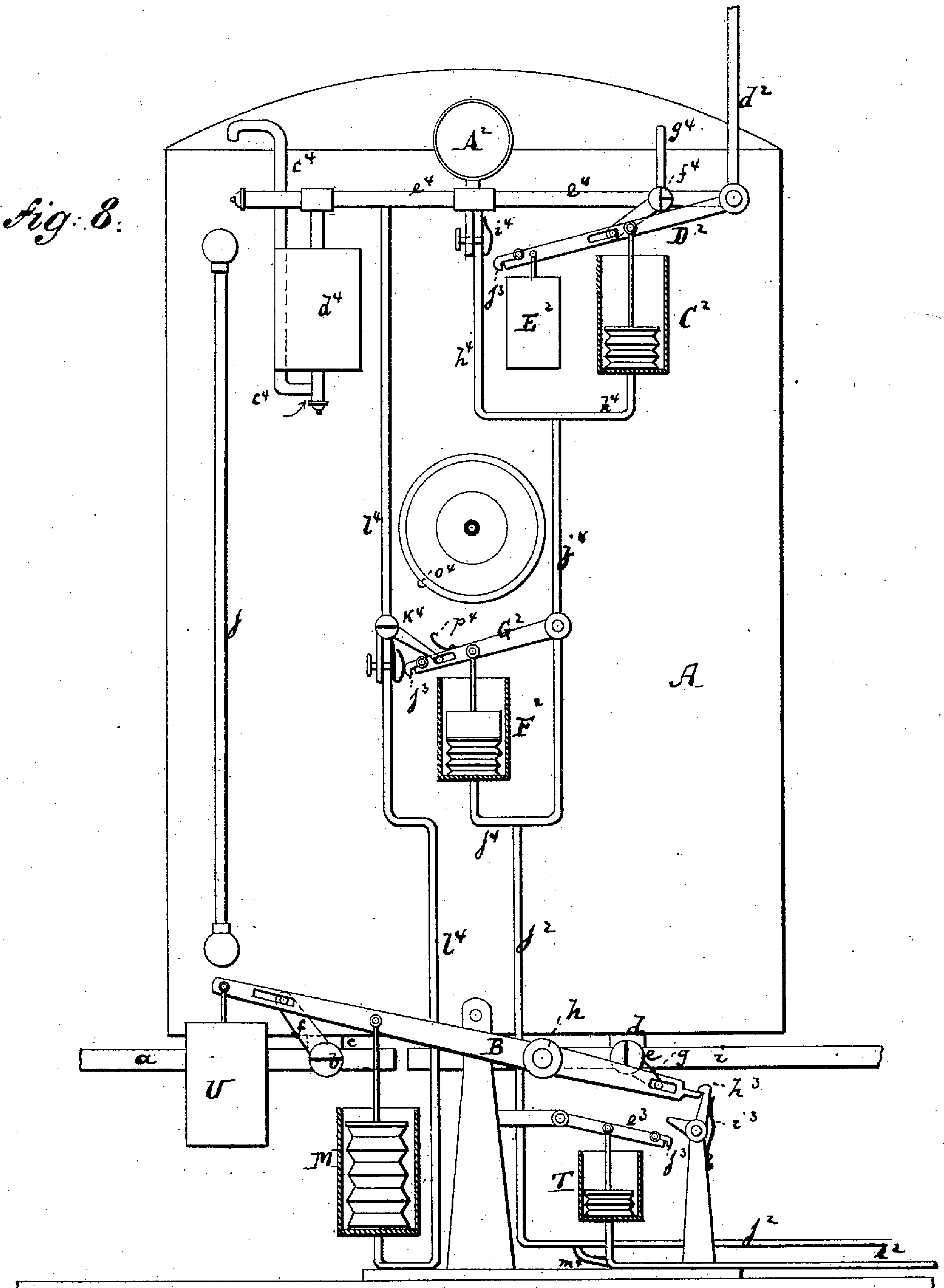
AUTO-PNEUMATIC CLOCK MECHANISM.

No. 360,481. Patented Apr. 5, 1887.

Fig. 8.



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UNITED STATES PATENT OFFICE.

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AUTO-PNEUMATIC CLOCK MECHANISM.

SPECIFICATION forming part of Letters Patent No. 360,481, dated April 5, 1887.

Application filed September 21, 1886. Serial No. 214,150. (No model.)

To all whom it may concern:

Be it known that I, PIERRE GUILLAUME PUTTEMANS, a resident of Brooklyn, in the county of Kings and State of New York, have invented an Improved Auto-Pneumatic Clock Apparatus, of which the following is a full, clear, and exact description, reference being made to the accompanying drawings, in which—

Figure 1 is a face view, partly in section, of my improved apparatus. Fig. 2 is a similar view of the same, showing the parts in a different position. Fig. 3 is a top view of part of the apparatus. Fig. 4 is a detail side view of the synchronizer proper. Figs. 5 and 6 are detail side views, on an enlarged scale, of the tripping mechanism which is connected with the main or controlling clock. Fig. 7 is a detail top view of part of said mechanism. Fig. 8 is a side elevation, partly in section, of a modification of the apparatus.

This invention relates to improvements on the pneumatic-clock system for which I made application for a patent, which is known as Serial No. 193,024, and which application was filed on the 23d day of February, 1886, and allowed on the 10th day of June, 1886.

The main object of the present invention is to separate the compressed-air chamber which starts the apparatus into activity from that compressed-air chamber which finally maintains it in activity. By such a separation of the compressed-air chamber into parts many important advantages are realized. Yet in each of the two compressed-air chambers air will be compressed to the same extent, one of the chambers serving, as already intimated, to merely set the apparatus into action, the other to maintain it in action after that has once been established.

The invention consists in the novel combinations and arrangements of parts, hereinafter more fully specified.

In the drawings, with more particular reference to Figs. 1, 2, and 3, the letter A represents a reservoir for receiving water in its lower part and compressing air in its upper part. This reservoir is supplied with water from a pipe, *a*, and branch pipe *c* whenever a valve, *b*, which is placed into the intersection of the pipes *a c*, is opened; but when that valve *b* is closed the water-supply to the chamber A is also interrupted.

From the chamber A the water, after the same has performed its labor of compressing air, flows off into the pipe *i*, by a branch pipe, *d*, whenever a valve, *e*, which is placed between the pipes *i* and *d*, is opened. The valves *b* and *e* have crank-projections *f* and *g*, respectively, which are connected with a lever, B, as appears clearly from Figs. 1 and 2, said lever being fulcrumed at the point *h*. This connection with the lever B is such that when the valve *b* is opened the valve *e* is closed, and when *e* is opened *b* is closed, so that whenever water flows into the vessel A no water will escape therefrom, while when water is allowed to flow out of the vessel A none will at the same time enter it.

In the vessel A the water, when it is let into it through the pipes *a c*, ascends, a suitable gage, *j*, indicating the height of the water, and compresses the air which was originally contained in said vessel A, so that such compressed air will be contained finally only in the upper part of the vessel A and in the pipes and vessels, hereinafter to be described, which connect with the upper part of said vessel A. My object is to compress the air by the ascending column of water to about ten pounds—that is to say, the compressed air shall exert a pressure of about ten pounds to the square inch.

From the upper part of the vessel A a pipe, *l*, extends to the upper part of the air-compression chamber D. This pipe *l* contains a cock or valve, *m*, between the ends which connect it to the vessels A and D. In a branch, *n*, of the pipe *l* (see Fig. 3) is contained a three-way cock, *o*, or valve, which may be turned, as in Fig. 2, to establish communication between the vessel A and a pipe, *p*, or which may be turned, as in Fig. 1, to interrupt communication between the pipe *p* and the branch *n*. Another pipe, *q*, extends downward from the branch *n*, and is affected by the valve *o*, so that when said valve is in the position shown in Fig. 1 communication between *q* and *n* is established, while when the valve *o* is in the position shown in Fig. 2 communication between the pipes *n* and *q* is interrupted. In other words, whenever the pipe *p* is in communication with the pipe *n* the pipe *q* is cut off, while on the other hand the pipe p is cut off whenever q is in communication with the pipe n. The valves o and m have projecting cranks r and s, respectively, which connect with a lever, E, that is pivoted to a stationary support at t, and this lever is so arranged as to its connection with said valves that when in the position shown in Fig. 1 it will hold the valve m closed and the valve o open to q, while when the lever E is in the position shown in Fig. 2 the valve m is open and the valve o closed to q, but opened to p.

Whenever the valve m is closed, as in Fig. 1, the connection between the vessels A and D is interrupted; hence, as long as the valve m is closed, if at the same time the valve b is opened, the air will be compressed in the upper part of the vessel A alone. I find that I can compress the air practically in the upper part of the vessel A when it is still disconnected from the vessel D to, say, about five pounds pressure to the square inch; but when this pressure has has been attained I intend to automatically establish connection between the vessels A and D and other parts, hereinafter to be mentioned, for the purpose of still further compressing air in the vessel A, and also in the vessel D and in another vessel, hereinafter to be mentioned, and, in fact, throughout the piping of the apparatus.

It will be seen from Fig. 1 of the drawings that when the lever E holds the valve m closed its lowered end is caught by an elbow-hook, u, which is pivoted to the framing of the apparatus, and which bears against a spring, v, the tension of which is regulated by a screw, w. The pressure of the spring v against the elbow u is regulated by the screw w in such manner that it requires, according to my system, a compression of about five pounds in the vessel A before the resistance of the spring v can be overcome. When the pressure in A becomes sufficiently strong to overcome this resistance, it acts in the following manner, it being understood that the three-way cock o at this time opens communication between the pipes n and q. Therefore whatever air is compressed in the vessel A passes into the pipe q. A branch, x, of the pipe q leads into a bellows or expansion-chamber, F, which chamber, by its movable piston and rod y, connects with the lever z.

As the air is being compressed in the vessel A and in the pipes q and x, the bellows in F will be gradually expanded until the end of the lever z bears against the toe of the elbow u, that holds the lever E locked; but until the pressure in A is at least five pounds the pressure of z against u will not be able to overcome the resistance of the spring v, which, as has already been shown, is held in a tension to correspond with the pressure of at least five pounds in the vessel A. Whenever, now, the pressure in A reaches the point desired, the end of the lever z will get sufficient strength to press the elbow u against the spring v and to release the lowered end of the lever E, whereupon, under the influence of a proper weight, G, which is suspended from the other end of the lever E, said lever will instantly fly from the position shown in Fig. 1 into the position shown in Fig. 2, opening the valve m and interrupting communication with the pipe q, but establishing communication with the pipe p. In this new position the now lowered end of the lever E will, as appears from Fig. 2, crowd a pivoted block, a^2, against another spring, b^2, which is held in a certain tension by a set-screw, c^2. The spring b^2 is to be held at a tension of about ten pounds—that is, it is to resist an air-pressure of ten pounds—where the spring v was only to resist a pressure of five pounds, as already stated. The object of this greater power of the spring b^2 and its effect upon the weighted block a^2 will be hereinafter more fully described.

Enough has been shown to make it clear that by the means described communication is automatically established between the vessels A and D as soon as the air in A is compressed to the extent, say, of five pounds to the square inch. The valve m being now open, the compressed air flows freely into the vessel D, and this vessel becomes charged with compressed air until the desired limit of compression is reached.

Between the valve m and the end of the pipe l where the same enters the chamber D there connects with said pipe l another pipe, d^2, which has a branch pipe, e^2, that leads into a reservoir, H. In the pipe d^2 is another three-way cock, f^2, which at this time is in such position as to permit communication between the pipe d^2 where it connects with l and the pipe e^2. It follows, therefore, that when the lever E is in the position shown in Fig. 2 the chamber A discharges by the pipe l into the chamber D, and by the pipes l, d^2, and e^2 into the chamber H. The chamber H is much smaller in size and capacity than the chamber D, its object being to start the time-regulating mechanism in its operation, while the object of the chamber D is to maintain the said mechanism in operation, all as will be hereinafter more fully stated.

At the time the lever E is by its weight G tripped into the position shown in Fig. 2 to open the valve m, the lever I is, by the means which will be hereinafter described, also in the position shown in Fig. 2, so as to permit communication between the pipes d^2 and e^2 by the proper position of the valve f^2, and when the valve is in this last-mentioned position it interrupts communication between the pipe d^2 and a small exhaust-nozzle, i^2. I now have my air-compression chambers D and H charged with compressed air to the desired extent, and before the regulating-clock begins its work it will be necessary to automatically close the valves m and f^2, so as to confine what compressed air has been introduced within said chambers D and H. To this end the pipe p, which leads into an expansion-chamber or bellows, J, is used. This pipe p is open to the pipe n whenever the lever E is in the position shown in Fig. 2, and the air compressed in the chamber A is therefore free to pass through the pipe p into the bellows J. The bellows J will have a tendency, by receiving the compressed air, to lift the lever E back into the position shown in Fig. 1; but in this effort it is opposed by the regulating-spring b^2, which, as already stated, is set to have a strength equal to oppose any air-pressure less than ten pounds. When the air-pressure gets to ten pounds in J it causes the weighted end of the lever E to overcome the resistance of the spring b^2, and carries said lever E back into the position shown in Fig. 1, where it is again arrested by the elbow-catch u. The block a^2, which hangs between the spring b^2 and the end of the lever E, is of such bulging or V-shaped form as to prevent a gradual elevation of the lever E, which would be detrimental to the operation of the apparatus. It is essential that a sudden motion of the lever E be effected when it is brought back to the position shown in Fig. 1; hence when the end of the lever E shall have passed the apex of the block a^2 the spring b^2, together with the inclined upper face of the block a^2, will co-operate to throw the lever E up suddenly, and will therefore assist the air in the bellows J in its effort to spring the lever E back to the position shown in Fig. 1.

As soon as the lever E is brought back into its new position (shown in Fig. 1) the pipe p will be cut off from communication, and the pipe q will have communication re-established. A branch, j^2, of the pipe q connects by another branch, k^2, with a bellows, L, which, by a rod, l^2, connects with the lever I. After the lever E is by the compressed air, which now has ten pounds, brought into the position shown in Fig. 1 to close the valve m, the air, having the same amount of pressure in the pipe q, will from the vessel A, through the pipes l, n, q, j^2, and k^2, enter the bellows L, and move the lever I into the position shown in Fig. 1, where it is held by the elbow-catch h^2, and thus close the valve f^2 to the pipe e^2. Now, therefore, I have the valves m and f^2 closed, and confine whatever compressed air has been obtained within the vessel D. At the same time that the lever I is turned on its pivot by the expansion of the bellows L, the lever B is also brought from the position shown in Fig. 2 into the position shown in Fig. 1 by the lower part of the pipe q entering a bellows, M, a rod, m^2, of which connects said bellows with the lever B, and when the lever B is thus brought into the position shown in Fig. 1 it closes the water-inlet valve b and opens the water-outlet valve e, so as now to permit the emptying of the vessel A.

Within the pipe e^2 is a cock or valve, n^2, which, by a crank, o^2, connects with a lever, N, that is fulcrumed at p^2, (see enlarged Figs. 5 and 6,) and this lever N has a rod, q^2, that connects with a bellows, O, to which leads the branch pipe j^2, that extends from the open pipe q. Whenever the pressure in the pipe q acts, as described, to move the lever I by the bellows L and the lever B by the bellows M, at the same time it moves the bellows O by pipe-connection j^2, and thereby swings the lever N into the position shown in Fig. 5, thereby closing the valve n^2. This valve n^2 is the valve which really confines the compressed air in the vessel H, because the three-way cock f^2, although at this time interrupting communication with that part of the pipe d^2 which leads from the vessel D, does not interrupt communication with the part of the pipe d^2 which leads to the clock mechanism to be regulated, nor does it interrupt communication between the pipes e^2 and the exhaust-nozzle i^2 in this position of the lever I.

In the vicinity of the lever N is the regulating-clock P, which is the clock from which a series of other clocks is to be controlled as to the position of their hands. The clock P, by suitable mechanism, imparts rotary motion to a wheel, r^2, which has a projecting toe, s^2, that moves in the path of an elbow-lever, Q. (See Fig. 5.) The lever Q, at the time the valve n^2 is closed, is in contact with a lever, t^2, as shown in Fig. 5, and the lever t^2 has a plate or bar, u^2, on which rests a pin, v^2, that projects from the lever N, all as shown in Fig. 5. In the same position a spring, w^2, holds the elbow-lever Q against a fixed pin, x^2, as shown in the same figure.

The lever t^2 is fulcrumed on a stationary pin, y^2, and connected thereto by a spring, z^2, the said spring having for its object to throw the lever t^2 from the position which is shown by dotted lines in Fig. 6 into the position shown by full lines in Fig. 6, for the purposes to be hereinafter more fully stated.

In a former part of this specification I have described how the bellows F, under the influence of air brought into it by the pipe x, moves the rod y and lever z in order to disengage the lever E from the elbow u, which elbow rests against the regulator-spring v. A similar mechanism is connected to the lever I for the same purpose, in fact, of bringing it from the position shown in Fig. 1 to the position shown in Fig. 2—that is to say, near the lever I is pivoted a little lever, a^3, which is carried by the piston-rod b^3 of a bellows, R, which bellows is supplied with compressed air from a branch, c^3, of the pipe e^2—so that whenever compressed air is allowed to flow into the bellows R by the branch pipe c^3 the lever a^3 will be moved to disengage the elbow-catch h^2 from the lever I, allowing a weight, S, to pull the lever I into the position shown in Fig. 2. The elbow h^2 is under the influence of a spring, d^3, which holds it in position to be thrown into engagement with the lever I whenever that lever is brought back by the action of the bellows L into the position shown in Fig. 1. Analogous to these devices, again, is a contrivance which is applied to the lever B, which controls the water-cocks—that is to say, a lever, e^3, is pivoted to a suitable stationary support at a short distance from the lever B and connected by a rod, f^3, with a bellows, T, which is supplied with air from a branch pipe, g^3, of the pipe e^2. The lever e^3 has for its object to move an elbow, h^3, which locks the lever B in the position shown in Fig. 1, but which, when moved by the ascending lever e^3, allows a weight, U, to pull the lever B into the position shown in Fig. 2. A spring, i^3, bears against the elbow h^3, to hold it in position for engagement with the lever B whenever the latter, by the action of the bellows M, is moved back into the position shown in Fig. 1.

It will be perceived from the drawings that the end of the lever E which is nearest the swinging block a^2 and the free ends of the levers z, a^3, and e^3 are provided with pivoted or jointed hook-like end pieces, j^3, each of which in the normal position finds a support on the body of the lever that carries it, while, nevertheless, each is free to swing on its own pivot upwardly, but not downwardly below its lever. The object of these attachments j^3 is to permit each of them to affect the obstruction which it meets in its upward motion, but to pass it freely in its downward motion. Thus, when the lever a^3 is moved up from the position shown in Fig. 1 to that shown in Fig. 2, its hook attachment j^3 will be rigid, and will, striking the elbow h^2, move the latter, for the purposes already stated; but when afterward, the bellows R collapsing, the lever a^3 is moved back into the position shown in Fig. 1, its attachment j^3 will not affect the elbow h^2, but will be swung up while passing by it, and then drop off upon its lever a^3 to assume the position shown in Fig. 1. The same function applies to each of these little attachments j^3, whether they be on the lever E, e^3, or z.

The air conduit or pipe d^2 leads from the apparatus so far described to the clock or clocks to be regulated. Fig. 4 shows the end of the pipe d^2 where it enters the parts connected with one of these clocks which are to be regulated—that is to say, the end of the pipe d^2 enters a bellows, V, which connects with a lever, W, that is pivoted at k^3 to a stationary support at some distance below the minute-arbor l^3 of the clock to be regulated. The said minute-arbor has one or more projections, m^3, one of which at the proper time is to be more or less aligned with a **V**-shaped opening in a slide, X. This **V**-shaped opening may, as shown in Fig. 4, in its center terminate in a spherical recess, n^3, which is adapted to receive a roller or pin at the end of the projection m^3.

The lever W carries a pawl, o^3, which bears against a shoulder, p^3, of the slide X. The lever W also carries a pin, q^3, which is adapted to throw a pawl, r^3, into engagement with the winding-wheel Y of the clock. The pawl r^3 is carried on a lever, s^3, which has a pin, t^3, against which a toe, u^3, on the pawl r^3 bears when the parts are in the position of rest, as in Fig. 4. Whenever the lever W is raised by the expanding bellows V, its pawl o^3 will at once move the slide X until the end of the projection m^3 reaches the end of the fork of said slide, at which time the stationary pin v^3 will move the pawl o^3 out of engagement with the slide X, allowing the latter to drop away from the minute-arbor of the clock, and at the time this takes place the pin q^3 of the still-ascending lever W reaches the pawl r^3, crowds it into the teeth of the wheel Y, and causes it to turn said wheel Y, which, being the winding-wheel, winds the clock.

Having described the mechanism connected with my apparatus, I will now describe its operation. Supposing the tanks D and H to be charged with compressed air and the tank A to be in connection, by the opening of the valve c, with the water-discharge pipe i, so that it will be emptied of water, all the parts will be in the position shown in Fig. 1, the lever B holding the valve e open and b closed, the lever I holding the three-way cock f^2 in such a position that the connection between the pipe e^2 and the part of the pipe d^2 that leads to the tank D is closed, the lever E holding the valve m closed and the three-way cock o in such a position that the pipe p is closed but q opened, and the lever N being in such a position (see Fig. 5) as to hold the valve n^2 closed. At the same time the lever W on each of the clocks to be controlled will be in its lower position, the bellows V being collapsed, and the bellows F, R, and T being also collapsed. The controlling-clock P, being moved by suitable clock-work, turns the disk r^2 in the direction of the arrow shown in Fig. 5, and at the proper period of time, which may occur once every three hours, or during any other desired subdivision of time, the toe s^2 will strike the elbow Q, and will swing that elbow on its pivot so as to draw it away from contact with the lever t^2. The instant this is done the plate u^2 will no longer furnish a support for the lever N, and the lever will by a suitable weight be drawn down into the position shown in Fig. 6. The particular weight which is shown in the drawings for this purpose is marked a^4, and is attached to the rod q^2 and lies on the bellows O, as indicated in Fig. 2; but any other weight may be used for the same purpose.

As soon as the lever N is thrown into the position shown in Fig. 6 it opens the cock or valve n^2. Before I describe how this affects the remaining mechanism I will direct attention to the relations of the levers N, t^2, and Q. It has been seen that in the position shown in Fig. 5, when the valve n^2 is closed, the lever N is held in the raised position by the plate u^2 of the lever t^2, the last-mentioned lever being held elevated by the elbow Q. As soon as the elbow Q is withdrawn by the action of the toe s^2, the lever N drops under the influence of the weight a^4, and drags, by the contact of the pin v^2 with the plate u^2, the lever t^2 down with it into the dotted position which is shown in Fig. 6, until the pin v^2 slips off the plate u^2, allowing the lever N to descend still farther. Meanwhile the spring z^2 throws the lever t^2 back into the position shown by full lines in Fig. 6, so as to carry the plate u^2 back into the path of the pin v^2, that path being indicated by the dotted line b^4 in Fig. 6. This is for the purpose of enabling the pin v^2, when the lever N afterward is moved up again by the bellows O, to get under the plate u^2, lifting it, pass by it, and afterward get on top of it again—that is to say, the lever N, when it is pushed up by the bellows O, will push the lever t^2 by the contact of the part v^2 against the under side of u^2 into a position of greater height than that shown in Fig. 5, until the pin v^2 passes the front end of the plate u^2. Thereupon the lever t^2 will by its own weight drop upon the elbow Q. The lever N, which was thus raised by the bellows to a greater height than that shown in Fig. 5, will be lowered down into the position shown in Fig. 5 by the subsequent collapsing of the bellows O, and will then be supported again by the plate u^2.

I will now resume the description of the main apparatus, showing what follows the opening of the valve n^2, which is supposed to have just taken place. The moment the valve n^2 is opened the compressed air contained in the chamber H passes through the pipe e^2 into the branch c^3, and thence into the bellows R, expanding the same, so as to swing the lever a^3 against the elbow h^2, pushing the latter off the lever I. This allows the weight S to swing the lever I into the position which is shown in Fig. 2 of the drawings, and to open the three-way cock f^2, so as to thereby establish communication in the pipe d^2 between the chamber D and the bellows V, which latter-named bellows is connected with the clocks to be wound and regulated. This turning of the cock f^2 liberates the compressed air in the vessel D, allowing it to act in the desired manner upon the bellows V. At about the same time that this motion of the lever I takes place the lever B is also swung from the position shown in Fig. 1 to that shown in Fig. 2. This is accomplished by air passing from the pipe e^2, through the branch pipe g^3, into the bellows T, allowing the lever e^3 to trip the elbow h^3, and to bring the lever B under the influence of the weight U. This opens the water-supply pipe at b, and closes the water-discharge cock e, allowing the compression of air to begin to take place in the chamber A by the water flowing into the lower part thereof. The air that was contained in the chamber H has performed its duty of starting the apparatus into action—that is to say, the chamber H is to do nothing but trip the lever I. That being done, its function ceases. The air in the chamber D now begins to do its work, and finding the valve f^2 open rushes through the pipe d^2 to the bellows V, and through the branch pipe g^3 to the bellows T. That part of the air from D which passes through the pipe g^3 trips the lever B, in manner already described. That part of the air which goes into the pipe d^2 expands the bellows V and lifts the lever W. The first part of the elevation of the lever W causes the pawl o^3 to lift the slide X until the fork-like upper part of said slide receives within it the projection m^3, which is on the minute-arbor l^3 of the clock to be regulated. If this projection is not in the proper vertical position at the time the slide X is raised it will strike one of the inclined sides of the fork, and will by that be moved into the proper vertical position, so that thus the slide X serves to set the minute-hand of the clock to be regulated into a certain particular desired position, performing thus the duty of a synchronizer. When the lever W has been partly raised, so as to synchronize the clock, the pin v^3 throws the pawl o^3 off said slide X, allowing the latter to drop away from the projection m^3 by its own weight. The synchronizing action of the lever W upon the minute-arbor is almost instantaneous, being very rapid, and will not interfere with the running of the clock which is to be regulated. The lever W, continuing to rise, will now carry the pin q^3 against the pawl r^3, crowding that into the teeth of the wheel Y and lifting it, with its carrying-lever s^3, so as to turn the wheel and wind the clock to a sufficient extent to enable it to run until the apparatus again turns said wheel Y and winds the clock again. During all this time the levers B and I are in the positions shown in Fig. 2, but the lever E still in the position shown in Fig. 1, so as to hold the valve m closed and the connection with the pipe p interrupted; but the water, having been allowed to flow into the tank A, has meanwhile done some work toward compressing the air in that tank up to about five pounds, and at this time, as has already been shown, the air passes through the pipe q into the bellows F, overcomes the resistance of the regulator-spring v, liberates the lever E from the elbow u, and permits the weight G to carry the lever E into the position shown in Fig. 2. This opens the valve m and allows the compressed air which is being formed by the still-ascending water in the tank A to pass into the tank D, and the cock f^2 being in the proper position the air also passes through the pipe d^2 into the pipe e^2, past the still-open valve n^2, into the tank H. At this time, therefore, the three tanks A, D, and H are in communication, the tank A charging the tanks D and H with compressed air. When the pressure reaches the desired extent—say ten pounds—in the tank A, it will also be ten pounds in the tanks D and H.

At the time that the lever E was brought into the position shown in Fig. 2, in manner last described, the valve o was turned so as to open the pipe p; hence when the pressure reaches ten pounds in the three tanks just named the air in p will be sufficiently powerful to expand the bellows J against the counteracting effort of the regulating-spring b^2, and will lift the lever E back into the position shown in Fig. 1, causing it to be relocked by the elbow u. This closes the valve m and the pipe p, but opens the pipe q, and causes the following operations to take place: In the first place, the pipe q, leading into the bellows M, expands the same, so as to lift the weight U and bring the lever B back into the position shown in Fig. 1, closing the water-supply cock and opening the water-discharge cock simultaneously. In the second place, the air from the pipe q passes through j^2 into branch pipe k^2, and thence into the bellows L, expanding the latter and causing it to overcome the resistance of the weight S, bringing the lever I back into the position shown in Fig. 1 and locking it by the elbow h^2. This turns the cock f^2, so that it will be a barrier within the pipe d^2, but opens the exhaust-nozzle i^2, to permit whatever compressed air was contained in the outer part of the pipe d^2 to escape. Lastly, the compressed air from q passes through the pipe j^2 into the bellows O, expanding the same, so as to overcome the resistance of the weight a^4 and lift the lever N first into a position still higher than that shown in Fig. 5, thereby also lifting the lever t^2, in manner already described.

The action of the bellows L, M, and O upon the levers I, B, and N, just described, was simultaneous. The moment these three levers are set into the positions which are shown in Fig. 1 of the drawings the water begins to flow out of the tank A, easing the pressure of air which was contained in the tube q and allowing the bellows L, M, and O to gradually collapse. This permits, among other things, the gradual descent of the lever N from the highest position into that position which is shown in Fig. 5, where it is supported by the plate u^2 of the lever t^2. I now have the parts again in position to be started into action by the toe s^2 of the disk r^2, when the operations already described will be repeated, and thus with a head of water in the pipe a always ready to supply the tank A when the valve b shall be opened I am in position to keep the whole apparatus automatically and constantly affected. In whatever manner the main clock which turns the disk r^2 is regulated, so will all the other clocks which are connected with the pipe d^2 be regulated from time to time.

In practice I propose to so time the motions of the toe s^2 that about every three hours it will open the valve n^2 and regulate the clocks and wind them; but, as already stated, this division of time may be changed *ad libitum.* The lever I carries a projecting toe, p^4, which is intended to move a projection, o^4, on an automatic indicator, Z, which is supported by a suitable stationary frame-work, and which is substantially described in its functions in my above-mentioned application No. 193,024, its object being to indicate automatically each actual function of the apparatus, so that if the apparatus should have failed to work at one of the predetermined intervals the pointer on the indicator Z will show this defect by its position on the dial.

The tank A carries a gage, A^2, which indicates the pressure of the air contained therein, and the tank D carries a gage, B^2, for the same purpose.

A modification of the invention consists in eliminating the tank D from the apparatus, retaining only the tanks A and H, as indicated, as far as is necessary for the purpose of this description, in Fig. 8 of the drawings. In that figure the tank A alone is shown, together with the pipes j^2 and e^2, that lead to the bellows O and tank H; but the tank H itself is not represented in Fig. 8, it being understood that it receives the end of the pipe e^2 which has the lever N near the clock P, the same as is represented in Fig. 2 of the drawings.

In Fig. 8 is also shown the lever B, which connects with the water-inlet valve b and with the water-outlet valve e in the same manner as has heretofore been described, and which is united with the weight U and bellows M and T the same as heretofore described, so that when the lever B is in the position shown in Fig. 8 the valve b will be closed and the valve e open. The tank A, which is shown in Fig. 8, discharges whatever compressed air is contained in its upper portion by a pipe, c^4, through a safety apparatus, d^4, similar to the safety apparatus described in my previous application No. 193,024, into a pipe, e^4, which has a three-way cock, f^4, which is placed at the intersection of the pipe d^2, that leads to the clocks to be regulated, and the exhaust-nozzle g^4. From the pipe e^4 also branches a pipe, h^4, which leads into a bellows, C^2, the rod of which connects with a lever, D^2, which lever is retained in the lower position by a weight, E^2, and prevented from being moved up by the expansion of the bellows before the certain pressure required is obtained by a regulator-spring, i^4, which is similar to the regulator-spring v, heretofore described. From the pipe h^4 extends a branch pipe, j^4, into a bellows, F^2, which connects with a lever, G^2, that controls a valve, k^4. This valve is located in a pipe, l^4, which leads from the pipe e^4 into the bellows M. From the pipe j^4 extends the pipe j^2, which leads to the bellows O near the clock P. The pipe e^2 leads directly into the bellows T, which connects with the lever c^3 for tripping the elbow h^3.

The operation of this modified apparatus is as follows: Supposing the tank H to be charged with compressed air and the clock P to trip the lever N by means of the toe s^2 on the disk r^2, so as to open the valve n^2 in the pipe e^2, the result will be that the bellows T will be expanded and the elbow h^3 moved so as to bring the lever B under the influence of the weight U. This will open the water-inlet valve b and close the water-outlet valve e. Water will now enter the lower part of the tank A and begin to compress the air in the upper part of said tank. Meanwhile the valve k^4 is closed and the valve f^4 closed against d^2. As the air in the tank A becomes compressed it enters, by the pipes c^4 and e^4, the branch h^4, and when it attains the pressure of five pounds it will be sufficiently strong to lift the lever D^2 and turn the valve f^4, so as to admit compressed air to the pipe d^2 and regulate and wind the auxiliary clocks. Meanwhile the pressure continues to increase in the upper part of the tank

A until it attains a strength of, say, ten pounds, when it will suffice to expand the bellows F^2 and move the lever G^2, so as to open the valve k^4. This will admit air under pressure of ten pounds to the bellows M and bring the lever B back into the position shown in Fig. 8. The compressed air before the bellows F^2 were expanded will also be free to pass by the pipe j^2 into the bellows O, so as to set the lever N back into the position shown in Fig. 5. Before the lever N was moved back into this position for closing the valve n^2, the tank H was charged with compressed air by the pipe e^2, which received its charge by a branch, m^4, from the pipe j^2. The moment the lever B is moved to close the valve *b* and open the outlet-valve *e* the air in the tank A will become expanded again, and will allow the weight E^2 to draw the lever D^2 back into the position shown in Fig. 8, so as to close the valve f^4 in the pipe e^4 and open the exhaust g^4 to the connection with d^2; hence whatever air was contained in the pipe d^2 may escape.

I claim—

1. The combination of the water-reservoir and air-compressing chamber A with the water-supply pipe *a c*, containing the valve *b*, having crank *f*, water-discharge pipe *d i*, valve *e*, having crank *g*, and with the lever B, all arranged so that by moving said lever both said valves will be turned, one to open and the other to close, substantially as herein shown and described.

2. In an auto-pneumatic clock apparatus, the combination of the auxiliary compressed-air chamber H with a main compressed-air chamber, communicating-conduits between said chambers, whereby the air in each is compressed to the same degree of pressure, and mechanism, substantially as described, for interrupting said communication and afterward utilizing the air in said chamber H for starting the actuating mechanism into activity and for opening said communication, substantially as specified.

3. The combination of the compressed-air chamber A with the auxiliary compressed-air chamber H, in both of which chambers the air is compressed to the same degree of pressure, and mechanism operated by the air in the chamber H for starting the mechanism which is operated by the air in the chamber A and for releasing the compressed air from the chamber H, as specified

4. The combination of the central clock, P, and its disk r^2, having toe s^2, with the pivoted elbow Q, lever t^2, having plate u^2, with the lever N, having pin v^2, and with the valve n^2, which is controlled by said lever N, as specified.

5. The lever N, having pin v^2, combined with the lever t^2, having plate u^2, and with the spring z^2, the said spring being adapted to carry the lever t^2 after it has been disconnected from the lever N into such a position that the plate u^2 will again be in the path of the pin v^2, as specified.

6. The combination of the lever a^3 with the pivoted hook-shaped attachment j^3 and with the vibrating elbow h^2, all arranged so that said pivoted attachment will be rigid when the lever a^3 is moved in one direction and free to turn on its pivot when the lever is moved in the opposite direction, as set forth.

7. The combination of the lever E and its valves *m* and *o*, which it controls, with the elbow *u* and regulating-spring *v*, against which spring said elbow bears, as specified.

8. The combination of the lever E and the valves which it controls with the pivoted block a^2 and regulating-spring b^2, and with means, substantially as described, for moving said lever, all as set forth.

9. The combination of the air-pipes *l n*, single valve *m*, and three-way cock *o* with the lever E, regulating-springs b^2 and *v*, lever *z*, elbow *u*, bellows F and J, weight G, and compressed-air pipes leading to the bellows F and J, substantially as described, all arranged to move the said lever E, in manner specified.

10. The combination of the lever I with the lever a^3, elbow-catch h^2, bellows L and R, weight S, cock f^2, and with compressed-air pipes leading into said bellows, respectively, all arranged for moving said lever I and turning said cock, as specified.

11. The combination of the lever B and its valves *b* and *e* with the catch h^3, lever e^3, bellows T M, and weight U, and with pipes leading to said bellows, respectively, all arranged for moving the lever B and both said valves simultaneously, as set forth.

12. The combination of the clock P and its wheel r^2, having toe s^2, with the elbow Q, lever N, lever t^2, valve n^2, rod q^2, bellows O, and weight a^4, all arranged for operation substantially as herein shown and described.

13. The combination of the bellows V with the lever W, and means operated by said lever for winding the clock with pawl o^3 and slide X, having forked upper end, as specified.

14. The combination of the bellows V, lever W, having pin q^3, with the pawl r^3, having heel u^3, lever s^3, having pin t^3, and toothed wheel Y, substantially as herein shown and described.

15. The combination of the bellows V with the lever W, having pawl o^3 and pin q^3, slide X, having prong p^3, pawl r^3, lever s^3, and toothed wheel Y, substantially as herein shown and described.

16. The combination of the synchronizing-slide X, having forked upper end with beveled inner faces, with the arbor l^3, having synchronizing projection m^3, as specified.

17. The lever E, constructed and combined with the articulated hooking end j^3 and yielding block a^2, substantially as and for the purpose herein shown and described.

18. The combination of the tank H and its air supply and discharge pipe e^2, leading to a bellows, with the cock n^2 in said pipe, mechanism, substantially as described, for opening said cock by the action of a central clock, and with the rod q^2, weight a^4, bellows O, and pipe

j^2, all arranged to enable compressed air in the pipe j^2 to close the cock n^2, as specified.

19. The combination of the compressed-air-supply pipe n and three-way cock o with the branch pipes p and q, bellows J and F, and lever E, all arranged so that when the cock o is in one position it admits air to the bellows F under lower pressure for moving the lever E in one direction, while when the cock o is in the opposite position it admits air by the pipe p to the bellows J under greater pressure for moving the lever E in the opposite direction, as specified.

20. The combination of the tanks A, D, and H with the weighted levers B I E N, bellows T, M, R, L, F, J, and O, and with the cocks m, o, f^2, b, c, and n^2, and with the system of connecting-pipes, substantially as herein shown and described.

21. The lever I, combined with the three-way cock f^2 in the pipe d^2, and with the exhaust-nozzle i^2 on said pipe, substantially as and for the purpose specified.

22. The combination of the auxiliary compressed-air chamber H and its discharge-pipe e^2, having cock n^2, with mechanism, substantially as described, for opening said cock, and with the bellows R and lever I, which controls the cock f^2, all arranged so that upon opening the valve n^2 said lever I and cock f^2 will be moved and the function of the compressed-air chamber H thereby performed, as specified.

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Witnesses:

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