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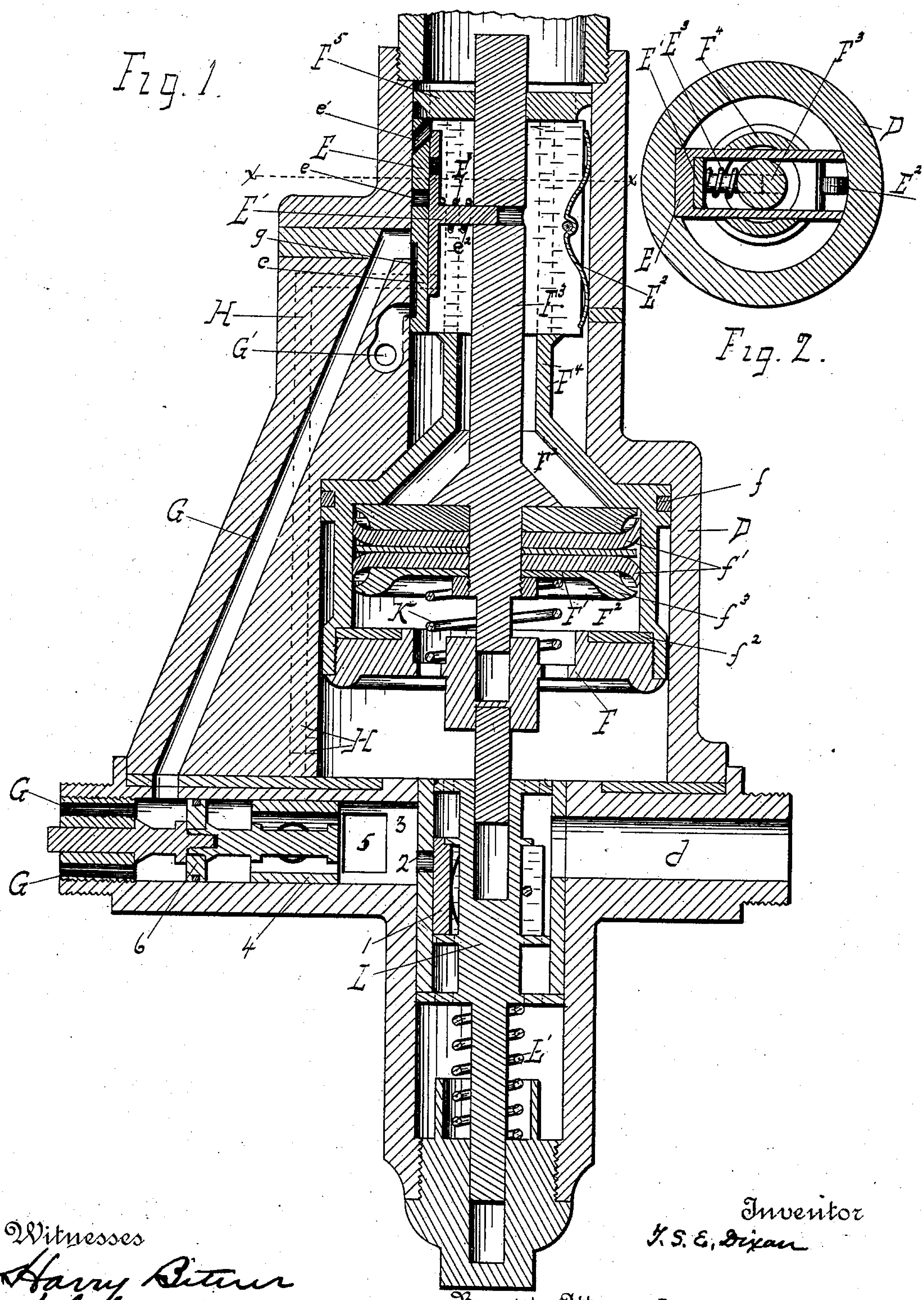
T. S. E. DIXON.

AIR BRAKE.

No. 389,643. Patented Sept. 18, 1888.



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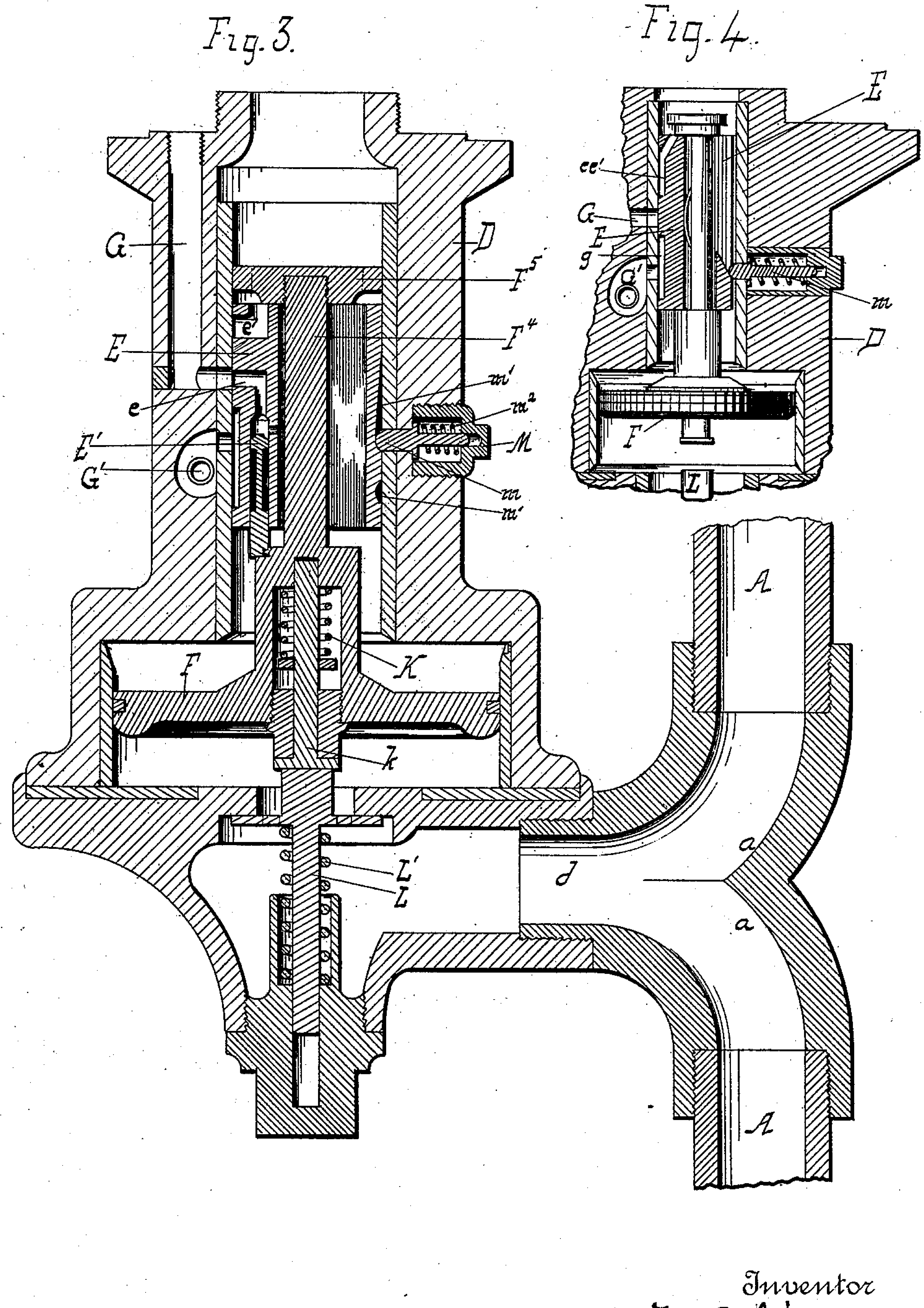

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Fig. 5.

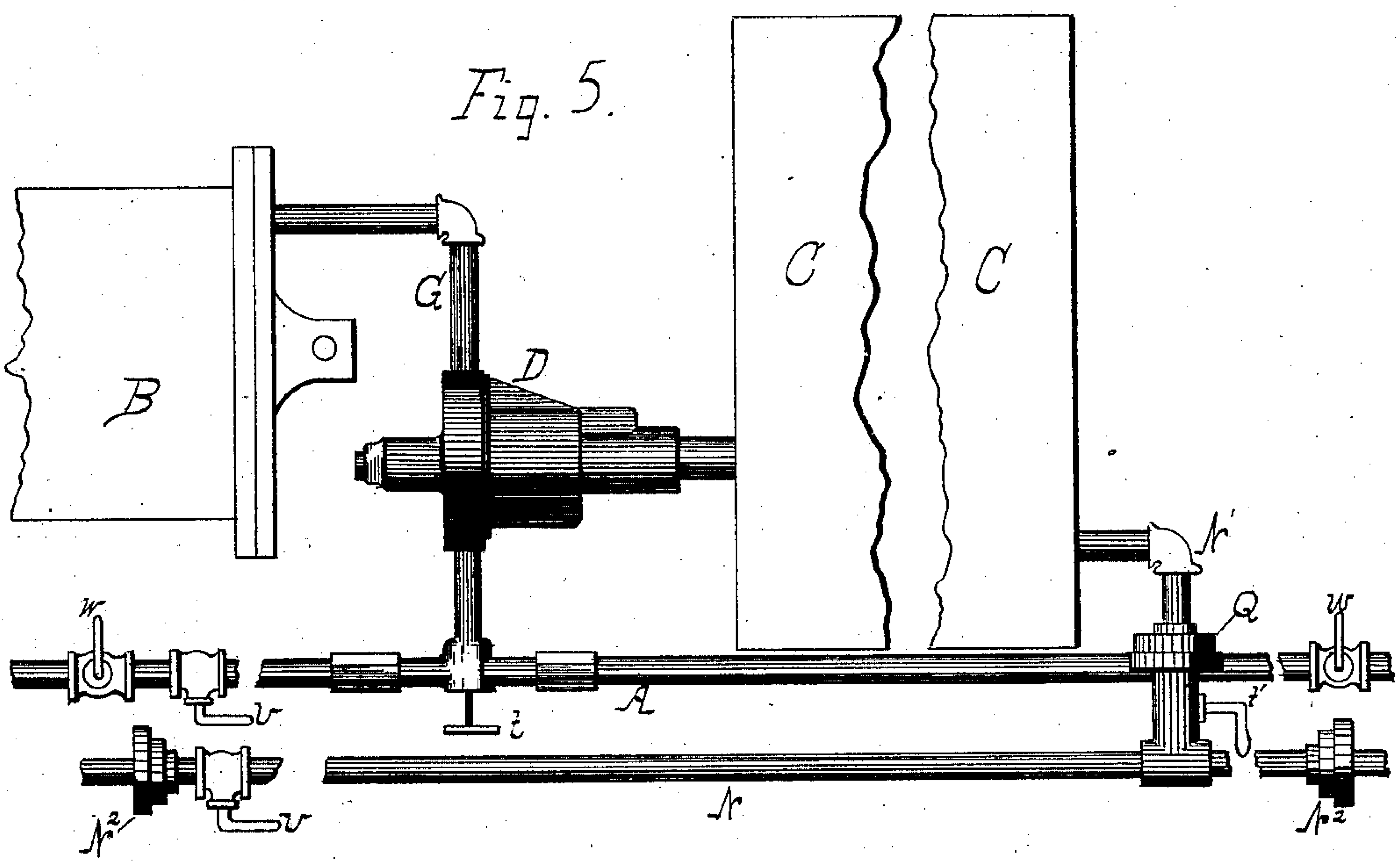

Fig. 6.

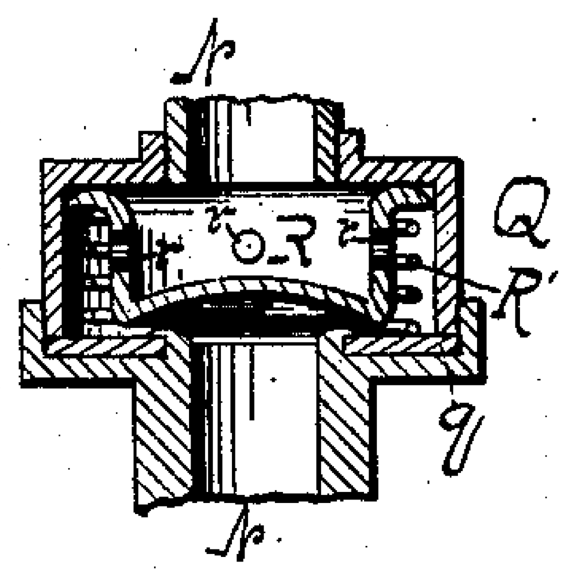

Fig. 7.

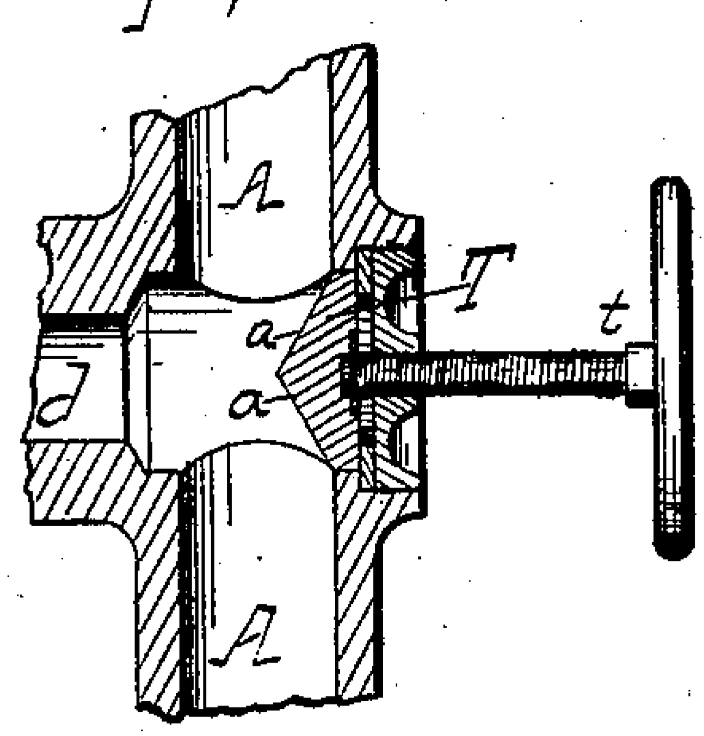

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Fig. 8.

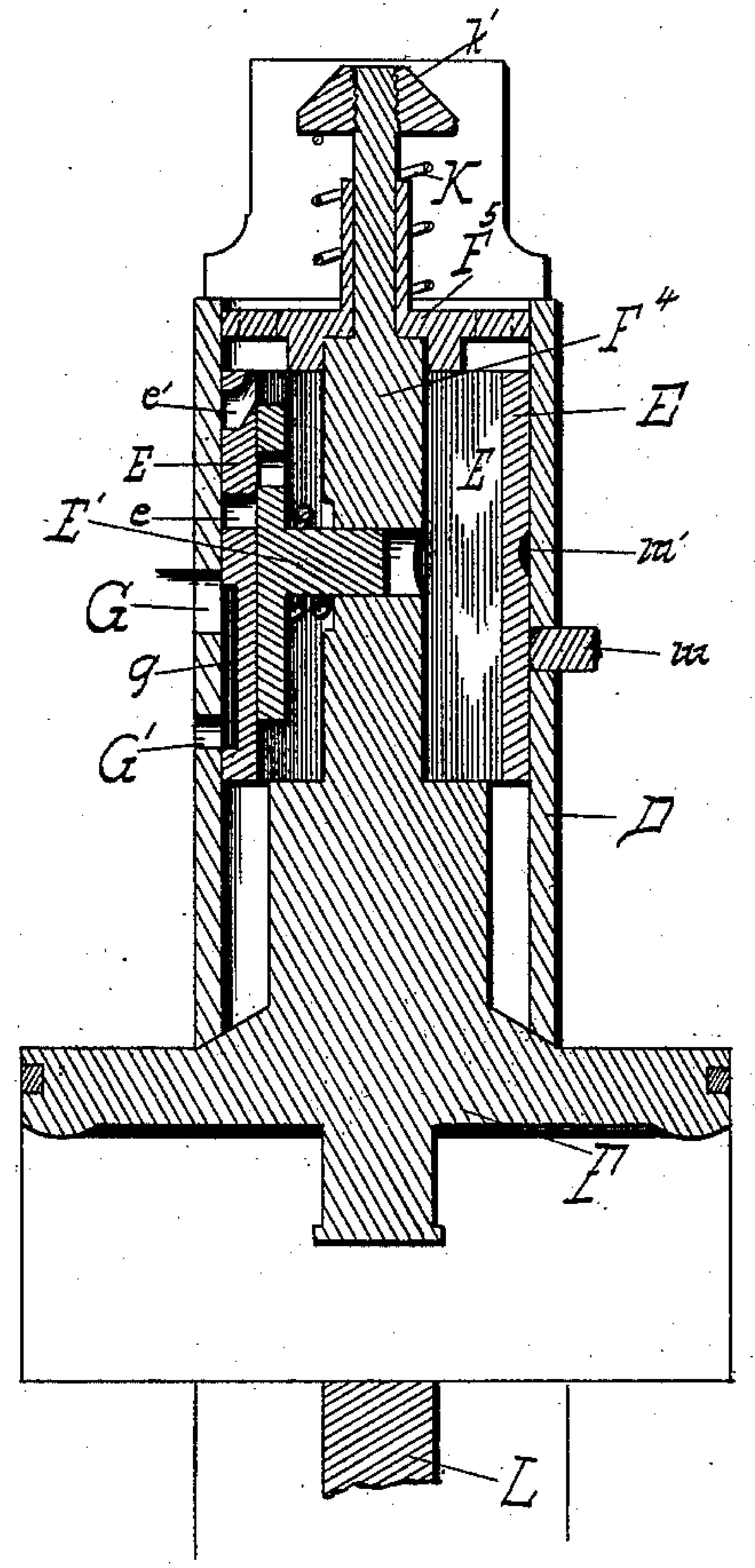

Fig. 9.

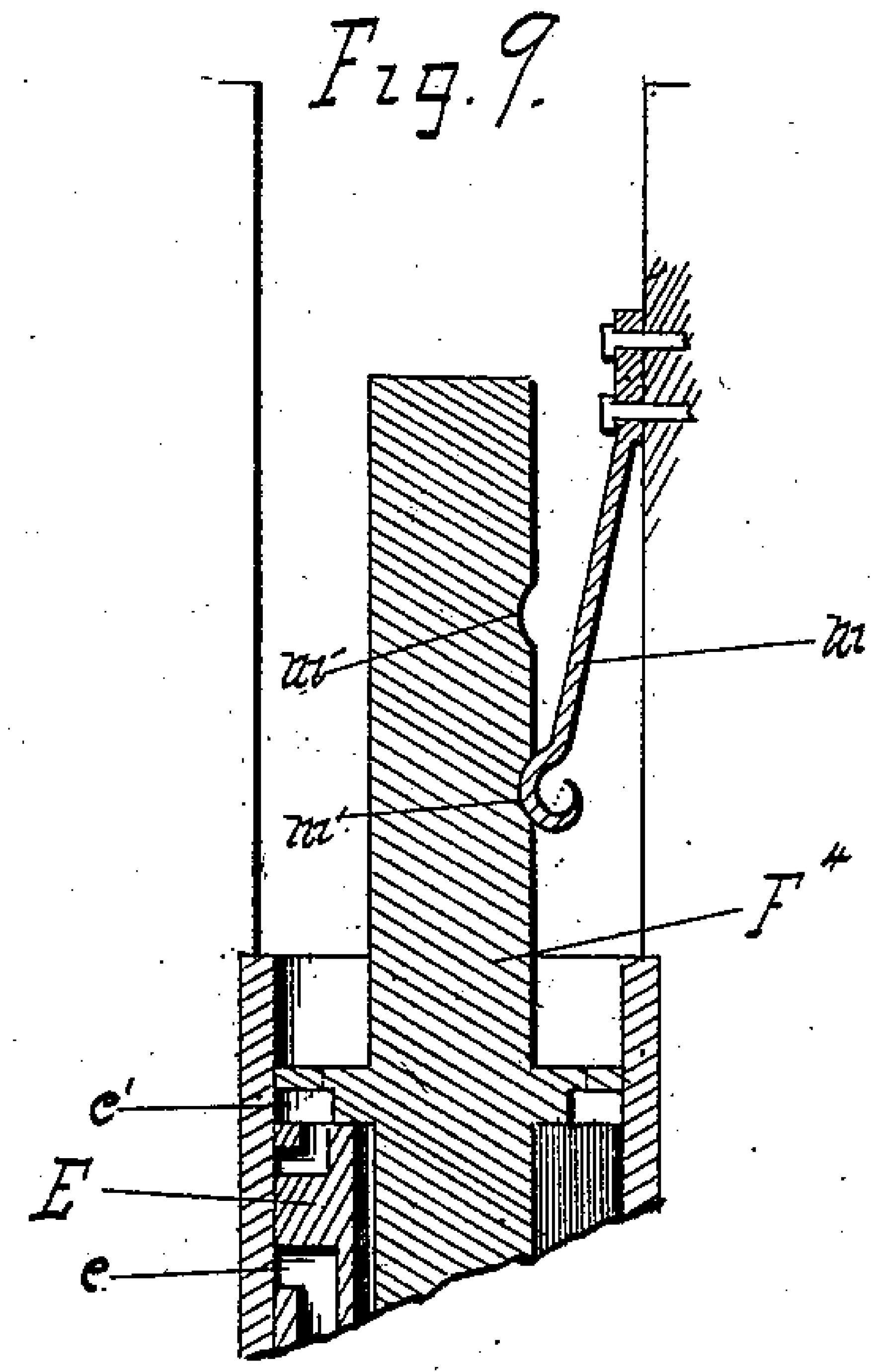

Fig. 10

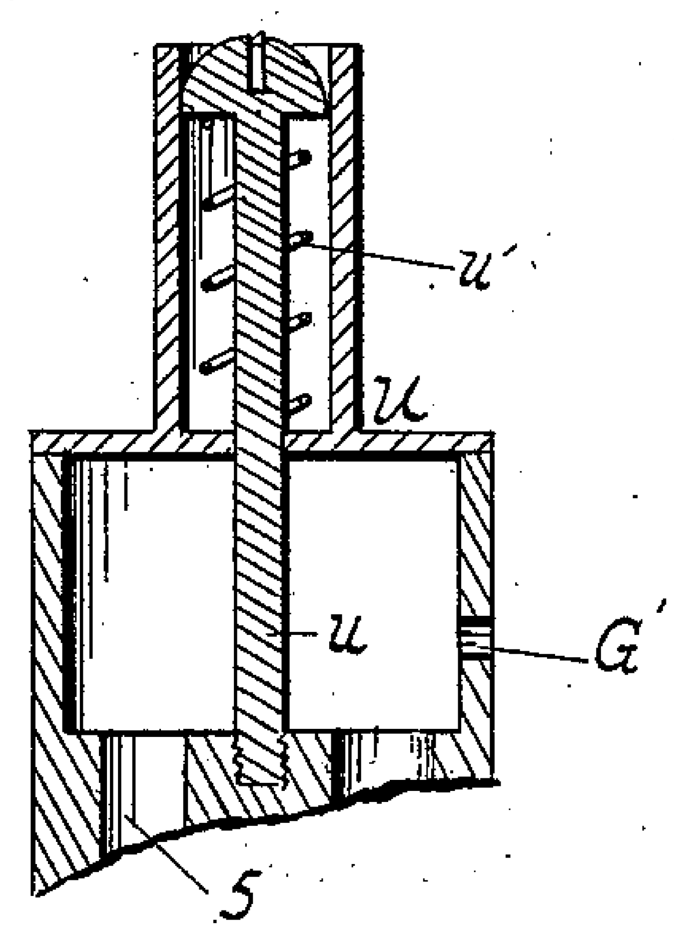

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Fig. 11

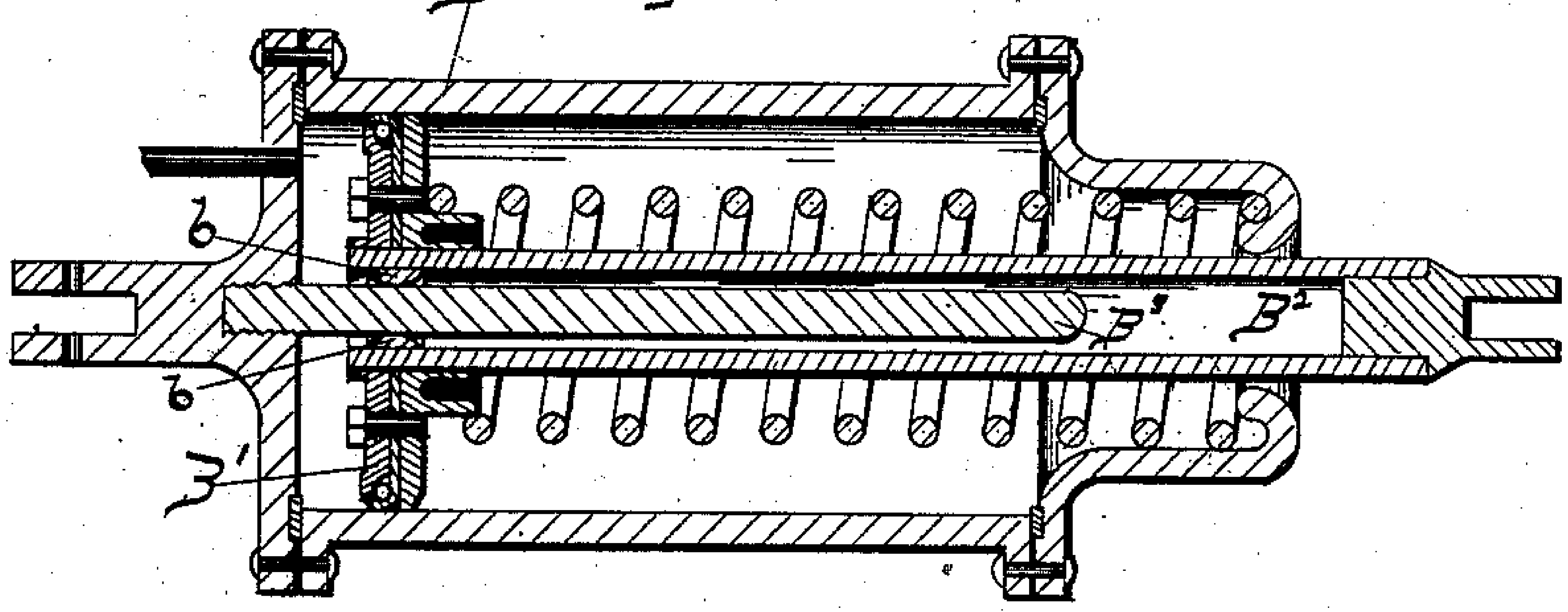
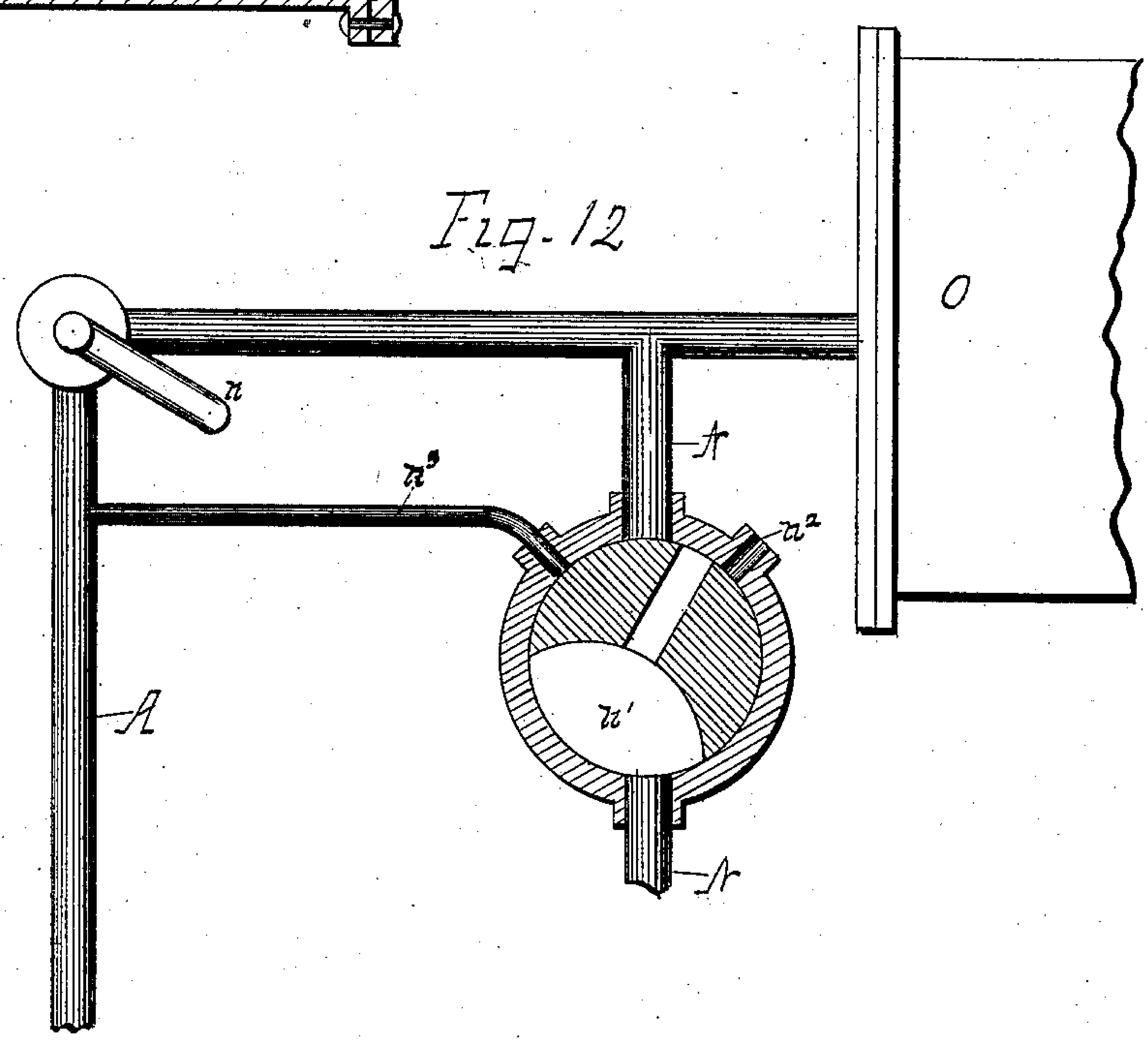


Fig. 12



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UNITED STATES PATENT OFFICE.

THERON S. E. DIXON, OF HYDE PARK, ILLINOIS.

AIR-BRAKE.

SPECIFICATION forming part of Letters Patent No. 389,643, dated September 18, 1888.

Application filed July 17, 1888. Serial No. 280,180. (No model.) Patented in Belgium August 1, 1888, No. 61,643.

To all whom it may concern:

Be it known that I, THERON S. E. DIXON, a citizen of the United States of America, residing at Hyde Park, in the county of Cook and State of Illinois, have invented certain new and useful Improvements in Air-Brakes, (for which I have obtained a patent in Belgium, dated August 1, 1888, and numbered 61,643,) of which the following is a specification.

In the drawings, wherein similar reference-letters indicate the same or corresponding parts, Figure 1 is an axial section of the governing-valve and its casing; Fig. 2, a cross-section, reduced in size, through line X X of Fig. 1; Fig. 3, an axial section showing a modified structure; Fig. 4, a partial section showing another form; Fig. 5, a plan view showing the preferable arrangement of the auxiliary reservoir, brake-cylinder, governing-valve, and train-pipes, with parts broken away to economize space in the drawings; Fig. 6, an axial section of the retaining-valve and casing; Fig. 7, an axial section of the combined deflector and plug; Fig. 8, a partial section showing the spring K arranged at the inner end of the governing-valve; Fig. 9, an axial section showing one mode of applying the spring-stop; Fig. 10, an axial section of the spring dust-shield; Fig. 11, an axial section of the brake-cylinder and the improved brake-piston and its stem; and Fig. 12, a partial plan and section of the two train-pipes, their controlling valves or cocks on the locomotive, and a portion of the main reservoir.

This invention relates to the so-called "automatic" air-brake system, in which an air-pump on the engine and a "main air-reservoir" on the engine or tender are combined, by means of a train-pipe extending throughout the train, with "auxiliary air-reservoirs" on the several cars, brake-cylinders containing pistons connected to the brake mechanism, and valve-casings, each containing an air-piston or diaphragm subject to the pressure of the auxiliary-reservoir air at one end and the train-pipe air at the other end, and controlling the movements of a valve which governs the admission of compressed air from the auxiliary reservoir to the brake-cylinder and its subsequent discharge therefrom to the atmosphere, and in which system the engineer, by charging or venting the train-pipe at the engine, operates said valve-controlling pistons, so as to cause the setting and releasing of the brakes on the several cars. As usually constructed and operated, when a small quantity of air is vented from the train-pipe at the engine, said valve-controlling pistons move outward till they rest against the end of a spring-rod and there stop, in which position they cause the valve to temporarily open the "service" or "grading" port and set the brakes with a moderate pressure against the car-wheels; but when a large quantity of air is vented from the train-pipe the pistons do not stop at the point where they cause the opening of the service-port, but move outward farther, compressing the spring of the spring-rod, and causing the valve to open another port, termed the "emergency-port," which vents the whole auxiliary-reservoir pressure into the brake-cylinder and sets the brakes with full force against the wheels.

My invention comprises several improvements, which are capable of separate or conjoint use, and which are respectively designed to improve the operation and promote the practical efficiency of such system and to remedy practical defects heretofore found to exist in it. Among the most serious of such defects are the following, to wit: First, "grading"—that is to say, the setting and holding of the brakes under a moderate pressure for a considerable time, and the increasing of such pressure at will, while the brakes are set and without releasing them, for the purpose of "slowing-up" a train or easing it down a grade—has not been able to be satisfactorily accomplished by the engineer through the manipulation of his charging or discharging cocks on the locomotive; secondly, the air-reservoirs have been liable to become exhausted, particularly on long downgrades, and thereby the whole air-brake system to become inoperative and useless at the very time when it is most needed; thirdly, the valve-pistons have been liable occasionally to stick immovably in their casings, and the entire apparatus to be thus rendered uncontrollable; fourthly, when, at the end of a trip, it becomes desirable to exhaust the compressed air from the auxiliary reservoirs—or, as it is technically termed, "bleed" them off—the engineer has not been able to accomplish it by his pressure-controlling cocks on the engine, but has been obliged to send men along the train to open special cocks provided for the purpose, and again to close said cocks preparatory to recharging the reservoirs for a new trip, and, fifthly, the heavy brake-pistons have been liable to gradually wear away at their lower edge and permit the compressed air to leak from the brake-cylinders.

In the following specification, for convenience of description, I shall use the term "governing-valve" to indicate the combined air-piston or diaphragm and its associated valve or valves, arranged in the valve-casing under each car, and operating to govern the admission of compressed air into the brake-cylinder and its subsequent discharge therefrom, and with reference thereto I shall use the term "inner" end to signify the end or side subject to the reservoir-pressure, and "outer" end to signify the end or side subject to the train-pipe pressure.

The several improvements by which I accomplish the novel and important results above referred to consist, first, in a governing-valve having a new construction and mode of operation, whereby the engineer is able at will to open the service-port and set the brakes, and then close it and hold them set for any length of time that he may desire, and if the brake-pressure should leak off, or he should desire to increase it, to again open said port and supply the pressure desired as often as he may wish and hold it thus applied without meanwhile allowing the brakes to be released; secondly, in a supplementary air-pipe extending from the locomotive and communicating with all the auxiliary reservoirs on the train through ports preferably provided with retaining-valves, whereby, through the manipulation of a suitable cock or cocks on the engine, the air-pressure in the several auxiliary reservoirs may be increased or reduced at will in order to operate or assist in operating the governing-valves, the auxiliary reservoirs may be bled off at any time without sending men along the train for that purpose, the air-pressure in all the auxiliary reservoirs will always be perfectly equalized, and when the service or emergency ports are opened a "straight-air" communication, controlled by the cocks on the engine, will be thereby established from the main reservoir or the air-pump directly to every brake-cylinder along the train, through which the air-pressure upon the brakes may be increased or controlled at will so long as said ports remain open; thirdly, in an improved construction of said retaining-valves and an improved combination of them with the supplementary train-pipe and the auxiliary reservoirs, whereby they operate to hold their respective ports normally open for the passage of air in either direction; but in case of the uncoupling of the cars, or the rupture of the supplementary pipe or any of its flexible hose-connections between the cars, they instantly close their ports and prevent any loss of air from said reservoirs or from the brake-cylinders; fourthly, in an improvement connected with the main train-pipe, whereby the venting of its air for the purposes of an "emergency-stop" will be rendered more quickly effective throughout the train; fifthly, in an improved construction of the brake-cylinder and its piston and piston-rod, for the purpose of preventing the leakage of air from said cylinder, and, sixthly, in certain other improved devices and combinations, hereinafter described, and more particularly pointed out in the claims hereto appended.

In the drawings, A indicates the well-known train-pipe of the automatic air-brake system, through which the engineer is accustomed to control the movements of the governing-valves, and which I term in my improved system the "main train-pipe."

B is the brake cylinder containing the brake-piston B′.

C is the auxiliary reservoir, and D is the casing or box which incloses the governing-valve apparatus.

The auxiliary reservoirs are preferably filled from the main train-pipe, and suitable ports or passages controlled by the governing-valve permit the compressed air at the proper times to vent from the auxiliary reservoir into the brake-cylinder to set the brakes and subsequently to exhaust from said cylinder to the open air to release the brakes. The governing-valve, as heretofore generally constructed, consists of a piston, (or diaphragm,) F, connected to and operating a valve, E, which opens and closes said ports, the piston being subject at its outer end to the pressure of the air in the main train-pipe and at its inner end to the air-pressure of the auxiliary reservoir, and standing normally at the inner end of its traverse, in which position of the governing-valve a passage, G, that leads from the brake-cylinder is caused to communicate with the open-air port or exhaust G′ by means of an elongated recess, *g*, in the side of the valve E, and the brakes are consequently released.

By venting a little air from the main train-pipe at the locomotive the engineer causes the superior pressure then remaining in the auxiliary reservoir to force the governing-valve outward until, after having put the recess *g* out of communication with one of the two passages G G′, and thus closed the exhaust from the brake-cylinder, it rests against the spring rod or stem L, in which position a "service-port" or "grading-port" or passage, *e*, extending through the valve E, communicates with the passage G, leading to the brake-cylinder. Thereupon the compressed air vents from the auxiliary reservoir through the passages *e* G into the brake-cylinder to set the brakes, and continues thus to vent until the air-pressure at the inner end of the governing-valve falls below that at the outer end, and the governing-valve, in consequence thereof, moves inward and closes communication between the passages *e* G. In order now to hold the brakes thus set for any considerable time, it is of course necessary that the governing-valve should cease to move inward as soon as it shall have cut off communication between the passages e G—or, in other words, closed the service-port—because if it should continue to the inner end of its traverse it would place the passages G g G′ in communication, or, in other words, open the exhaust and immediately release the brakes. The difficulty has been to stop the governing-valve at the proper place, for the reason that a preponderance of air-pressure at its outer end sufficient to initiate its inward or return movement is ordinarily sufficient to carry it clear back to the inner end of its traverse. Attempts have been made to overcome this difficulty by arranging a supplementary puppet-valve to open and close the passage e through the main valve, giving the actuating-piston a slight play or "lost motion" with respect to the main valve and utilizing this independent play of the piston to operate the supplementary valve for the purpose of opening and closing the passage through the main valve, whereby it was expected that the first slight preponderance of air-pressure which should occur at the outer end of the piston would be sufficient to start it back to the extent of its lost motion, and thus seat the puppet-valve and stop the further escape of air from the reservoir to the brake-cylinder, but would be insufficient to overcome the friction of the main valve against the wall of the casing, and therefore that, under such conditions, the piston would simply seat the puppet-valve and then stop until, by the admission of greater pressure through the train-pipe, the engineer should force the piston with both of its connected valves to the inner end of their traverse, and thus release the brakes; but experience has shown that the friction of the main valve and that of the piston itself against the walls of the casing are uncertain elements, and that a preponderance of air-pressure sufficient to overcome the latter is quite liable to overcome both and return the governing-valve at once to the brake-releasing position, or else, if not, is insufficient to hold the puppet-valve properly seated, and hence allows the reservoir-air to continue leaking into the brake-cylinder. This practical difficulty, which has hitherto proved insurmountable in the automatic air-brake system, is entirely overcome by my improvements, wherein I introduce two new principles or modes of operation, which, for their respective purposes, may be used independently of or in conjunction with each other.

My first improvement consists, broadly, in operating the main valve by means of a piston, (or diaphragm,) which I shall term the "main piston," and operating the supplementary valve to preliminarily open or close the passage through the main valve by means of a member which, for that purpose, moves independently of any movement of the main piston. The preferable construction is shown in Fig. 1, and (excluding from consideration for the present the spring K shown in said drawing) is as follows:

F^2 is a chamber formed in the main piston F and communicating with the air-spaces at the ends of said piston.

F′ is a piston, (or diaphragm,) which I shall term the "supplementary piston," arranged in the chamber F^2 so as to have a limited movement or play therein, and connected to the supplementary slide-valve E′ by a stem, F^3, and pin e^2. The main valve E is in the form shown by the cross-section, Fig. 2, and is held to its seat by a spring, E^2.

The stem F^4 of the main piston F is preferably made tubular, slotted, or bifurcated to accommodate the main valve, and guided at its inner end by a cross-head or spider, F^5, attached to and sliding with it, and so constructed as not to obstruct the movements of the air. The stem F^3 of the supplementary piston extends through the hollow stem F^4 and passes through the cross-head F^5, which also serves to guide it in its independent movement. A spring, E^3, holds the supplementary slide-valve E′ pressed against the main valve. Thus constructed the supplementary piston moves back and forth with the main piston in the general traverse of the latter, but has, to the extent of its limited motion in chamber F^2, a limited movement independently of the main piston. Both pistons are actuated by the air-pressure against their ends; but the supplementary piston is so packed and its valve E′ so applied that, together, their independent preliminary movement will be subject to less frictional resistance than will the movement of the main piston and its connected main valve, and therefore they will perform this preliminary movement under the influence of a preponderance of air-pressure so small as to be practically insufficient to move the main piston and valve. This result can easily be obtained by packing the main piston, as usual, with the ordinary metal ring-packing, f, and the supplementary piston with leather or other soft packing, f', or by using a stronger spring, E^2, to hold the main valve against its seat than is employed in connection with the supplementary valve. The two pistons may also be made differential, so that under the same air-pressure the one which actuates the supplementary valve will move more readily than the one which actuates the main valve.

The operation is as follows: In the normal position of the governing-valve apparatus (which consists, in this instance, of the two pistons and valves) the supplementary valve will hold the passage e through the main valve closed; but when the engineer vents a little air from the train-pipe A the preponderance of pressure thus caused at the inner end of the governing-valve will first move the supplementary piston outward independently of the main piston, so as to open the passage e, and will then move both pistons together outward till the governing-valve apparatus rests against the spring-stem L, in which position the open passage e will be in line with the air-passage G, and the reservoir-air will pass into the brake-cylinder to set the brakes. Now, as soon as the air-pressure at the inner end of the governing-valve shall have fallen slightly below that which remains at the outer end, the preponderating pressure at the outer end will move the supplementary piston inward and close the passage e before the difference of air-pressure has become sufficient to start the main piston back, and the governing-valve will thus hold the service or grading port closed without opening the brake-release port—a position of things which may be maintained for an indefinite period at the will of the engineer. In this construction it is unnecessary to give either valve any lost motion with respect to its actuating-piston, and a sufficient differential in favor of the supplementary piston will be established, independently of the difference of friction, by making its exposed and effective area larger than that of the main piston, or by so fitting the surfaces of the main piston and the stem L to each other that when in contact they will exclude air from between them and thus temporarily reduce the effective area of air-pressure against the main piston.

It will be observed that both in the old construction, where the supplementary valve is preliminarily moved by the main piston while the latter is passing through the range of its lost motion with respect to the main valve, and in my new construction, where the supplementary valve is preliminarily moved by a mechanical element which has a motion independent of the main piston, an actual preponderance of air-pressure at the outer end of the governing-valve is required to close the passage e through the main valve, and is the only force by which such closing is effected.

My second improvement consists, broadly, in providing another and different source of power to preliminarily close, or aid in closing, the passage e through the main valve, and in adapting means to practically apply that power for the purpose referred to, to the end that the supplementary valve may be moved to close said passage before any effective preponderance of air-pressure is established at the outer end of the governing-valve, for example, while the air-pressure is equalized at both ends of said valve, or is even slightly less at the outer than at the inner end. In the application of this new principle I preferably employ a spring to furnish the additional power, combining such spring with the piston which actuates the supplementary valve to preliminarily close the port through the main valve in any suitable way, whereby the outward movement of said piston under the influence of the reservoir-air, to open the service-port, will compress the spring and open the passage e, and, when the air-pressure on both sides of the governing-valve becomes substantially equalized, the spring will react and move, or aid in moving, the supplementary valve back to close said passage. The principle is clearly illustrated in Figs. 3 and 8, which represent the old construction of governing valve apparatus, wherein one and the same piston operated both the main valve and the supplementary valve.

K is the spring, arranged in Fig. 3 at the lower end, and in Fig. 8 at the upper end, of the piston and piston-stem. In the former case the spring acts against a projecting rod or plunger, k, that has a limited movement coincident with or slightly greater than the limited play of the supplementary valve in opening and closing the passage e. In the latter case the spring is arranged between a nut, k', attached to the upper end of the piston-stem, and a guide bar or plate, F^5, attached to or resting upon the upper end of the main valve. In either case, when the engineer vents air from the train-pipe A to open the service-port, the piston F, in the act of moving outward against the end of the spring-stem L, compresses the spring K and opens the passage e. The reservoir-air now rushes into the brake-cylinder until the air-pressure at the inner end of the governing-valve has sufficiently decreased to allow the spring K to act, whereupon said spring tends to move the piston F back far enough to seat the supplementary valve E' and close the passage through the main valve; but, there being no preponderance (or, in any event, no large preponderance) of air-pressure at the outer end of the governing-valve, there is no possibility of the main valve E moving back to open the brake-release port until the engineer shall have increased the pressure in the train-pipe A for that purpose.

One great advantage in preliminarily closing the passage e by a force which is free to act for that purpose before the pressure at the inner end of the governing-valve is reduced materially below that at the outer end arises from the fact that with such construction the supplementary valve will close earlier, and a less quantity of reservoir-air may therefore be vented into the brake-cylinder, and hence the brakes can be set with a comparatively light pressure against the car-wheels, which is very desirable for grading purposes where the speed of the train is to be merely slackened more or less.

I have found that with my improvement the brakes can be applied and held for an indefinite period at a pressure as low as from three to five pounds per square inch of brake-piston surface. Any other arrangement of the spring which will enable it to effect or aid in effecting the preliminary closing movement of the supplementary valve (whether it also operates to open said valve or not) I regard as coming within the limits of this part of my invention.

Taking these two new principles—to wit, that of preliminarily operating the supplementary valve by a member which is capable of moving independently of the piston which operates the main valve and that of employing a force independent of the air-pressure to aid in moving the supplementary valve—my third improvement consists, broadly, in combining them both together in one and the same governing-valve apparatus. This improvement is illustrated in Fig. 1, in which the two pistons and valves, constructed and applied substantially as hereinabove described, are combined with a spring, K, which is so arranged that when compressed by the movement of the supplementary valve to open the passage *e* it will tend by its spring action to force said valve back and close said passage, any arrangement that will produce this result being within the limits of the invention, but the preferable mode of construction being that which is indicated in the drawings; and I may here remark that in all cases, especially when the two pistons are employed, I prefer to make the supplementary valve in the form of a slide-valve, for the reason that it closes the port or passage more tightly than any other form of valve under slight pressures of air and is less liable to be held open by particles of dust. With the two principles thus combined I am able to control the frictional resistance of the supplementary valve, so as to insure its closing before the main valve moves, and I am able to close it against or over its port *e* before the air-pressure at the outer end of the governing-valve apparatus is able under any circumstances to disturb the position of the main valve; and hence I am able not only to apply my grading pressure from a minimum of four or five pounds up to the maximum of equalization with the auxiliary reservoirs, but to hold it thus applied for any desired length of time with absolute certainty, (ordinary leakage from the brake-cylinders only excepted.) I have found in practice that when two pistons are employed and the spring K is made a little stronger than is necessary for its purposes the two valves will move outward together till the main piston strikes the spring-stem L, and the supplemental valve will then move outward independently of the main valve and open the passage *e*.

By arranging the spring K substantially as indicated in Figs. 1 and 8—that is to say, in such manner that when the piston F is seated against the stem L and the spring K is compressed by the superior air-pressure at the inner end of the governing-valve its reacting spring force tends simultaneously to force the main valve outward and the supplementary valve inward—not only is an essentially new mode of operation imparted to the structure, but thereby an important practical result is produced—to wit, that the spring both acts to hold the main valve from moving and to move the supplementary valve with relation to it, thus practically insuring the complete and effective closing of the passage *e* without permitting the main valve to move inward at the same time. With regard to any possible outward movement of the main valve under the action of the spring K at such time, this is prevented in the arrangement shown in Fig. 1 by the spring L′, and in the arrangement shown in Fig. 8 by the spring-stop *m* (hereinafter described) plus the friction of the main valve against the casing. The preferable arrangement is that shown in Fig. 1, where the spring K is placed between the two actuating-pistons, so as to react equally, but in opposite directions, against them, and thereby against the valves which they control.

The employment of a slide-valve for the purposes of the supplementary valve enables me to effect a further and important improvement in the means for charging the auxiliary reservoirs with compressed air from the main train-pipe A. To this end I connect the air chambers or spaces at the opposite ends of the governing-valve by a passage, H, in the wall of the casing D, (shown in dotted lines in Fig. 1,) provide in the main valve E a port or passage, *c*, (also shown in dotted lines,) which will communicate with the inner end of the passage H when the governing-valve is at its normal position, and arrange the supplementary valve so that it will then hold the passage *c* open to the passage H when the passage *e* is closed and closed when the passage *e* is open. When, therefore, the governing-valve is at its normal position, the passage H *c* is open and the auxiliary reservoirs will fill from the main train-pipe; but the instant that the train-pipe pressure begins to be reduced for the purpose of setting the brakes the supplementary and extremely-sensitive valve E′ will close the passage *c* and cut off further communication between the train-pipe and auxiliary reservoirs. In thus guarding the refilling-port H *c* by means of a valve more sensitive than the main valve E, I prevent the possibility of air venting back through the passage H from the auxiliary reservoir to the train-pipe A when the pressure of the latter is but slightly reduced. It also enables me to fill the reservoirs through a passage in the wall of the casing, and therefore to pack the pistons more satisfactorily, and it dispenses with the necessity of a check-valve in the refilling-passage. The refilling-passage H is similar to that described in Letters Patent No. 382,031, granted to me May 1, 1888, and shown in Figs. 1, 3, and 4 of that patent. The passage H *c* being open when the brakes are off, it then furnishes not only a refilling-channel, as aforesaid, but also an equalizing-passage, through which all the auxiliary reservoirs communicate with the main train-pipe, and thereby with each other, and thus an absolutely uniform air-pressure is assured throughout the system so long as the brakes are off.

As an independent improvement, a spring-stop may be employed to temporarily hold the main valve E in any desired position with relation to the service-port or the brake-release port, or both. To this end I make a depression or series of depressions, *m*′, in the surface of the valve E or in its actuating-stem or other connections, preferably giving the walls of the depressions an inclined or dishing form, and I arrange a spring-stop, m, (or, if preferred, a series of them,) so that when the valve reaches the position in which it is desirable to temporarily hold it the spring-stop will enter one of the depressions and tend to hold the valve from further movement; but if a sufficiently-increased force be brought to bear on the valve to move it along its traverse the spring-stop will ride up the inclined wall of the depression and release the valve. The spring-stop may be made and applied in a variety of forms, some of which are shown in the drawings. In Figs. 3, 4, and 8 it consists of a rod, m, pressed inward through the wall of the casing D by a spring, m^2, arranged in a cap, M, which is screwed air-tight into the outer surface of the casing. In Fig. 9 it consists of a spring, m, affixed to the inner wall of the casing, so that its free extremity, suitably shaped for the purpose, will bear against the side of the valve stem and successively enter the depressions m' therein. The precise form and arrangement are immaterial so long as the spring is adapted to exert at a predetermined point or points in the traverse of the main valve a resistance which is greater than is exerted against its movement at either side of said point or points, and thereby to yieldingly lock or engage with said valve at such point in the manner and for the purpose substantially as above indicated. It is obvious that the position of the depressions and stop may be reversed—that is to say, the stop may be carried with the valve and the depressions arranged in the wall of the casing—without departing from the principle of my invention, and that projections may be substituted for the depressions. I arrange one of these depressions where it will act to hold the valve in its normal position, with the brake-release port G′ open; another where it will hold the valve at the service-port, and, if desired, another where it will hold the valve between the service-port and the brake-release port, with both of said ports closed; but any one or more of the locking-depressions above specified may be omitted and only the other or others used, if the constructer prefers. These various positions are respectively illustrated in Figs. 3, 4, and 8. This improvement may be applied with or without the supplementary valve. It acts entirely upon the main valve to hold the latter temporarily at any desired point in its traverse; but when the supplementary valve is also used it co-operates with both, holding the one properly in place while the other is moving to a new and predetermined relative position.

As an independent improvement, when the two pistons are employed, I provide one of them with a soft packing-ring, f^2, and the other with a raised ring or bead, f^3, adapted to seat on the soft packing-ring when the passage e is opened. This device, in connection with the spring K, performs a twofold function, to wit: First, it packs the joint between the two pistons absolutely air-tight when the emergency-port is open, thereby preventing the air under the great difference of pressure then existing from leaking through into the comparatively empty train-pipe A; secondly, with regard to the inward movement of the pistons, it tends to establish a small initial differential of air-pressure in favor of the main piston, which, however, instantly disappears when the surfaces $f^2 f^3$ separate from each other. The force of the spring K being preferably adjusted so as to slightly overcome the differential action caused by the contact of the surfaces $f^2 f^3$, the supplementary piston will commence to move inward before the main piston, and the instant that this initial movement causes the surfaces $f^2 f^3$ to separate from each other the opposing differential action disappears and the supplementary valve E′ shoots back with increased force and closes the port e perfectly air-tight, notwithstanding the fact that at the instant of closing said port the friction upon said valve is somewhat greater than at other times in consequence of the air-pressure over the port. With the two pistons F F′ arranged as shown in Fig. 1, there will normally be a differential action in favor of the piston F′ so long as the latter is free to move independently of the other, owing to the fact that the chamber F^2 communicates freely with the air-spaces at the ends of the governing-valve, and also owing to the seating of the main piston on the stem L, and the ring and bead $f^2 f^3$ will merely vary the amount of this differential with the effect and for the purpose above referred to.

An independent and important improvement consists in a supplementary train-pipe, N, connecting the several auxiliary reservoirs to each other and to the air-pump and main reservoir on the engine and tender by an air-passage which is not under the control of the governing-valves, but normally is open from end to end of the train and filled with air under the same pressure as the air in the auxiliary reservoirs. By means of a cock or cocks on the locomotive the engineer can fill this pipe from the main reservoir O or the air-pump, hold it closed, vent its contents to the atmosphere, or open an equalizing-passage between it and the main train pipe A. The two train-pipes A N enable him to vary the air-pressure at either or both ends of the governing-valve at will and to simultaneously reduce the pressure on one side and increase it on the other, said valve being held between the two opposing pressures and controlled by varying either.

In the practical operation of the brake system the supplementary train-pipe N performs several important functions, to wit: First, it preserves an absolute uniformity of air-pressure in all the auxiliary reservoirs along the train at all times, thus insuring the uniform action of all the governing-valves; second, by venting it to the atmosphere all the auxiliary reservoirs, together with the brake-cylinders and main train-pipe A, can be "bled off" by the engineer without sending men along the train for that purpose; third, its contents being normally in communication with those of the auxiliary reservoirs, it operates to the extent of its capacity as an enlargement of the auxiliary-reservoir capacity; fourth, by increasing its air-pressure above that of the main train-pipe it can be employed at any time to force the governing-valves outward and set the brakes with any desired degree of brake-pressure, or to increase their pressure as little or as much as may be desired after they have been preliminarily set by the action of either train-pipe, or to restore any pressure lost by leakage from the brake-cylinders; fifth, by reducing its air-pressure below that of the main train-pipe, when the brakes have been set, it will at any time enable the pressure in the main train-pipe to force the governing valves inward and release the brakes; sixth, by simultaneously increasing the pressure of the one pipe and reducing that of the other the brakes can at any time be set or released far more quickly than by the action of either pipe alone; seventh, it enables the engineer to refill his auxiliary reservoirs and keep up their pressure at all times, and whether the brakes be set or released at the time, for even when they are held set by grading pressure the engineer, by first opening the equalizing-passage between the two train-pipes, can fill both of them and all the auxiliary reservoirs without disturbing the position of the governing-valves, and therefore without releasing the brakes or affecting their pressure, or he can, without refilling, hold the brakes thus set for an indefinite period; eighth, it enables him to fill or refill the auxiliary reservoirs almost instantaneously, for the reason that its carrying capacity is many times greater than that of the necessarily small refilling-passage H *c*, which leads from the main train-pipe; ninth, it prevents any accidental reduction of the main-reservoir pressure from rendering it impossible to release the brakes except by the slow action of the air-pump heretofore necessary in such case; tenth, when the emergency-port is open and the brakes therefore set with the full available pressure of the auxiliary reservoirs, a "straight-air" passage will be open from the brake-cylinders to the engine by means of the pipe N, through which the brake-pressure may be increased to any desired extent by venting air from the main reservoir or the air-pump into the supplementary train pipe; eleventh, in conjunction with the main train-pipe it increases the effective means for forcing the governing-valves to move, if any of them should accidentally stick at any part of their traverse. Cocks *n n'* are represented in Fig. 12, by which the engineer may control at will the pressure in the two train-pipes.

The cock *n* in the main train-pipe is of the form usually employed for that purpose. The cock *n'* in the supplementary train-pipe is of very similar character; but its discharge-vent n^2 is preferably smaller, and it also connects with a small equalizing pipe or passage, n^3, extending to the main train-pipe. Its construction is so clearly shown in Fig. 12 that further description is deemed unnecessary.

Even if by the jar of the running train any governing-valve should at any time, when the air-pressure at both of its ends is equal, work outward in its casing until its piston rests against the spring-stem L, no harm will result, for the supplementary valve E' will hold the service-port closed so long as the pressure remains equal. When the spring stop *m* is employed to hold the governing valve in its normal position, however, no such accidental displacement can occur.

In Fig. 4, instead of employing separate passages in the governing-valve to register with the passage G for the purposes of a service-port and an emergency-port, respectively, I make use of a single elongated passage, which I have marked *e e'* to indicate its double function. This passage may be made larger at or near its inner than at its outer end, in order to allow the air to pass more freely into the brake-cylinder for the purposes of an emergency-stop than for service-stops or grading. This elongated passage is, however, merely the equivalent of the two ports—service and emergency—permitting of the delivery of air to the brake-cylinder both upon the first outward movement of the piston and after it has made a further movement in overcoming a greater resistance by depressing the spring-stem L.

In connection with the supplementary train-pipe the well-known coupling-hose may be used between the cars to unite its sections, and may be provided with the ordinary retaining-valves, which close automatically when the hose is uncoupled, thereby preventing the depletion of the auxiliary reservoirs at such times; but whether such coupling-valve be used or not, I prefer, also, to employ a new retaining-valve of my own invention, preferably arranged in a connecting branch, N', between each auxiliary reservoir and the main line of the supplementary train-pipe, and which, while normally open, will close automatically whenever the air-pressure in the supplementary pipe is suddenly reduced a given number of pounds from any cause whatever. The essential characteristics of this new retaining-valve are that it shall open toward the auxiliary reservoir, shall be held normally open by a predetermined spring-pressure, and shall be adapted to close only when the reduction of air-pressure behind it is so sudden and decided that the resisting spring-pressure will be overcome and the valve seated before equalization can take place through the valve-port. The best form in which I have contemplated the application of such valve is that represented in Fig. 6, in which Q is a valve-casing provided with an annular valve-seat covered with leather, rubber, or other soft packing, *q*. R is a valve, sliding in the casing Q, and normally pressed away from its seat q by means of a spring, R', which also holds the packing in place, and r is a passage through or around the sides of the valve. When the valve is seated on the packing q, its imperforate bottom closes the pipe or valve-port and acts as a check-valve to prevent the reflux of air from the auxiliary reservoir into the supplementary train-pipe. When the air-pressure in the supplementary pipe plus the pressure of spring R' exceeds the back-pressure of the air from the auxiliary reservoir, the valve unseats, the air-pressure equalizes on both sides of it, and the spring holds it unseated, leaving the branch pipe open for the passage of air in either direction. If, now, the air be slowly vented from the supplementary train-pipe at the cock n', the auxiliary-reservoir air will pass the valve and escape to the atmosphere, and said reservoirs may in this way be entirely emptied. On the other hand, if a coupling-hose should burst or the train part, and the air suddenly discharge in large quantities from the supplementary train pipe, the pressure of the auxiliary-reservoir air will instantly overcome the spring R' and close the retaining-valve, and no escape of air from said reservoirs will take place. I prefer to so proportion the resistance of the spring R' and the size of the vent n^2 that even if the latter be thrown wide open the air will not escape from the pipe fast enough to close the retaining-valves, in which case the retaining-valves will take care of themselves, and the engineer need not concern himself about them. I have found that by adjusting the springs R' to act against the retaining-valves with a force equal to from two to five pounds air-pressure per square inch satisfactory results are produced. This form of retaining-valve may also, if preferred, be employed at the ends of the pipe-sections instead of the old form of coupling-valves above referred to—an arrangement shown at N^2, Fig. 5.

Heretofore the several governing-valve casings D have communicated with the main train pipe A through branches d, perpendicular to the latter. In the improved forms of air-brake belonging to this class and known as the "quick-action" brake, one form of which is represented in Fig. 1, the sudden venting of the main train-pipe at the locomotive for the purpose of an emergency-stop is designed to open a series of local vents through the several governing-valve casings, in order that the train-pipe air may escape through the branches d, as well as from the forward end of the pipe, and the emptying of the pipe be thereby correspondingly hastened. The violent rush of the air through the train-pipe, however, tends to force it past the lateral branches toward the forward end of the pipe, thereby more or less interfering with the usefulness of the local vents for this purpose aforesaid. To remedy this difficulty, I construct the train-pipe, at the points where the lateral branches connect with it, in such manner that the air in rushing through it will be diverted or deflected into the lateral branches or directly into the valve-casings D, and thereby escape to the atmosphere by the shortest route. To this end I provide within the main train-pipe, and opposite to each lateral branch d, an inclined deflecting-surface, a, preferably arranged with its apex substantially in line with the center of the lateral branch or passage, so that the air rushing along through the train-pipe in either direction will be deflected into the mouth of the lateral passage. This may be accomplished in a variety of ways—for example, by curving the main pipe inward toward the lateral branches, as shown in Fig. 3; but I prefer to make the train-pipe straight, as shown in Fig. 7, and to arrange within it a sliding block, T, having the inclined surfaces aforesaid, and capable of being moved inward and outward by a screw-stem, t, the block, when screwed inward, operating as a valve to close the lateral branch d and leave the train-pipe unobstructed, and when screwed outward to open the lateral branch and establish a deflecting device at the opposite side of the main pipe, as shown. In case any brake should accidentally become disabled, the branch d, leading to its valve casing D, can be closed by means of the plug T, as described. A cut-off cock, t', is also arranged in each of the branches N', between the supplementary train-pipe and the auxiliary reservoirs, to enable the air communication on that side of the valve-casing D to be cut off under the same circumstances.

When the engineer wishes to suddenly stop the train, he vents the main train-pipe sufficiently to send the governing-valve outward beyond the point where it opens the service-port to the point where, having compressed the spring L', connected with stem L, it puts the emergency-port e' into communication with the passage G and applies the full reservoir-pressure to the brakes. In thus moving outward beyond the service-port in the quick-action form of brake the main piston F, or some part which moves therewith, strikes and moves a valve, 1, (see Fig. 1,) to open a port, 2, by which air is locally vented from the train-pipe under each car through an exhaust-passage provided with a valve which closes automatically to cut off the exhaust from the train-pipe when the pressure in the latter falls below that in the brake-cylinder. Heretofore said last-named valve has been constructed in the form of a plug or puppet-valve. In my present construction I enlarge the local exhaust-passage into a chamber, 3, immediately outside of the port 2, and construct said valve in the form of a slide-valve, 4, which covers and uncovers a lateral vent, 5, controlling the slide-valve by a piston, 6, exposed on its rear side to the pressure of the brake-cylinder air (through the passage G) and on its front to that of the air in chamber 3. The slide-valve, in addition to its normal function of cutting off the local exhaust when the train-pipe is sufficiently vented, prevents leakage and dust from interfering with the proper action of the mechanism. In Fig. 1, in order to reveal the exhaust-port 5, I have shown the piston 6 and slide-valve 4 retracted, although in the operation of the brake they would ordinarily be pushed in so as to close said port when the governing-valve stands in the position represented in said figure.

To prevent dust from working into the valve-casing D through the exhaust-ports, I provide each of them at its outer end with a spring dust-shield, which will close automatically to exclude dust from the port, but will open under the pressure of the escaping air to allow the exhaust to take place. The spring-shield may be applied in a variety of forms; but I prefer to make it in the form of a cap or plate, U, supported upon a stem, *u*, and provided with a spring, *u'*, to normally hold it closed against the outer end of the discharge-orifice, as shown in Fig. 10.

Fig. 10 is a detached view, in cross-section, of the well-known cylindrical discharge-orifice or exhaust-passage opening outward from the casing D to the atmosphere and inward at G' in Fig. 1, and when applied to the train-pipe exhaust opening inward at 5 in Fig. 1, together with the improvement of the dust cap or shield U, attached to the casing D by the stem *u*, with a light spring, *u'*, to hold it normally closed.

By arranging a "bleeding-cock," *v*, in each of the train-pipes under each car, employing stop-cocks or retaining-valves at the ends of the sections of pipe N, and placing a stop-cock, *w*, at the end of each section of pipe A, an important advantage results, to wit: When the locomotive is to be detached or any part of the train side-tracked, the cocks or valves at the extreme ends of the train-pipes of the detached cars can be preliminarily closed, so as to retain the compressed air in their brake system, and after the cars have then been detached their brakes can be set and released several times successively by merely venting a little air from one or the other of the two train-pipes, thus saving the trouble of operating the hand-brakes for that purpose. The functions of the two cocks *v w* or *v* N^2 may be united in a single cock or valve, if preferred.

In brake-cylinders a peculiar difficulty is encountered in the effort to fit the pistons air-tight, from the fact that the piston-rods are connected at their outer end to the brake-levers, which, moving in the arc of a circle, give the piston-rods and pistons a slight oscillating movement during their traverse. These pistons, too, are heavy, and their weight has always been supported entirely upon their lower edge, which has, therefore, tended to wear away and ultimately to produce a leakage of air from the cylinder. To remedy this, I make the piston-rod B^2 tubular from its inner nearly to its outer end, and center it upon a stout steel bar, B^3, which is fastened rigidly into the cylinder-head and projects through the piston B' into the larger chamber of the hollow piston-rod, as shown. A bearing-ring, *b*, rounded on its inner side, is inserted into the piston, so as to fit and ride upon the stem or bar B^3. The weight of the piston and a part of the piston-rod is thus supported upon the steel bar, which centers the moving ports and keeps them from unequal wear without interfering with their necessary oscillation, and which also, to some extent, reduces the frictional resistance against the piston. The function of the ring is merely to contract the cavity of the piston-rod at or near its inner end, so as to enable the bar B^3 to properly guide the piston and yet allow the piston and its rod to slightly oscillate on the bar, and any other method of making this contraction may be substituted.

It will of course be understood that the drawings which illustrate the general principles of the improvements herein described merely represent preferable forms of their embodiment, which forms may be varied at the pleasure of the constructer without departing from the invention, so long as the essential functions and mode of operation of the several improvements remain substantially as herein set forth.

Having thus described my invention, what I claim as new, and desire to secure by Letters Patent, is—

1. In an air-brake system, the combination of the train-pipe, auxiliary reservoir, and brake-cylinder with a governing-valve consisting, essentially, of two valves, one of which opens or closes a passage leading through the other, for the delivery of the reservoir-air to the brake-cylinder, said valves being operated by separate pistons, one of which has a limited movement independently of the other, substantially as described.

2. In an air-brake system, the combination of a main piston and a main valve operated thereby with an auxiliary valve operated by an auxiliary piston to open or close a passage leading through the main valve, for the delivery of reservoir-air to the brake-cylinder without necessarily moving the main valve, substantially as described.

3. In an air-brake system, the combination of a train-pipe, auxiliary reservoir, and brake-cylinder, and a piston and a main valve operated thereby, with an auxiliary valve to open or close a passage leading through the main valve, for the delivery of air from the auxiliary reservoir to the brake-cylinder without necessarily moving the latter, and a spring to aid the movement of the auxiliary valve, substantially as described.

4. In an air-brake system, the combination of a train-pipe, auxiliary reservoir, and brake-cylinder, and a piston and a main valve actuated thereby, with an auxiliary valve to open or close a passage leading through the main valve, for the delivery of air from the auxiliary reservoir to the brake-cylinder without necessarily moving the latter, and a spring whose force is exerted in opposite directions against said valves, substantially as described.

5. In an air-brake system, the combination of a main piston and a main valve actuated thereby with an auxiliary valve to open or close a passage leading through the main valve, for the delivery of reservoir-air to the brake-cylinder without necessarily moving the latter, and a spring and auxiliary piston to move the auxiliary valve, substantially as described.

6. In an air-brake system, the combination of a main piston and a main valve actuated thereby with an auxiliary piston and an auxiliary valve actuated thereby to open or close a passage leading through the main valve, for the delivery of reservoir-air to the brake-cylinder, and a spring whose force is exerted in opposite directions against said valves, substantially as described.

7. In an air-brake system, the combination of a main piston and a main valve actuated thereby with an auxiliary valve actuated by an auxiliary piston arranged in a chamber in the main piston, and having a limited movement therein for the purpose of moving the auxiliary valve to open or close a passage leading through the main valve, for the delivery of reservoir-air to the brake-cylinder without necessarily moving the main valve, substantially as described.

8. In an air-brake system, the combination of a main valve, an auxiliary valve to open or close a passage leading through the main valve without necessarily moving the latter, a main piston having a tubular stem to operate the main valve, and an auxiliary piston having a stem which extends into or through the stem of the main piston to operate the auxiliary valve, substantially as described.

9. In an air-brake system, the combination of a main piston and a main valve actuated thereby with an auxiliary valve actuated by a spring, and an auxiliary piston to open or close a passage leading through the main valve without necessarily moving the latter, one of said pistons having a packing-ring, f^2, and the other a bead, f^3, adapted to operate substantially as described.

10. In an air-brake system, the combination, with the train-pipe and auxiliary reservoir provided with a connecting-passage for refilling the reservoir, of a piston and main valve provided with a port for controlling said passage, and a sensitive auxiliary valve whose movement opens or closes said port or passage leading through the main valve, substantially as described.

11. In an air-brake system, the combination of a piston and a main valve actuated thereby, and having two passages leading through it—one a port or passage, *e*, for the passage of air from the auxiliary reservoir to the brake-cylinder, and the other, *c*, for the passage of air from the train-pipe to the reservoir—with a sensitive auxiliary valve to open or close said passages without necessarily moving the main valve, substantially as described.

12. In an air-brake system, the combination of a piston and a valve operated thereby with a spring-stop adapted to effect a greater resistance to the movement of said valve at a predetermined point or points in its traverse than at other points in either direction therefrom by its engagement against a resisting stop or depression upon the valve or its connections, substantially as described.

13. In an air-brake system, the combination of a piston and a valve operated thereby with a spring-stop adapted to apply a yielding force in a lateral direction to resist the movement of the valve and to vary the resistance at a predetermined point or points in said movement by its engagement against a resisting stop or depression upon the valve or its connections, substantially as described.

14. In an air-brake system, the combination of a piston and a valve operated thereby with a spring-stop adapted to apply a yielding force in a lateral direction to initially resist the movement of the valve from its normal position by its engagement against a resisting stop or depression upon the valve or its connections, substantially as described.

15. In an air-brake system, the combination of a piston and a valve operated thereby with a spring-stop adapted to apply a yielding force in a lateral direction to initially resist the return of the valve to its normal position by its engagement against a resisting stop or depression upon the valve or its connections, substantially as described.

16. In an air-brake system, the combination of a piston and a valve actuated thereby with the spring-stop *m* and the depression *m'*, adapted to operate substantially as described.

17. In an air-brake system, the combination of a piston and a main valve actuated thereby with an auxiliary valve to open or close a passage leading through the main valve without necessarily moving the latter, and a spring-stop to resist the return or inward movement of the main valve at a predetermined point or points in its traverse without resisting the independent movement of the auxiliary valve by its engagement against a resisting stop or depression upon the main valve or its connections, substantially as described.

18. In an air-brake system, the combination of a piston and a main valve actuated thereby with an auxiliary valve to open or close a passage leading through the main valve without necessarily moving the latter, and a spring-stop adapted to apply a yielding force in a lateral direction to resist the return or inward movement of the main valve and to vary such resistance at a predetermined point or points in said movement without resisting the independent movement of the auxiliary valve by its engagement against a resisting stop or depression upon the main valve or its connections, substantially as described.

19. In an air-brake system, the combination of a piston, a main valve actuated thereby, and an auxiliary valve to open or close a passage leading through the main valve, with a spring-stop, *m*, and depressions *m'*, to resist

the movement of the main valve at a predetermined point or points in its traverse without resisting the independent movement of the auxiliary valve, substantially as described.

20. In an air-brake system, the combination of a piston and a main valve actuated thereby with an auxiliary valve to open or close a passage through the main valve without necessarily moving the latter, a spring whose force is exerted in opposite directions against said valves, and a stop to temporarily hold the main valve from moving outward under the action of said spring while the auxiliary valve is moving inward, substantially as described.

21. In an air-brake system, the combination of a piston and a main valve actuated thereby with an auxiliary valve to open or close a passage through the main valve without necessarily moving the latter, a spring whose force is exerted in opposite directions against said valves, and a stop to temporarily hold the main valve from moving in either direction while the auxiliary valve is moving inward, substantially as described.

22. In an air-brake system, the combination of the auxiliary reservoirs, the brake-cylinders, the governing-valves, and the main train-pipe A with a supplementary train-pipe, N, which forms a normally-open air-communication between all the auxiliary reservoirs along the train, and which communicates with the main reservoir or air-pump on the locomotive by a passage controlled by a cock, substantially as described.

23. In an air-brake system, the combination of the auxiliary reservoirs, the brake-cylinders, and the governing-valves with a normally-open train-pipe, A, for communicating air-pressure to the outer end of the governing-valve, and a normally-open train-pipe, N, for communicating air-pressure to the inner end of said governing-valves, both of said train-pipes extending to the engine, and being there provided with means by which the engineer can charge them with compressed air and vary or exhaust their pressure, substantially as described.

24. In an air-brake system, the combination of the auxiliary reservoirs, the brake-cylinders, the governing-valves, and the main train-pipe A with an air-pipe leading from the auxiliary reservoirs to the engine and there provided with a cock, by opening which the engineer can bleed off the several auxiliary reservoirs, and also provided with retaining-valves, whereby in case of accidental parting of the train the air is retained in the auxiliary reservoirs, substantially as described.

25. In an air-brake system, the combination of the auxiliary reservoirs, the brake-cylinders, and the governing-valves with two train-pipes normally charged with compressed air, and both of them normally in communication with both the auxiliary reservoirs and the governing-valves, and with a connecting-passage controlled by a cock or valve arranged on the engine, substantially as described.

26. In an air-brake system, the combination of the valve-controlling pistons F F′ and the valves E E′, operating as herein set forth, with the two train-pipes A N, by which said pistons and valves may be actuated at will by varying the air-pressure at either end of the pistons, substantially as described.

27. In an air-brake system, the combination of an air pipe or passage leading from a train-pipe into an air-reservoir with a retaining-valve normally held open by a yielding force which permits it to close under the action of a sufficient air-pressure in the reservoir, substantially as described.

28. In an air-brake system, the combination of an auxiliary reservoir and a supplementary train-pipe, N, with a retaining-valve held normally open by a spring, substantially as described.

29. In an air-brake system, the combination of an auxiliary reservoir, a supplemental train-pipe, N, and a retaining-valve arranged in a branch, N′, between the pipe and the reservoir and held normally open by a spring, substantially as described.

30. In an air-brake system, the combination of the two train-pipes A N, the governing-valve, and the auxiliary reservoir with a retaining-valve connected with the supplementary train-pipe N and held normally open by a spring, substantially as described.

31. In an air-brake system, the combination of the two train-pipes A N, the governing-valve, and the auxiliary reservoir with a retaining-valve arranged at each end of the pipe N on each car and operating to automatically close such end when the cars are separated or the connecting-hose broken, and with a cock, *w*, arranged at each end of the pipe A on each car, and means for bleeding the air from either of said pipes at will when the engine is detached or said terminal cocks and valves closed, substantially as described.

32. In an air-brake system, the combination of the main train-pipe A and its lateral branch *d*, leading to the local discharge under the car, with a deflecting-surface, *a*, arranged in the train-pipe opposite to the end of the lateral passage, substantially as described.

33. In an air-brake system, the combination of the train-pipe A and lateral passage *d* with the movable valve T, controlled by the screw-stem *t*, and adapted to close the passage *d* and leave the train-pipe free, or to open the passage *d* and deflect the moving air-currents into it, substantially as described.

34. In an air-brake system, the combination of an exhaust-passage with a movable dust-shield covering the same, which, under the action of the exhausting air, opens against an opposing spring force, substantially as described.

35. In an air-brake system, the combination of the ring or contraction *b* with the piston B′, hollow piston-rod B^2, and guide-bar B^3, substantially as described.

36. In an air-brake system, the combination

of the valve E with a spring-stop adapted to apply a yielding force against its rear side, for the double purpose of holding the valve against the ported wall of the casing and also resisting its movement and varying the degree of such resistance at a predetermined point or points in its traverse by its engagement against a resisting stop or depression upon the valve or its connections, substantially as described.

37. In an air brake system, the combination of a train-pipe, auxiliary reservoir, and brake-cylinder, and a piston and a main valve operated thereby, with an auxiliary valve to open or close a passage leading through the main valve, for the delivery of air from the auxiliary reservoir to the brake-cylinder without necessarily moving the latter, and a spring to aid the movement of the auxiliary valve, and a spring-stem, L, to stop the outward movement of the main valve when it has opened the service-port, substantially as and for the purpose set forth.

THERON S. E. DIXON.

Witnesses:

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W. C. CORLIES.