(No Model.)

3 Sheets—Sheet 1.

T. S. E. DIXON.

AIR BRAKE.

No. 382,031. Patented May 1, 1888.

Figure. 1.

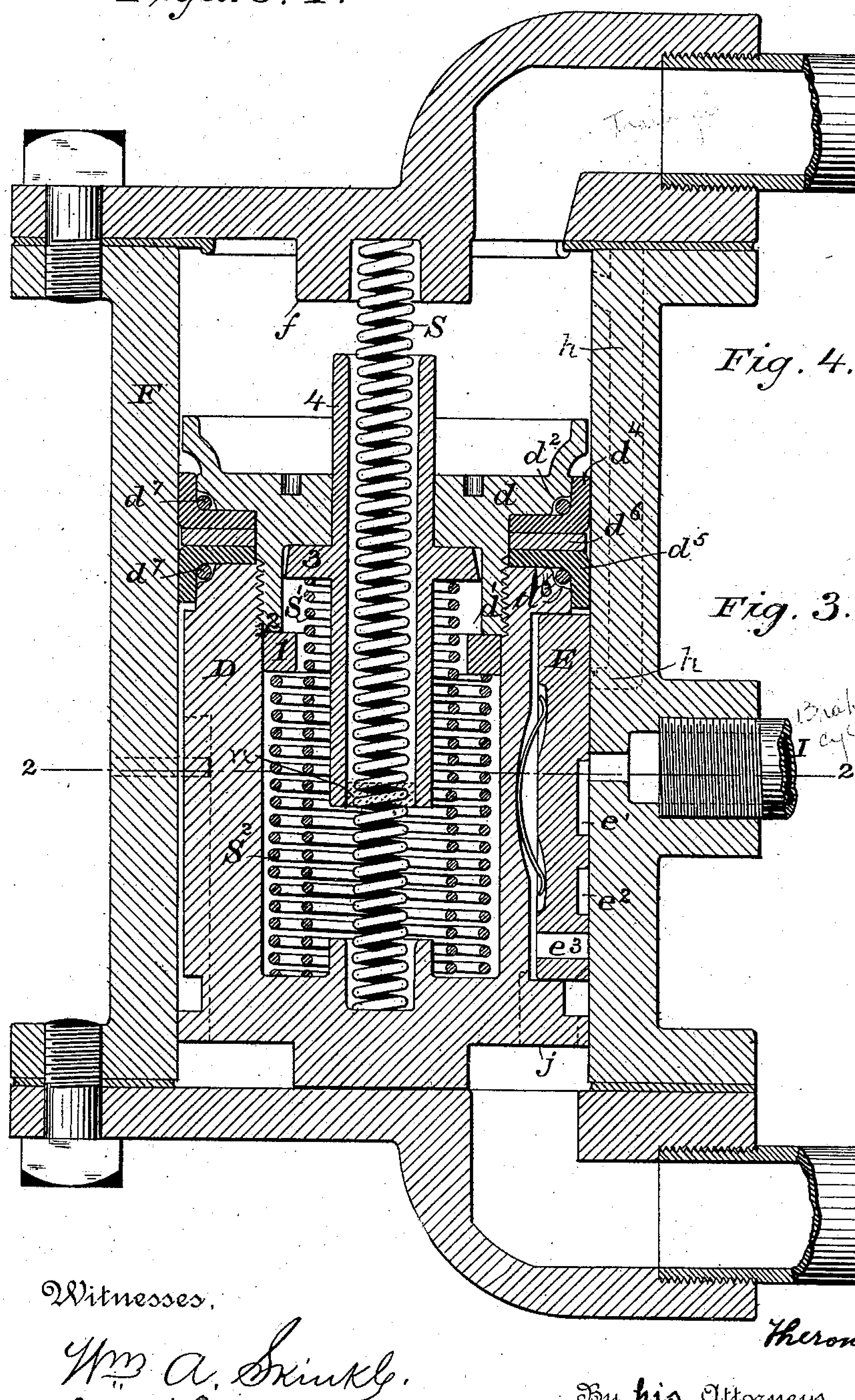


Fig. 4.

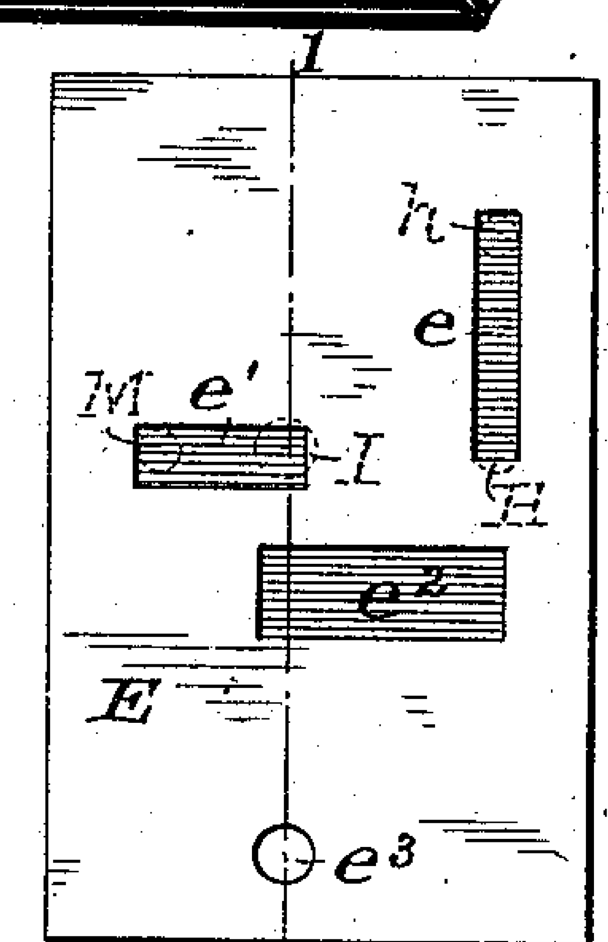
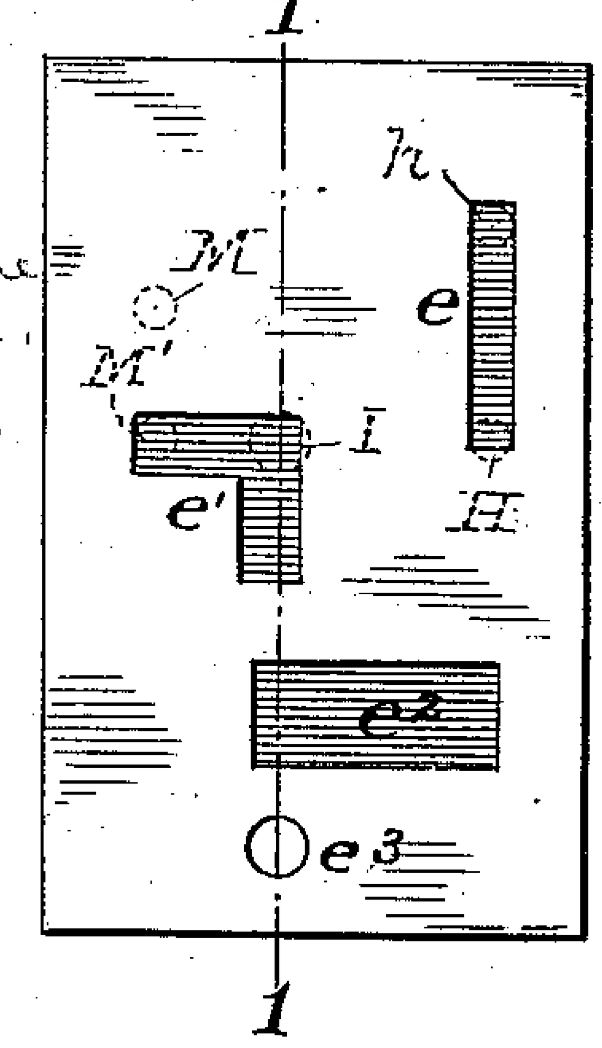


Fig. 3.



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(No Model.)

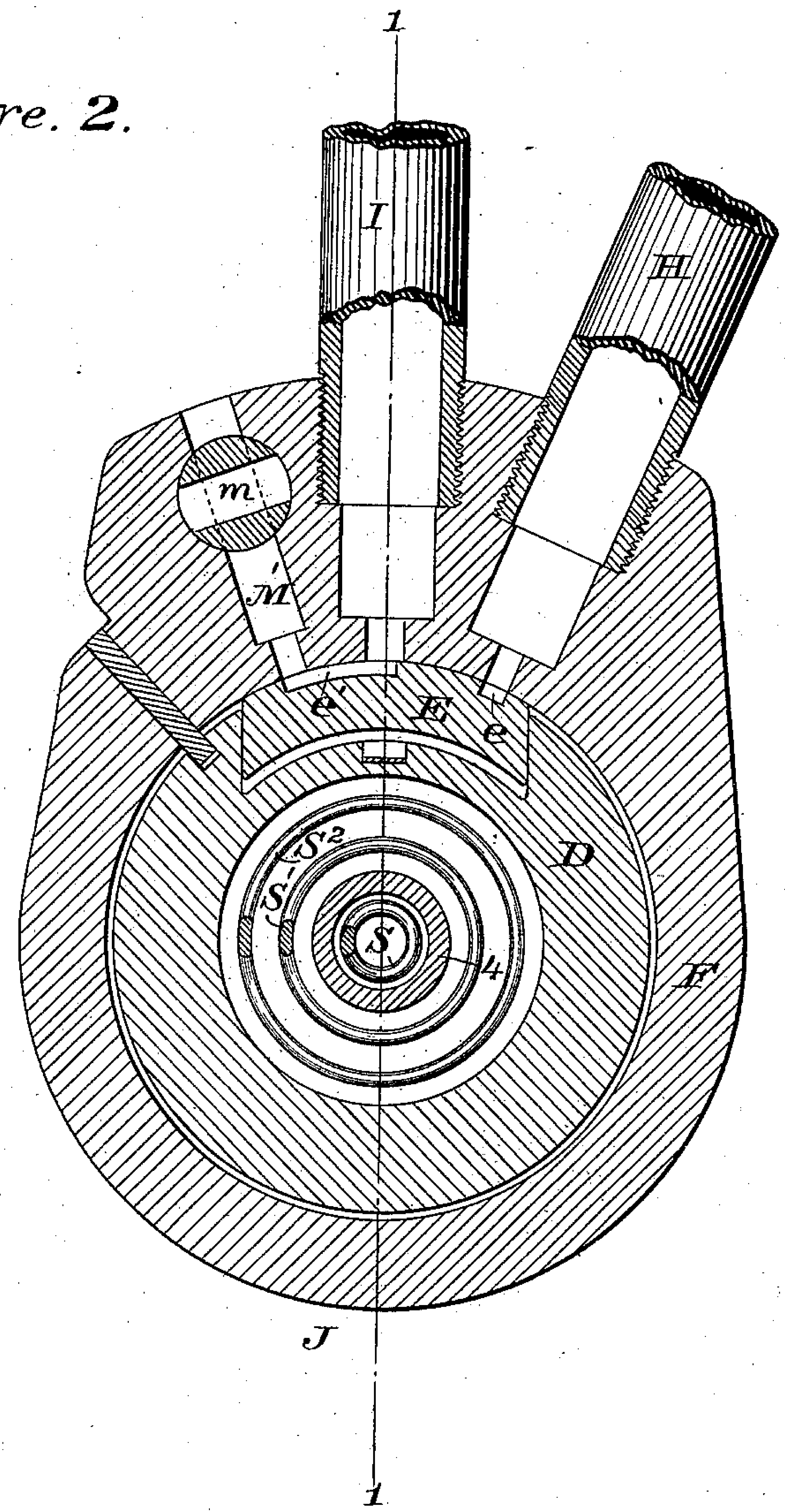
3 Sheets—Sheet 2.

T. S. E. DIXON.

AIR BRAKE.

No. 382,031. Patented May 1, 1888.

Figure. 2.



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(No Model.) 3 Sheets—Sheet 3.

T. S. E. DIXON.

AIR BRAKE.

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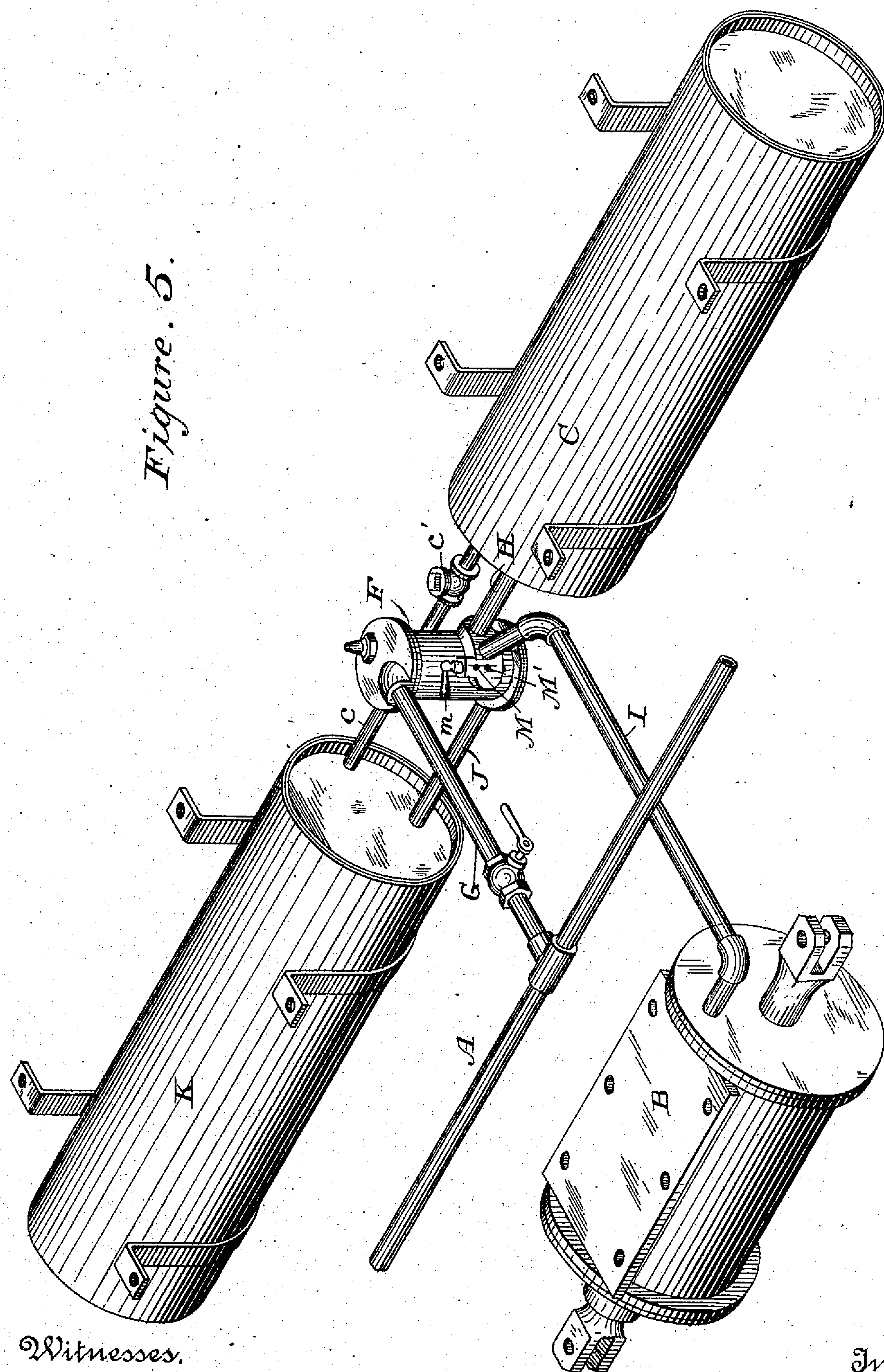
Figure. 5.



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UNITED STATES PATENT OFFICE.

THERON S. E. DIXON, OF CHICAGO, ILLINOIS, ASSIGNOR OF ONE-HALF TO LYSANDER HILL, OF SAME PLACE.

AIR-BRAKE.

SPECIFICATION forming part of Letters Patent No. 382,031, dated May 1, 1888.

Application filed December 16, 1887. Serial No. 25?,111. (No model.)

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 Chicago, in the county of Cook and State of Illinois, have invented certain new and useful Improvements in Air-Brakes, of which the following is a specification.

In all so-called "automatic" air-brakes heretofore known, so far as I am aware, in which the admission of compressed air to the brake-cylinder and its discharge therefrom are governed by a sliding piston which is actuated by varying the air-pressure in a train-pipe leading from the locomotive, and which controls the admission of air to the brake-cylinder from a separate storage-reservoir under each car, said piston has always been subjected to a variable pressure at both of its ends—a mode of operation that renders its action more or less uncertain and unreliable under many conditions of use.

In the following specification, for convenience of description, I shall term that end of the piston against which the air from the train-pipe acts the "outer" end, and its opposite extremity the "inner" end, and shall speak of its traverse as "outward" when moving in a direction from its inner toward its outer end and as "inward" when moving in the reverse direction.

One of the main objects of my invention is to obviate the practical defect above referred to by subjecting the inner end of the piston to a constant normal pressure which is substantially uniform throughout its entire traverse, so that when the air-pressure in the train-pipe is raised and maintained above a predetermined degree the piston will move inward to the end of its traverse, and when reduced and held below such degree the piston, unless arrested by independent stops, will move outward to the end of its traverse—a mode of operation entirely new, so far as I am aware, in air-brakes having a separate storage-reservoir attached to each car, and which constitutes one of the main principles of my invention. In the preferred form of apparatus herein shown and described I obtain the constant pressure referred to from the back action of the compressed air contained in an auxiliary storage-reservoir communicating with the inner end of the piston and of such capacity as to produce a substantially uniform pressure thereon throughout its traverse, said auxiliary reservoir not being used for ordinary service-stops and grading the speed of the train, and therefore not subject to fluctuations of pressure during the traverse of the piston.

Another independent and important principle of my invention consists in the employment of a series of graduated yielding resistances or stops for the purpose of arresting the movement of the piston at different points along its traverse, in order that it may open and hold open, or close and hold closed, the several ports at the will of the engineer and upon his bringing the train-pipe air to a predetermined and foreknown degree of pressure corresponding to each of said resistances.

Another independent and important principle of my invention consists in employing a series of car-reservoirs, some of which are caused to communicate with the brake-cylinder when said piston is at one position and others when it is at other positions, the main object of this part of my invention being to provide for the purpose of "emergency-stops" an independent source of compressed air not liable to depletion by "service-stops" or "grading," but always full to its maximum capacity and ready for instant and effective use in case of any emergency.

Another independent and important principle of my invention consists in arranging the discharge-port of the brake-cylinder so that it will be opened and the brakes released when the valve-piston aforesaid is at some intermediate position between the extreme ends of its traverse, and not when it is at the inner end of its traverse, as heretofore; and another important principle of my invention consists in providing means whereby a piston constructed to release the brakes when it is at intermediate points of its traverse, as aforesaid, can at any time, if desired, be readily caused to release the brakes when at the inner end of its traverse, instead of releasing them when at said intermediate points, and can afterward be as readily converted back to its original mode of operation.

Subordinate improvements are found in the various devices and combinations more particularly specified in certain of my claims hereto appended.

The broad principles of my invention above stated are capable of practical embodiment in a variety of apparatus, of which one form is illustrated in the drawings. The structure therein shown is simple, durable, and not liable to get out of order. Its operation is such that at any time, by a most simple manipulation of the air-cock on the locomotive, any desired degree of air-pressure can be admitted from the service-reservoir to the brake-cylinder, and can then be as readily increased or decreased at the will of the engineer without releasing the brakes, the apparatus being as perfectly controllable in that respect as the "electric" air-brake. Whenever the train-pipe is emptied for an emergency, the maximum pressure is behind the piston to force it out and insure its action, and the maximum reservoir-pressure is always present to enter the brake-cylinder and set the brakes. The various reservoirs can be refilled whether the brakes are on or off at the time.

A car containing the invention can at any time, by simply turning a cock, be adapted to work in the same train with other cars containing the old forms of air-brakes.

Having thus stated the general principles, mode of operation, and practical advantages of my improvements, I will now proceed to particularly describe one form of apparatus in which they are all embodied, making reference, for purposes of illustration, to the accompanying drawings, in which—

Figure 1 is a vertical section of my valve device; Fig. 2, a horizontal section (looking upward) in line 2 2 of Fig. 1; Figs. 3, 4, plans of the valve-surface, showing the two alternative arrangements of the service and release ports herein described; and Fig. 5, a perspective view of the entire apparatus when appropriately arranged for service under a car.

Referring to said drawings, in which similar letters of reference indicate like parts, A is the train-pipe; B, the brake-cylinder; C, the ordinary service-reservoir, and D the valve-piston provided with a valve surface, E, whose movements open and close the several ports. The piston is arranged in a suitable casing, F, connected to the train-pipe by a passage, G, to the service-reservoir by a passage, H, to the brake-cylinder by a passage, I, to an auxiliary air-reservoir, K, by a passage, J, or an opening in the wall of such reservoir, and to the atmosphere by a passage, M. The valve-piston and its accessories may be widely varied in structure without departing from the principles of my invention. In the preferable form herein shown said piston is made hollow and contains two sliding members having different ranges of movement and held normally in position in the piston by two springs. One of the sliding members is preferably in the form of a ring (marked 1) which seats against a shoulder, 2, and is normally held thereto by a spring, S^2. The other sliding member is preferably in the form of a plate, block, or flange (marked 3) attached to a stem, 4, and normally held against the end plate of the piston, or a suitable shoulder of the latter, by a spring, S′. The piston itself, under the action of a light spring, S, normally stands in the position shown in Fig. 1, with the air-pressure of the reservoir K acting against its inner end and the air-pressure from the train-pipe acting against its outer end. When the train-pipe pressure is reduced a few pounds, the pressure of the compressed air in the auxiliary reservoir K, overcoming the resistance of the light spring S, will move the piston outward till the stem 4 strikes the end wall of the casing at *f*, whereupon its movement will be arrested, and it will remain in that position so long as the train-pipe pressure remains unchanged. Upon decreasing the train-pipe pressure, however, until the excess of pressure at the inner end of the piston is sufficient to overcome the combined resistance of the springs S S′, the piston will move outward still farther until the head or block 3 strikes against the ring 1 and again arrests its movement. Upon further reducing the train-pipe pressure until the excess of pressure at the inner end of the piston is sufficient to overcome the combined resistance of the three springs S S′ S^2, the piston will move outward to the limit of its traverse. Then, conversely, upon restoring the train-pipe pressure to such a degree that, in combination with the three springs S S′ S^2, it is able to overcome the resistance of the air from reservoir K, the piston will return to the point where the spring S^2 ceases to act, and will stop there. Upon further increasing the train-pipe pressure until, in combination with the two springs S S′, it is able to overcome the resistance from reservoir K, the piston will continue its retrograde movement to the point where the spring S′ ceases to act, and will stop there, and upon further increasing the train pipe pressure until, in combination with the spring S alone, it is able to overcome the resistance from reservoir K, the piston will return to its normal position. The piston thus moves in each direction step by step to predetermined and fixed positions by the discharge or admission of predetermined amounts of air-pressure through the train-pipe, and its position at any time is manifest to the engineer by a glance at his train-pipe pressure-gage.

An incidental improvement consists in reversing the usual position of the piston and casing, so as to connect the train-pipe to their upper end and the reservoir K to their lower end, whereby the weight of the piston tends to bring it to and keep it in its normal position at the inner end of its traverse and to prevent it from being jarred out of such position by the movements of the car, and whereby, by suitably weighting the piston, the spring S may be dispensed with, if preferred, and whereby the usual plugged drip-cup is enabled to be dispensed with, as all drainage will flow through the pipe J into the reservoir K, whence it can be drawn off through the usual bleeding-cock.

The relative force of the springs S S′ S^2 or the springs S′ S^2 and weight may be graduated and fixed as the constructor's experience shall approve; but it is best to so graduate it that a preliminary change of several pounds in the train-pipe air-pressure shall be required to effect each separate step in the movement of the piston, thereby allowing several degrees of latitude for differences in the friction of different valves and for carelessness or inattention on the part of the engineer. I recommend such a graduation that a reduction of five-eighths of a pound in the train-pipe pressure will move the piston from its normal position to its first stop, five-eighths of a pound further reduction will move it to its second stop, and five-eighths of a pound further reduction will move it to the outer limit of its traverse; but these proportions may be varied, if preferred. Any competent arrangement of springs or their equivalents to arrest the traverse of the piston at its several predetermined points, as aforesaid, may be adopted instead of the particular construction here shown, the latter being only a preferable form adapted to the use of long, and therefore comparatively equable, springs in a comparatively compact structure. A modification which has some merit consists in extending the spring S only from the outer end of the casing F to some part—preferably the inner end—of the stem 4.

In Fig. 1 dotted lines at *n* indicate that the tubular stem is closed at its inner end, and that the spring S, adapted to this modified construction, terminates at the closed end of the stem. The advantage of this modified construction is that from the moment when the stem 4 strikes the casing at *f* until it again separates therefrom the resistance of the spring S to the movements of the piston is absolutely uniform, because the spring can be compressed no farther. It is obvious that the same principle may be applied in connection with the spring S′. If these springs are made of cast-steel, nickel-plated in the rough, they will endure for years without change of tension.

Those features of my invention hereinabove particularly described are independent of any specific arrangement of the parts controlled by the piston-valve. The reservoirs, however, are preferably refilled when the piston is at its normal position. To this end I arrange in the wall of the casing a passage, *h*, (dotted lines, Fig. 1,) extending from the space at the outer end of the piston to and through the inner wall of the casing at a point near the end of the passage H, which leads to the service-reservoir, and provide in the side of the valve surface E a refilling-port or by-pass, *e*, which, when the piston is at its normal position, puts the passages H *h* into communication with each other, as shown in Figs. 3, 4, and enables the reservoir to be filled or refilled from the train-pipe to the maximum pressure desired. The independent reservoir K may be filled in any appropriate manner—for example, by a passage, *c*, leading from the service-reservoir C—and provided with a check-valve, *c′*, seating backward, as shown in Fig. 5. If the check-valve *c′* be loaded one or two pounds to the square inch, it will produce the same effect as the spring S on the piston D, and will be a practical equivalent therefor. The automatic or emergency stop port E^3, which communicates with the passage J by a hole in the piston, (shown in dotted lines at *j*, Fig. 1,) is arranged, as usual, to put the appropriate storage-reservoir into communication with the brake-cylinder when the piston has arrived at or nearly at the outer extremity of its traverse.

I contemplate two different arrangements of the service port or by-pass e^2 and brake-release port or by-pass *e′*, as shown, respectively, in Figs. 3 and 4.

In Fig. 3 (the preferred form) the brake-release port *e′* puts the passage I into communication with the passage M, leading to the atmosphere, and thereby releases the brakes when the piston arrives at the first stop in its outward traverse, and the service-port e^2 puts the passages H I into communication with each other, and thereby applies the brakes for service-stops or grading when the piston reaches its second stop. With this arrangement the piston may be moved to its second stop and the brakes thereby applied with any desired force, depending upon the length of time it is held there; and it may then, at will, be either moved back to its first stop and retained there long enough to wholly or partially release the brakes, or, by suddenly increasing the train-pipe pressure to the maximum, it may be shot back from its second stop to its normal position so quickly as not to release the brakes, and then the reservoirs may be refilled with the brakes set.

In Fig. 4 the release-port *e′* is arranged to put the passages I M into communication and thus release the brakes when the piston is at its normal position, and the service-port e^2 is arranged to open communication from H to I when the piston arrives at its first stop. With this arrangement the engineer can, by moving the piston to its first stop, apply the brakes with any degree of pressure desired, depending, as before, upon the length of time it is held there, and he can then, by moving it to its second stop, hold the brakes so set, or by moving it back to its normal position release them and refill his reservoir. With either arrangement the piston can be moved back and forth between the service-port and the release-port as often as desired, and held at either port as long as desired; and hence for service-stops or grading speed the brakes can be applied and their pressure increased, reduced, or discharged altogether, at the will of the engineer, and by the simplest manipulation of the pressure-controlling cock on the engine, the train-pipe pressure-gage always showing exactly where the piston is and what to do with it next for any purpose required. The service-port and release-port being made of the proper size, the amount of reservoir air-pressure vented into the brake-cylinder or discharged therefrom will always depend upon the length of time that the respective ports are held open, in which respect the operation of my pneumatic system is superior to that of the electric air-brake, giving as ready and more perfect control of the brake-pressure for service and grading purposes, without that liability to accidental derangement which necessarily attends the use of electric connections and devices, and without the expense and care of electric appliances.

It will be observed that in Fig. 3 the valve is adapted to wholly or partially release the brakes when the piston is in an intermediate position between the extreme ends of its traverse. This I regard as an important improvement in the art, in that it enables the brakes to be held under moderate pressure in "grading," and the reservoirs to be refilled without releasing the brakes when set. Cars provided with this improvement are liable, however, to be sometimes coupled in the same train with other cars having the brake-release operative when the piston is at the inner end of its traverse, in which case the two systems would conflict, as all the brakes could not be released simultaneously. To provide for this contingency I arrange a second open-air port, M′, in such position that it will be put into communication with the passage I through the release-port e' when the piston is at the extreme inner end of its traverse, and I extend the ports M M′ through two cocks, or, preferably, through a two-way cock, m, which, when turned to one position, opens the escape-passage M and closes M′, and when turned to another position opens M′ and closes M, thus putting either of the open-air ports at will under the control of the piston and excluding the other.

In connection with or independently of the above-described improvements I provide each car with a series of two or more reservoirs in order that I may draw the air from one of said reservoirs, C, for the purposes of service-stops and grading without interfering with the air reserved in another reservoir, K, for the purpose of emergency-stops. To this end the reservoir K is cut off from all communication with the service-port e^2, and only communicates with the brake-cylinder through the emergency-port e^3, while the service-reservoir C is cut off from all direct communication with the emergency-port. With this construction, and using the emergency-reservoir to furnish the air-pressure against the inner end of the piston, it results that while such pressure is not liable to variation during the traverse of the piston, yet the application of the emergency-stop, which involves a considerable preliminary reduction of train-pipe pressure, is followed, at the outer end of such traverse, by a consequent reduction of the resistance at the inner end of the piston through the discharge of air from reservoir K to the brake-cylinder, and therefore the piston is able to be more readily and quickly returned to the release-port or refilling-port.

Another advantage which arises from filling the emergency-reservoir from the service-reservoir by means of the passage C and check-valve c' is, that although the depletion of the reservoir C for service-stops or grading will not affect the contents of the emergency-reservoir, yet the opening of the emergency-port will vent air from both of said reservoirs to the brake-cylinder, and the increased air capacity, when filled, thus obtained for emergency purposes will enable the brakes to be set with greater force than would otherwise be attainable. The air from reservoir K can, under no circumstances, get back to the train-pipe. Even if the piston should stick at its normal position from some accidental cause and allow the contents of the service-reservoir to vent back through the passage H e h the check-valve c' will prevent any depletion of the reservoir K, thus insuring certainty in the movement of the piston. I prefer to make the piston D about three inches in diameter, giving a transverse sectional area of about seven square inches. With the ordinary reservoir pressure of sixty pounds per square inch, therefore, I have over four hundred pounds of air-pressure available against the inner end of the piston to insure its proper working. The initial pressure is sixty pounds to the square inch, and, if the reservoir K is made of suitable size, the diminution of this pressure which results from the outward movement of the piston will be practically inconsequential.

It should be remembered that by suddenly emptying or refilling the train-pipe the piston can be shot from one end of its traverse to the other in either direction without practically bringing the intermediate parts into operation, and hence, whether the brakes be set by air from the service-port or from the emergency-port, the piston, in the form shown in Fig. 3, can be returned to its normal position and the reservoirs refilled without releasing them. It is well known that by proper attention to his pressure-gage and air-cock the engineer can govern the pressure in the train-pipe to within the fraction of a pound. The piston is therefore perfectly under his control. He can move it to open the service-port and apply any brake-pressure desired. Then, if he desires to reduce such brake-pressure, he can move it back to the release-port and discharge the pressure more or less at will. If he then needs more brake-pressure, he can send it back to the service-port and apply such increase. If he desires to hold the brakes under a medium pressure without change—for example, down a long grade—he can return it to its normal position for that purpose, when he can also refill his service-reservoir. If he needs the full emergency pressure, he can use it at any moment. In a word, he can handle the piston-valve just as he may desire, whether for emergency-stops, service-stops, grading the speed of the train, releasing brakes, or refilling his reservoirs. No complicated manipulation of the "engineer's cock" is required, a simple movement, indicated by the reading of the pressure-gage, being all that is necessary to effect any of these results. The air for service-stops and grading being applied from the reservoir C, and the air for emergency-stops being derived from an independent reservoir, the depletion of the former never affects or diminishes the full pressure of the latter, which is always ready with its entire reserved force for any contingency. If the engineer should by inattention or accident increase or reduce his train-pipe pressure several pounds more than is necessary to effect any movement desired by him, the result will be the precise movement required—in fact, in ordinary practice, he will so increase or reduce it a pound or two more than is necessary in order to allow for differences of friction among the different valves and to insure the exact result desired. Only by not venting enough or by carelessly venting at least about double the amount necessary can he fail to produce this result.

It will be observed that normally the air-pressure against the opposite ends of the piston is equal, and hence there is no danger of leakage around it. To guard against any temporary leakage when the train-pipe pressure is reduced, or when after emergency-stops the pressure of reservoir K is reduced, the piston should be suitably packed air-tight in its casing. Inasmuch as this packing passes no air-ports or by-pass, any ordinary means—such as rubber, leather, or ring packing—may be employed. I have devised a very simple and efficient leather packing for the purpose, as follows: I construct the outer head of the piston in a separate piece, d, provided with a neck, d', which screws into the interior of the piston and forms the stop for the ring 1. I bevel or curve the proximate outer edges of the piston D and its head d, as shown at d^2 d^3, to accommodate leather rings d^4 d^5, held between the piston and head, with their outer edges overlapping said beveled corners. Between the two leather rings I preferably place an annular disk, d^6, of metal or some rigid substance. Spring-rings d^7 may also be inserted to aid in holding the leathers to their seat. When the head is screwed into the piston, it binds all these packing-rings securely in place and causes the joint to be effectively packed against leakage. The fact that the piston-packing passes by no port, by-pass, or other opening in the wall of the casing not only enables me to use "soft packing"—such as leather, &c., which is well known to give the best protection against air-leakage—but prevents the possibility of any air escaping back from the reservoir K to the train-pipe through any such port or by-pass in case the valve or piston should accidentally stick at any point in its traverse, and thus insures the proper movement of the piston under all circumstances.

The valve-surface E is preferably made in the old and well-known form of a block or plate fitted into a recess in the side of the piston and held to its seat by a spring or by the pressure of air admitted behind it through the space or passage j.

The ordinary air-pump, locomotive-reservoir, pressure-gages, and engineer's controlling cock or cocks may be employed, as in the old systems, no change of the apparatus connected with the locomotive being necessary to adapt it to the use of my inventions. The employment of a flexible diaphragm as an equivalent for a sliding piston to control the movements of a valve is too well known in the art to require description here.

The two great advantages of my improvements as a whole are, first, that they enable the brakes to be more simply, easily, and perfectly controlled, and, second, that they greatly increase the efficiency and the certainty and reliability of operation of air-brakes as a means for controlling the movements of railroad-trains. The certain initial pressure of sixty pounds per square inch (or other maximum pressure allowed in the reservoirs) to act against the valve-piston; the substantial uniformity of the powerful reservoir-pressure against the piston throughout its traverse; the presence of an emergency-reservoir always charged to its full capacity and ready for instant use; the increased brake-pressure which results from the discharge of air from both reservoirs into the brake-cylinder when the emergency-port is opened; the ability to recharge the reservoirs while the brakes are set; the absence of any port, by-pass, or hole from that part of the inner wall of the casing which is swept by the traverse of the piston-packing, whereby the most efficient material can be used for such packing and whereby no avenue past the side of the piston is ever open for the passage of air, and the check-valve c', which guards again any possible loss of air-pressure from the reservoir K in case of any accidental sticking of the piston—particulars of certainty not heretofore attained—all combine to render the apparatus, if properly constructed and kept in repair, so absolutely certain of effective action that the responsibility for any failure of its operation must rest with the engineer alone.

As already in effect stated, the several improvements herein described may be employed in conjunction with or independently of each other.

Having thus described my invention, I claim as new—

1. In an air-brake system having an air-reservoir for each car and in which the movement of compressed air to and from the brake-cylinder is governed by a sliding piston actuated by varying the air-pressure in the train-pipe, the combination of the piston, the train-pipe, and the auxiliary reservoir, K, not used for

service-stops or grading purposes, but for applying air-pressure to the inner end of the piston, and of such capacity that its pressure is practically unaffected by the movements of the piston, substantially as described, whereby the initial pressure against the inner end of the piston is maintained substantially undiminished during the entire outward traverse thereof.

2. In an air brake system having an air-reservoir for each car and in which the movement of the compressed air to and from the brake-cylinder is governed by a sliding piston actuated by varying the air-pressure in the train-pipe, the combination of the piston and ports with a storage-reservoir for ordinary service purposes and a separate reservoir for applying a practically uniform air-pressure to the inner end of the piston, substantially as described.

3. In an air-brake system in which the movement of the compressed air to and from the brake-cylinder is governed by a sliding piston actuated by varying the air-pressure in the train-pipe above the normal atmospheric pressure, the combination of the piston and ports with a storage-reservoir for ordinary service purposes and an independent reservoir for emergency-stops, both of which are controlled by the movement of a single piston, substantially as described.

4. In an air-brake system in which the movement of the compressed air to and from the brake-cylinder is governed by a sliding piston actuated by varying the air-pressure in the train-pipe above the normal atmospheric pressure, the combination of the piston with the service-reservoir and its port, all of which are controlled by the movements of a single piston, and with an independent emergency-reservoir and its port, substantially as described.

5. In an air-brake system in which the movement of the compressed air to and from the brake-cylinder is governed by a sliding piston actuated by varying the air-pressure in the train-pipe, the combination of the piston and its ports with a storage-reservoir for ordinary service purposes, and with an independent reservoir or reservoirs for applying air-pressure to the inner end of the piston and for emergency-stops, substantially as described.

6. In an air-brake system having an air-reservoir for each car, the combination, with the train-pipe and brake-cylinder, of two or more reservoirs under each car and a controlling-valve and ports operated by a piston and adapted for the admission of air from either of said reservoirs at will to the brake-cylinder, substantially as described.

7. In an air-brake system having an air-reservoir for each car, the combination of two or more storage-reservoirs with a valve and its ports attached to a piston, which at different points of its traverse successively discharge their contents into the brake-cylinder, substantially as described.

8. In an air-brake system, the combination of a port-controlling piston with two storage-reservoirs which, through different ports in the piston, discharge into the brake-cylinder at different positions of said piston, substantially as described.

9. In an air-brake system, the combination of a service-reservoir and an independent reservoir with a valve and its ports attached to a piston and so arranged that the air in the independent reservoir is applied in a substantially uniform pressure upon the piston between the limits of its traverse and is discharged into the brake-cylinder at the outer end of such traverse, substantially as described.

10. In an air-brake system, the combination of two or more storage-reservoirs with a piston and ports capable of admitting air from either of said reservoirs at will to the brake-cylinder, said piston being subject at one end to the variable air-pressure of the train-pipe and at the other end to an air-pressure which is substantially uniform between the limits of its traverse, as herein set forth.

11. In an air-brake system, the combination of the port-controlling piston, the train-pipe, and an independent reservoir whose contents are not subject to depletion or variation for service-stops, grading, or the governing of the piston, but are employed to furnish a uniform pressure against the inner end of the latter between the limits of its entire traverse, substantially as described.

12. In an air-brake system in which the movement of the compressed air to and from the brake-cylinder is governed by a sliding piston actuated by varying the air-pressure in the train-pipe, the combination of the train-pipe, brake-cylinder, car-reservoir, and a valve and its ports attached to a piston and arranged so as to open the brake-release port and discharge the brake cylinder when the piston is at an intermediate position between the extreme ends of its traverse and to close the same when at the end of its traverse, substantially as described.

13. In an air-brake system, the combination of a service-reservoir, an emergency-reservoir, and a train-pipe and brake-cylinder with a valve and its ports attached to a piston and arranged so that it at one end of its traverse vents air from the emergency-reservoir to the brake-cylinder, at an intermediate position vents air from the service-reservoir to the brake-cylinder, and at another intermediate position discharges the air from the brake-cylinder, substantially as described.

14. In an air-brake system, the combination of the port-controlling piston with a graduated series of springs arranged to apply yielding resistances at different points along its traverse corresponding to the several ports, whereby it is adapted to temporarily hold said

ports open or closed, substantially as described.

15. In an air-brake system, the combination of the train-pipe, brake-cylinder, and car-reservoir with a valve and its ports attached to a piston which at one extremity of its traverse holds the discharge-port of the brake-cylinder closed, at an intermediate position between the ends of its traverse holds said port open, and at another position admits air from a reservoir to the brake cylinder, substantially as described.

16. In an air-brake system, the combination of a service-reservoir, an emergency-reservoir, a train-pipe, and a brake-cylinder with a valve and its ports attached to a piston which at one end of its traverse holds the brake-cylinder closed, at the other end of its traverse vents air from the emergency reservoir to the brake-cylinder, at one intermediate position vents air from the service-reservoir to the brake-cylinder, and at another intermediate position discharges air from the brake-cylinder, and a series of springs to temporarily hold the piston in its required positions for operating the intermediate service and release ports, substantially as described.

17. In an air-brake system, the combination of a port-controlling valve attached to a piston subject throughout its traverse to a substantially uniform pressure against its inner end with a series of differential springs acting successively against said uniform pressure, substantially as described.

18. In an air-brake system, the combination of two or more storage-reservoirs, a piston and ports capable of admitting air from either of said reservoirs at will to the brake-cylinder, and a graduated series of springs to hold the piston temporarily at different points in its traverse, substantially as described.

19. In an air-brake system, the combination of two or more storage-reservoirs, a piston-valve and ports capable of admitting air from either of said reservoirs at will to the brake-cylinder, said piston being subject at one end to the variable air-pressure of the train-pipe and at the other end to a pressure substantially uniform throughout its traverse, and a graduated series of springs to hold the piston temporarily at different points in its traverse, substantially as described.

20. In an air-brake system, the combination of a train-pipe, brake-cylinder, air-reservoir, and ports connecting the same with a valve controlling said ports and operated by a piston so arranged as to discharge the brake-cylinder at a position intermediate between the extreme ends of the traverse of the piston, with a spring or weight arranged to co-operate in the restoration of the piston to its normal position at the end of its traverse when the pressure is increased in the train-pipe, whereby this restoration may be effected without releasing the brakes, substantially as described.

21. In an air-brake system, the combination of a port-controlling piston which at a position intermediate between the extreme ends of its traverse opens the release-port to discharge the brake-cylinder and release the brakes with a resistance-spring arranged to temporarily arrest the movement of the piston at the point where it opens said release-port, substantially as described.

22. In an air-brake system, the combination of separate service and emergency reservoirs on each car, and ports with a piston and valve governing said ports, and a resistance-spring adapted to temporarily arrest the movement of the piston at the point where it opens the service-port, substantially as described.

23. In an air-brake system, the combination of a service-reservoir, a piston whose inner end is subject to a substantially uniform pressure between the limits of its traverse, a release-port opened by the piston at an intermediate point in its traverse, and a spring to temporarily arrest the movement of the piston at the point where it opens said release-port, substantially as described.

24. In an air-brake system, the combination of a service reservoir, a piston whose inner end is subject to a substantially uniform pressure between the limits of its traverse, and a resistance-spring to arrest the piston at the service-port from the service-reservoir to the brake-cylinder and enable the latter to be held open or closed at will, substantially as described.

25. In an air-brake system, the combination of a train pipe, brake-cylinder, and car-reservoir and ports connecting the same, and a valve controlling the ports and attached to a piston with two or more springs which apply their resistance to the piston in the same direction, and which, as the piston moves in its traverse, come successively into action, substantially as described.

26. In an air-brake system, the combination of a train-pipe, brake-cylinder, and car-reservoir and ports connecting the same, and a valve controlling the ports and attached to a piston operating under a substantially uniform pressure upon its inner end, with two or more springs which come successively into action against its outer end to resist said pressure, substantially as described.

27. In an air-brake system, the combination of the piston and ports, spring S or weight, the springs S' S^2, the reservoirs, and the train-pipe, arranged to operate substantially as described.

28. In an air-brake system in which the piston releases the brakes when at an intermediate position between the extreme ends of its traverse, the combination of the cock *m* with the separate open-air port M' and the normal open-air port M, whereby the piston may be enabled to release the brakes when at the inner end of its traverse or when in said intermediate position, substantially as described.

29. In an air-brake system, the combination of a port-controlling piston with an open-air

port, M, which, when unobstructed, causes the brakes to be released when the piston is at a position intermediate between the ends of its traverse, an open-air port, M', which, when unobstructed, causes the brakes to be released when the piston arrives at the inner end of its traverse, and means for putting either of said open-air ports under the control of the piston and withdrawing the other from its control so long as it may be desirable so to do, substantially as described.

30. The combination of the movable hollow piston D with the sliding ring 1, flange or plate 3, stem 4, and springs S' S², substantially as described.

31. In an air-brake system, the combination of a train-pipe, brake cylinder, air-reservoir, and ports connecting the same, and a valve controlling the ports and operated by a piston, with two slides and two springs acting, respectively, upon said slides, and arranged so that the piston in its movement successively encounters the resistance of said springs, substantially as described.

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Witnesses:
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