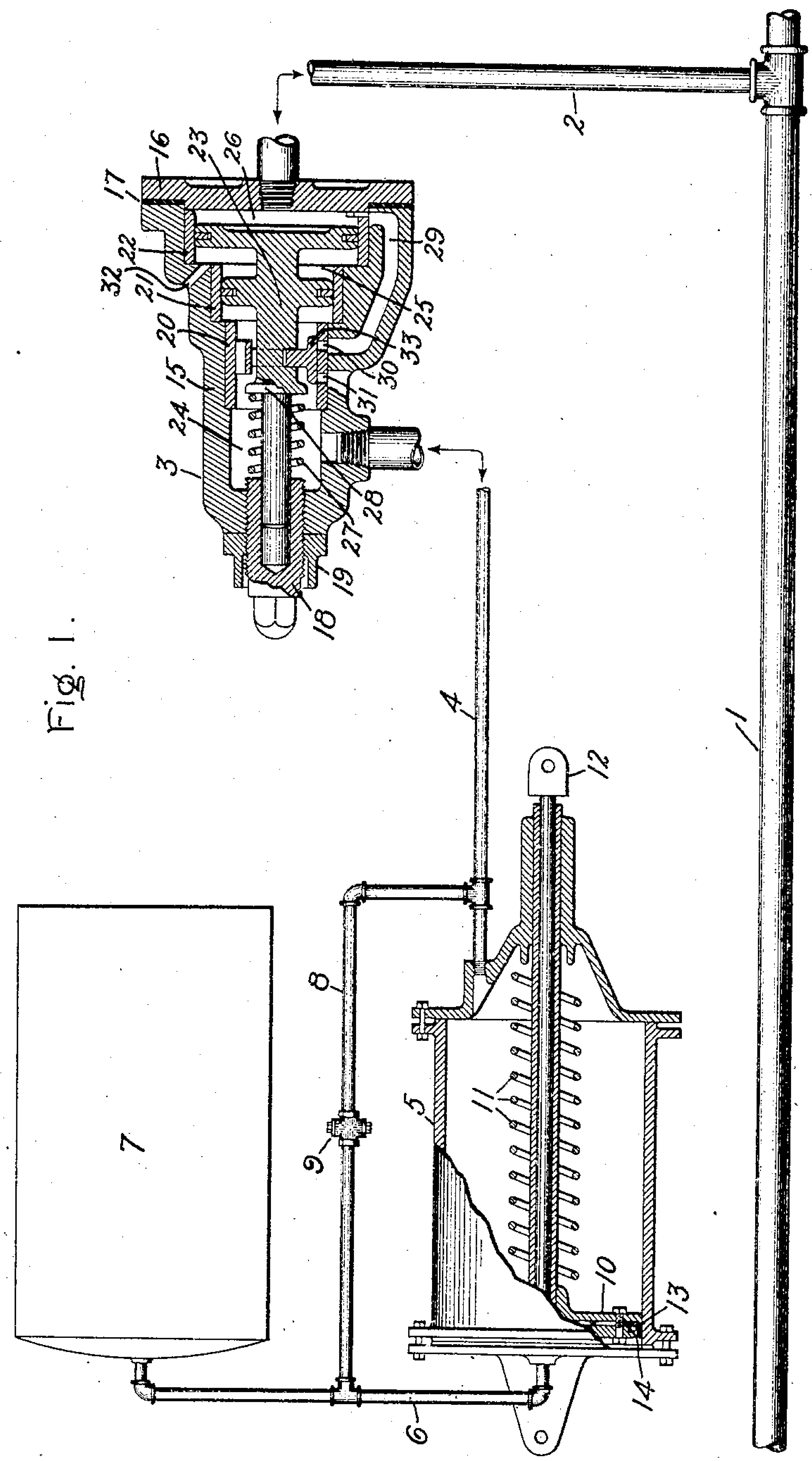
No. 786,007. PATENTED MAR. 28, 1905.

F. B. COREY.

AUTOMATIC AIR BRAKE SYSTEM.

APPLICATION FILED JULY 21, 1903.

3 SHEETS—SHEET 1.



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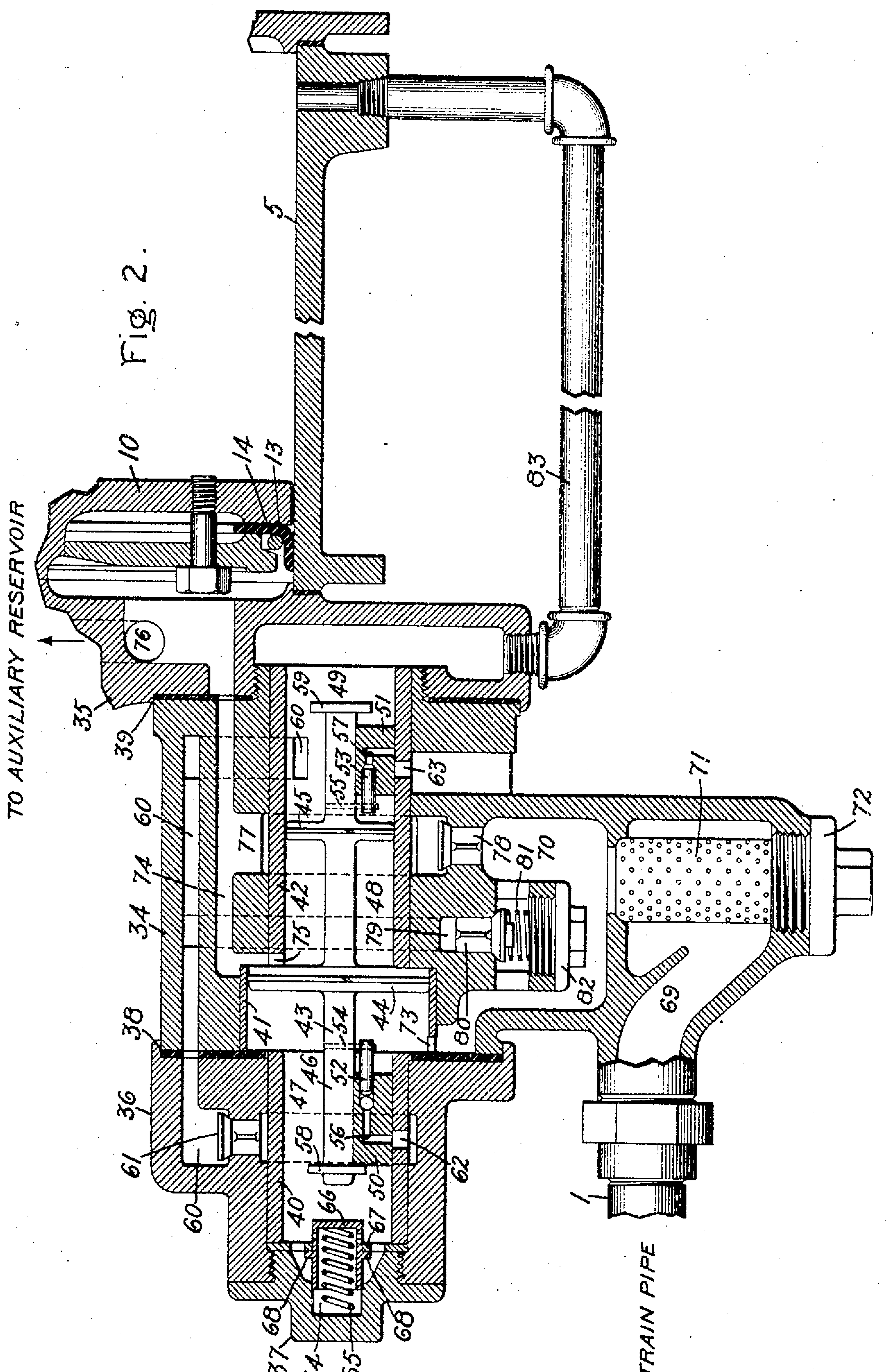

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3 SHEETS—SHEET 3.

Fig. 3.

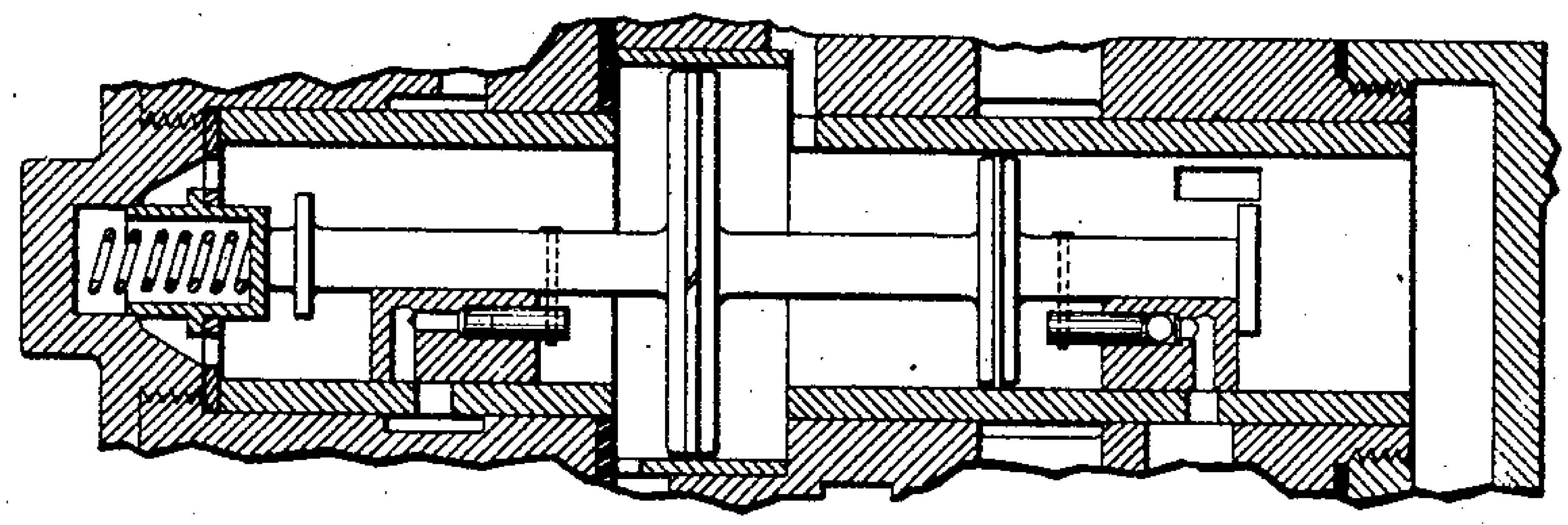


Fig. 4.

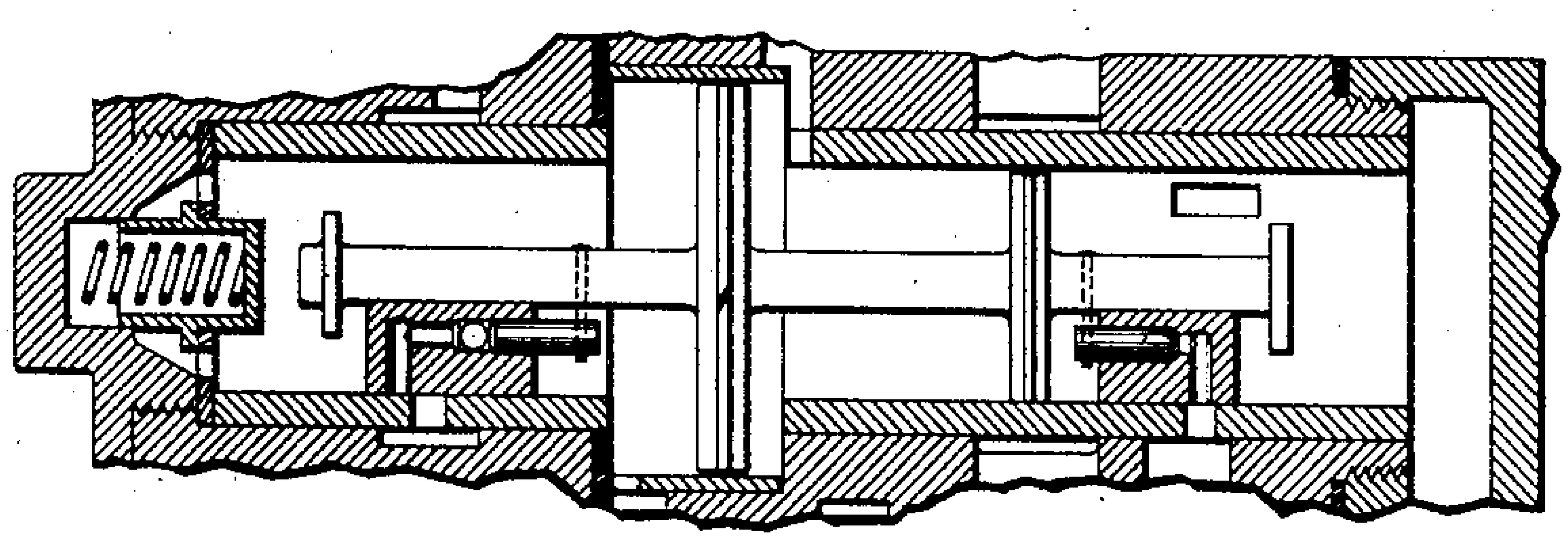
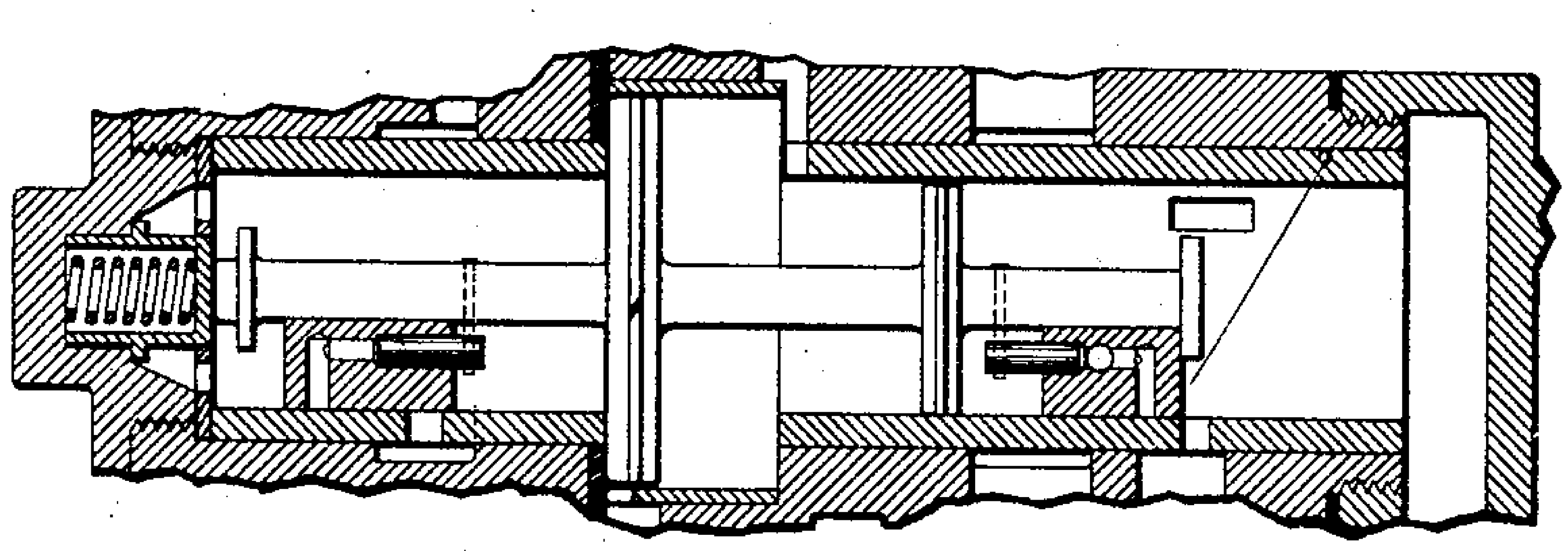


Fig. 5.



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UNITED STATES PATENT OFFICE.

FRED B. COREY, OF SCHENECTADY, NEW YORK, ASSIGNOR TO GENERAL ELECTRIC COMPANY, A CORPORATION OF NEW YORK.

AUTOMATIC AIR-BRAKE SYSTEM.

SPECIFICATION forming part of Letters Patent No. 786,007, dated March 28, 1905.

Application filed July 21, 1903. Serial No. 166,466.

To all whom it may concern:

Be it known that I, FRED B. COREY, a citizen of the United States, residing at Schenectady, in the county of Schenectady and State of New York, have invented certain new and useful Improvements in Automatic Air-Brake Systems, of which the following is a specification.

My invention relates to certain novel and useful improvements in automatic air-brake systems—that is, systems in which the brakes are applied by a reduction in the pressure of the air in the train-pipe in contradistinction to systems in which the brakes are applied by an increase in such pressure.

One object of my invention is to provide an improved air-brake system by which the engineer may control the release of the brakes so as to maintain any desired braking-power in the brake-cylinder—in other words, to provide an improved means for gradually releasing the brakes and stopping the releasing operation at any desired point.

In the case of the systems now in common use serious difficulties often arise in the handling of long trains, such as are common in freight service, because of the inability of the engineer to partially release the brakes. In such systems the brakes on each car are fully released at a single operation, and the releasing action also takes place on the different cars in succession, so that it often happens that when the brakes are released while the train is running at a considerable speed—say ten or twelve miles per hour—the head of the train, having the check to its speed suddenly removed in advance of the rear, moves forward with such force as often to break the train in two or more parts. By the employment of my invention this difficulty is overcome.

Another object of my invention is to provide means which may be readily operated by the engineer to apply the brakes in case he fails to get a proper braking action upon moving his valve to make the usual service application. This is a safety feature of importance, and its function, so far as I know, is not accomplished by any form of brake mechanism now in use.

Another object of my invention is to improve automatic systems of the differential type in which compressed air is admitted to both sides of the brake-cylinder piston and in which the application and release of the brakes is brought about by establishing a difference of pressure on the opposite sides of said piston. Heretofore it has been necessary in systems of this type to reduce the pressure of the air in the train-pipe to that of atmosphere in order to secure a maximum brake application. This reduction causes an enormous waste of air, since in the ordinary brake equipment the capacity of the train-pipe and its connections is many times the piston displacement. I overcome this serious objection by means of certain improvements by which I am enabled to secure the maximum brake application with a relatively small reduction in the pressure of the air in the train-pipe and, conversely, a great restoration of pressure in the brake-cylinder with a small restoration of pressure in the train-pipe, thus securing a great saving of air in the operation of the system.

Other objects and advantages of my invention will appear from the following detailed description, taken in connection with the accompanying drawings, and the different features and combinations of the invention will be definitely pointed out in the appended claims.

In the drawings, Figure 1 is a view illustrating, partly in diagram, one form of my invention and showing the equalizing-valve detached from the other parts and drawn to a slightly-enlarged scale. Fig. 2 is a vertical section of an equalizing-valve attached to the end of the brake-cylinder and illustrates the preferred form of my invention; and Figs. 3, 4, and 5 are fragmentary views illustrating different operative positions of the latter equalizing-valve.

The form shown in Fig. 1 does not embody the safety feature previously referred to as one of the objects of my invention, but by reason of its simplicity discloses the principle of operation of the other features much more clearly than the preferred form and is described and shown largely for that reason.

Referring to the drawings, in which like characters refer to like parts throughout the several views, and particularly to Fig. 1, which illustrates the simpler form of my invention, 1 designates the train-pipe, which is connected by a pipe 2 to an equalizing-valve 3, which in turn is connected by a pipe 4 with the right or lower end of a brake-cylinder 5. A pipe 6 connects the left or upper end of the brake-cylinder with an auxiliary reservoir 7, and a pipe 8, which is provided with a check-valve 9, connects the pipes 4 and 6. The brake-cylinder 5 is of the differential type previously referred to and contains a piston 10, which is moved to the left end of the cylinder by a spring 11 when the air-pressures on its opposite sides are equal and toward the right when the pressure at its right falls off, the former position corresponding to "brakes off" and the latter to different degrees of "brakes on," depending upon the extent of movement. The spring 11 surrounds the piston-rod 12 and bears against said piston and the right end of the cylinder. The piston-rod 12 is adapted to be connected at its outer end to the usual brake-lever mechanism. The brake-piston 10 is provided with a cupped packing-ring 13, of leather or other suitable material, which is clamped between said piston and its follower and is held down against the inner surface of the cylinder by a spring-ring 14. The packing-ring 13 is so arranged that air may leak between it and the cylinder from the right side of the piston to the left, but not from the left to the right. This construction serves as a means for supplying air under pressure from the pipe 4 to the left side of the piston and to the auxiliary reservoir 7 in addition to the passage through the pipe 8. The check-valve 9 serves a similar purpose in the pipe 8 and prevents air from flowing from the reservoir 7 toward the train-pipe, but allows it to flow in the opposite direction. The casing of the equalizing-valve 3 consists, essentially, of the body 15, a head 16, secured to one end thereof, with a suitable interposed gasket 17, and a plug 18, screwed into the opposite end of the body 15 and held in place by a check-nut 19. Suitable bushings 20, 21, and 22 are fitted within the valve-body 15, and within these a double piston 23 is adapted to reciprocate. The bushings are of different diameters to accommodate the different diameters of the piston-heads, which are so spaced as to divide the interior of the valve into three chambers 24, 25, and 26, two of which chambers, 24 and 26, communicate with the train-pipe 1 and the brake-cylinder 5 through the pipes 2 and 4, respectively. A spiral spring 27, located between the plug 18 and the collar 28 on the piston 23, normally holds the piston at the extreme right of its travel, and a passage 29, with a port 30, connects the chambers 24 and 26 for certain positions of the piston. The port 31 for other positions of the piston connects the chamber 24 with atmosphere, and a passage 32 connects the chamber 25 at all times with atmosphere. A slide-valve 33, which is mounted so as to move with the piston, is adapted to open and close the ports 30 and 31. For the purpose of explaining the operation of this form of my invention let it be assumed that the maximum train-pipe pressure is seventy pounds, that the area of the larger piston-head is two square inches, that the effective area of the smaller piston-head is one square inch, and that the tension maintained on the spring 27 is seventy pounds. Starting with the condition when all the air is off the system, air under pressure is admitted to the train-pipe, and the pressure of the air in the train-pipe continues to increase, but will have no effect upon the equalizing-valve until it has reached a pressure of thirty-five pounds per square inch. At this point the effective pressure on the right of the larger piston-head will be two times thirty-five or seventy pounds, which will be just sufficient to balance the pressure exerted by the spring 27. A slight increase of train-pipe pressure will therefore force the piston toward the left and move the slide-valve 33 beyond the port 30, thus connecting the chamber 26 with the chamber 24. For this position of parts a through-passage will be provided from the train-pipe to the right or lower end of the brake-cylinder through the pipe 2, chamber 26, passage 29, chamber 24, and pipe 4 and thence to the auxiliary reservoir either through the pipes 8 and 6 or around the edges of the piston 10 to the left or upper end of the brake-cylinder and thence through the pipe 6, thus charging all parts of the system except the chamber 25 in the valve 3 with air at train-pipe pressure. A further increase of the train-pipe pressure will continue to increase the pressure in the various parts of the system without again changing the position of the piston 23 until said pressure has reached seventy pounds per square inch. At this point the pressure exerted on the right of the larger piston-head will be two times seventy or one hundred and forty pounds, while that exerted in opposition to it will be seventy pounds, the pressure exerted by the spring plus seventy pounds, the pressure exerted on the left of the smaller piston-head, which makes a total of one hundred and forty pounds exerted in opposition. This will give a balanced condition of the valve. If now a reduction of ten pounds is made in the train-pipe for the purpose of applying the brakes, the pressure exerted on the right of the larger piston-head will be two times sixty or one hundred and twenty pounds, while that exerted in opposition will be one hundred and forty pounds, as previously shown. This difference will cause the piston to move toward the right, and thereby through the agency of the slide-valve 33 close the port 30 and open the port 31 to atmosphere. Air will then escape from the right of the piston 10 in the brake-cylinder to atmosphere through the pipe 4, the chamber 24, and the exhaust-port 31, and this action will continue until the pressure of the air in the chamber 24 has fallen sufficiently to allow the pressure of one hundred and twenty pounds acting on the right of the larger piston-head to move the piston 23 toward the left, and thereby through the agency of the slide-valve 33 close the port 31. This will occur when the pressure in the right end of the brake-cylinder and the chamber 24 of the equalizing-valve 3 is slightly less than fifty pounds. A pressure of fifty pounds acting on the left of the smaller piston would be just sufficient to balance the one hundred and twenty pounds acting on the right of the larger piston. From the above it will be seen that for a reduction of ten pounds in the train-pipe pressure a reduction of twenty pounds is obtained in the brake-cylinder at the right of the piston 10. A further reduction in train-pipe pressure is followed by a reduction in the same proportion at the right of the brake-piston, and continued reductions in train-pipe produce corresponding reductions in the brake-cylinder until the train-pipe pressure has been reduced to thirty-five pounds, when the brake-cylinder pressure becomes zero. Reductions in pressure at the right of the piston 10 are not communicated to its left or to the auxiliary reservoir, and consequently for each reduction the piston 10 is moved toward the right by the greater pressure acting upon its left, and in each case the extent of the movement depends upon the amount of the reduction, the piston moving until the pressures on opposite sides balance each other. Since the movement of the piston 10 toward the right applies the brakes, it is apparent that any desired application may be had by producing a greater or less reduction in train-pipe pressure and that the maximum application is had when the train-pipe pressure is reduced to thirty-five pounds. The operation of releasing the brakes is the converse of that of applying them, and for each increase in train-pipe pressure above thirty-five pounds there will be a corresponding movement of the piston 10 to the left and consequent reduction in brake-shoe pressure, and continued increases in train-pipe pressure will produce corresponding reductions in brake-shoe pressure until the train-pipe pressure reaches seventy pounds, when the brakes will be fully released. The first increase in train-pipe pressure will move the piston 23 of the valve 3 toward the left to open the passage between train-pipe and brake-cylinder, thereby increasing the pressure at the right of the brake-piston 10 in the manner previously described, and subsequent increases may be made thereafter as desired.

Referring now to Figs. 2, 3, 4, and 5, which illustrate the preferred form of equalizing-valve, 34 designates the valve-body, which is secured at one end to the head 35 of the brake-cylinder 5 and is provided at it opposite end with a cap 36, which is closed at its outer end by a screw-plug 37. Suitable gaskets 38 and 39 are interposed between the valve-body, cap, and cylinder-head to secure tight joints. The structure thus formed is provided with suitable bushings 40, 41, and 42, fitted tightly into its interior and within which a double piston 43 is adapted to reciprocate, the bushings 41 and 42 being of different diameters to accommodate the different diameters of the piston-heads 44 and 45, which are so disposed upon the piston-rod 46 as to divide the large chamber formed by the three bushings into smaller chambers 47, 48, and 49. Slide-valves 50 and 51, located within the bushings 40 and 42, respectively, and adjacent to the ends of the piston-rod 46, are provided with graduating-valves 52 and 53, respectively, which are firmly secured to the piston-rod 46 by pins 54 and 55. The graduating-valves 52 and 53 control ports or passages 56 and 57 in the slide-valves and, together with the heads 58 and 59 at the opposite ends of the piston-rod 46, limit their movement relative to the piston 43, so that said slide-valves have a short range of motion independent of said piston-rod. This lost motion between the slide-valves and the piston permits the graduating-valves to be operated in advance of the slide-valves when the direction of movement of the piston is changed for a purpose which will more fully appear in the statement of operation hereinafter given. A passage 60 surrounds the bushing 40 and extends longitudinally through a portion of the cap 36 and the body 34 to the chamber 49 at the right of the smaller piston-head 45. A valve 61, located in this passage, permits a flow of air through said passage toward the chamber 49 and prevents a flow in the opposite direction. The passage 60 is provided with a port 62 in the bushing 40, with which the port 56 in the slide-valve 50 is adapted to register to bring the chamber 47 at the left of the larger piston-head 44 into communication with chamber 49 at the right of the smaller piston-head 45. A port 63 in the bushing 42 is adapted to register with the port 57 in the slide-valve 51 to connect the chamber 49 to atmosphere. The interior of the plug 37 is cut away, so as to form a socket 64 for the reception of a graduating spring 65, which at one end bears against the interior of the socket and at the other against the interior of a cup 66, which is adapted to move in and out of said socket as the spring is compressed and expanded. A plate 67, firmly held in place between the bushing 40 and the plug 37, is provided with a central opening, through which the end of the cup 66 is adapted to pass. Suitable lugs 68 upon the cup 66 engage the plate 67 to limit the outward movement of the cup. The graduating-spring 65 and its inclosing cup 66 are located in line with the piston-rod 46, which is adapted to engage said cup and compress the spring when the piston is forced to the left by a large reduction in train-pipe pressure, such as occurs in making an emergency application. The function of this spring mechanism is to return the piston and its valves after such an emergency reduction to cut off the escape of air from the brake-cylinder in a manner which will more fully appear in the statement of operation hereinafter given. The lower portion of the valve-body 34 is provided with communicating chambers 69 and 70 and a suitable connection for the train-pipe 1, leading to the chamber 69. A strainer 71 of the usual type is held in place within the chamber 69 by a drain-plug 72 and strains all air that passes from the train-pipe into the valve. The chamber 70 communicates with the chamber 47 at the left of the large piston-head 44 through the port 73 in the bushing 41, so that the chambers 47, 69, and 70 are in constant communication and the left face of the larger piston-head is always subjected to air at train-pipe pressure. A longitudinal passage 74 extends from a port 75 in the bushing 42, opening into the chamber 48 between the piston-heads 44 and 45, to the left or upper end of the brake-cylinder 5, which is in constant communication through a passage 76 with the auxiliary reservoir. This connection keeps the pressure of the air in the chamber 48 at all times equal to auxiliary-reservoir pressure. A passage 77, extending around the bushing 42 and normally closed by a check-valve 78, located adjacent the chamber 70, is adapted to connect said chamber to the passage 74, and thereby the train-pipe, with the left end of the brake-cylinder. The check-valve 78 permits a flow of air only from the train-pipe toward the brake-cylinder, so that said passage is open only when the pressure in the train-pipe exceeds that in the auxiliary reservoir. A passage 79 leads from the chamber 70 to the passage 60 and when unobstructed places the chamber 49 at the right of the piston 45 in communication with the train-pipe. This passage, however, is normally closed by a valve 80, which is held upon its seat by a spring 81, secured in place and adjusted by a screw-plug 82. The valve 80 operates only when the pressure in the passage 60 and at the right of the piston 45 exceeds that in the train-pipe sufficiently to overcome the spring 81. This valve 80 therefore controls an otherwise unobstructed passage between the train-pipe and the lower end of the brake-cylinder and when the reduction of train-pipe pressure is sufficient to operate it affords means for reducing the air at the right of the brake-piston 10, which can be operated independently of the equalizing-valve. The chamber 49 at the right of the piston-head 45 is in constant communication with the right or lower end of the brake-cylinder 5 through the pipe 83, while, as previously pointed out, the chamber 47 at the left of the piston-head 44 and the chamber 48 between said piston-heads are in like communication with the train-pipe and the auxiliary reservoir, respectively. Figs. 2 to 5, inclusive, illustrate the principal operative positions of the equalizing-valve mechanism as follows: Fig. 2, the release or charging position; Fig. 3, the service-application position; Fig. 4, the lap position, and Fig. 5 the emergency-application position. The operation of this form of my invention is as follows: Beginning with the condition when all the air is off the system, the air-compressor is started and the main reservoir brought up to pressure. The engineer's valve being then brought to running position, compressed air will flow from the main reservoir through the train-pipe to the chamber 47 of the equalizing-valve and there acting on the left of the piston-head 44 move the piston and the slide-valves and graduating-valves to the position shown in Fig. 2. The slide-valve 50 and the graduating-valve 52 being opened by this operation, air will pass from the chamber 47 to the chamber 49 at the right of the smaller piston-head 45 through the passage 60, the increased pressure acting on the lower side of the valve 61 being sufficient to open said valve. The chamber 49 and the right end of the brake-cylinder being in constant communication, air will then flow to the right of the brake-piston 10 and pass around the outer edge of the piston-head to the left end of the brake-cylinder and to the auxiliary reservoir. Compressed air will also flow from the train-pipe to the auxiliary reservoir through the additional path formed by the passages 77 and 74. Thus both sides of the piston 10, the auxiliary reservoir, the chambers 47, 48, and 49 of the equalizing-valve, and the train-pipe—in fact the whole system beyond the engineer's valve—will be brought to the same pressure by this operation. At this point it should be noted that by reason of the check-valve 78 and the cupped leather on the brake-piston 10 the air that first enters the auxiliary reservoir and that portion of the brake-cylinder at the left of the piston will be entrapped and will serve to force the brake-piston toward the right in the subsequent operation of the brakes, as hereinafter noted. By reason of the relatively large volume of the auxiliary reservoir compared with the piston displacement the pressure of the entrapped air will be substantially constant. When it is desired to make a service application of the brakes, the engineer's valve is moved to service-application position and held there until a sufficient reduction has been made in the train-pipe pressure. This reduction will be communicated only to the chamber 47 at the left of the large piston-head 44, and the greater pressure of the auxiliary-reservoir and the brake-cylinder air acting on the right of the piston-heads will force the piston to the left, moving the valves to the position shown in Fig. 3, the graduating-valve 52 closing the port 56 in the slide-valve 50 and the graduating-valve 53 opening the port 56 of the slide-valve 51, which will register with the atmospheric port 63. Air will then flow from the right end of the brake-cylinder through the pipe 83, chamber 49, and port 57 to atmosphere until the pressure in the chamber 49 has fallen sufficiently to allow the train-pipe pressure in the chamber 47, acting on the left of the piston-head 44, to move the piston 43 to the right enough to operate the graduating-valve 53 to close said passage 57. The resulting position of the parts is known as the "lap" position and is illustrated in Fig. 4. The reduction of pressure at the right of the brake-cylinder piston 10 produced by such operation of the equalizing-valve will cause the greater pressure of the entrapped air at its left to move it to the right to apply the brakes, and the extent of such movement and application will depend upon the extent of the particular reduction. In the above operation the reduction of train-pipe pressure is not communicated through the passage 79 to the chamber 49 at the right of the small piston-head 45, because the valve 80 will not be opened by such a reduction, the spring 81 having sufficient strength to hold the valve 80 upon its seat at all times except when a reduction is made in excess of that ever required to make a service application. In case a more severe application of the brakes is desired further reduction in train-pipe pressure is made, and such reduction acting again on the left of the piston-head 44 moves the piston and the graduating-valves again to the left to the position shown in Fig. 3, thus allowing air from the right of the brake-cylinder piston to escape to atmosphere and the then greater pressure of the auxiliary-reservoir air to still further move the piston 10 and apply the brakes with increased pressure. If when the engineer has operated his valve in the above manner to obtain the usual service application of the brakes he finds that the brakes have not been applied, he may operate his valve to still further reduce the pressure in the train-pipe. This further reduction, which will be in excess of the greatest reduction required in making a service application, will operate the valve 80 to open the passage 79 in all those valves whose pistons or slide-valves have failed to operate in response to the service-application reduction, whereby communication will be established in each case from the right end of the brake-cylinder through the pipe 83, chamber 49, passages 60 and 79, and chambers 70 and 69 to train-pipe. This will allow the pressure of the air at the right of the brake-cylinder pistons 10 and that in the train-pipe to equalize and the air from the auxiliary reservoirs to force said pistons 10 to the right to apply the brakes. By this means the engineer is sure to obtain a satisfactory application of the brakes even though a large number or even all of the equalizing-valves fail to operate. When it is desired to make an emergency application of the brakes, a sudden large reduction in train-pipe pressure is made. This reduction is communicated to the chamber 47 and causes the piston 43 to move to the left suddenly and with enough force to compress the spring 65 and carry the slide-valves 50 and 51 to the position shown in Fig. 5. In this position the chamber 49 is in direct communication with atmosphere through the port 63, so that the air will escape from the right end of the brake-cylinder to atmosphere through a large opening, thus effecting a sudden reduction of pressure at the right of the piston 10 and allowing the air from the auxiliary reservoir to suddenly apply the brakes at their maximum pressure. As soon as sufficient air has escaped from the brake-cylinder to produce the necessary brake application the spring 65 will force the piston 43 and the slide-valves to the right to close the exhaust-port 63 and cut off said escape. Such movement will carry the piston 43 to the position shown in Fig. 3, but will move the slide-valves 50 and 51 only a little to the right of their position in Fig. 5 and will operate the graduating-valves to open and close the ports 56 and 57, respectively, thus bringing the graduating-valves to the position shown in Fig. 4. The sudden reduction of pressure in the train-pipe will also cause the valve 80 to be forced downward against the pressure of the spring 81, so as to allow air to escape from the right end of the brake-cylinder through the pipe 83, chamber 49, and passages 60 and 79 to the train-pipe. This escape, however, will be insufficient to interfere with the proper movement of the piston 43 or its valves, as above indicated.

From the above description of the operation it will be seen that after an application of the brakes, whether a service or an emergency application, the piston 43 is never left at either limit of its travel, but is moved to some intermediate position, so that the entire left face of the piston-head 44 is always subjected to subsequent variations of train-pipe pressure made either to apply or release the brakes. If then it is desired to partially release the brakes, any increase of train-pipe pressure being communicated to the chamber 47 will act upon the left face of the large piston-head 44 and will be sufficient to destroy the balance between the pressures acting on the piston and to force it and the slide-valves to the right sufficiently to bring the port 56 in the slide-valve 50 over the port 62, thereby establishing communication between the chambers 47 and 49 and allowing the increase in train-pipe pressure to be communicated to the chamber 49 and thence to the right of the piston 10 in the brake-cylinder 5. This increase of pressure on the right of the piston 10 will force it toward the left until the condition of equilibrium is reached, and this movement of the piston will correspondingly release the brakes. In this operation air at train-pipe pressure will continue to flow into the right end of the brake-cylinder until the pressure in the chamber 49 is sufficient to overcome the balance of the forces acting on the piston 43 and force it to the left to operate the graduating-valve 52 to close the port 56, thus shutting off the supply of air to the brake-cylinder. For a further release of the brakes further increase in train-pipe pressure is made, and the port 56 is again opened and communication established between the train-pipe and the right end of the brake-cylinder, and this is maintained until the pressure in the chamber 49 again increases sufficiently to cause the pressure on the right of the piston-heads to overbalance those acting on the left, and thereby force the piston 43 to the left to close said port 56 as before. When the train-pipe pressure becomes sufficient to keep the piston at the right-hand limit of its travel—*i. e.*, when the piston and valves are in running position—the right end of the brake-cylinder will remain in communication with the train-pipe and the brakes will be fully released. Because of the arrangement of the chambers 47, 48, and 49 and the connecting ports and passages the larger piston-head is always subjected to the opposing forces of train-pipe pressure on its left and auxiliary-reservoir pressure on its right, while the smaller piston-head is similarly subjected to auxiliary-reservoir pressure on its left and brake-cylinder pressure on its right—that is, the pressure in that portion of the brake-cylinder at the right of the brake-piston 10. In operation the pressure of the air in the chamber 48, considered irrespective of other pressures, tends to move the piston 43 to the left by reason of the greater area of the piston-head 44 and, being practically constant, performs the same function as the spring 27 in the form illustrated in Fig. 1. Such being the case, an increase or decrease in train-pipe pressure acting on the left of the larger piston-head, in this form as in the other, will be balanced only by a correspondingly greater increase or decrease of pressure acting on the right of the smaller piston-head. From this it follows that what is true in the case of the form of invention illustrated in Fig. 1 is equally true in the case of this the preferred form and that increases or decreases in train-pipe pressure are followed by correspondingly greater increases or decreases of pressure in the brake-cylinder (at the right of the brake-piston 10) and that the advantages of gradual application and gradual release of the brakes and saving of air pertain to this form as well as to the other and that this form also possesses the safety feature embodied in the valve 80 and passage 79, by which an application of the brakes may be had even though the piston 43 or some of its coöperating parts be out of order and fail to operate.

I do not wish to be limited to the specific forms of my invention illustrated, but aim to cover by the terms of the appended claims all modifications and alterations which may fall within the spirit and scope of my invention.

What I claim as new, and desire to secure by Letters Patent of the United States, is—

1. In an air-brake system, the combination of a train-pipe, a brake-cylinder, a piston therein, and means responsive to an increase in train-pipe pressure for admitting air from said train-pipe to said cylinder at opposite sides of said piston and responsive to subsequent variations of train-pipe pressure for causing variations in pressure at one side of said piston greater than the train-pipe-pressure variations which produce them.

2. In an air-brake system, the combination of a train-pipe, a brake-cylinder, a piston therein, means for entrapping compressed air in the cylinder at one side of said piston, and means responsive to a variation of train-pipe pressure for causing a variation in pressure at the other side of said piston greater than the train-pipe-pressure variation which produces it.

3. In an air-brake system, the combination of a train-pipe, a brake-cylinder, a piston therein, means responsive to an initial increase in train-pipe pressure for causing an equal increase of pressures on opposite sides of said piston and responsive to subsequent variations of train-pipe pressure for causing corresponding variations in pressure on one side of said piston greater than the train-pipe-pressure variations which produce them.

4. In an air-brake system, the combination of a train-pipe, a brake-cylinder, a piston in said cylinder, connections for admitting air from the train-pipe to opposite ends of said cylinder, a check-valve in the connection leading to one end of the cylinder, and means in the connection between the train-pipe and the other end of said cylinder responsive to variations in the train-pipe pressure for producing corresponding but relatively greater variations of pressure in that end of the brake-cylinder.

5. In an air-brake system, the combination of a train-pipe, a brake-cylinder, a piston in said cylinder, an auxiliary reservoir communicating with one end of said cylinder, connections for admitting air from the train-pipe to opposite ends of said cylinder, a check-valve in the connection leading to that end of the cylinder with which the auxiliary reservoir communicates, and means in the connection between the train-pipe and the other end of said cylinder responsive to variations in the

train-pipe pressure for producing corresponding but relatively greater variations of pressure in that end of the brake-cylinder.

6. In an air-brake system, the combination of a train-pipe, a brake-cylinder, means operable by a reduction in train-pipe pressure to vary the pressure in the brake-cylinder to apply the brakes to produce "service" and "emergency" stops according to the amount of said reduction, and an auxiliary means for applying said brakes independent in its operation of the aforesaid means and operable upon a still further reduction of train-pipe pressure.

7. In an air-brake system, the combination of a train-pipe, a brake-cylinder, a piston therein, means for admitting compressed air from the train-pipe to opposite sides of said piston, means operable upon a reduction in train-pipe pressure to reduce the air-pressure at one side of said piston to apply the brakes, and means independent in its operation of the aforesaid means and operable upon a further reduction in train-pipe pressure for making said brake-cylinder reduction.

8. In an air-brake system, the combination of a train-pipe, a brake-cylinder, a piston therein, a valve located between said train-pipe and said brake-cylinder and operable upon variations of train-pipe pressure to control the flow of air to and from said brake-cylinder, and a check-valve located in an otherwise unobstructed passage between said brake-cylinder and said train-pipe and arranged so as to permit a flow of air only toward the train-pipe and adjusted to open only upon a variation in train-pipe pressure greater than is necessary to operate the first-mentioned valve.

9. In an air-brake system, the combination of a train-pipe, a brake-cylinder, a piston therein, an equalizing-valve connected between said train-pipe and said brake-cylinder to vary the pressure at the lower side of the brake-piston in accordance with corresponding variations in the train-pipe pressure, and a check-valve located in an otherwise unobstructed passage between the lower end of said brake-cylinder and said train-pipe and adjusted so as to permit a flow of air only toward the train-pipe and only upon a reduction in train-pipe pressure greater than is necessary to operate the equalizing-valve.

10. In an air-brake system, the combination of a train-pipe, a brake-cylinder, a piston therein, and valve mechanism connected between said brake-cylinder and said train-pipe and comprising a double-headed piston having heads of different diameters subjected, the one to train-pipe pressure and the other to opposing brake-cylinder pressure, and means operated thereby for controlling the flow of air from the train-pipe to the brake-cylinder and from said brake-cylinder to atmosphere.

11. In an air-brake system, the combination of a train-pipe, a brake-cylinder, a piston therein, means for permitting a flow of air from the lower to the upper side of said piston and preventing a flow in the opposite direction, and valve mechanism connected between said train-pipe and the lower end of said brake-cylinder and comprising a double-headed piston having heads of different diameters subjected, the one to train-pipe pressure and the other to opposing brake-cylinder pressure, and means operated thereby for controlling the flow of air from the train-pipe to the cylinder and from said brake-cylinder to atmosphere.

12. An equalizing-valve comprising a casing provided with train-pipe and brake-cylinder connections and an interior chamber having cylindrical portions of different diameters, and valve mechanism coöperating with ports in said casing to control the passage of air to and from the brake-cylinder, said valve mechanism comprising a double-headed piston having heads of different diameters located within the cylindrical portions of said interior chamber and subjected, the one to train-pipe pressure and the other to opposing brake-cylinder pressure, and means tending to move the piston in opposition to one of said pressures.

13. An equalizing-valve comprising a casing provided with train-pipe and brake-cylinder connections and an interior chamber having cylindrical portions of different diameters, and valve mechanism comprising a double-headed piston having heads of different diameters located within the cylindrical portions of said interior chamber and subjected, the one to train-pipe pressure and the other to opposing brake-cylinder pressure, valves operated thereby, one of said valves controlling a passage between the train-pipe and the brake-cylinder and another controlling a passage between the brake-cylinder and atmosphere.

14. An equalizing-valve comprising a casing provided with train-pipe and brake-cylinder connections and an interior chamber having cylindrical portions of different diameters, and valve mechanism comprising a double-headed piston having heads of different diameters located within the cylindrical portions of said interior chamber and subjected, the one to train-pipe pressure and the other to opposing brake-cylinder pressure, slide-valves coöperating with ports in said casing to control the flow of air from the train-pipe to the brake-cylinder and from the brake-cylinder to atmosphere, said valves being arranged on the piston-rod and having a short range of motion independent of said rod, and a graduating-valve for each slide-valve operated by the same rod to open and close ports in the slide-valves without necessarily moving said slide-valves.

15. In a valve mechanism, the combination of a piston and its rod, slide-valves arranged on said rod and having a short range of motion independent of said rod, a graduating-

valve for each slide-valve operated by the same rod to open a port in one slide-valve and close a port in the other when said piston is moved in one direction and to close the former port and open the latter when said piston is moved in the opposite direction, said graduating-valves being operated without necessarily operating said slide-valves, supply and exhaust ports coöperating with said slide-valves, the exhaust-port and its slide-valve being so arranged that when said piston is moved to the limit of its travel in one direction said slide-valve will be drawn beyond the exhaust-port, and spring mechanism placed under stress by such extreme movement of the piston and serving to return the piston so as to bring the exhaust slide-valve and its graduating-valve into a position to cut off the exhaust.

In witness whereof I have hereunto set my hand this 20th day of July, 1903.

FRED B. COREY.

Witnesses:

BENJAMIN B. HULL,

HELEN ORFORD.