No. 792,378. PATENTED JUNE 13, 1905.

M. R. ZEHNDER.

CYLINDER RELIEF VALVE.

APPLICATION FILED JUNE 11, 1904.

4 SHEETS—SHEET 1.

Fig. 1.

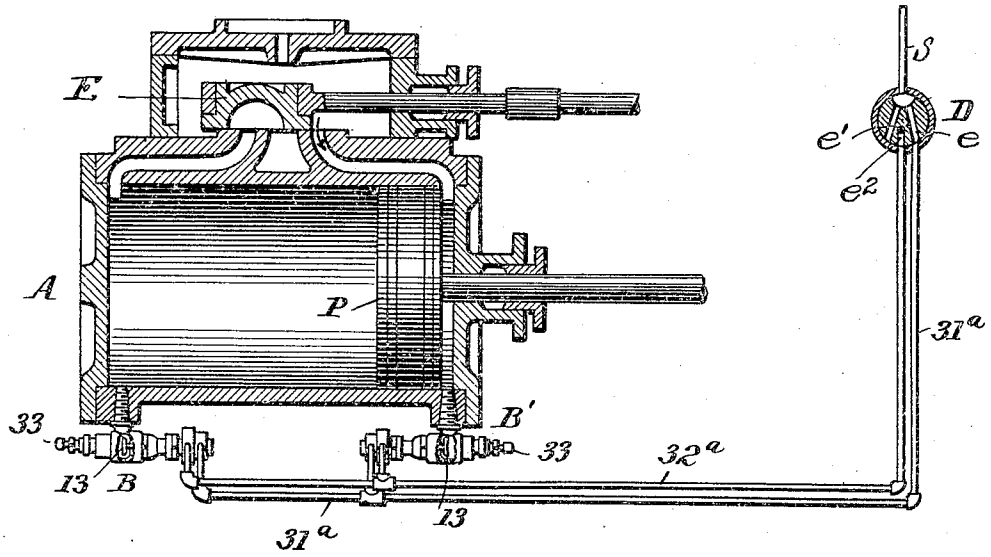


Fig. 1a.

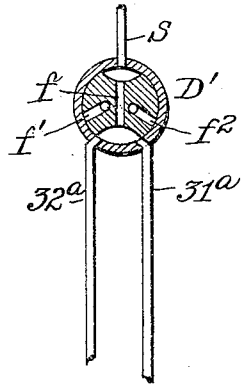


Fig. 4.

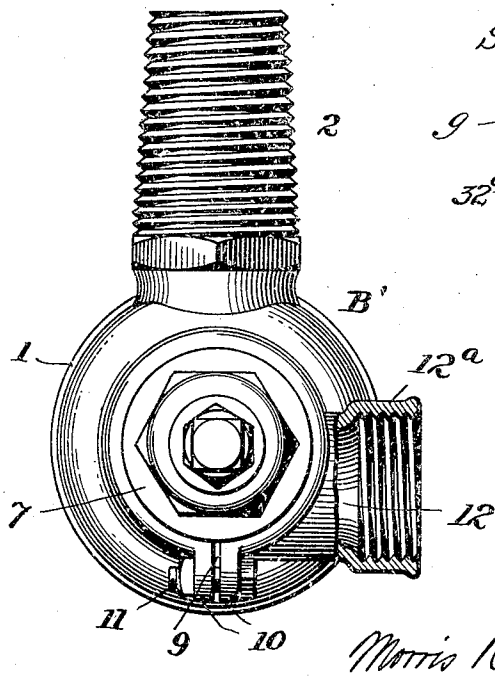
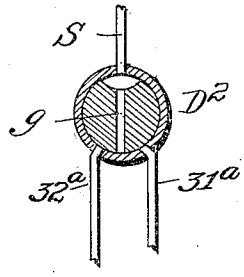


Fig. 1b.



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4 SHEETS—SHEET 2.

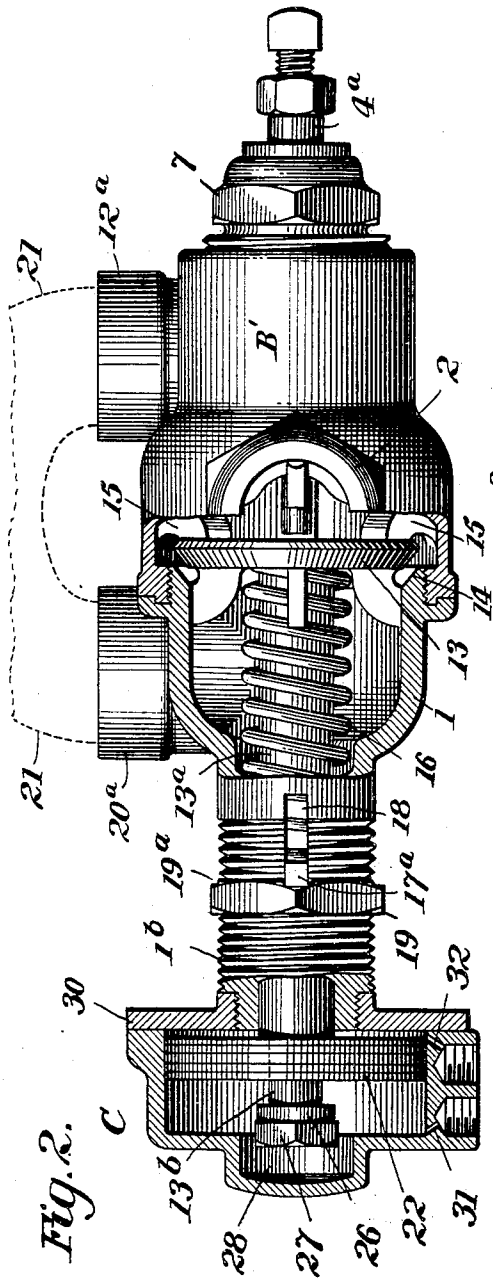

Fig. 2.

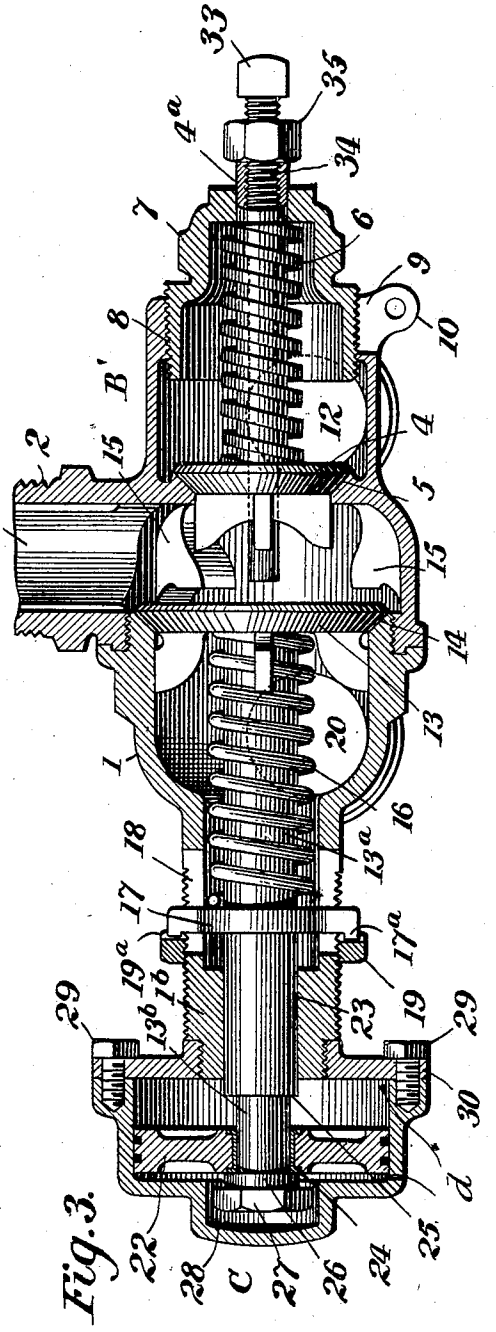

Fig. 3.

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4 SHEETS—SHEET 3.

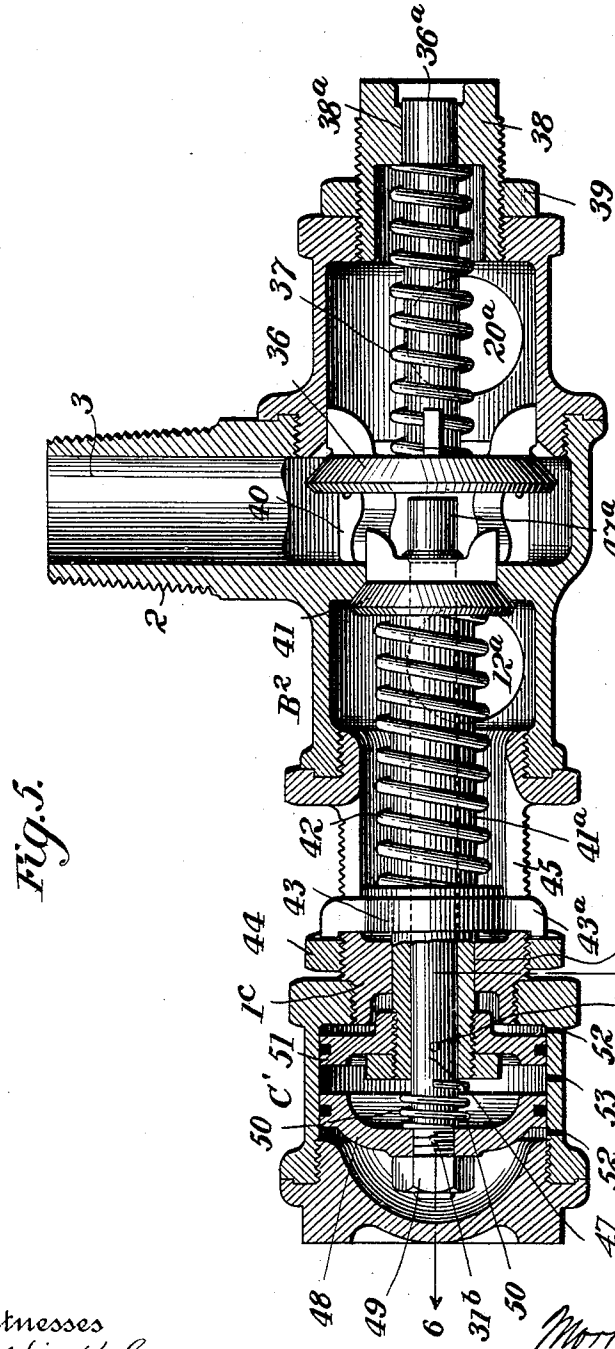

Fig. 5.

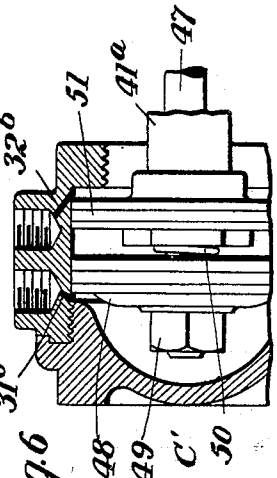

Fig. 6

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4 SHEETS—SHEET 4.

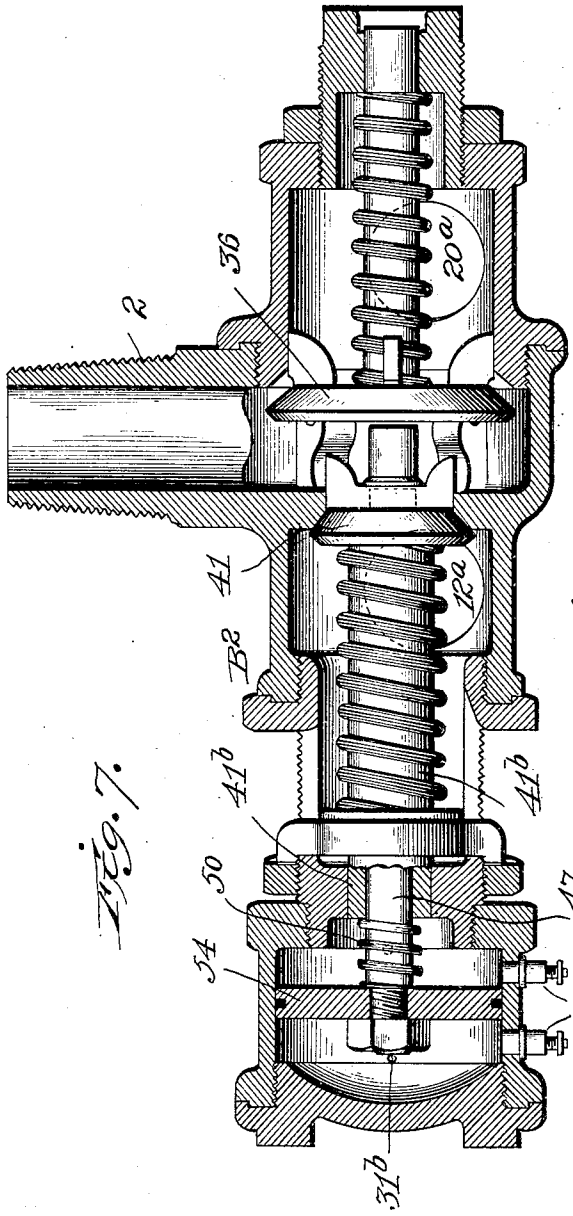

Fig. 7.

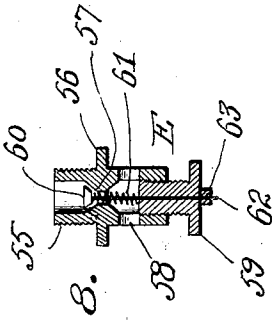

Fig. 8.

Witnesses

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No. 792,378. Patented June 13, 1905.

UNITED STATES PATENT OFFICE.

MORRIS R. ZEHNDER, OF SCRANTON, PENNSYLVANIA, ASSIGNOR TO THE ZEHNDER VALVE AND BRAKE MANUFACTURING COMPANY, OF SCRANTON, PENNSYLVANIA, A CORPORATION.

CYLINDER RELIEF-VALVE.

SPECIFICATION forming part of Letters Patent No. 792,378, dated June 13, 1905.

Application filed June 11, 1904. Serial No. 212,164.

To all whom it may concern:

Be it known that I, MORRIS R. ZEHNDER, a citizen of the United States, residing at Scranton, in the county of Lackawanna and State of Pennsylvania, have invented certain new and useful Improvements in Cylinder Relief Devices, of which the following is a specification.

This invention comprises improvements in devices for attachment to steam-engine cylinders adapted to relieve the cylinders of drainage-water, to obviate the retarding action upon the piston ordinarily caused by air compression and rarefaction within the cylinder when the engine is running under its own momentum, and to prevent excessive internal pressure in the cylinder; and the invention relates particularly to means actuated by steam or other fluid pressure for controlling the operation of the valves in the device at the will of the engineer to provide for certain contingencies which arise in the practical running of locomotives.

In the accompanying drawings, which illustrate my invention, Figure 1 is a central vertical section through a steam-engine cylinder, showing drainage and relief devices connected thereto and partly broken away and the connections to the controlling-valve. Figs. 1^a and 1^b are views illustrating different forms of controlling-valves. Fig. 2 is a top plan view, partly in section, of one of the drainage and relief devices. Fig. 3 is a central vertical section through the same. Fig. 4 is an end view of the same looking from the right in Fig. 3. Fig. 5 is a central vertical section through a drainage and relief device in which the controlling-cylinder is arranged at the opposite end of the device from that to which it is attached in the previous figures, and two pistons are arranged therein. Fig. 6 is a horizontal section through the controlling-cylinder of Fig. 5 on the line 6 6. Fig. 7 is a view similar to that shown in Fig. 5, only one piston being provided for operating the valves; and Fig. 8 is a vertical central section through one of the drain and exhaust valves for the controlling-cylinder.

Referring to Figs. 1 to 4, inclusive, of the drawings, A indicates the steam-cylinder of a locomotive or other steam-engine, P the piston, and B and B′ indicate the drainage and relief devices which are secured within the drainage-outlets at the ends of the cylinder. The two drainage and relief devices are similarly constructed, and a description of one will therefore apply to both. As shown in Figs. 2 and 3 of the drawings, each device comprises a hollow casing 1, having a threaded pipe connection 2, adapted to fit into a drainage-outlet opening in the cylinder, as shown in Fig. 1, or to be connected to a pipe leading from such opening. The drainage-water live and exhaust steam enter the interior of the valve-casing 1 through the pipe connection 2, which forms an inlet-opening 3 for the casing. An excess-pressure valve 4 is arranged within the casing at one side of the opening 3 and is normally held against its seat 5 with sufficient pressure to prevent it from opening under the normal steam-pressure of the boiler by a spring 6, the tension of which may be varied by means of an adjustable cap or follower 7, fitting around the stem 4^a of the valve and having a threaded connection 8 with the valve-casing 1. The spring 6 is interposed between the end of the cap or follower 7 and the valve 4, and it will be apparent that by turning the follower the pressure of the valve against its seat may be adjusted so that the valve will open at any desired pressure above the normal steam-pressure in the boiler or the engine-cylinder. The threaded end of the casing within which the cap or follower 7 fits has a longitudinal slot 9 and a lug 10 at each side of the slot, and the follower may be clamped in any position by means of a clamping-bolt 11, extending through openings in said lugs. An outlet-opening 12 extends from the interior of the casing in the rear of the valve 4 through a suitable pipe connection or fitting 12^a, and when the valve is lifted from its seat by excessive pressure in the cylinder the steam or water, or both, as the case may be, may pass out through the opening 12. The excess-pressure valve 4 is held normally closed under all ordinary conditions and opens out-

wardly only under extraordinary conditions when the internal pressure is abnormal.

A relief-valve 13 is arranged within the casing at the opposite side of the inlet-opening 3 and when closed is adapted to fit against a valve-seat 14. The valve 13 opens inwardly and is normally held in its open position against suitable stops 15 in the central part of the casing by a spring 16, which is coiled around the stem 13[a] of the valve and interposed between the back of the valve and an adjustable collar 17, fitting around the valve-stem within the casing. This collar is provided with lugs or projections 17[a], which extend through slots 18 in the wall of the casing, and the collar may be adjusted to vary the tension of the spring, as desired, by means of a nut 19, threaded onto the exterior of the casing, as shown, and bearing against the rear edges of the projections 17[a]. This nut has a series of shallow notches 19[b] at one side arranged in diametrically opposite pairs and adapted to receive the lugs or projections 17[a] upon the collar or follower 17. By turning the nut the spring may be set so that the valve will close at any desired fluid-pressure, which should be less than the normal live-steam pressure in the engine-cylinder. The engagement of the lugs 17[a] with the notches 19[b] prevents the accidental turning of the nut. The casing is provided with a drainage-outlet opening 20 in the rear of the valve 13 and extending through a suitable pipe connection 20[a]. This connection, as well as the connection 12[a], may be connected to a pipe 21 common to both, as indicated in Fig. 2. When applied to a locomotive, this pipe terminates at some point beneath the locomotive in preference to discharging at the side.

During ordinary movements of the engine while operating under steam-pressure the excess-pressure valve 4 remains closed, as previously stated, while the relief-valve 13 opens automatically by the pressure of the spring 16 to permit the drainage-water to flow out from the exhaust end of the cylinder and is closed immediately by steam-pressure when live steam is applied to the end of the cylinder to which the device is connected. As there is a relief device connected to each end of the cylinder, of course the drainage-valves in these devices will open and close alternately, and thus drain both ends of the cylinder.

When the engine is at rest and also while running under its own momentum with steam cut off, the drainage-valves will be held off of their seats by the springs, and the cylinder will thus be drained at all times, whether in motion or stopped. When the engine is running under its own momentum, also as the drainage-valves are held open, air may enter and pass out of the cylinder by way of said valves, and the compression of air in front of the piston and vacuum in the rear of the piston, which naturally result from the pumping action of the piston, are in whole or in part averted.

The back pressure in the cylinder, caused by the complete or partial closing of the exhaust-port by the engine-valve before the piston reaches the end of the stroke, results in back pressure upon the piston, which back pressure may be relieved through the drainage-valves if the tension of the springs upon these valves is made sufficient to withstand such pressure, or any desired amount of back pressure may be retained by suitable adjustment of the springs adapting them to close at any predetermined pressure. The valves 13, therefore, in both casings serve the several useful purposes of draining the cylinder, relieving the air-pressure within the cylinder, preventing the formation of a vacuum, and preventing or regulating the back pressure upon the piston.

It is sometimes desirable to hold the drainage and compression regulating valves 13 against their seats and prevent their operation—as, for instance, when a locomotive is passing a station and it is desired to prevent the escape of exhaust steam and water until the engine has passed the station. It is also desirable at times to hold the drainage-valves open and inoperative—as, for instance, when the locomotive has stopped for some time and the cylinders have become cooled so that there is considerable condensation of steam when the steam is first applied to the cylinders in starting. In such case it is desirable to prevent the closure of the drainage-valves until the cylinders have become heated. It is also desirable at times to be able to force the drainage-valves off of their seats against the live-steam pressure in the cylinder. It frequently occurs in starting long heavy trains, particularly on up grades, that the engineer will open his throttle-valve and admit steam to the cylinder; but owing to the fact that there is no slack between the cars the locomotive is unable to start the train and the driving-wheels will not move. When this occurs, the engineer wishes to reverse his engine so as to provide slack at the couplings between the cars of his train; but the steam-pressure upon the reversing-valve in the steam-chest is so great that with ordinary valves it is difficult or impossible to move the reversing-valve until steam has been cut off at the throttle-valve and the steam from the chest and steam end of the cylinder has been allowed to escape through the drain-pipes or to condense.

In order to provide for holding the drainage-valve inoperative either in its open or closed positions and for forcing the drainage-valve open against live-steam pressure, I provide a controlling-cylinder C, which is conveniently supported upon the end of the casing 1, and within this cylinder is arranged a close-fitting piston 22, having suitable packing-rings on

its periphery to render it steam-tight. The valve-stem 13^a projects through and fits closely within an opening 23 in the end 1^a of the relief-valve casing and into the controlling-cylinder, and the part 13^b of the valve-stem within the cylinder extends through an axial opening in the piston 22. The piston is movable longitudinally of the valve-stem, and in order to prevent wear a bushing 24 is interposed between the piston and stem. The valve-stem has a shoulder 25 at one side of the piston and a collar 26 at the opposite side of the piston, which is held in place by a nut 27 upon the end of the valve-stem, this shoulder and collar, which form stops for the piston, being within the cylinder and separated from one another by a distance which during the ordinary opening and closing operations of the valve will permit the valve-stem to slide through the bushing without disturbing the piston. The drainage-valve may therefore operate without being retarded in its movements by the piston, and the latter during ordinary operations remains stationary and does not wear out the packing-rings. When steam is admitted to one side or the other of the piston to move or hold the valve, as hereinafter explained, the piston will be forced against one of the stops 25 or 26, and the end of the bushing, fitting against the stop, will make a steam-tight joint which will prevent steam from passing between the bushing and valve-stem from one side of the piston to the other in case there is leakage at this point.

The controlling-cylinder C, as shown, consists of a cup-shaped casting having a recess 28 at its outer end to provide clearance-space for the nut and the end of the valve-stem, and this casting is secured by bolts 29 to a head 30, which is threaded, as shown, or otherwise suitably secured to the end of the relief-valve casing, this head forming one end of the cylinder. By removing the bolts 29 the cylinder may be removed for the purpose of repacking the piston or inserting a new bushing.

Inlet-openings 31 and 32 for steam or other fluid under pressure are arranged at the outer and inner ends of the cylinder, respectively, and, as shown in Fig. 1, the openings 31 in the cylinders of both drainage devices B and B′ are connected by a pipe 31^a to a valve D, which is arranged within the engine-cab at a point convenient to the engineer. Similarly, the openings 32 are connected by a pipe 32^a to the valve D. The valve D (shown in Fig. 1) is so arranged that live steam or other fluid under pressure may be admitted from a pipe S, connected with the source of supply through the passage-ways e and e' to either of the pipes 31^a or 32^a, respectively, and exhausted through the port e^2, or the fluid may be shut off from said pipes. When fluid is admitted to the pipe 31^a, as shown in Fig. 1 of the drawings, the controlling-pistons 22 will, as shown in Fig. 2, be forced against the shoulders 25 of the relief-valve stems, and this fluid-pressure, together with the pressure of the springs 16, will hold the relief-valves 13 open against full boiler-pressure applied to the inner side of said valves. If the locomotive in attempting to start a heavy train, for instance, becomes stalled with live steam applied to the right-hand end of one of the engine-cylinders, as shown in Fig. 1, and the reversing-valve E is held against its seat by live-steam pressure, and therefore difficult to move, the admission of steam or other fluid under pressure by the hand-valve D, through the pipe 31^a, will force open the relief-valves, as shown in Fig. 1, and the live steam may pass out through the drainage and relief device B′, thus relieving the pressure upon the reversing-valve E in the steam-chest, so that the latter may be readily moved into position to reverse the locomotive and provide sufficient slack in the train to enable the locomotive to start. When it is desired to keep the drainage-valves closed against their spring-pressures, fluid under pressure is admitted from the valve D, through the pipe 32^a, into the inner ends of the controlling-cylinder C, and the controlling-pistons 22 are thereby forced outwardly against the collars or shoulders 26, as shown in Fig. 3, and the relief-valves will thus be drawn to and firmly held against their seats. This is desirable, as previously stated, for the purpose of shutting off the exhaust while passing stations, and it may also be desirable to keep the drainage-valves closed when the locomotive is running and there is little or no drainage to be disposed of. When pressure is shut off from both of the pipes 31^a and 32^a, the piston assumes an intermediate position, and the drainage-valve stem slides freely through the bushing in the piston as the valve plays back and forth, while the piston remains stationary.

Very small drainage-openings d extend through the lower wall of the controlling-cylinder for the purpose of permitting the water of condensation to pass out without causing much loss of steam, although small automatic drain-valves E, such as are shown in Figs. 7 and 8 and hereinafter referred to, may be arranged in the lower wall of the cylinder for drainage and exhaust purposes.

Instead of employing a normally closed controlling-valve for admitting and exhausting the actuating fluid to and from the controlling-cylinder a valve D′, (shown in Fig. 1^a,) may be employed, in which the valve in its central position normally admits the actuating fluid through the passage-way f and both pipes 31^a and 32^a to opposite sides of the controlling-piston, and when the valve is moved in either direction from its central position the fluid from one of the pipes will exhaust through the ports f' or f^2, relieving the pressure on one side of the piston and allowing the latter to be actuated by the pressure which

is maintained at the opposite side of the piston. This is advantageous in cold weather when steam may be employed as an actuating medium, and thus prevent ice from forming in the cylinder.

In Fig. 1[b] I have shown a controlling-valve D[2], which is not provided with an exhaust-port and which is suitable for operating the controlling-piston, the exhaust taking place through the small drainage-openings *d* in the controlling-cylinder or through the automatic drain-valves E. In Fig. 1[b] the valve has a single passage-way *g*, which is normally closed in the central position of the valve, but when turned in either direction from the center may connect with one or the other of the pipes 31[a] or 32[a], and thus admit the actuating fluid to either side of the controlling-piston, as desired. When the valve is again closed, the condensation and leakage through the drainage-outlets *d* or the drain-valves E will reduce the pressure on the piston in a few moments, so as to render the piston again inoperative.

In case of breakage of the valve-stem 13[a], which may sometimes occur in the operation of the device, it is desirable to provide means for holding the valve 13 against its seat to prevent the escape of steam. In case of wear between the valve 13 and the stops or bridge-pieces 15, which would permit the valve to open farther than is suitable for the most efficient operation of the valve, it is desirable to provide adjustable means for limiting the opening movement of the valve. For these purposes, as shown in Figs. 2 and 3, I extend a regulating-screw 33 axially through the valve-stem 4[a], its inner end, as shown, extending into the interior of the casing between the valves 4 and 13. The screw 33, as shown in Fig. 3, has a threaded connection 34 with the outer end of the valve-stem 4[a], and the screw may be locked in any desired adjustment by means of a nut 35, threaded onto the screw and adapted to abut against the outer end of the valve-stem. In case of breakage of the valve-stem 13[a] the screw 33 may be turned, so that its inner end will bear against the valve 13 and hold the latter firmly against its seat, the tension on the spring 16 being at the same time released, if necessary, by turning the nut 19. Should the stops or bridge-pieces 15 and the parts of the valve 13 which strike the stops become worn or hammered, so as to permit the valve to open farther than is desirable, the adjusting-screw may be turned so that its inner end will form a stop for the valve in the correct position.

In Figs. 5 and 6 I have shown a modified form of device in which the controlling-piston also normally remains inactive. Instead of extending the drainage and compression regulating-valve stem into the controlling-cylinder, as in Figs. 2 and 3, a rod is extended through the excess-pressure valve and its stem into the controlling-cylinder, and a double piston is arranged in the latter in such manner that by admission of steam or other fluid pressure to the cylinder this rod may be forced against the drainage-valve to hold the latter in its closed position when desired, or the excess-pressure valve may be held in its open position to relieve the cylinder when desired.

Referring to Figs. 5 and 6, 36 indicates the drainage and compression-regulating valve, which is normally held off of its seat, as shown, by the spring 37, coiled around the valve-stem 36[a] and interposed between the valve and an adjustable cap or follower 38, which is threaded into one end of the casing B[2] and secured by a lock-nut 39. The valve-stem slides within an opening 38[a] in the follower 38. The valve 36 normally rests against stops 40, similar to the stops or bridge-pieces 15 in Figs. 2 and 3, and a drainage-opening 20[a], corresponding to the opening 20 in said figures, is arranged in the rear of the valve 36. The excess-pressure valve 41 is normally held against its seat, as shown, by a spring 42, coiled upon the valve-stem 41[a] and interposed between the back of the valve and a follower 43, which is adjustable by means of a nut 44. The follower 43 and nut 44 are substantially the same as the follower 17 and nut 19 in Figs. 2 and 3, and the lugs 43[a] upon the follower slide in slots 45, which are arranged diametrically opposite in the casing, as shown. The valve-stem 41[a] is tubular and projects through an opening 46 in the end 1[c] of the valve-casing and into the controlling-cylinder C'. A rod 47 extends through the tubular valve-stem, as shown, and is movable longitudinally therein. One end of this rod has a head 47[a] in front of the valve, and a piston 48 is suitably secured upon the opposite end of the rod within the controlling-cylinder. This piston, as shown in the drawings, is threaded onto the end of the rod and secured by a lock-nut 49, and a spring 50 is interposed between this piston and the adjacent end of the valve-stem 41[a], so that the head 47[a] is normally drawn against the valve 41. Another piston 51 is arranged within the cylinder and secured, as shown, upon the end of the tubular valve-stem. Ports 31[b] and 32[b], corresponding to the ports 31 and 32 of Figs. 2 and 3, are arranged in the side of the cylinder for the admission of fluid under pressure from a controlling-valve in the engine-cab.

In operation when steam is applied during ordinary movements of the engine the valve 36 opens and closes automatically and the valve 41 remains closed. If it is desired to hold the valve 36 against its seat for any purpose, fluid-pressure is admitted through the port 31[b], and the piston 48 is thereby moved to the right, compressing the spring 50 and forcing the rod 47 against the valve 36, which is thereby moved and held against its seat. When the pressure is released from the left-hand end of

the cylinder, the rod 47 is returned by the spring 50, and the valve 36 is forced open by its spring 37. When it is desired to maintain communication between the engine-cylinder and the atmosphere while the engine is in motion under steam-pressure for drainage or other purposes, fluid-pressure is admitted through the controlling-valve and port 32^b to the right-hand end of the controlling-cylinder, and the piston 51 is thereby moved to the left, carrying with it the excess-pressure valve 41, which is thereby held off of its seat until the fluid-pressure is cut off from the right-hand end of the controlling-cylinder. When this is done, the spring 42 returns the excess-pressure valve to its seat.

Small drainage-openings 52 or automatic valves E, Fig. 8, are arranged at the ends of the controlling-cylinder to permit the water of condensation to escape, and a small vent 53 is arranged in the wall of the cylinder between the pistons for the same purpose and also to prevent air compression between the pistons.

The drainage and relief device shown in Fig. 7 is the same in construction as that shown in Figs. 5 and 6, and the controlling-cylinder is substantially the same. The tubular valve-stem 41^b, however, is shorter and is not provided with a piston, as in said figures. A controlling-piston 54 is secured upon the rod 47, and a small spring 50 is interposed between said piston and the adjacent end of the valve-stem 41^b. The piston normally rests in central position in the cylinder, and the head 47^a of the rod 47 is normally drawn against the valve 41 by the spring 50.

When the actuating-fluid is admitted to the right of the piston in Fig. 7, the valve 41 will be pulled to the left off of its seat, and when admitted to the left of the piston the rod 47 will be forced against the drainage and compression-regulating valve 36, thus closing the latter.

In Fig. 7 I have shown automatic drain and exhaust valves E applied to the controlling-cylinder at its ends. These may be of any suitable form adapted to close when full pressure is admitted to the controlling-cylinder and to open when the pressure falls below a predetermined amount. Each drain and exhaust valve, as shown in detail in Fig. 8, comprises a tubular casing having a threaded nipple 55, adapted to fit into a drain-port of the cylinder, an annular shoulder 56, which abuts against the outer wall of the cylinder, a valve-seat 57 within the casing, lateral openings 58 below the valve-seat, and a threaded opening in its lower end, into which is fitted an adjusting-screw or follower 59. Within the casing is arranged a valve 60, adapted to fit against the seat 57, but normally held off of its seat by a spring 61, coiled around the valve-stem 62 and interposed between the valve and the follower. The valve-stem, as shown, extends through an axial opening in the follower, which forms a guide for the valve-stem. An adjustable stop 63, threaded upon the end of the valve-stem, limits the upward movement of the valve and regulates the tension of the spring.

The area of the valve 60 is purposely made small, and the tension of the spring is adjusted so that the valve will open whenever the fluid-pressure in the controlling-cylinder is materially reduced below the normal pressure employed for operating the controlling-piston. If the full fluid-pressure for operating the piston be admitted to one end of the controlling-cylinder through a valve, such as the valve D^2, (shown in Fig. 1^b,) the valve 60 at that end of the cylinder will immediately close and prevent the escape of steam. When the valve D^2 is closed, the pressure in the controlling-cylinder rapidly decreases by inevitable leakage and by condensation when steam is the fluid employed, and the pressure falls in a few moments to a point where the pressure of the spring 61 overbalances the fluid-pressure upon the valve 60 and the latter opens, thus relieving the pressure in the cylinder and also permitting the latter to drain freely through the openings 58. The exhaust from the controlling-cylinder is thus not carried back to the controlling-valve, but is permitted to escape directly from the cylinder to the atmosphere. These drain and exhaust valves may be employed on any of the cylinders shown in the drawings and with any form of controlling-valve to prevent the escape of steam and permit the cylinder to drain; but they are particularly desirable in connection with the simple form of controlling-valve illustrated in Fig. 1^b, having no exhaust-port, wherein they answer a threefold purpose.

I have shown in the drawings two different arrangements of the controlling-cylinder with respect to the valve-casing and valves; but I do not wish to confine myself to any particular arrangement of the controlling cylinder and piston with relation to the valve-casing and valves, as the controlling-cylinder may be supported and arranged in various ways upon the valve-casing or independently thereof, suitable mechanical connections being arranged between the controlling-piston and the valve which it is to operate. Where the controlling-cylinders are secured to the valve-casings the pipes leading from the controlling-valve will not, of course, in practice extend below the casings, as shown diagrammatically in the drawings for convenience of illustration.

It will be noted that in the various forms of devices illustrated in the drawings the free normal operation of the drainage and compression-regulating valve is not retarded or interfered with by the controlling-piston, which normally remains stationary, and that this valve may be held firmly to its seat by the

piston or one of the valves within the casing may be held open as long as desired by the operation of the piston.

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

1. In a drainage and relief device for engine-cylinders, a casing, a normally open valve therein adapted to close by fluid-pressure from the engine-cylinder, a controlling-piston arranged to hold said valve inoperative in its closed position, and means comprising a controlling-valve, for moving said piston by fluid-pressure.

2. In a drainage and relief device for engine-cylinders, a casing, a normally open valve therein adapted to close by fluid-pressure from the engine-cylinder, a controlling-piston arranged to hold said valve inoperative in its closed position, said piston and valve being movable relatively to one another, and means comprising a controlling-valve, for moving said piston by fluid-pressure.

3. In a drainage and relief device for engine-cylinders, a casing, a normally open valve therein adapted to close by fluid-pressure from the engine-cylinder, a controlling-piston arranged to hold said valve inoperative in its open position, said piston and valve being movable relatively to one another, and means comprising a controlling-valve, for moving said piston by fluid-pressure.

4. In a drainage and relief device for engine-cylinders, a casing, a normally open valve therein adapted to close by fluid-pressure from the engine-cylinder, a controlling-piston arranged to hold said valve inoperative in either its open or closed positions, and means comprising a controlling-valve, for moving said piston by fluid-pressure in two directions.

5. In a drainage and relief device for engine-cylinders, a casing, a normally open valve therein adapted to close by fluid-pressure from the engine-cylinder, a controlling-piston arranged to hold said valve inoperative in either its open or closed positions, said piston and valve being movable relatively to one another, and means comprising a controlling-valve, for moving said piston by fluid-pressure in two directions.

6. In a drainage and relief device for engine-cylinders, a casing, a normally open valve therein adapted to close by fluid-pressure from the engine-cylinder, a controlling-cylinder, a piston within said cylinder and connections between said valve and piston whereby said valve may be held inoperative by the piston, and means comprising a controlling-valve and suitable pipe connections, for admitting fluid-pressure to said controlling-cylinder.

7. In a drainage and relief device for engine-cylinders, a casing, a normally open valve therein adapted to close by fluid-pressure from the engine-cylinder, a controlling-cylinder, a piston within said controlling-cylinder, connections between said valve and piston, whereby, when fluid-pressure is admitted to said controlling-cylinder, the piston will hold the valve inoperative, said piston and valve being relatively movable, and means for admitting fluid-pressure to the controlling-cylinder.

8. In a drainage and relief device for engine-cylinders, a casing, a normally open valve therein adapted to close by fluid-pressure from the engine-cylinder, a controlling-cylinder connected to said casing, a stem upon said valve projecting through said casing and into said controlling-cylinder, a piston within the controlling-cylinder and adapted to move said valve-stem, and means for admitting fluid-pressure to the controlling-cylinder.

9. In a drainage and relief device for engine-cylinders, a casing, a normally open valve therein adapted to close by fluid-pressure from the engine-cylinder, a controlling-cylinder connected to said casing, a stem upon said valve projecting through said casing and into said controlling-cylinder, a piston within the controlling-cylinder and movable upon the valve-stem, a stop upon said stem for limiting the movement of the valve upon the stem, and means for admitting fluid-pressure to the controlling-cylinder.

10. In a drainage and relief device for engine-cylinders, a casing, a normally open valve therein adapted to close by fluid-pressure from the engine-cylinder, a controlling-cylinder connected to said casing, a stem upon said valve projecting through said casing and into said controlling-cylinder, a piston within the controlling-cylinder and movable upon the valve-stem, a pair of stops upon said stem for limiting the movement of the valve upon the stem, and means for admitting fluid-pressure to the controlling-cylinder.

11. In a drainage and relief device for cylinders, the combination with a casing, of a valve therein adapted to open and close a port in said casing, a follower having parts projecting through slots in said casing, a spring interposed between said follower and valve, and a nut threaded onto the exterior of the casing and engaging said follower.

12. In a drainage and relief device for cylinders, the combination with a casing, of a valve therein adapted to open and close a port in said casing, a follower having parts projecting through slots in said casing, a spring interposed between said follower and valve, and a nut threaded onto the exterior of the casing, said nut having notches adapted to be engaged by the projecting parts of said follower.

13. In a drainage and relief device, a casing, a normally open valve therein adapted to close by internal fluid-pressure, fixed stops for limiting the opening movement of the valve, and an adjustable stop also adapted to limit the movement of the valve, or to close the same.

14. In a drainage and relief device, a casing,

a normally open valve therein adapted to close by internal fluid-pressure, a normally closed valve adapted to open by excessive internal pressure, and an adjustable rod extending through said latter valve and adapted to limit the movement of the normally open valve or hold the latter closed.

15. In a drainage and relief device for engine-cylinders, a casing having a normally open valve therein adapted to close by the fluid-pressure from the engine-cylinder, a controlling-cylinder, a piston within said controlling-cylinder, a rod operatively connected to said piston and adapted to abut against and close said valve when the piston is moved in one direction, and means for admitting fluid-pressure into said controlling-cylinder.

16. In a drainage and relief device for cylinders, a casing having a normally open valve and a normally closed valve, in combination with a controlling-cylinder, a piston therein, means for admitting fluid-pressure to each end of said cylinder, and means connected with the piston for holding said normally open valve closed and for holding said normally closed valve open.

17. In a drainage and relief device for cylinders, a casing, a normally open valve and a normally closed valve therein, a tubular valve-stem connected to the latter valve, a rod extending through and movable within said stem, and a piston adapted to move said rod against and close the normally open valve.

18. In a drainage and relief device for cylinders, a casing, a normally open valve and a normally closed valve therein arranged opposite one another, a controlling-cylinder connected to the casing, a tubular valve-stem connected to said normally closed valve and extending into the controlling-cylinder, a piston in the controlling-cylinder secured to said stem, a rod movable through said stem and having one end within the controlling-cylinder and its opposite end arranged to engage the normally open valve, and a piston within the controlling-cylinder secured to said rod.

19. In a drainage and relief device for cylinders, a casing, a normally open valve and a normally closed valve therein arranged opposite one another, a controlling-cylinder connected to the casing, a tubular valve-stem connected to said normally closed valve and extending into the controlling-cylinder, a piston in the controlling-cylinder secured to said stem, a rod movable through said stem and having one end within the controlling-cylinder and its opposite end arranged to engage the normally open valve, a piston within the controlling-cylinder secured to said rod, and a spring interposed between said latter piston and the tubular stem.

20. In a drainage and relief device for engine-cylinders, a casing, a normally open valve therein adapted to close by fluid-pressure from the cylinder, a controlling-piston arranged to hold said valve inoperative in its open position, and means comprising a controlling-valve, for moving said piston by fluid-pressure.

21. In a drainage and relief device for engine-cylinders, a casing, a normally open valve therein adapted to close by fluid-pressure from the cylinder, a controlling-cylinder, a piston within said controlling-cylinder, and connections between said piston and valve, whereby, when the piston is moved in one direction, the valve will be closed, and means for admitting fluid-pressure to said controlling-cylinder to move the piston.

22. In a drainage and relief device for engine-cylinders, a casing, a spring-pressed valve normally closing a port in said casing, a controlling-cylinder and a piston within said cylinder, a rod connecting said valve and piston, and means for moving said piston by fluid-pressure to open the valve.

23. In a drainage and relief device for engine-cylinders, a casing, a normally open drainage-valve therein adapted to close by the normal internal fluid-pressure, a normally closed excess-pressure valve adapted to open by excessive internal fluid-pressure, and means for holding said latter valve open comprising a controlling-cylinder, a piston therein operatively connected to the excess-pressure valve, and means for admitting fluid under pressure into said controlling-cylinder.

24. In a drainage and relief device for engine-cylinders, a casing, a normally open drainage-valve and a normally closed excess-pressure valve therein, a controlling-cylinder secured to said casing, a rod extending through said excess-pressure valve and adapted, when moved in one direction, to abut against and close the normally open valve and when moved in the opposite direction to open the excess-pressure valve, a piston within the controlling-cylinder connected to said rod, a spring arranged to hold said rod out of engagement with the normally open valve.

In testimony whereof I affix my signature in presence of two witnesses.

MORRIS R. ZEHNDER.

Witnesses:

C. R. BEDFORD,

A. L. DENMAN.