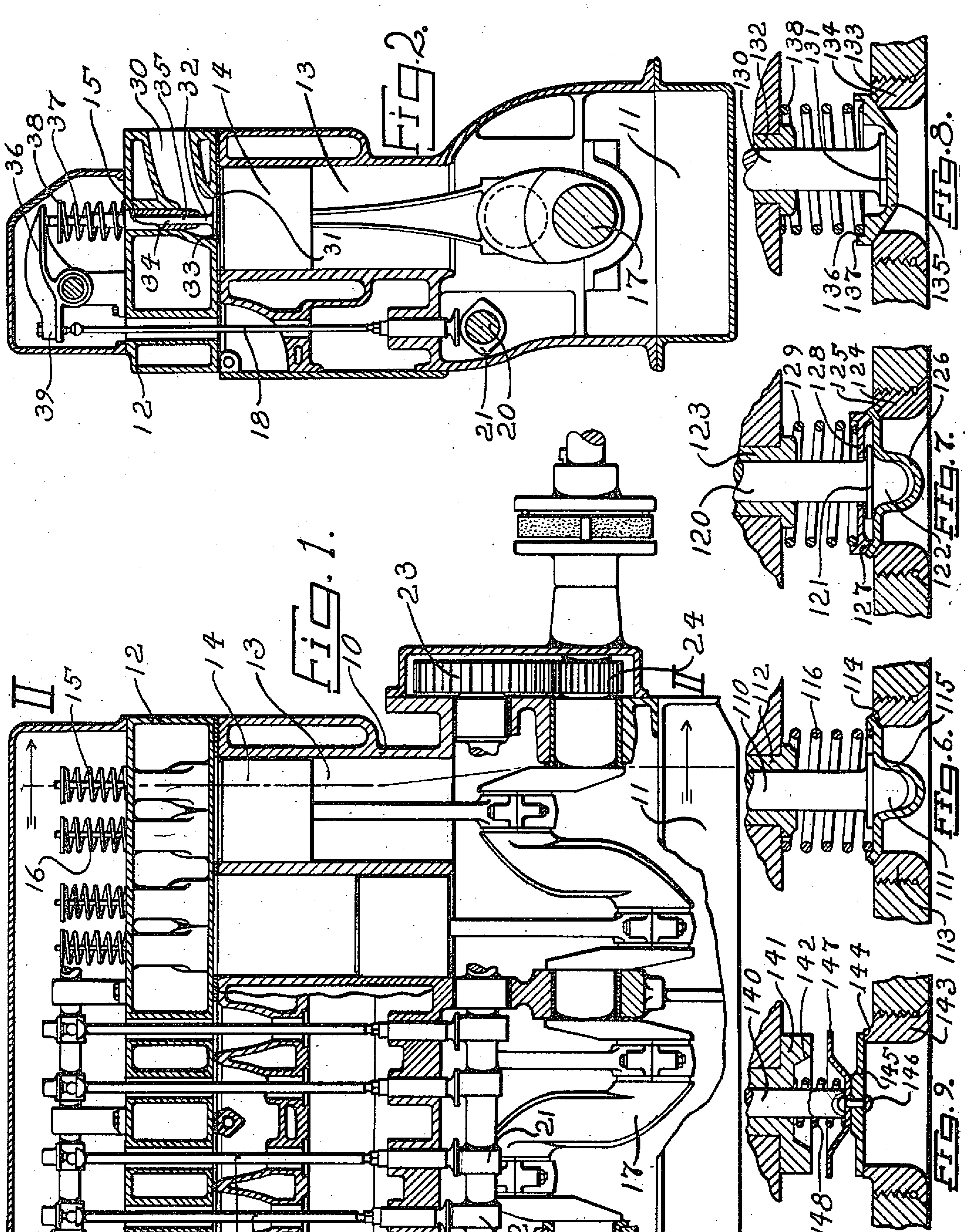
Aug. 20, 1935. A. C. STALEY 2,011,780

VALVE MECHANISM

Filed July 28, 1932 3 Sheets-Sheet 1



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VALVE MECHANISM

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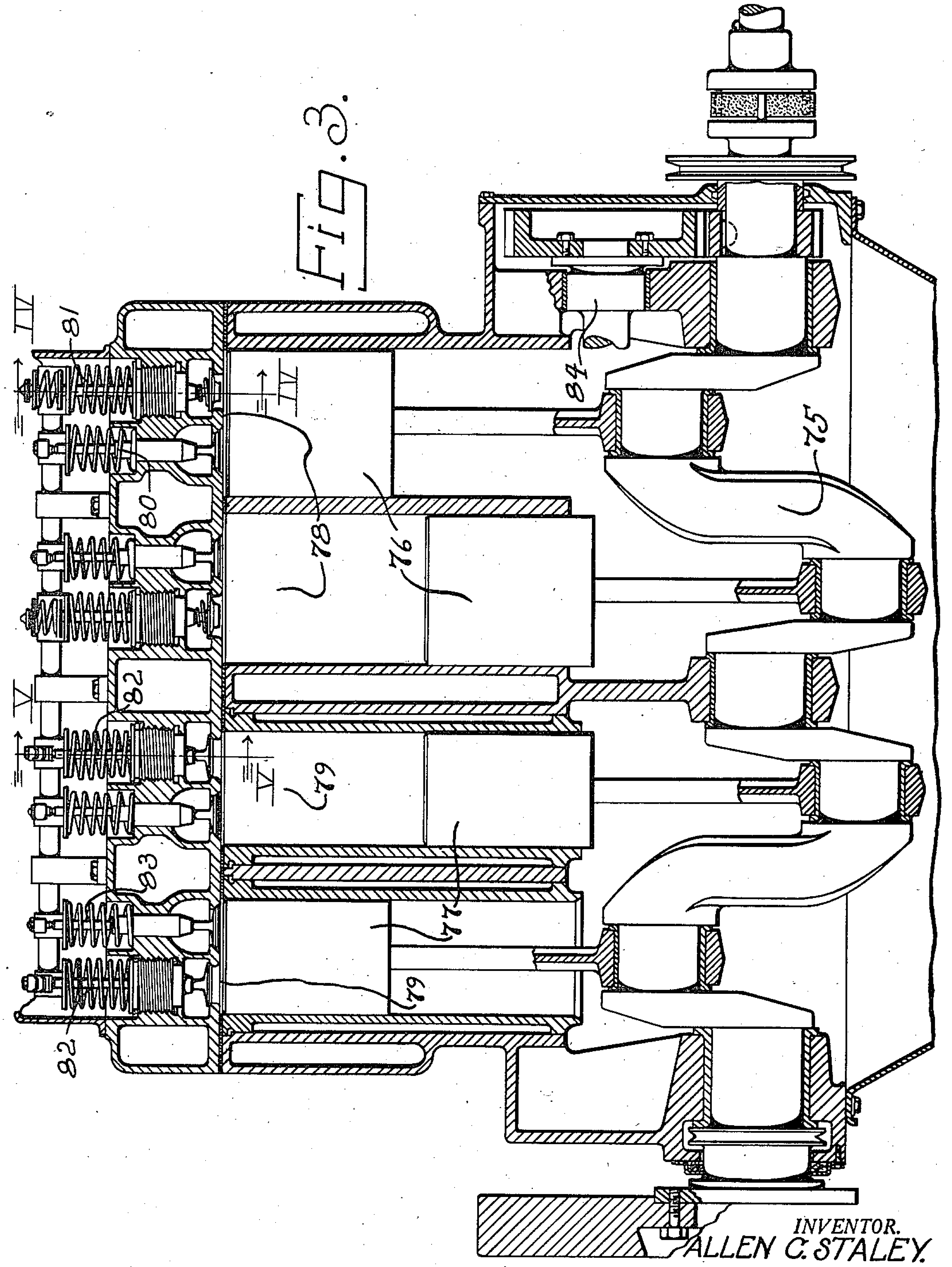

Fig. 3.

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VALVE MECHANISM

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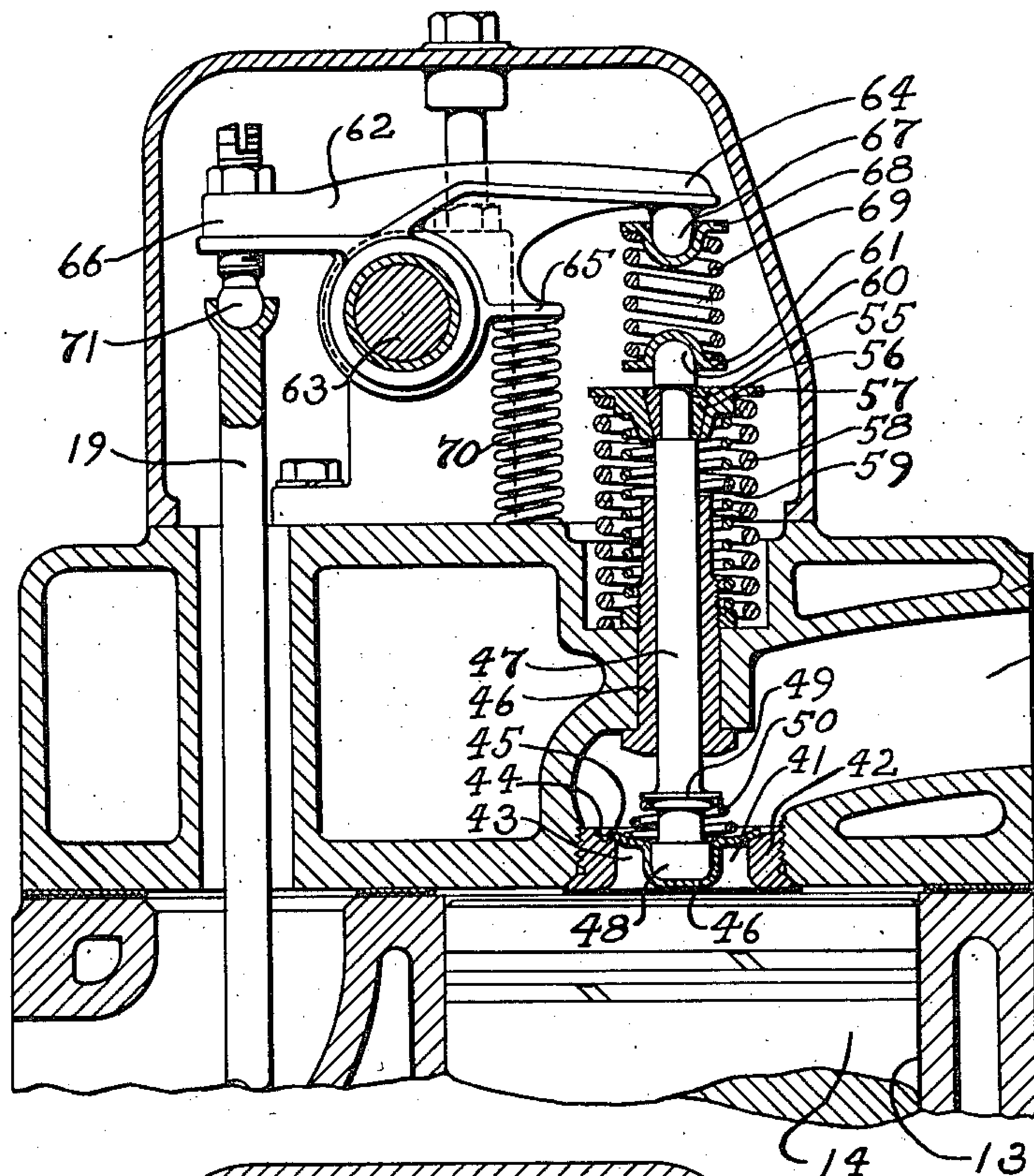

Fig. 4.

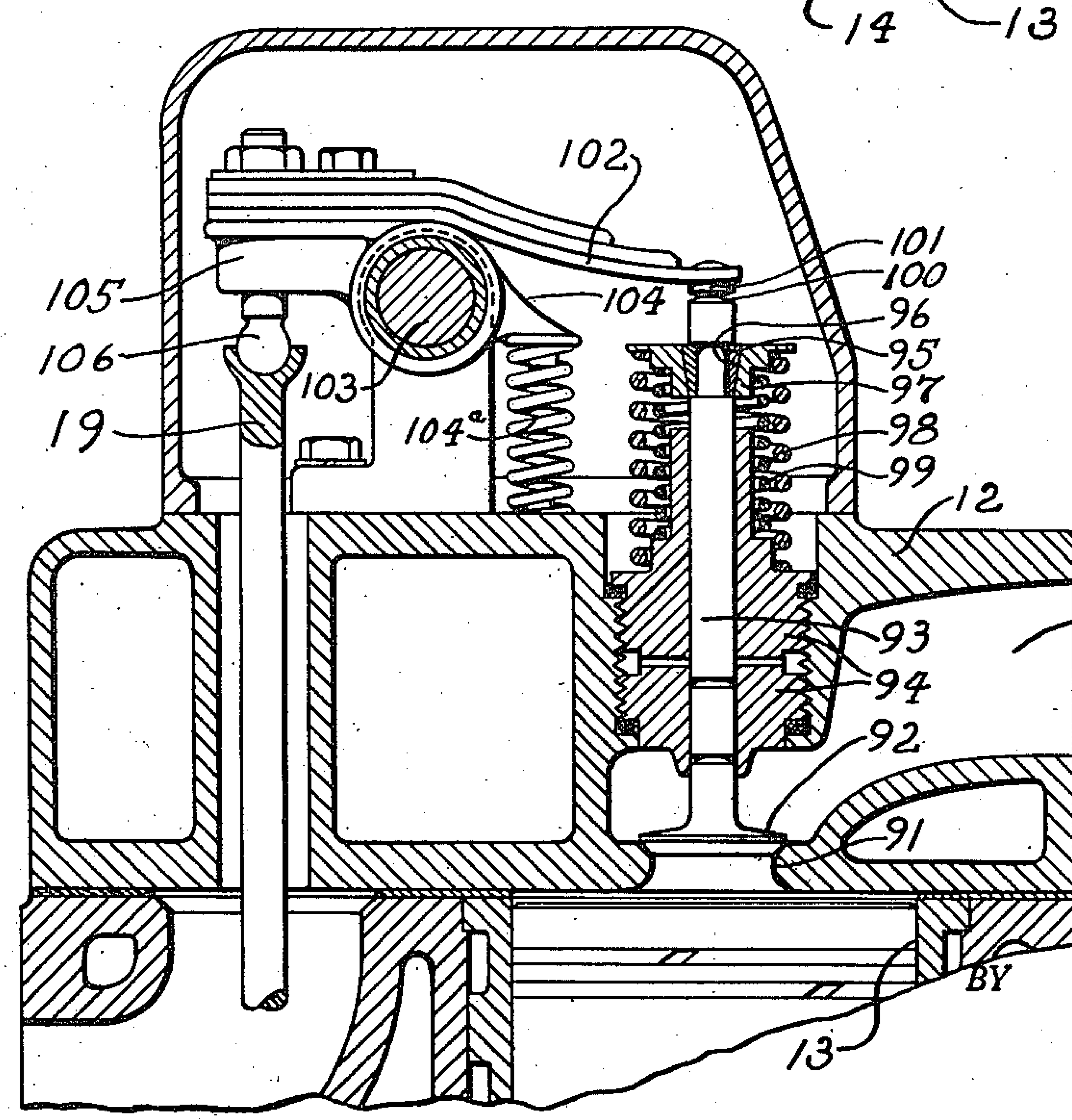

Fig. 5.

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UNITED STATES PATENT OFFICE

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VALVE MECHANISM

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Application July 28, 1932, Serial No. 625,449

16 Claims. (Cl. 230—222)

My invention relates to air or gas compressing and air or gas expanding mechanism of the reciprocating piston type and has particular relation to several novel types of valve mechanism, and several novel combinations of such types, for use in equipment of the character designated.

More particularly, my invention relates to novel types of inlet and exhaust valve mechanism, and to novel combinations thereof for use in air compressors and in air or gas expanding mechanism for use in refrigerating systems.

By my invention, I have provided a mechanically operated valve of the poppet type for use as an intake valve in an air motor in which a cam of normal contour is employed to operate the valve and in which the valve is mechanically closed at the proper time.

One of the objects of my invention consists in providing a novel type of valve adapted for use as an exhaust valve of a compressor of the reciprocating type which eliminates the objections of both the mechanically operated and the pressure operated valve and retains the advantages of both types.

A still further object of my invention consists in providing a novel type of valve mechanism in which the effect of the inertia of the valve closing member is eliminated as a factor in the timing of operation of pneumatically operated valves.

An additional object is to provide a novel combination for use in compressors and an additional novel combination of intake and exhaust valve mechanism for use in air motors or in expanding machines as used in refrigerator equipment.

For a more detailed understanding of my invention, reference may now be had to the accompanying drawings, of which:

Fig. 1 is a longitudinal cross-sectional view of an air compressor constructed in accordance with my invention.

Fig. 2 is a transverse cross-sectional view of the structure illustrated in Fig. 1, the section being taken along the line II—II thereof.

Fig. 3 is a longitudinal cross-sectional view of a combined compressor and expander, or air motor, constructed in accordance with my invention, and adapted for use in a refrigerating system.

Fig. 4 is a fragmentary transverse cross-sectional view of the structure illustrated in Fig. 3, the section being taken along the line IV—IV thereof.

Fig. 5 is a fragmentary transverse cross-sectional view of the structure illustrated in Fig. 3, the section being taken along the line V—V thereof.

Figs. 6, 7, 8, and 9 are cross-sectional views of modified forms of valve constructions which embody my invention.

In Fig. 1 I have illustrated a compressor of the reciprocating type consisting of a cylinder block 10, a crankcase 11, and a cylinder head 12. The cylinder block 10 is provided with four cylinders 13, all of which are identical, and each of which is provided with a piston 14. Each cylinder is provided with an intake valve mechanism 15 and an exhaust valve mechanism 16, both of the poppet valve type. The pistons 14 are operated by a crankshaft 17 and the valve mechanisms 15 and 16 are operated by valve operating rods 18 and 19 which in turn are operated by a camshaft 20 provided with four inlet valve operating cams 21 and a similar number of exhaust valve operating cams 22. The camshaft 20 is driven at half the speed of the crankshaft by means of a gear 23 secured thereon which meshes with a smaller gear 24 mounted on the crankshaft.

In Fig. 2 is shown a cross-sectional view of the compressor inlet valve shown in Fig. 1. In this construction the valve mechanism is of the usual type employed in internal combustion engines in which an intake manifold passageway 30 communicates with the interior of the cylinder 13 through a valve port 31 which is guarded by a port closing member 32. The port closing member comprises a valve head 33 which seats in the valve port 31 and an integral valve stem 34 which extends upwardly through a valve stem guide 35. The upper end of the valve stem 34 is disposed in engagement with a laterally extending projection of a pivotally mounted rocker arm 36. A compression spring 37 surrounds the upper end of the valve stem 34, one end being disposed in engagement with the upper surface of the cylinder head 12 and the other end in engagement with a disc or pin 38 mounted on the valve stem 34. The spring 37 thus tends to hold the valve head 33 in engagement with the seat of the valve port 31. The rocker arm 36 is provided with a second laterally extending projection 39 which is engaged by the valve operating rod 18 in such manner that the cam 21 on the camshaft 20 raises the rod and thereby opens the valve twice during each revolution of the camshaft.

In Fig. 4 is illustrated in detail an exhaust valve of the type employed in the structure illustrated in Fig. 1. In this construction the cylinder 13 communicates with a passageway 40 connected to the exhaust manifold through a passageway 41 in which is disposed in threaded engagement a sleeve 42. The sleeve 42 is provided with a centrally disposed valve opening or port 43 and with a valve seat 44. The valve seat 44 is adapted to be engaged by a port closing member 45 which is provided with a centrally disposed recess 46, the walls of which are substantially straight. Disposed vertically above and concentrically with the valve port 43 is a hollow valve stem guide 46a rigidly secured in the cylinder head 12. A valve stem 47 is slidably mountd within the guide 46a and is provided at its lower end with an enlarged portion 48 provided with straight sides and similar in shape to the recess 46 in the port closing member 45.

The valve stem 47 is also provided with a collar 49 and a coiled spring 50 which surrounds the lower end of the valve stem and engages at one end the collar 49 and on the other end the port closing member 45. The spring 50 serves to resiliently urge the port closing member 45 away from the collar 49 and the enlarged portion 48 serves to guide the movement of the port closing member 45 as it slides thereon when the valve stem 47 is in other than its lowermost position and serves to rigidly hold the port closing member 45 on the seat 44 when the valve stem 47 is in its lowermost position.

Adjacent its upper end the valve stem 47 is provided with an annular groove 55 within which is disposed a two-part locking washer 56. The exterior of the two-part member 56 is conical and provides a seat for a spring retaining collar member 57. Disposed intermediate the collar member 57 and a portion of the cylinder head 12 is a relatively large coiled compression spring 58 and a smaller interiorly disposed coiled compression spring 59. The springs 58 and 59 are so designed that when no pressure is exerted on the top of the valve stem 47 the valve stem is raised thereby, thus serving to eliminate the inertia of the valve stem as a factor in the time of opening the valve.

The valve stem 47 is provided at its upper end with a hemispherical surface 60 on which is mounted a cap 61 having a hemispherical depression therein adapted to fit over and engage the surface 60. A rocker arm 62 is pivotally mounted on a pin 63 which in turn is mounted on the cylinder head 12. The rocker arm is provided with three outwardly projecting arms 64, 65, and 66. The arm 64 is provided with a downwardly projecting portion 67 provided with a hemispherical end portion over which is fitted a cap 68 provided with a hemispherical depression therein. A coiled compression spring 69 is mounted intermediate the caps 60 and 68 and is of such rigidity that when the arm 64 of the rocker arm 62 moves downwardly the valve stem 47 is resiliently forced downwardly to close the valve. The arm 65 of the rocker member 62 serves as means for mounting a coiled compression spring 70 between the rocker member 62 and the top of the cylinder head 12, which tends to hold the arm 64 of the rocker arm 62 in its uppermost position.

The rocker arm is actuated by means of a cam (not shown in Fig. 4) which operates the tappet rod 19 which engages a ball joint 71 adjustably mounted on the arm 66 of the rocker member 62. It will be apparent from this description that raising of the tappet rod 19 exerts a pressure on the valve stem 60 through the spring 69, serving to move the port closing member 45 into positive engagement with the valve seat 44, thus closing the valve. When the cam has passed from engagement with the tappet rod 19 the spring 70 immediately raises the arm 64, thus removing the force by which the valve stem 47 was moved downwardly. When this occurs, the springs 58 and 59 immediately raise the valve stem 47 until the member 48 is raised partially out of the recess 46 in the port closing member 45. The spring 50, having been unloaded by raising the valve stem 47, now exerts no force on the port closing member 45 except that due to its weight. The pressure in the chamber 40 holds the member 45 on its seat until such time as the pressure within the cylinder 13 becomes greater than the pressure within the passageway 40 and the force of the spring. When this occurs the relatively light closing member 45 rises from the seat 44 guided by the member 48, again compressing the light spring 50. The spring 50 thus serves as a shock absorber for the member 45 during opening of the valve.

It is thus apparent that this valve will open as soon as the pressure in the cylinder exceeds the pressure in the passageway 40, and without any delay incident to overcoming the inertia of the relatively heavy valve stem or to overcoming the force of a relatively stiff valve closing spring. Also, by reason of very small mass of the member 45 and the light force of the spring 50, the valve will immediately open to its wide open position, and, at the end of its movement, will be cushioned by the spring 50. In addition, the valve is mechanically closed at the correct point with respect to the position of the piston, which eliminates any delay in closing the valve incident to overcoming the inertia of the relatively heavy valve stem. Thus, this valve enjoys all of the advantages of both the pressure operated and the mechanically operated valves but suffers from none of the objections thereto.

In Fig. 3 is illustrated a combination gas or air compressing and expanding machine adapted particularly for use in a refrigerating system. In this construction, a crankshaft 75 operates two compressor pistons 76 and has connected thereto two expanding machine or air motor pistons 77. The two pistons 76 move within compressor cylinders 78 which are of larger diameter than the expander or air motor cylinder 79 within which the pistons 77 operate. The compressor cylinders 78 are each provided with an intake valve mechanism 80 similar to that illustrated in Fig. 2, and an exhaust valve mechanism 81, similar to that illustrated in Fig. 4. The expander or air motor cylinders are each provided with an intake valve mechanism 82, similar to that illustrated in Fig. 5, and an exhaust valve mechanism 83, similar to that illustrated in Fig. 2.

In refrigerating systems of this type it is customary to employ a compressor or compressor cylinder which serves to compress air or other gas, preferably the former, which compressed gas is then carried to an air cooling means, such as a water or air cooled radiator or the like. The compressed gas, now cooled, is in turn admitted to the expander or air motor which reduces the pressure thereof, and the cold air at the reduced pressure is then conducted to the chamber to be cooled, such as a refrigerating chamber, room, or the like. The valve mechanisms 80 to 83, are operated by means of a camshaft 84 driven from the crankshaft 75, as described in connection with Fig. 1.

In Fig. 5 is illustrated a valve mechanism which may be employed either as the intake valve mechanism of an air motor or expander, or as the exhaust valve mechanism of a compressor. In this figure I have illustrated the usual cylinder 13 provided with the cylinder head 12 in which is disposed a passageway 90 communicating with the cylinder 13 through a valve port 91 which is guarded by a valve head 92, the latter being provided with an integral valve stem 93. The valve stem 93 moves within any suitable arrangement of valve guides 94. The upper end of the valve stem 93 is provided with a groove 95 in which is fitted a two-part locking collar 96 provided with a conical exterior surface and serves as a seat for a spring collar member 97, similar to that described in connection with Fig. 4. The valve stem is surrounded by two coiled compression springs 98 and 99, which together serve to raise the valve head 92 from its seat when no pressure is exerted thereon by the rocker arm.

The valve stem 93 is provided at its top with a curved portion 100 which is engaged by a contacting member 101 mounted upon an end portion of a rocker arm 102. The rocker arm 102 is pivotally mounted upon a pin 103 mounted on the cylinder head 12. The rocker arm 102 is composed of a plurality of leaf springs which serve to provide a resilient engagement between the rocker arm and the valve stem. The rocker arm 102 is provided with an arm 105 on which is mounted an adjustable member 106 which in turn is engaged by the tappet rod 19 and with an oppositely disposed arm 104, which is engaged by a compression spring 104a which serves to raise the arm 102 when the member 19 is in its lowermost position.

In this particular construction there is normally a considerable pressure in the chamber 90 which exerts a pressure on the upper side of the valve head 92 and serves to hold the valve closed. As the piston approaches the upper end of its stroke, there being but comparatively little clearance between the cylinder head and the piston, the pressure created thereby is sufficient, together with the aid of the springs 98 and 99, to raise the valve head 92 from its seat against the pressure in the chamber 90. When this occurs, the pressure is immediately equalized on both sides of the valve head and the springs 98 and 99 open the valve wide instantly. The upwardly moving valve stem 93 engages the resilient arm 102 and is cushioned thereby, so as to prevent any sharp blows to any part of the valve mechanism, thus eliminating any slowness of movement resulting from the inertia of the valve head and valve stem. It will be apparent that, by reason of the force of the springs 98 and 99 being additive to the pressure within the cylinder, the valve will start to open before the pressure in the cylinder equals that in the chamber 90. This small interval of time is sufficient for overcoming the inertia of the valve closing member and its stem so that the valve actually opens at the time when the pressure in the cylinder is equal to that in the passageway 90. When the cam engages the tappet rod 19 it moves the rocker arm 102 downwardly, thus promptly and positively closing the valve through a resilient connection. The rocker arm may be raised immediately thereafter but the valve remains closed because of the pressure in the passageway 90 on the upper side of the valve head being greater than the pressure exerted thereon by the springs 98 and 99, and the valve will remain closed until the piston again reaches the upper portion of its stroke and pneumatically raises the valve, as previously described.

From this description it will be apparent that the air motor intake valve is positively mechanically closed at the desired predetermined point and is pneumatically opened during its normal operation. It will also be apparent that the compressor exhaust mechanism is likewise mechanically positively closed and is pneumatically opened by the differential in pressure on the two sides thereof. In each instance the valve opens without any retardation caused by the inertia of the valve member and instantly opens widely. Also, in each instance, the valve closing member moving upwardly engages at the uppermost portion of its movement a resilient cushioning member which serves to eliminate shocks to the mechanism.

In Fig. 6 I have illustrated another form of exhaust valve mechanism in which a valve stem 110 is provided at its lower end with a hemispherical surface 111. The valve stem is adapted to move within a valve guide 112 and is disposed in alignment with an annular member 113, which is provided with a valve seat 114. The valve closing member consists of an annular disc 115 provided with a centrally depressed portion having a contour similar to that of the portion 111 of the valve stem 110. A coiled compression spring 116 extends between a stationary portion of the cylinder head and the valve closing member 115. The upper end of the valve stem is provided with a plurality of springs, similar to those shown in Fig. 4, which tend to raise the valve stem as soon as the pressure from the cooperating rocker arm is released therefrom. When the valve stem 110 has been raised the spring 116 serves to retain the valve closing member 115 on the seat 114, thus keeping the valve closed until such time as the pressure within the cylinder is sufficiently great to raise the valve closing member 115 from its seat. It thereupon moves upwardly, guided by the member 111, and is cushioned by the spring 116. The valve closing member is subsequently returned to engagement with the valve seat by means of the usual rocker arm engaging the upper end of the valve stem 110. This structure differs from that illustrated in Fig. 4 primarily in that the spring 116 extends between the valve closing member and a stationary part or seat rather than between the valve closing member and valve stem.

In Fig. 7 I have illustrated a valve stem 120 provided at its lower end with a disc 121 on the lower side of which is mounted a hemispherical member 122. The valve stem 120 slides within a valve stem guide 123 disposed in alignment with an annular member 124 provided with a valve seat 125. The valve port is closed by means of a circular member 126 which is provided with a hemispherical depression in its central portion, which conforms in contour with the member 122, and with an outwardly projecting flange 127 which engages the seat 125 of the valve. On the upper side of the disc 121 is loosely mounted an annular collar 128. A coiled compression spring 129 is mounted intermediate a stationary seat and the collar 128. When the pressure of the rocker arm on the upper end of the valve stem 120 is released the springs mounted on the upper end of the valve stem immediately raise the valve stem to its uppermost position, carrying with it the collar 128 and compressing the spring 129. The valve closing member 126 remains in engagement with the seat 125 until the pressure within the cylinder becomes greater than the pressure within the communicating passageway, whereupon it immediately rises, guided in its path of movement by the member 122 on the end of the valve stem. As the valve closing member 126 reaches the upper end of its movement it engages the collar 128 so that the spring 129 serves to cushion the engagement of the valve closing member 126 with the valve stem 120. In practice, I have found that by properly proportioning the mass of the members 126 and 128, any desired portion of the inertia of the member 126 may be dissipated in striking the member 128, after which the remainder of the inertia is dissipated, first by compressing the spring 129 and finally by engaging the member 121. As the area of engagement of the members 126 and 128 is relatively large, the unit stresses may be controlled at will by varying the mass of the members 126 and 128 and the strength of the spring 129 so as to absorb any desired portion of the inertia of the member 126 in any one of the three stages of stopping the movement of the member 126. At present it appears desirable that the mass of the member 128 should be approximately sixty percent of the mass of the member 126 for good performance.

In the structure shown in Fig. 8, I have illustrated a valve stem 130 provided at its lower end with a flat disc 131. The valve stem moves within a guide 132 which is disposed in alignment with an annular member 133 provided with a valve seat 134. The valve port is closed by means of a valve closing member 135 provided with a substantially flat upper surface which conforms with the lower surface of the disc 131. The valve closing member 135 is likewise provided with an annular flat shoulder 136 and an outer annular upper projecting flange 137. A coiled compression spring 138 is mounted intermediate the valve stem guide 132 and the flat surface 136 of the valve closing member 135. When the pressure on the valve stem exerted by the rocker arm is removed the springs mounted on the upper end immediately raise the valve stem 131. The valve closing member 135 remains on its seat, however, until the pressure within the cylinder is greater than that in the exhaust passageway, whereupon it moves upwardly against the action of the relatively light spring 138. The spring 138, by reason of the flange 137, serves to guide the upward movement of the member 135. The walls of the shoulder 136 aid in guiding the valve closing member with respect to the valve stem. The spring 138 also serves to cushion the valve closing member at the upper end of its movement.

In the structure illustrated in Fig. 9, I have shown a valve stem 140 which moves within a valve stem guide 141 which in turn is provided with a central recess 142. The valve stem guide 141 is disposed in alignment with an annular member 143 provided with a valve seat 144. The valve is closed by means of a valve closing member 145 which engages the seat 144. Secured to the valve closing member 145 by means of a rivet 146 is a circular disc 147 composed of resilient material, such as spring steel. Disposed intermediate the valve guide 141 and the disc 147 is a relatively light coiled compression spring 148. When the pressure on the upper end of the valve stem 140 exerted by the rocker arm is released the springs secured to the upper end of the valve stem 140 immediately raise it out of contact with the resilient member 147. The valve closing member 145 remains in engagement with the seat 144 until the pressure within the cylinder becomes sufficiently great to raise it from the seat, whereupon it moves upwardly guided either by the spring 148 or by engagement by the head of the rivet 146 with the walls of a recess in the end of the valve stem 140 until the resilient member 147 engages the lower surface of the valve stem guide 141, thus providing a cushion to stop the valve closing member 145 at the upper end of its movement.

Although I have illustrated several forms of my invention and have described in detail several applications thereof, it will be apparent to those skilled in the art that my invention is not so limited but that various changes and modifications may be made therein without departing from the spirit thereof or from the scope of the appended claims.

What I claim is:

1. In combination, a cylinder, a movable piston, an intake and an exhaust valve, each constructed to be moved between an open and a closed position, one of said valves being constructed to be moved from one position to the other by positively actuated mechanical means and to be returned to the first position by gas pressure.

2. In combination, a cylinder, a movable piston, an intake and an exhaust valve, each constructed to be moved between an open and a closed position, one of said valves being constructed to be moved from one position to the other by a pressure differential on opposite sides thereof and to be returned to the first position by engagement with positively actuated mechanical means associated with said movable piston.

3. In combination, a cylinder, a movable piston, an intake and an exhaust valve, each constructed to be moved between an open and a closed position, one of said valves being constructed to be closed by positively actuated mechanical means, to be temporarily held closed pneumatically, and to be opened pneumatically.

4. In a compressor, a cylinder, a movable piston, an intake valve and an exhaust valve of the poppet type, each constructed to be opened and closed, said exhaust valve being constructed to be opened by a pressure differential on opposite sides thereof and to be closed by positively actuated mechanical means.

5. In a compressor, a cylinder, a movable piston, an intake and an exhaust valve, said exhaust valve being of the poppet type, each of said valves being constructed to be opened and closed, positively actuated mechanical means constructed to close the exhaust valve and to retain it in its closed position during a predetermined portion of the piston movement, said valve being adapted to be opened by a pressure differential on opposite sides thereof during other portions of the piston movement.

6. In a compressor, a cylinder, a movable piston, an intake and an exhaust valve of the poppet type, each constructed to be opened and closed, positively actuated mechanical means constructed to open and close the intake valve and to close the exhaust valve at predetermined points in the travel of the piston and to hold said exhaust valve closed during a predetermined portion of the piston travel, said exhaust valve being adapted to be opened by a pressure differential on opposite sides thereof during other portions of the piston travel.

7. In combination, a cylinder, a movable piston, a fluid passageway disposed exteriorly of said cylinder, a valve port interconnecting said cylinder and said passageway, a valve member of the pop-

pet type adapted to close said port, resilient means associated with said valve member and adapted ot exert a pressure thereon, said resilient means being so disposed that the fluid pressure within the cylinder and the pressure of the resilient member each tend to move said valve member to its open position and the fluid pressure in the passageway tends to hold said valve member in its closed position.

8. In combination, a cylinder, a movable piston, a fluid passageway disposed exteriorly of said cylinder, a valve port interconnecting said cylinder and said passageway, a valve member of the poppet type adapted to close said port, means associated with said valve member adapted to resiliently hold said valve member in its open position, and positively actuated means adapted to move said valve member to its closed position.

9. In combination, a cylinder, a movable piston, a fluid passageway disposed exteriorly of said cylinder, a valve port interconnecting said cylinder and said passageway, a valve member of the poppet type adapted to close said port, means associated with said valve member adapted to resiliently hold said valve member in its open position, and mechanically actuated means adapted to intermittently resiliently urge said valve member towards its closed position.

10. In combination, a cylinder, a movable piston, a fluid passageway disposed exteriorly of said cylinder, a valve port interconnecting said cylinder and said passageway, a valve member of the poppet type adapted to close said port and provided with a stem, a spring surrounding said stem and exerting a pressure thereon tending to move said valve member away from said port, a rocker arm adapted to engage said valve stem, and means adapted to actuate said rocker arm once during each complete cycle of movement of the piston to move said valve member to its closed position against the action of the spring.

11. In combination, a cylinder, a movable piston, a fluid passageway disposed exteriorly of said cylinder, a valve port interconnecting said cylinder and said passageway, a valve member of the poppet type adapted to close said port and provided with a stem, a spring surrounding said stem and exerting a pressure thereon tending to move said valve member away from said port, a rocker arm having a portion disposed in alignment with said valve stem, a spring disposed between said portion and said valve stem, and means for mechanically actuating said rocker arm to resiliently move said valve toward the valve port against the action of the first mentioned spring.

12. In combination, a cylinder, a movable piston, a fluid passageway disposed exteriorly of said cylinder, a valve port interconnecting said cylinder and said passageway, a valve member of the poppet type adapted to close said port and provided with a stem, a spring surrounding said stem and exerting a pressure thereon tending to move said valve member away from said port, a rocker arm having a portion adapted to engage said stem to move said valve to its closed position, and means adapted to actuate said rocker arm to move said valve member to its closed position and to retain said valve member in its closed position during a predetermined portion of a cycle of movement of the piston, said valve member being under the combined control of said spring, the fluid pressure within the cylinder and the fluid pressure within the passageway during the remaining portion of the movement of the piston.

13. In combination, a cylinder, a movable piston and a valve port, means for closing said valve port comprising a valve port closing member, a valve stem disposed in alignment therewith and movable relative thereto, a resilient member interconnecting said member and a stationary seat, and means adapted to guide any movement of said member in alignment with said valve port.

14. In combination, a cylinder, a movable piston and a valve port, means for closing said valve port comprising a metallic disc having a depressed central portion, a valve stem having an end portion projecting into said depressed portion of said disc and movable with respect thereto, and a coiled compression spring surrounding said end portion and resiliently urging said valve stem and said disc apart.

15. In combination, a cylinder, a movable piston and a valve port, means for closing said valve port comprising a valve port closing member, a valve stem disposed in alignment therewith and movable relative thereto, resilient means tending to move said valve stem away from said valve port closing member, a resilient member adapted to cushion the opening movement of the valve port closing member, and means for positively mechanically seating said valve port closing member in said valve port during a predetermined portion of the movement of said piston.

16. In combination, a cylinder, a movable piston and a valve port, means for closing said valve port comprising a valve port closing member, a valve stem disposed in alignment therewith and movable relative thereto, a coiled spring interposed between said valve port closing member and an adjacent portion of said valve stem, a coiled spring interposed between the opposite end of said valve stem and a stationary spring seat, and a mechanically actuated rocker arm adapted to move said stem positively towards said valve port closing member.

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