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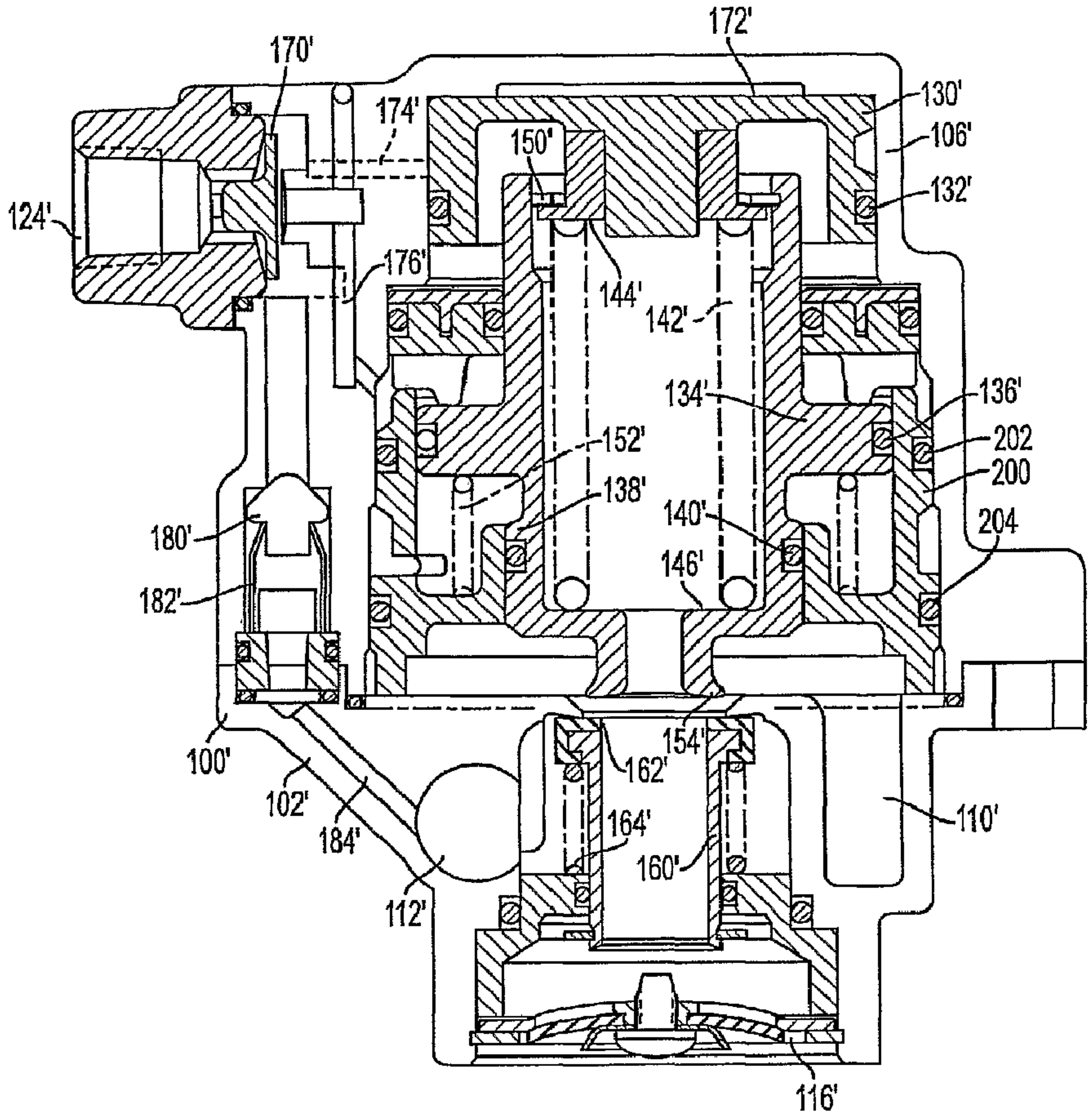
(54) Title: SPRING BRAKE MODULATING RELAY VALVE



(57) **Abrégé/Abstract:**
A combined spring brake modulating relay valve integrates the functions of a relay valve and a modulating valve. The housing includes a valve assembly movable in response to air pressure provided to selected ports in the housing. A relay piston selectively

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(57) Abrégé(suite)/Abstract(continued):
communicates with a control port and a primary brake circuit port. A modulating piston includes surfaces selectively pressurized by the primary brake circuit port and a secondary brake circuit port. This modulates the pressure from the delivery port to thereby selectively apply the associated spring brakes if a failure is detected at the primary brake circuit port. The exhaust member selectively controls communication between the supply and delivery ports as necessary.

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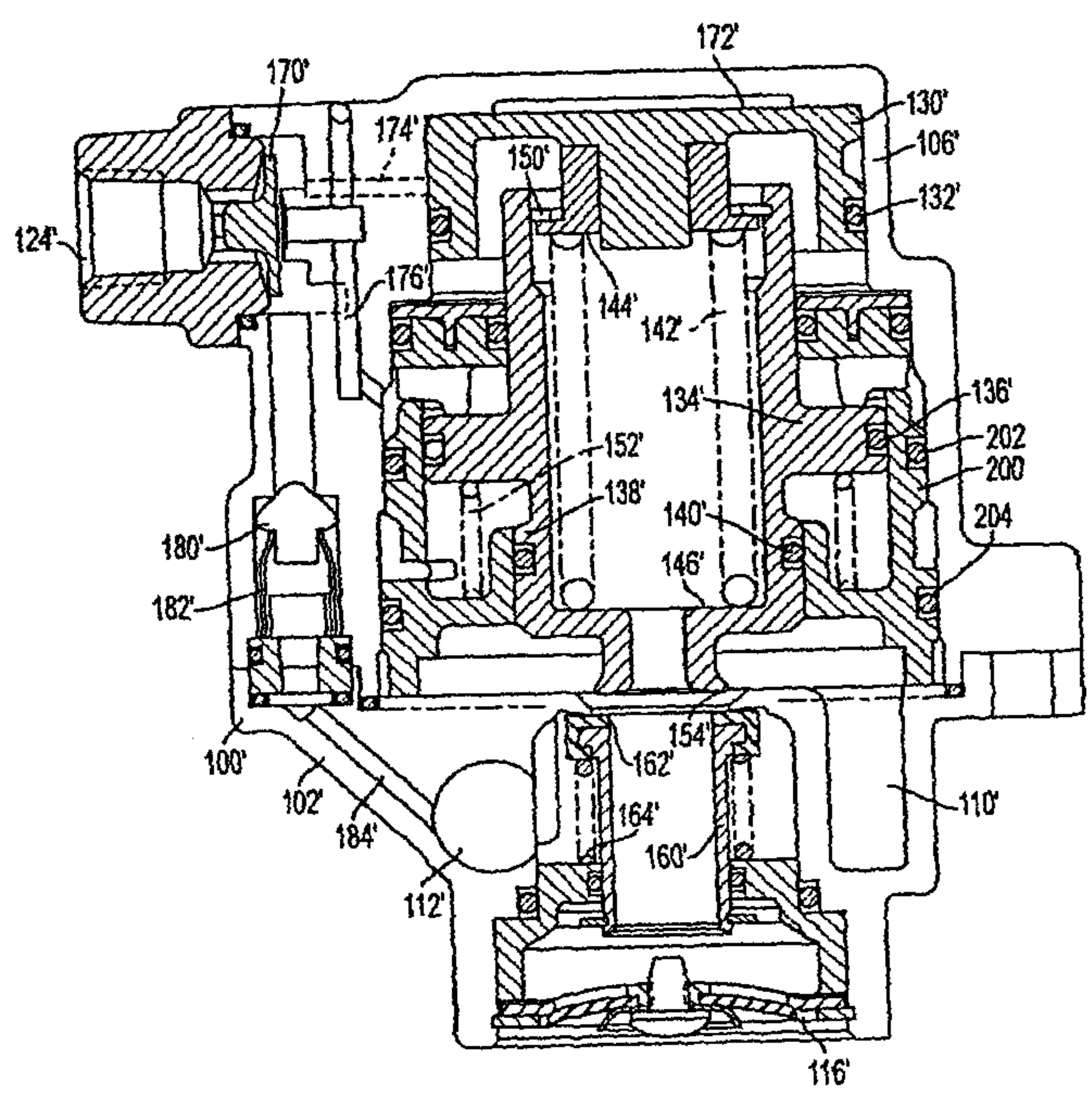

(57) Abstract: A combined spring brake modulating relay valve integrates the functions of a relay valve and a modulating valve. The housing includes a valve assembly movable in response to air pressure provided to selected ports in the housing. A relay piston selectively communicates with a control port and a primary brake circuit port. A modulating piston includes surfaces selectively pressurized by the primary brake circuit port and a secondary brake circuit port. This modulates the pressure from the delivery port to thereby selectively apply the associated spring brakes if a failure is detected at the primary brake circuit port. The exhaust member selectively controls communication between the supply and delivery ports as necessary.

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SPRING BRAKE MODULATING RELAY VALVE

Background of the Invention

Field of the Invention

This application relates to a combined or integrated spring brake modulating valve and relay valve that are contained in a single housing for an air brake system.

Discussion of the Art

It is common in presently available brake circuits to employ a separate modulation valve with a relay valve or with a separate quick-release valve. For example, FIGURE 1 illustrates a six-by-four straight truck, i.e., a non-towing vehicle, that employs spring brakes for parking the vehicle and in which pressurized air is delivered to the spring brakes to release them during normal operation. As shown in FIGURE 1, each wheel includes a brake chamber connected with a relay valve to provide air pressure to the drive axle and selectively control service application of the brakes. In addition, each wheel includes a spring brake chamber selectively supplied with air to release a large mechanical spring typically used for the park function. Air pressure to these spring brake chambers releases the mechanical spring and allows the vehicle to roll.

As is generally known in the art, if a primary circuit fails, it is desirable to take advantage of the spring brakes, yet modulate the operation of the spring brakes through a foot control valve. This is provided by the spring brake modulation valve so that the spring brakes are selectively applied through operation of the foot control valve. The secondary circuit controls the steer axle (not shown). This arrangement provides a desired braking action and modulation of the spring brakes when required.

FIGURE 2 illustrates a four-by-two or six-by-two straight truck configuration. Again, a spring brake modulation valve is used in conjunction with a separate spring brake quick release valve. It is evident from a comparison of FIGURES 1 and 2 that different system configurations and plumbing arrangements are thus encountered by truck manufacturers even though the brake needs are not entirely dissimilar. Thus a need exists for simplified plumbing for the truck manufacturers that provides standardized installation across all of its vehicles. In addition, enhanced performance characteristics are always desirable.

Summary of the Invention

The present invention provides an integrated spring brake modulating relay valve that simplifies known, multi-component systems.

More particularly, the valve includes a housing having a control port, supply port, delivery port, exhaust port, and primary and secondary circuit brake ports that communicate with a chamber in the housing. A first piston received in the housing moves in response to pressure from the control port. A second piston monitors the primary and secondary circuits and modulates spring brake pressure if the primary circuit fails. An exhaust valve is interposed between the supply and delivery ports and controls communication with the exhaust port to selectively supply and release the spring brakes.

The first or relay piston is connected to the second or modulating piston through a biasing spring. Thus, the pistons can operate in unison but are also adapted to move relative to one another for their particular functions.

A primary benefit of the invention is the ability to integrate separate components into a multi-component arrangement in a single housing.

Another benefit of the invention resides in the improved response time, while maintaining all of the features and benefits of known systems.

Yet another benefit results from the simplified plumbing and standardized installation for truck manufacturers.

In accordance with a preferred aspect of the present invention there is provided a combined spring brake modulating relay valve comprising a housing having a control port, supply port, delivery port, exhaust port, and a chamber formed therein in selective communication with the supply port adapted to receive pressurized air from an associated reservoir, the delivery port adapted to communicate with associated spring brake chambers, and the exhaust port adapted to communicate with ambient; a valve member in the chamber normally biased to preclude communication between the supply and delivery ports and permit communication between the delivery port and the exhaust port; a first piston received in the housing and movable in response to pressure from the control port; a second piston received in the housing and operatively associated with the first piston for selective movement relative to the first piston and selective movement with the first piston; and primary and secondary ports communicating with opposite faces of the second piston and communicating with primary and secondary brake circuits so that when both brake circuits are operational, there is no impact on the second piston.

Another preferred aspect of the present invention provides a spring brake modulating relay valve for an air brake system comprising a housing having a supply port, delivery port, exhaust port, control port, primary brake circuit port, and a secondary brake circuit port; and a valve assembly received in the housing and movable in response to air pressure in the housing, the valve assembly including a relay piston in selective communication with the control port and the primary brake circuit port, a modulating piston having surfaces selectively pressurized by the primary brake circuit port and the secondary brake circuit port to modulate pressure from the delivery port thereby selectively applying pressure to associated spring brake chambers when a failure is detected at the primary brake circuit port, and an exhaust member that selectively controls communication between the supply and delivery ports.

Yet another preferred aspect of the present invention provides a spring brake modulating relay valve, comprising (a) a housing, the housing further comprising a plurality of ports formed in the housing; an internal chamber in selective communication with the plurality of ports, and wherein the plurality of ports further comprises (i) a supply port for receiving pressurized air, a delivery port, and an exhaust port formed in a lower portion of the housing; (ii) a port for a primary brake circuit and a port for a secondary brake circuit, the ports being formed in an intermediate portion of the housing; and (iii) a control signal port formed in an upper portion of the housing; (b) a relay piston mounted in the chamber, wherein the relay piston further comprises a first internal shoulder; (c) a modulating piston mounted in the chamber, wherein the modulating piston further comprises a second internal shoulder; (d) an auxiliary piston mounted in the chamber and forming an extension of a bottom portion of the modulating piston; (e) a first spring for engaging one side of the first internal shoulder and one side of the second internal shoulder, and wherein the first spring permits the relay and the modulating pistons to move as a unit under predetermined pressure conditions; (f) a retention ring for providing an abutment surface for an opposite side of the first shoulder and for defining the engagement between the relay and modulating pistons in an absence of air pressure; (g) a second spring mounted between the housing and the modulating piston for urging the relay, modulating, and auxiliary pistons toward a first or upper position; (h) an exhaust valve for engaging and forming a seal with the auxiliary piston; (i) a third spring for urging the exhaust valve toward a seated position within the housing such that the supply port cannot communicate with the delivery port; (j) a first check valve in communication with the control signal port normally biased for permitting communication between the control signal port and the relay piston and preventing communication between the control signal port and the primary brake circuit port; and (k) a second check valve normally biased to preclude communication between the control port and the supply port.

In a further preferred aspect there is provided a spring brake modulating relay valve, comprising (a) a housing including a plurality of ports and an internal chamber in selective communication with the plurality of ports, the ports including (i) a supply port for receiving pressurized air, a delivery port, and an exhaust port; (ii) a port for a primary brake circuit and a port for a secondary brake circuit; and (iii) a control signal port; (b) a relay piston mounted in the chamber, wherein the relay piston further comprises a first internal shoulder; (c) a modulating piston mounted in the chamber, wherein the modulating piston further comprises a second internal shoulder; (d) an auxiliary piston mounted in the chamber and forming an extension of a bottom portion of the modulating piston; (e) a first spring for engaging one side of the first internal shoulder and one side of the second internal shoulder, and wherein the first spring permits the relay and the modulating pistons to move as a unit under predetermined pressure conditions; (f) a retention ring for providing an abutment surface for an opposite side of the first shoulder and for defining the engagement between the relay and modulating pistons; (g) a second spring mounted between the housing and the modulating piston for urging the relay, modulating, and auxiliary pistons toward a first or upper position; (h) an exhaust valve for engaging and forming a seal with the auxiliary piston; (i) a third spring for urging the exhaust valve toward a seated position within the housing such that the supply port cannot communicate with the delivery port; and (j) a first check valve in communication with the control signal port normally biased for permitting communication between the control signal port and the relay piston and preventing communication between the control signal port and the primary brake circuit port.

In a further preferred aspect there is provided a spring brake modulating relay valve, comprising a housing including an internal chamber in selective communication with a supply port for receiving pressurized air into the chamber, a delivery port for delivering the pressurized air from the chamber to a spring brake chamber, a primary port for receiving a pressure from a primary service brake circuit, a secondary port for receiving a pressure from a secondary service brake circuit, a control signal port for receiving a control pressure, and an exhaust port for exhausting pressurized air from the chamber; a relay piston mounted in the chamber, a position of the relay piston in the chamber being controlled as a function of the control pressure; and a modulating piston mounted in the chamber, the modulating piston interacting with the relay piston under predetermined pressure conditions, a position of the modulating piston being controlled as a function of the respective pressures at the primary and secondary ports acting directly on opposite faces of the modulating piston for controlling fluid communication of the pressurized air between the supply port, the delivery port, and the exhaust port.

In a further preferred embodiment of the present invention there is provided a spring brake modulating relay valve, comprising a housing including an internal chamber in selective communication with a supply port for receiving pressurized air into the chamber, a delivery port for delivering the pressurized air from the chamber to a spring brake chamber, a primary port for receiving a pressure from a primary service brake circuit, a secondary port for receiving a pressure from a secondary service brake circuit, a control signal port for receiving a control pressure, and an exhaust port for exhausting pressurized air from the chamber; a relay piston mounted in the chamber, a position of the relay piston in the chamber being controlled as a function of the control pressure; and a control piston mounted in the chamber, the control piston modulating between a supply position for supplying pressurized air from the supply port to the delivery port to release an associated spring brake, a hold position for maintaining air pressure in the spring brake chamber, and an exhaust position for exhausting pressurized air from the spring brake chamber to apply the associated spring brake, the position of the control piston being determined as a function of the respective pressures at the control signal port and the primary port and the respective pressures at the primary and secondary ports acting directly on opposite faces of the control piston.

In another preferred embodiment of the present invention there is provided a spring brake modulating relay valve, comprising a housing including an internal chamber in selective communication with a supply port for receiving pressurized air into the chamber, a delivery port for delivering the pressurized air from the chamber to a spring brake chamber, a primary port for receiving a pressure from a primary service brake circuit, a secondary port for receiving a pressure from a secondary service brake circuit, a control signal port for receiving a control pressure, and an exhaust port for exhausting pressurized air from the chamber; and means for modulating between supplying pressurized air from the supply port to the delivery port to release an associated spring brake, maintaining air pressure in the spring brake chamber, and exhausting pressurized air from the spring brake chamber to engage the associated spring brake.

In yet another preferred embodiment of the present invention there is provided a method for modulating a control piston, the method comprising selectively receiving respective pressures at a supply port of an internal chamber of a housing, the supply port fluidly communicating with a supply of compressed air, a control signal port which fluidly communicates with the internal chamber and a control pressure circuit, a primary port which fluidly communicates with the internal chamber and a primary service brake circuit, and a secondary port which fluidly communicates with the internal chamber and a secondary service brake circuit; controlling a position of a relay piston in the internal chamber as a function of the control pressure received at the control signal port; modulating a position of a control piston, which is mounted in the chamber and which interacts with the relay piston under predetermined pressure conditions, as a function of the respective pressures at the primary port and the secondary port acting directly on different faces of the control piston; and controlling fluid communication between the supply port and a delivery port, which delivers the compressed air from the internal chamber to a spring brake chamber, and an exhaust port, which exhausts the compressed air from the internal chamber, as a function of the position of the control piston.

Still other features and benefits of the invention will become apparent to those skilled in the art upon reading and understanding the following detailed description

Brief Description of the Drawings

FIGURES 1 and 2 are schematic representations of prior art truck brake systems.

FIGURE 3 is a schematic representation of the spring brake modulating relay valve of the present invention incorporated into an air brake system.

FIGURE 4 is a sectional view through the spring brake modulating relay valve illustrating relative positions of the valve components during a system charging.

FIGURE 5 is a view similar to that of FIGURE 4, where the pressure has been elevated above 105 psi.

FIGURE 6 illustrates normal service brake application.

FIGURE 7 illustrates the position of the valve components during system park.

FIGURE 8 illustrates service brake application where a failure has occurred in the primary brake circuit.

FIGURE 9 shows the valve components where a failure in the secondary brake circuit has occurred.

FIGURE 10 illustrates the anti-compounding feature of the subject valve.

FIGURE 11 is an illustration of another preferred embodiment of a combined spring brake modulating relay valve.

Detailed Description of the Preferred Embodiments

Turning first to FIGURE 3, a brake system **20** includes a first or primary reservoir **22** and a second or secondary reservoir **24** that provide a supply of pressurized air for the brake system. The reservoirs are periodically charged by a compressor (not shown) and typically an air dryer is interposed between the compressor and the reservoirs to remove moisture and contaminants from the air before it is stored. Lines **26, 28** lead from the first and second reservoirs, respectively, to a foot control valve **30**. The valve includes a foot pedal **32** that is selectively depressed by an operator to supply pressure from the foot control valve to a standard service relay valve **40** via line **42**. The relay valve delivers normal service braking to brake chambers **50** via lines **52** associated with each of the drive wheels (not shown). In addition, line **54** extends from the relay valve to a spring brake modulation relay valve **60**. In this manner, and as will be described in greater detail below, operability of the primary brake circuit is communicated to the spring brake modulation valve **60**.

The foot control valve also provides a signal through line **62** to the spring brake modulation valve representative of the operation of the secondary brake circuit. Although the secondary circuit is not shown in FIGURE 3 for purposes of simplicity and brevity, it is well known that a separate or secondary circuit controls braking for the steering axle from the foot control valve.

Moreover, a separately actuated control valve **70** is typically mounted in the operator compartment, such as on the dashboard. Again, as is known in the art, the control valve **70** provides a control signal (pneumatic signal) through line **72**. That control signal cooperates with a spring brake modulating valve, here combined in the spring brake modulation relay valve **60**, to provide pressurized air through lines **74** to the spring brake chambers **76** and thereby release the mechanical spring brakes (not shown).

With this brief overview of the brake system, attention is turned to FIGURE 4 where the details of the structure and function of the combined spring brake modulating relay valve **60** is shown in greater detail. It includes a housing **100** which, in this embodiment, includes a first or lower housing portion **102**, a second or intermediate housing portion **104**, and a third or upper housing portion **106**. An internal cavity or valve chamber **110** selectively communicates with a number of ports provided in the housing. For example, a supply port **112**, delivery port **114**, and exhaust port **116** are all formed in the lower housing portion **102**. In the intermediate housing portion, a primary brake circuit port **120** and a secondary brake circuit port **122** are provided while a control signal port **124** is provided in the upper housing portion.

A first or relay piston **130** includes a seal member such as O-ring **132** for sealing, sliding engagement in the housing. A second or modulating piston **134** likewise includes a seal member, such as O-ring, **136** for sliding sealing engagement within the housing. A lower extension of the modulating piston includes an auxiliary piston **138** having an O-ring seal member **140**. A first biasing member or spring **142** engages an internal shoulder **144** of the relay piston **130** at one end and an internal shoulder **146** of the modulating piston at the other end. The spring permits the relay and modulating piston to move as a unit under certain pressure conditions. On the other hand, a retention ring **150** provides an abutment surface for the opposite face of shoulder **144** to define the engagement between the first and second pistons in the absence of air pressure. In addition, a second biasing member or spring **152** is interposed between the housing and the modulating piston for urging the valve assembly toward a first or upper position.

The lower end or modulating end of the second piston includes a seat portion **154** adapted to sealingly engage an exhaust valve **160**. As shown in FIGURE 4, the exhaust valve is closed as a result of the seat portion **154** engaging a seal surface **162** of the exhaust valve. The exhaust valve is normally urged toward a seated position with the housing via spring **164**. When seated against the housing and forming a lap seal therewith, the supply port **112** cannot communicate with the delivery port **114** as will be described further below.

A check valve **170** is associated with the control port **124**. In a first position (as shown), the check valve permits communication between the control port and an upper face **172** of the relay piston via passage **174**. In the first position, passage **176** is sealed by the check valve **170** so that the primary brake circuit port (i.e., on the upper face of the second piston **134**) cannot communicate with the passage **174**. In addition, a check valve **180** is urged by spring **182** toward a closed position and precludes communication between passage **176** and passage **184** that leads to the supply port.

The position of the valve components in FIGURE 4 represent the system when it is charging and the pressure is below a predetermined level (here 105 psi). The control valve **70** is actuated by the operator and supplies a pneumatic control signal to control port **124.** This seats the check valve **170** and provides air pressure to the relay piston surface **172.** The air pressure acting over the relay piston surface exerts a force in a downward direction so that the inlet valve and seal surface **162** is lifted or spaced from the housing seat and provides communication between the supply port **112** and the delivery port **114** to the spring brakes. This provides pressurized air that retracts the mechanical spring brakes and releases the spring brakes to allow the wheels to roll freely.

It is desired that the pressure to the spring brakes be limited to 105 psi. Accordingly, once that preselected pressure level is reached, the exhaust valve is urged to a sealed position with the valve seat (FIGURE 5) and remains in contact with the lower portion of the modulating piston. This lapped position assures that only 105 psi is delivered to the spring brakes.

A normal service application is illustrated in FIGURE 6. Pressure is provided at the control port **124** to urge the relay piston **130** to its lower position as shown. In addition, air pressure is provided at the primary circuit port **120,** as well as the secondary circuit port **122.** This provides a balancing force on the modulating piston **134** so that it does not engage against the lower shoulder (e.g. as it does in FIGURE 4), and instead remains in a balanced position as shown in FIGURE 6. Thus, the pistons have moved relative to one another and the spring **142** is under compression. The spring brakes have already been released and are held in the release position due to the lapped arrangement between the sealing surface **162** and the housing. Likewise, the lower end of the modulating piston **134** is seated against the seal surface **162** to prevent communication with the exhaust port.

To effect system park, no pressure is provided to the control port **124** or the primary and secondary circuit ports **120, 122**, respectively. The components of the valve adopt the positions illustrated in FIGURE 7. Note that the relay piston is urged to a second or upper position. Likewise, the modulating piston **134** is urged upwardly by the springs. This lifts the end of the modulating piston from its sealed engagement with the seat **162** and thereby establishes communication with the exhaust port **116**. Thus, the air pressure which released the mechanical spring brakes is now free to communicate with ambient through the exhaust port and the spring brakes are applied. The pressure at the supply port **112** cannot communicate with the delivery port due to the closing force imposed by the spring **164**.

If a primary circuit brake failure occurs, the modulation function of the valve **60** comes into play. This is best illustrated in FIGURE 8. The control port **124** is still pressurized and the air pressure urged the relay piston **130** toward its lower position. Because of the failure, there is no pressure at the primary port **120**. Thus, the pressure at the secondary port **122** moves the modulating piston upwardly as shown. This lifts the modulating end of the piston from its sealed engagement with seal member **162**, again establishing communication between the delivery port **114** and the exhaust port. Consequently, the mechanical springs can be applied through selective depression of the foot valve when the primary circuit has failed. This, of course, is a very desirable and beneficial feature of the valve assembly.

If a failure occurs in the secondary circuit, and the primary circuit is still operative, the rear axle or drive brakes can still be operated. The modulating piston moves downwardly, as shown in FIGURE 9, resulting in the supply reservoir pressure being delivered to the spring brakes. However, no modulation occurs since the service brakes are still operative and can satisfy safe stopping distance requirements.

Another feature incorporated into the valve is generally referred to as anti-compounding (FIGURE 10). That is, it is undesirable to apply both the spring brake and the normal service braking at the same time, i.e., compounding the brakes. To prevent this undesired result, an anti-compounding feature is incorporated into the valve assembly. For example, if the vehicle is parked, i.e., there is no air pressure at the control port **124**, then air from the primary circuit drives the pistons downwardly by providing pressure to the upper face **172** of the relay piston. The lower end of the modulating piston moves the exhaust valve from its sealed position with the seat and thereby establishes communication between the supply port **112** and the delivery port **114**. As will be recognized, this backs the spring brakes from the applied position and prevents compounding of the brake application.

The valve of FIGURE 11 is similar to that shown and described with reference to FIGURES 4-10. It is preferred from the standpoint, however, that a more compact assembly is provided since the intermediate housing portion is removed. Instead, an inner static piston **200** is received in a modified upper housing portion. As will be appreciated, the static piston **200** is sealed relative to the upper housing portion via O-ring seals **202, 204**. It has an internal cavity that receives the sliding seals **136'** and **140'** of the modulating piston. In substantially all other respects, the correspondence between the valve of FIGURES 4-10 and that in FIGURE 11 is exhibited through the use of components identified with a primed suffix ('). Accordingly, operation and function of the combined spring brake modulating relay valve of FIGURE 11 is the same as described above.

The invention has been described with reference to the preferred embodiments. Obviously, modifications and alterations will become apparent to those skilled in the art. It is intended to include all such modifications and alterations insofar as they fall within the scope of the appended claims or the equivalents thereof.

WHAT IS CLAIMED IS:

1. A combined spring brake modulating relay valve comprising:

a housing having a control port, supply port, delivery port, exhaust port, and a chamber formed therein in selective communication with the supply port adapted to receive pressurized air from an associated reservoir, the delivery port adapted to communicate with associated spring brake chambers, and the exhaust port adapted to communicate with ambient;

a valve member in the chamber normally biased to preclude communication between the supply and delivery ports and permit communication between the delivery port and the exhaust port;

a first piston received in the housing and movable in response to pressure from the control port;

a second piston received in the housing and operatively associated with the first piston for selective movement relative to the first piston and selective movement with the first piston; and

primary and secondary ports communicating with opposite faces of the second piston and communicating with primary and secondary brake circuits so that when both brake circuits are operational, there is no impact on the second piston.

2. The combined valve of claim 1 wherein the second piston and the valve member are normally disposed in spaced relation and engage one another in response to pressure in the control port.

3. The combined valve of claim 2 wherein the second

piston and the valve member are spaced from one another when the primary circuit is inoperative.

4. The combined valve of claim 1 or 2 wherein, in response to failure of the primary brake circuit, there is no air pressure on one side of the second piston, and the second piston is separated from the valve member permitting pressure from the spring brake chambers to be modulated and used to control the primary brake circuit.

5. The combined valve of any one of claims 1 to 4 wherein, in response to failure of the secondary brake circuit, the second piston sealingly engages the valve member and urges the valve member from a seat for the valve member allowing an increased pressure flow between the supply and delivery ports.

6. The combined valve of any one of claims 1 to 5 wherein when the primary and secondary brake circuits are operational, there is no modulation of the pressure at the delivery port.

7. The combined valve of any one of claims 1 to 6 further comprising a first spring urging the first piston toward abutting engagement with the second piston under certain pressure conditions.

8. The combined valve of any one of claims 1 to 7 further comprising a biasing spring for urging the second piston from disengagement with the valve member.

9. The combined valve of any one of claims 1 to 8 further comprising a biasing member operatively associated

with the valve member for urging the valve member toward a seated position to preclude communication between the supply port and the delivery port.

10. The combined valve of any one of claims 1 to 9 further comprising an anti-compounding feature that provides pressure to the spring brake chambers during normal service braking.

11. The combined valve of claim 10 wherein the anti-compounding feature routes a portion of the primary brake circuit pressure to the first piston.

12. A spring brake modulating relay valve for an air brake system comprising:

a housing having a supply port, delivery port, exhaust port, control port, primary brake circuit port, and a secondary brake circuit port; and

a valve assembly received in the housing and movable in response to air pressure in the housing, the valve assembly including a relay piston in selective communication with the control port and the primary brake circuit port, a modulating piston having surfaces selectively pressurized by the primary brake circuit port and the secondary brake circuit port to modulate pressure from the delivery port thereby selectively applying pressure to associated spring brake chambers when a failure is detected at the primary brake circuit port, and an exhaust member that selectively controls communication between the supply and delivery ports.

13. The spring brake modulating relay valve of claim 12 wherein the relay piston and the modulating piston are

operatively connected via biasing members that urge the pistons to move together as a unit and allow relative movement therebetween in response to pressure conditions.

14. The spring brake modulating relay valve of claim 12 or 13 wherein the exhaust member is urged toward a closed position that precludes communication between the supply and delivery ports.

15. The spring brake modulating relay valve of claim 12, 13 or 14 wherein the primary brake circuit port communicates with the relay piston in the absence of pressure at the control port to provide an anti-compounding feature to the spring brake modulating relay valve.

16. A spring brake modulating relay valve, comprising:

(a) a housing, said housing further comprising:

a plurality of ports formed in said housing;

an internal chamber in selective communication with said plurality of ports, and

wherein said plurality of ports further comprises:

(i) a supply port for receiving pressurized air, a delivery port, and an exhaust port formed in a lower portion of said housing;

(ii) a port for a primary brake circuit and a port for a secondary brake circuit, said ports being formed in an intermediate portion of said housing; and

(iii) a control signal port formed in an upper portion of said housing;

(b) a relay piston mounted in said chamber, wherein said relay piston further comprises a first internal shoulder;

(c) a modulating piston mounted in said chamber, wherein said modulating piston further comprises a second internal shoulder;

(d) an auxiliary piston mounted in said chamber and forming an extension of a bottom portion of said modulating piston;

(e) a first spring for engaging one side of said first internal shoulder and one side of said second internal shoulder, and wherein said first spring permits said relay and said modulating pistons to move as a unit under predetermined pressure conditions;

(f) a retention ring for providing an abutment surface for an opposite side of said first shoulder and for defining the engagement between said relay and modulating pistons in an absence of air pressure;

(g) a second spring mounted between said housing and said modulating piston for urging said relay, modulating, and auxiliary pistons toward a first or upper position;

(h) an exhaust valve for engaging and forming a seal with said auxiliary piston;

(i) a third spring for urging said exhaust valve toward a seated position within said housing such that said supply port cannot communicate with said delivery port;

(j) a first check valve in communication with said control signal port normally biased for permitting communication between said control signal port and said relay piston and preventing communication between said control signal port and said primary brake circuit port; and

(k) a second check valve normally biased to preclude communication between said control port and said supply port.

17. The spring brake modulating relay valve of claim 16 wherein said second check valve permits communication between said control port and said supply port in the event of a failure in said secondary brake circuit.

18. The spring brake modulating relay valve of claim 16 or 17 wherein said pressurized air may be received from a single, secondary air source or from primary and secondary sources of pressurized air.

19. A spring brake modulating relay valve, comprising:

(a) a housing including a plurality of ports and an internal chamber in selective communication with said plurality of ports, the ports including:

(i) a supply port for receiving pressurized air, a delivery port, and an exhaust port;

(ii) a port for a primary brake circuit and a port for a secondary brake circuit; and

(iii) a control signal port;

(b) a relay piston mounted in said chamber, wherein said relay piston further comprises a first internal shoulder;

(c) a modulating piston mounted in said chamber, wherein said modulating piston further comprises a second internal shoulder;

(d) an auxiliary piston mounted in said chamber and forming an extension of a bottom portion of said modulating piston;

(e) a first spring for engaging one side of said first internal shoulder and one side of said second internal shoulder, and wherein said first spring permits said relay and said modulating pistons to move as a unit under predetermined pressure conditions;

(f) a retention ring for providing an abutment surface for an opposite side of said first shoulder and for defining the engagement between said relay and modulating pistons;

(g) a second spring mounted between said housing and said modulating piston for urging said relay, modulating, and auxiliary pistons toward a first or upper position;

(h) an exhaust valve for engaging and forming a seal with said auxiliary piston;

(i) a third spring for urging said exhaust valve toward a seated position within said housing such that said supply port cannot communicate with said delivery port; and

(j) a first check valve in communication with said control signal port normally biased for permitting communication between said control signal port and said relay piston and preventing communication between said control signal port and said primary brake circuit port.

20. The spring brake modulating relay valve of claim 19, wherein:

a pressure at the control signal port above a predetermined control pressure causes the modulating piston to be positioned for supplying pressurized air from the supply port to the delivery port for releasing an associated spring brake.

21. The spring brake modulating relay valve of claim 19 or 20 wherein:

the modulating piston is positioned for exhausting air from the delivery port and applying an associated spring brake if a pressure at the primary brake circuit port is below a predetermined primary pressure, a pressure at the secondary brake circuit port is above a predetermined secondary pressure, the pressure at the primary brake circuit port is less than the pressure at the secondary brake circuit port, and a pressure at the control signal port is above a predetermined control pressure.

22. The spring brake modulating relay valve of claim 21 wherein:

the modulating piston is positioned for supplying air from the supply port to the delivery port for releasing an associated spring brake if the pressure at the primary brake circuit port is substantially equal to the pressure at the secondary brake circuit port and the pressure at the control signal port is above the predetermined control pressure.

23. The spring brake modulating relay valve of claim 22 wherein:

the modulating piston modulates between being positioned for exhausting air from the delivery port and supplying air from the supply port to the delivery port as a function of the pressures at the primary brake circuit port and the secondary brake circuit port.

24. The spring brake modulating relay valve of claim 19 wherein:

the modulating piston is positioned for supplying air from the supply port to the delivery port for releasing an associated spring brake if a pressure at the primary brake circuit port is above a predetermined primary pressure, a pressure at the secondary brake circuit port is below a predetermined secondary pressure, and a pressure at the control signal port is above a predetermined control pressure.

25. The spring brake modulating relay valve of claim 19 wherein:

the modulating piston is positioned for supplying air from the supply port to the delivery port, for releasing an associated spring brake, when a pressure at the control signal port is below a predetermined control pressure and a pressure at the primary brake circuit port is above a predetermined primary pressure.

26. A spring brake modulating relay valve, comprising:

a housing including an internal chamber in selective communication with a supply port for receiving pressurized air into the chamber, a delivery port for delivering the pressurized air from the chamber to a spring brake chamber, a primary port for receiving a pressure from a primary service brake circuit, a secondary port for receiving a pressure from a secondary service brake circuit, a control signal port for receiving a control pressure, and an exhaust port for exhausting pressurized air from the chamber;

a relay piston mounted in said chamber, a position of the relay piston in the chamber being controlled as a function of the control pressure; and

a modulating piston mounted in said chamber, the modulating piston interacting with the relay piston under predetermined pressure conditions, a position of the modulating piston being controlled as a function of the respective pressures at the primary and secondary ports acting directly on opposite faces of the modulating piston for controlling fluid communication of the pressurized air between the supply port, the delivery port, and the exhaust port.

27. The spring brake modulating relay valve as set forth in claim 26 wherein:

respective pressures at the primary port below a predetermined primary pressure level and at the secondary port above a predetermined secondary pressure level cause the modulating piston to be positioned for exhausting the pressurized air from the spring brake chamber via the delivery port, the internal chamber, and the exhaust port.

28. The spring brake modulating relay valve as set forth in claim 26 wherein:

respective pressures at the primary port above a predetermined primary pressure level, at the secondary port below a predetermined secondary pressure level, and at the control signal port above a predetermined control pressure level cause the modulating piston to be positioned for providing fluid communication between the supply and delivery ports to supply the pressurized air to the spring brake chamber.

29. The spring brake modulating relay valve as set forth in claim 26 wherein:

under normal service brake operating conditions, the respective pressures at the primary and secondary ports are substantially equal and act on the opposite faces of the modulating piston.

30. The spring brake modulating relay valve as set forth in claim 29 wherein:

an associated spring brake is released when the pressurized air in the spring brake chamber is above a predetermined spring brake level; and

the associated spring brake is engaged when the pressurized air in the spring brake chamber is below the predetermined spring brake level.

31. The spring brake modulating relay valve as set forth in claim 26 wherein the relay piston is positioned for opening fluid communication between the supply and delivery ports when the control pressure is applied.

32. The spring brake modulating relay valve as set forth in claim 26 wherein:

when the control pressure at the control signal port is below a predetermined control pressure and the pressure from the primary service brake circuit at the primary port is above a predetermined primary pressure level, the pressure at the primary port positions the relay piston for causing fluid communication between the supply port and the delivery port for pressurizing the spring brake chamber and releasing an associated spring brake.

33. The spring brake modulating relay valve as set forth in claim 26 wherein:

respective pressures at the primary port below a predetermined primary pressure level and at the secondary port above a predetermined secondary pressure level cause the modulating piston to be positioned for exhausting the pressurized air from the spring brake chamber via the delivery port, the internal chamber, and the exhaust port; and

respective pressures at the primary port above the predetermined primary pressure level and at the secondary port below the predetermined secondary pressure level cause the modulating piston to be positioned for providing fluid communication between the supply and delivery ports to supply the pressurized air to the spring brake chamber.

34. A spring brake modulating relay valve, comprising:

a housing including an internal chamber in selective communication with a supply port for receiving pressurized air into the chamber, a delivery port for delivering the pressurized air from the chamber to a spring brake chamber, a primary port for receiving a pressure from a primary service brake circuit, a secondary port for receiving a pressure from a secondary service brake circuit, a control signal port for receiving a control pressure, and an exhaust port for exhausting pressurized air from the chamber;

a relay piston mounted in said chamber, a position of the relay piston in the chamber being controlled as a function of the control pressure; and

a control piston mounted in said chamber, the control piston modulating between a supply position for supplying pressurized air from the supply port to the delivery port to release an associated spring brake, a hold position for maintaining air pressure in the spring brake chamber, and an exhaust position for exhausting pressurized air from the spring brake chamber to apply the associated spring brake, the position of the control piston being determined as a function of the respective pressures at the control signal port and the primary port and the respective pressures at the primary and secondary ports acting directly on opposite faces of the control piston.

35. The spring brake modulating relay valve as set forth in claim 34 wherein:

the control piston is set for releasing the pressurized air from the spring brake chamber, for applying the associated spring brake, when the control pressure at the control signal port is above a predetermined control signal pressure, the pressure at the primary port is below a predetermined primary pressure, the pressure at the secondary port is above a predetermined secondary pressure, and the predetermined primary pressure is lower than the predetermined secondary pressure.

36. The spring brake modulating relay valve as set forth in claim 34 wherein:

the control piston is set for passing the pressurized air from the supply port to the delivery port, for charging the spring brake chamber and releasing the associated spring brake, when the control pressure at the control signal port is above a predetermined control signal pressure and the respective pressures at the primary and secondary ports are substantially equal.

37. The spring brake modulating relay valve as set forth in claim 34 wherein:

when the control pressure at the control signal port is below a predetermined control pressure and the pressure from the primary service brake circuit at the primary port is above a predetermined primary pressure level, the pressure at the primary port positions the control piston for causing fluid communication between the supply port and the delivery port for pressurizing the spring brake chamber and releasing an associated spring brake.

38. The spring brake modulating relay valve as set forth in claim 34 wherein:

the control piston is set for releasing the pressurized air from the spring brake chamber, for applying the associated spring brake, when the control pressure at the control signal port is below a predetermined control signal pressure.

39. The spring brake modulating relay valve as set forth in claim 34 wherein:

the control piston is set for passing the pressurized air from the supply port to the delivery port, for charging the spring brake chamber and releasing the associated spring brake, when the control pressure at the control signal port is above a predetermined control signal pressure, the pressure at the primary port is above a predetermined primary pressure, the pressure at the secondary port is below a predetermined secondary pressure, and the predetermined primary pressure is higher than the predetermined secondary pressure.

40. A spring brake modulating relay valve, comprising:

a housing including an internal chamber in selective communication with a supply port for receiving pressurized air into the chamber, a delivery port for delivering the pressurized air from the chamber to a spring brake chamber, a primary port for receiving a pressure from a primary service brake circuit, a secondary port for receiving a pressure from a secondary service brake circuit, a control signal port for receiving a control pressure, and an exhaust port for exhausting pressurized air from the chamber; and

means for modulating between supplying pressurized air from the supply port to the delivery port to release an associated spring brake, maintaining air pressure in the spring brake chamber, and exhausting pressurized air from the spring brake chamber to engage the associated spring brake.

41. The spring brake modulating relay valve as set forth in claim 40 wherein the means for modulating includes:

a relay piston mounted in said chamber, a position of the relay piston in the chamber being controlled as a function of the control pressure; and

a control piston mounted in said chamber, the control piston modulating between a supply position for supplying the pressurized air from the supply port to the delivery port to release the associated spring brake, a hold position for maintaining air pressure in the spring brake chamber, and an exhaust position for exhausting pressurized air from the spring brake chamber to apply the associated spring brake, the position of the control piston being determined as a function of the pressure at the control signal port and the respective pressures at the primary port and the secondary port directly acting on different faces of the control piston.

42. A method for modulating a control piston, the method comprising:

selectively receiving respective pressures at a supply port of an internal chamber of a housing, the supply port fluidly communicating with a supply of compressed air, a control signal port which fluidly communicates with the internal chamber and a control pressure circuit, a primary port which fluidly communicates with the internal chamber and a primary service brake circuit, and a secondary port which fluidly communicates with the internal chamber and a secondary service brake circuit;

controlling a position of a relay piston in the internal chamber as a function of the control pressure received at the control signal port;

modulating a position of a control piston, which is mounted in the chamber and which interacts with the relay piston under predetermined pressure conditions, as a function of the respective pressures at the primary port and the secondary port acting directly on different faces of the control piston; and

controlling fluid communication between the supply port and a delivery port, which delivers the compressed air from the internal chamber to a spring brake chamber, and an exhaust port, which exhausts the compressed air from the internal chamber, as a function of the position of the control piston.

43. The method for modulating a control piston as set forth in claim 42 further comprising:

setting a position of the control piston as a function of the pressure at the control signal port.

44. The method for modulating a control piston as set forth in claim 43 wherein the step of setting includes:

if the pressures at the primary port and the secondary port are substantially equal, setting the control piston as a function of the pressure at the control signal port.

45. The method for modulating a control piston as set forth in claim 44 wherein the step of setting further includes:

if the pressures at the primary port and the secondary port are substantially equal and the pressure at the control signal port is above a predetermined control pressure, setting the control piston for fluidly communicating the compressed air from the supply port to the delivery port and the spring brake chamber for releasing an associated spring brake.

46. The method for modulating a control piston as set forth in claim 45 wherein the step of setting further includes:

if the pressures at the primary port and the secondary port are substantially equal and the pressure at the control signal port is below a predetermined control pressure, setting the control piston for fluidly communicating the compressed air from the delivery port and the spring brake chamber to the exhaust port for applying the associated spring brake.

47. The method for modulating a control piston as set forth in claim 45 wherein the step of setting further includes:

if the pressure at the primary port is below a predetermined primary pressure and the pressure at the secondary port is above a predetermined secondary pressure, setting the control piston for fluidly communicating the compressed air from the delivery port and the spring brake chamber to the exhaust port for applying the associated spring brake.

48. The method for modulating a control piston as set forth in claim 47 wherein the step of modulating includes:

modulating the control piston between the position for releasing the associated spring brake and the position for applying the associated spring brake.

49. The method for modulating a control piston as set forth in claim 43 wherein the step of setting further includes:

if the pressure at the control signal port is below a predetermined control signal pressure level and the pressure at the primary port is above a predetermined primary pressure level, setting the relay piston and the control piston for fluidly communicating the compressed air from the supply port to the delivery port and the spring brake chamber for releasing an associated spring brake.

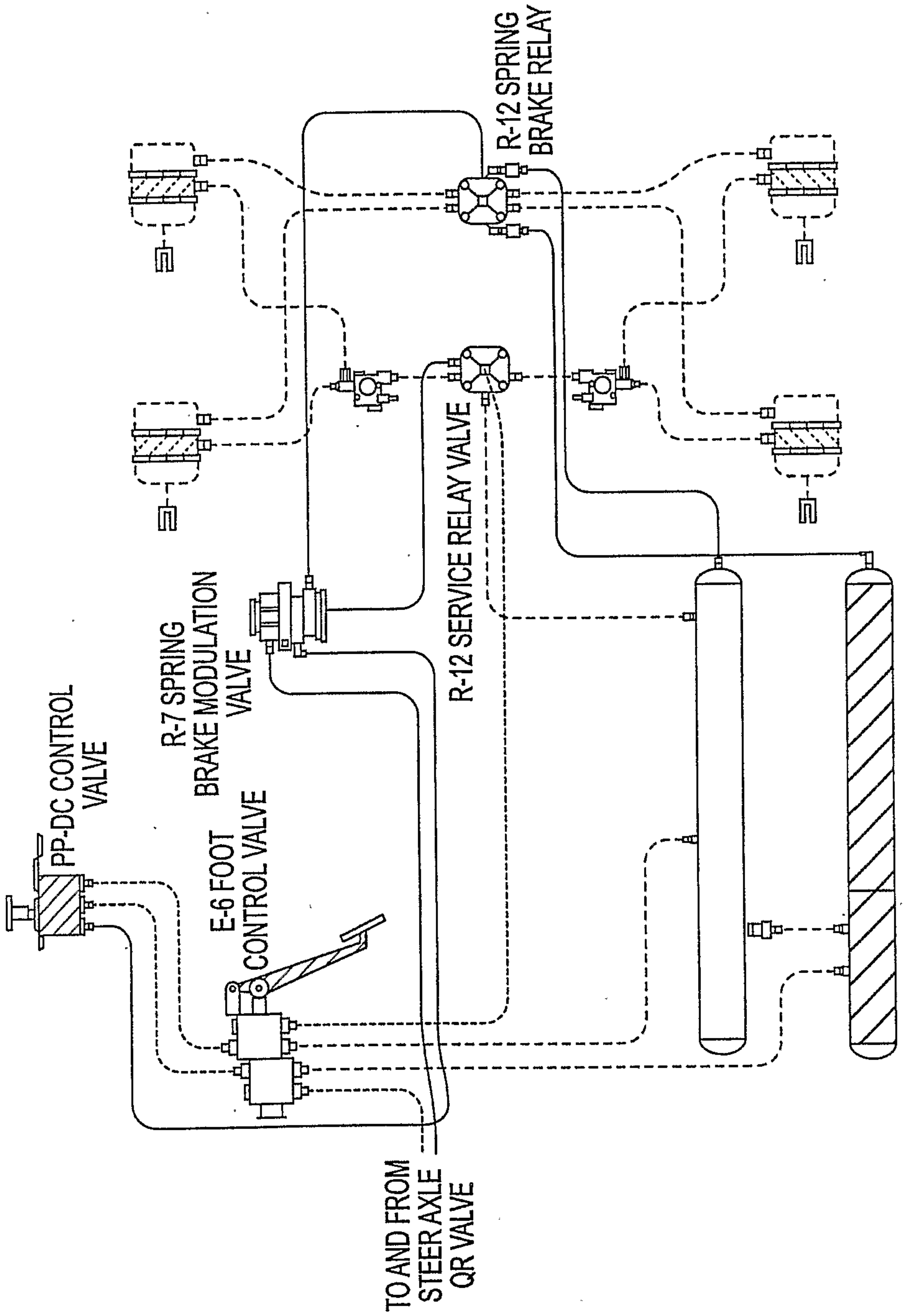


FIG. 1
(PRIOR ART)

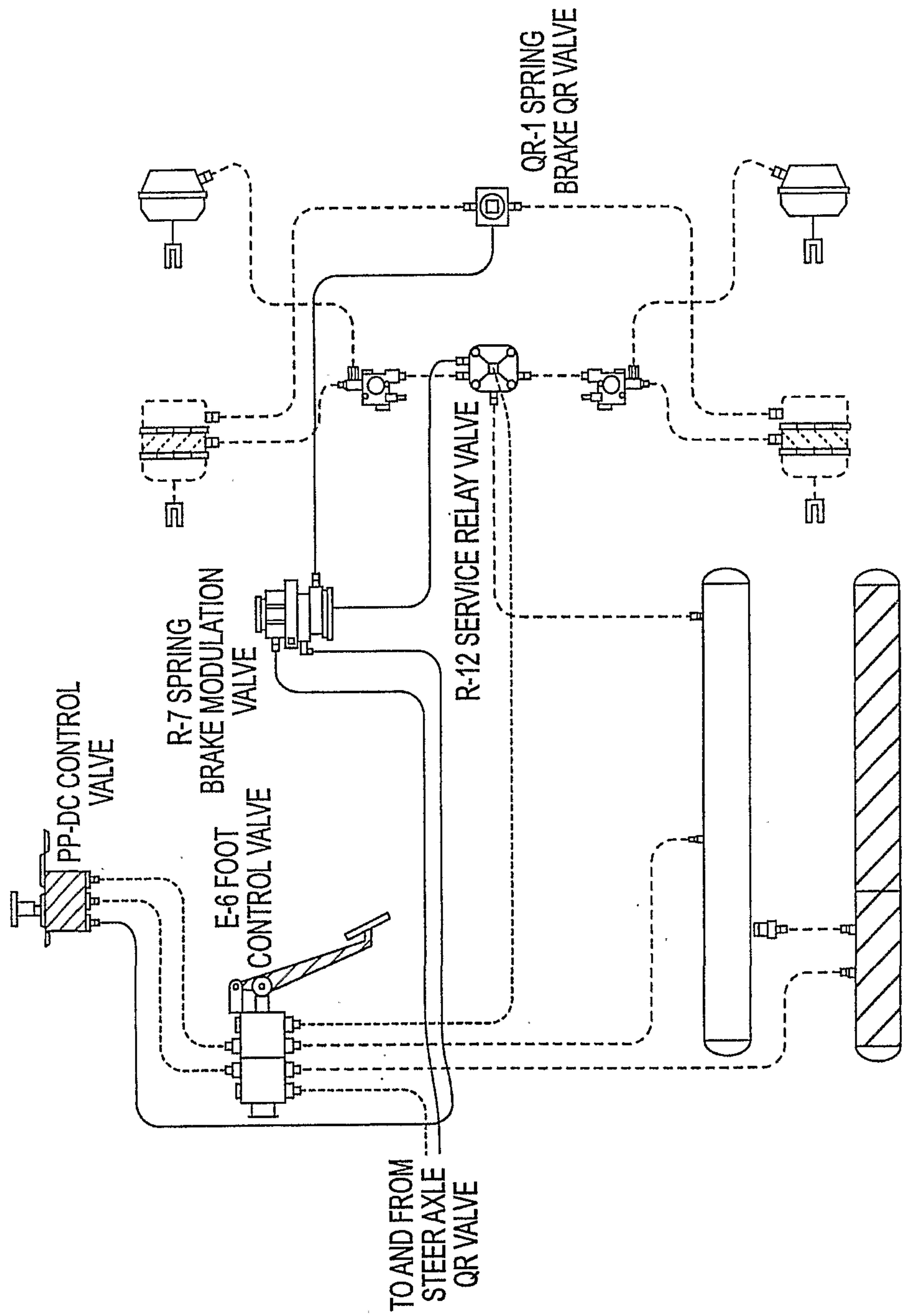
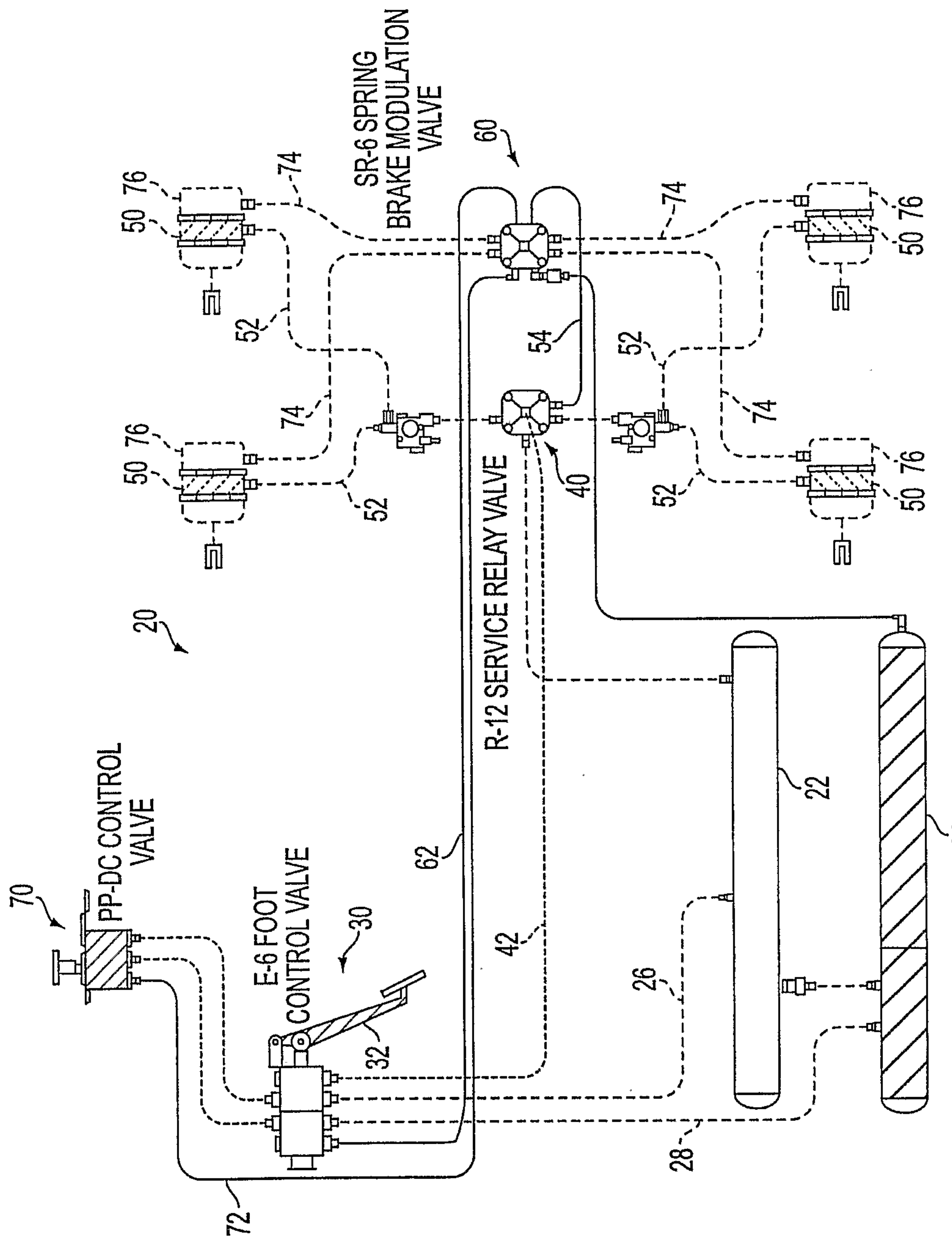


FIG. 2
(PRIOR ART)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E-6 FOOT
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FIG. 3

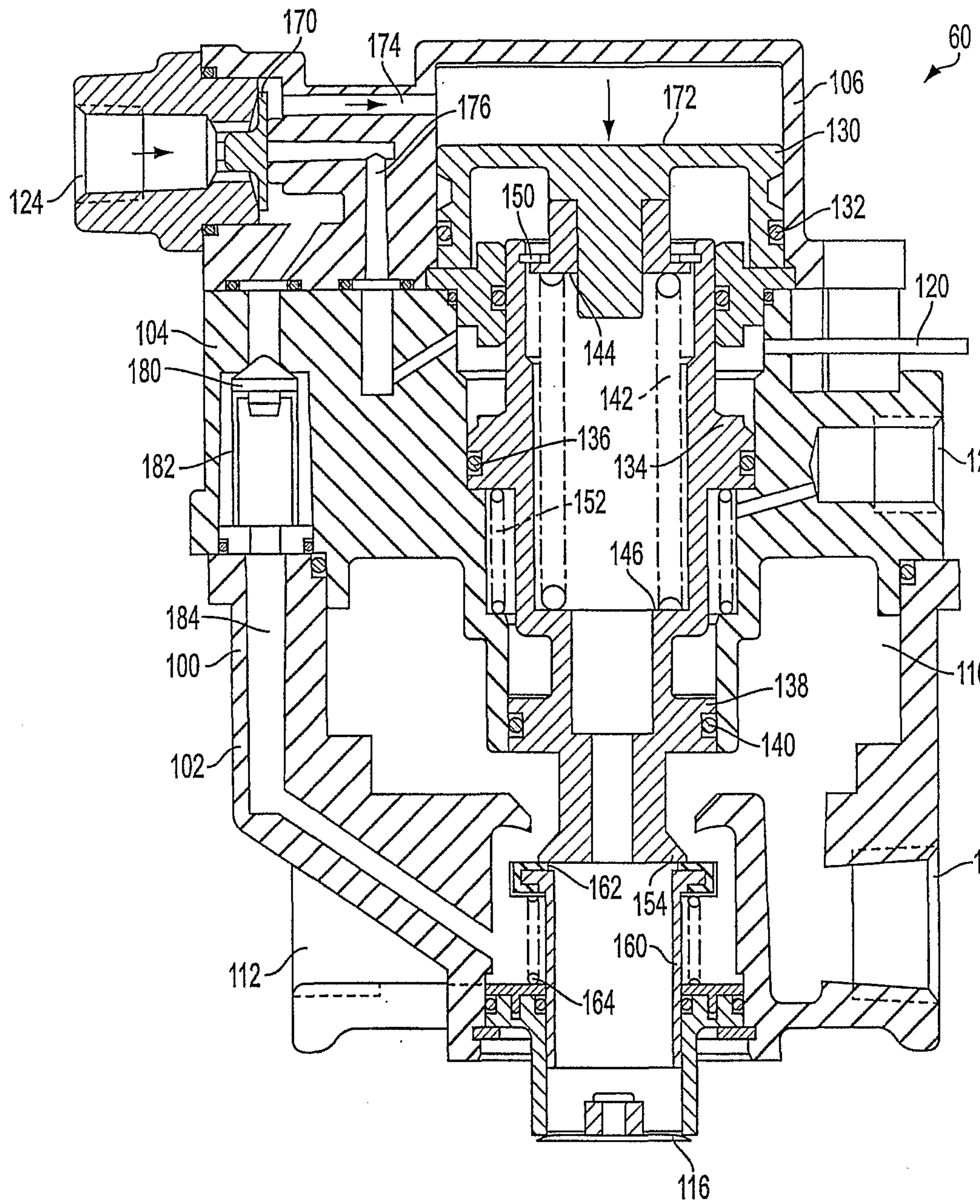
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FIG. 4

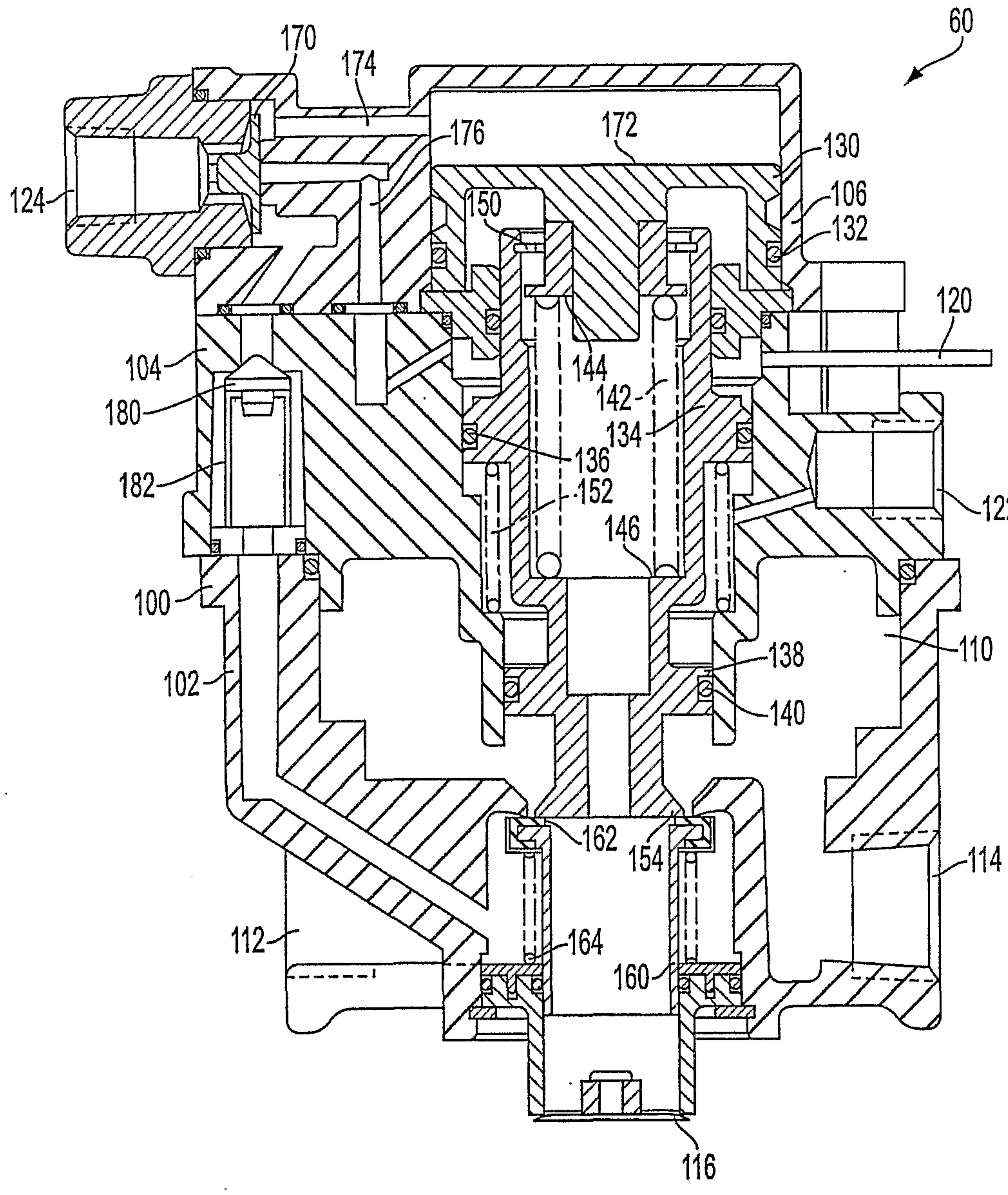
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FIG. 5

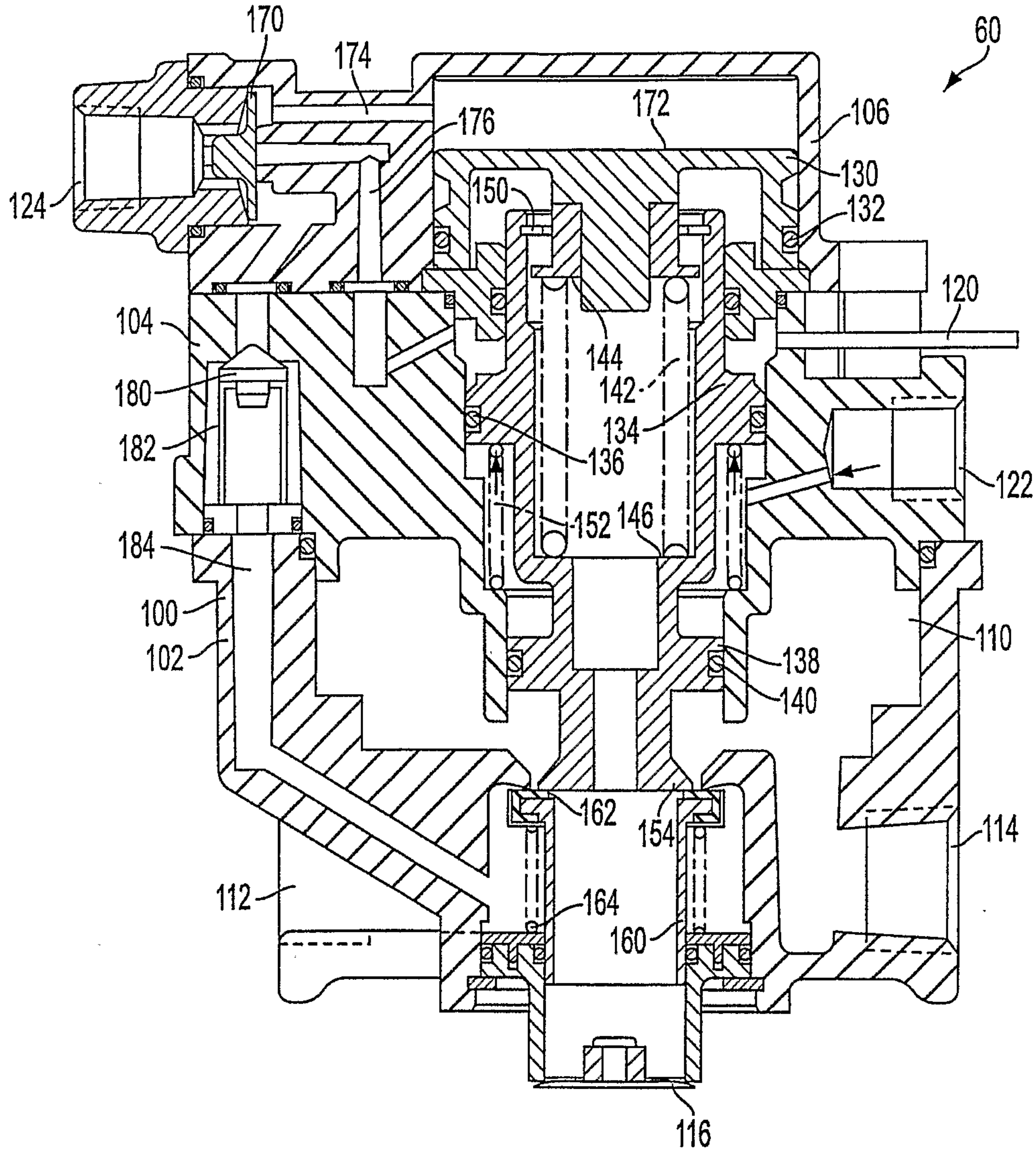
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FIG. 6

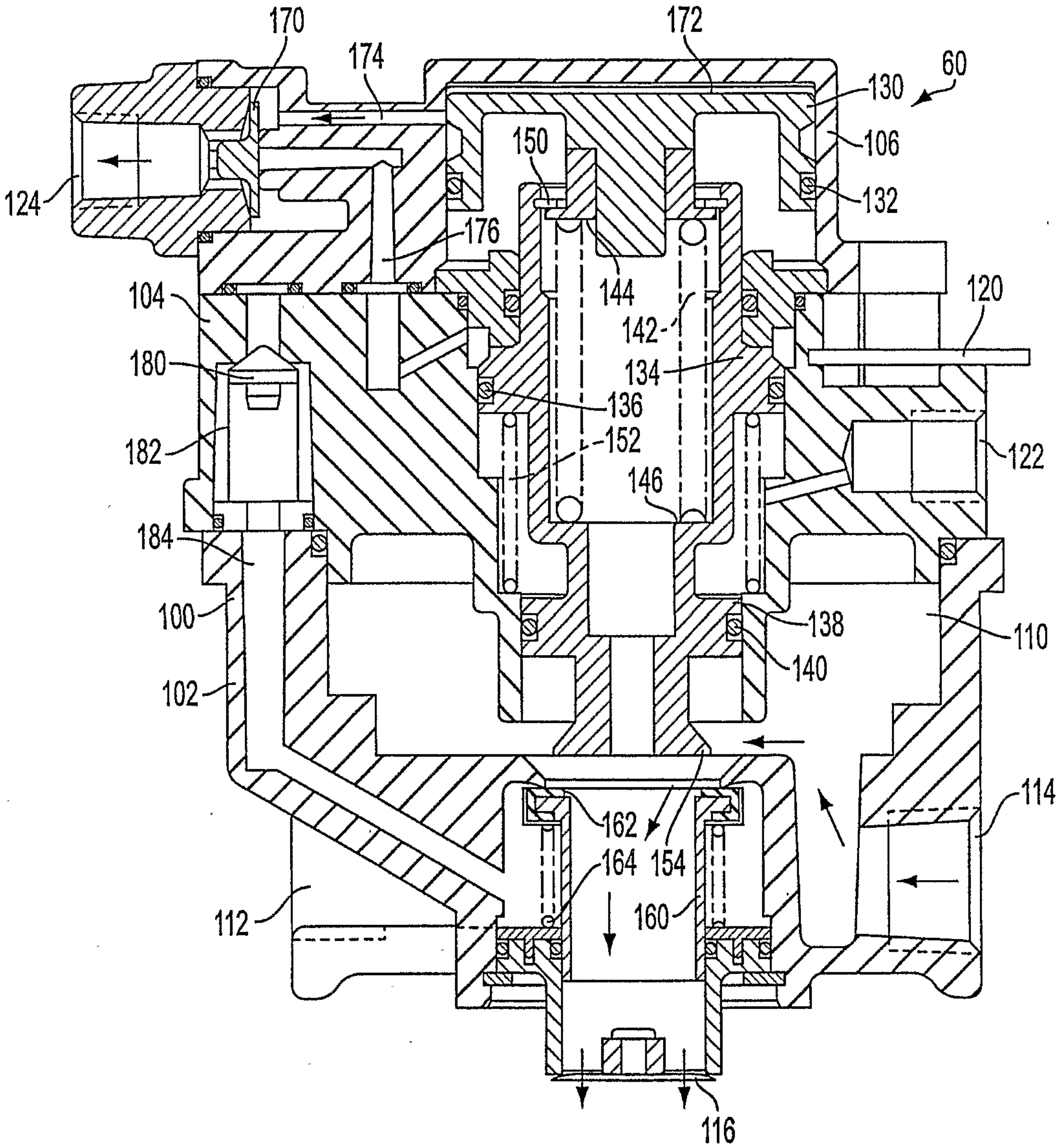
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FIG. 7

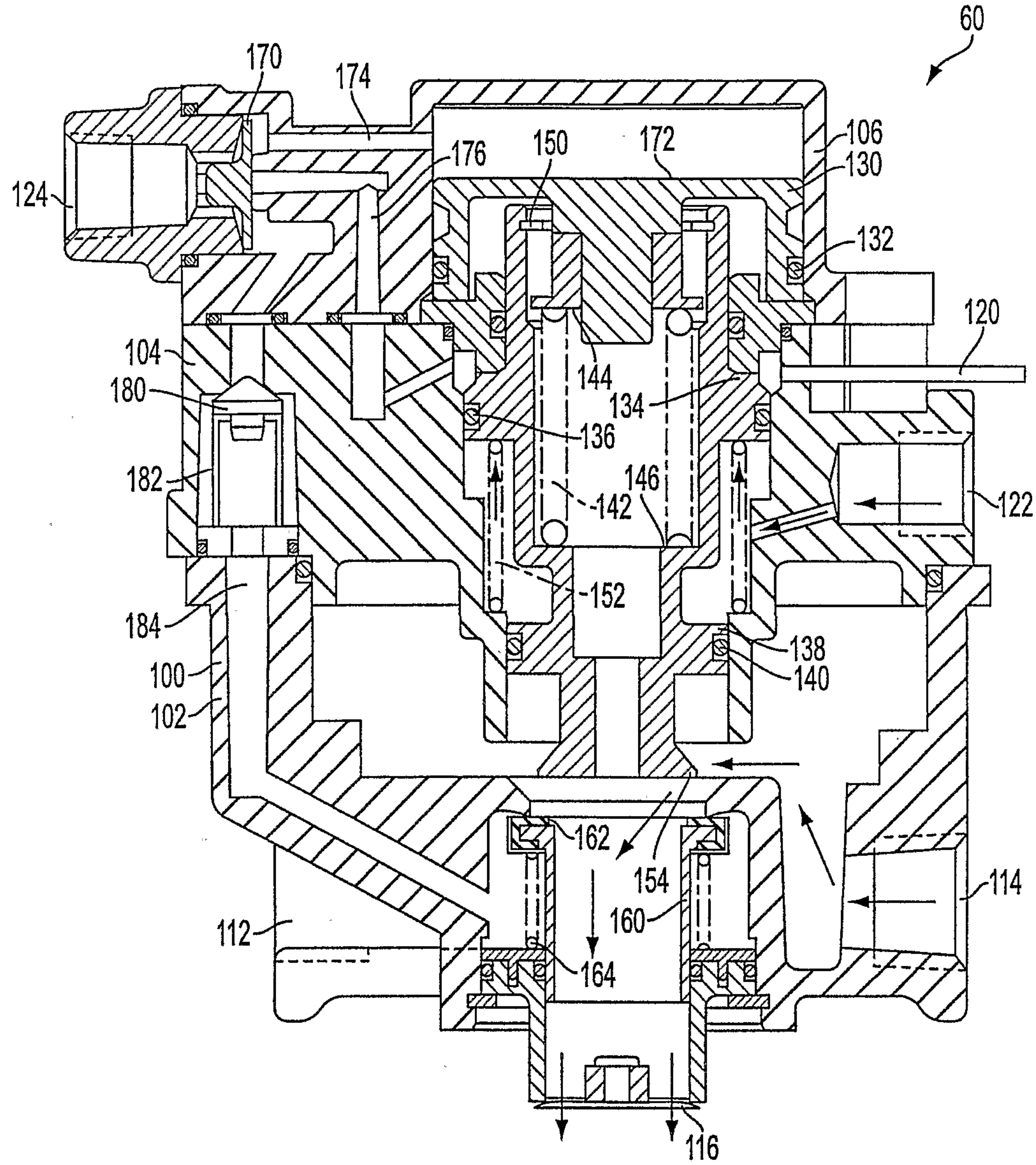
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FIG. 8

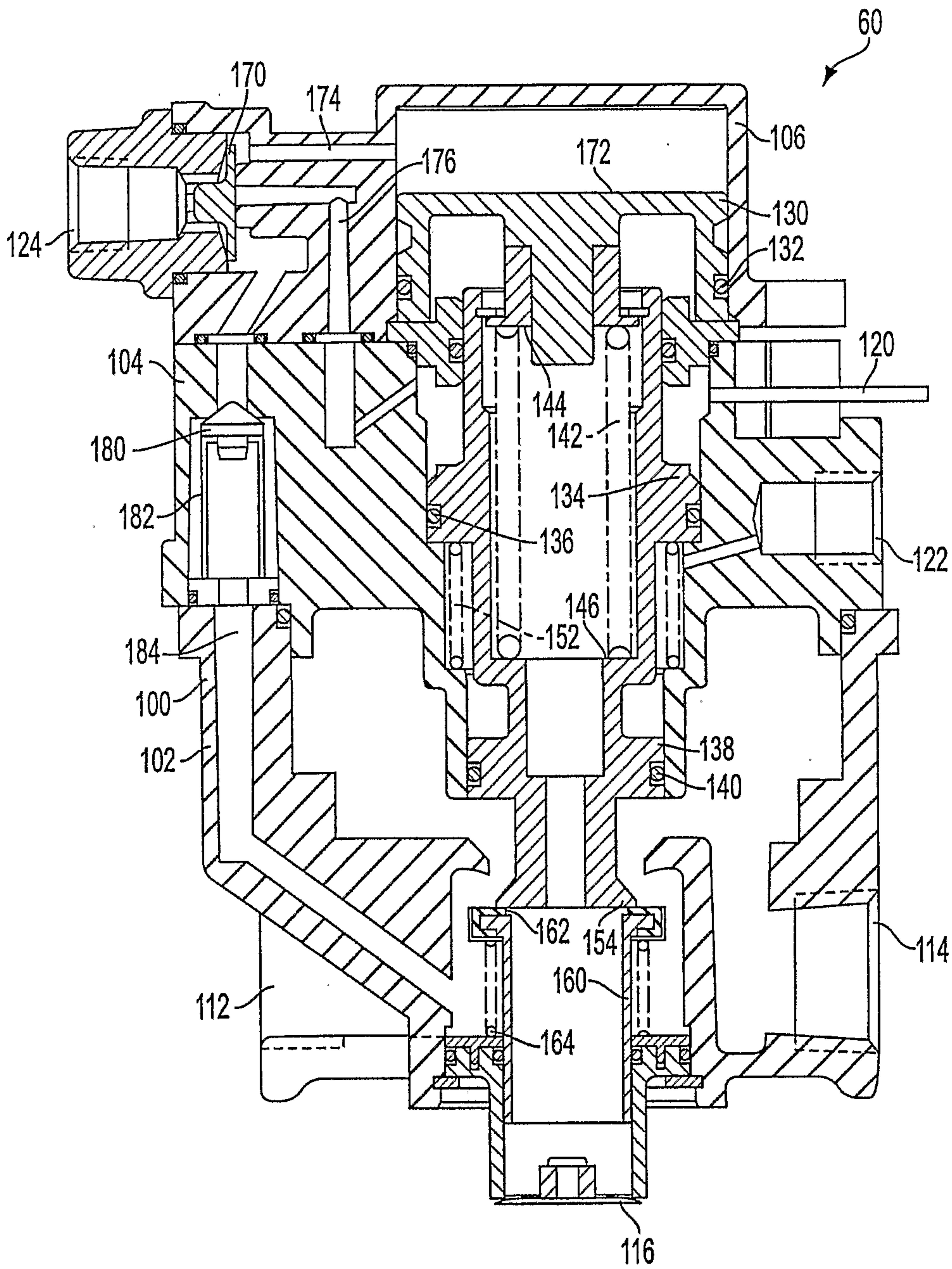
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FIG. 9

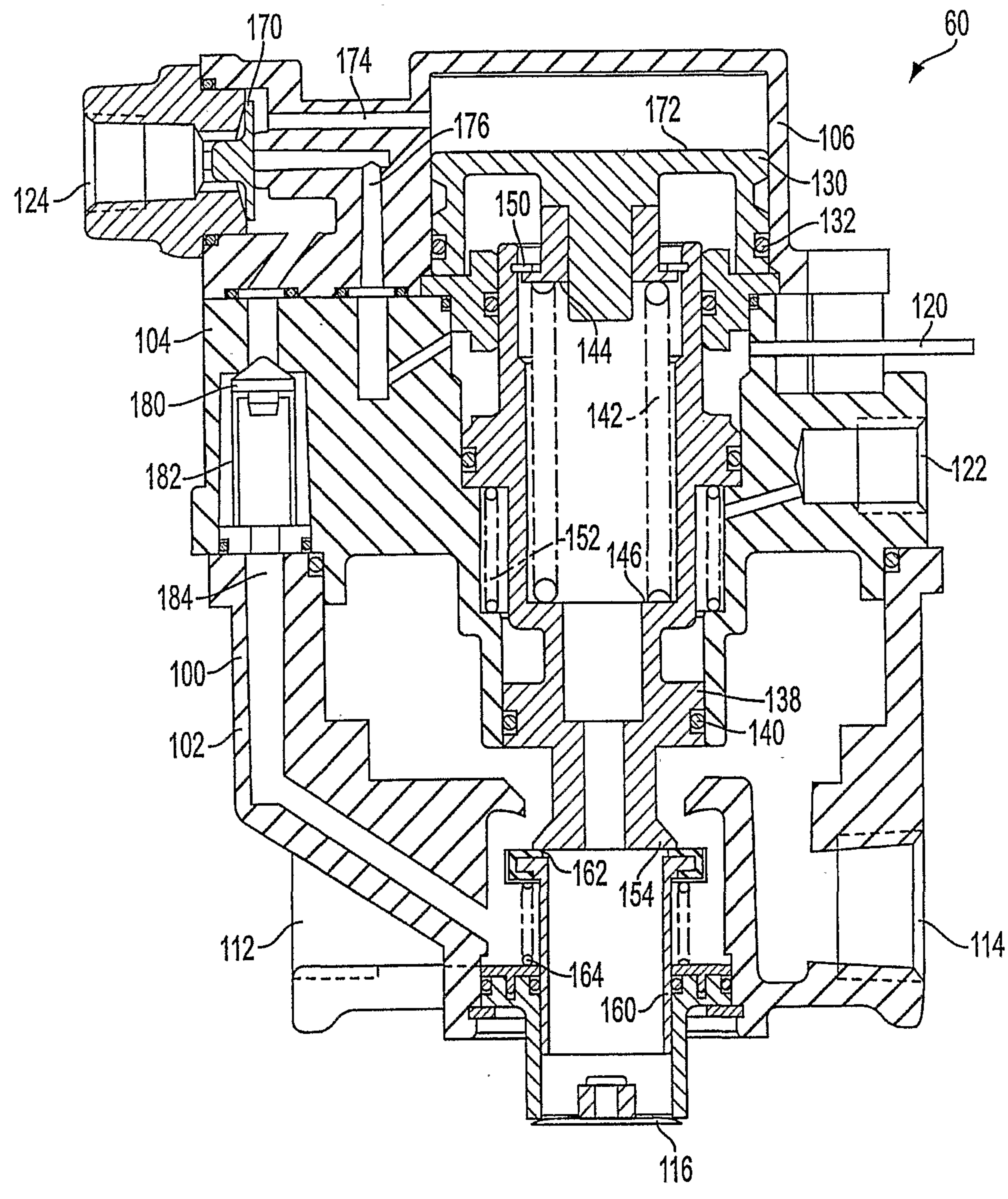
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FIG. 10

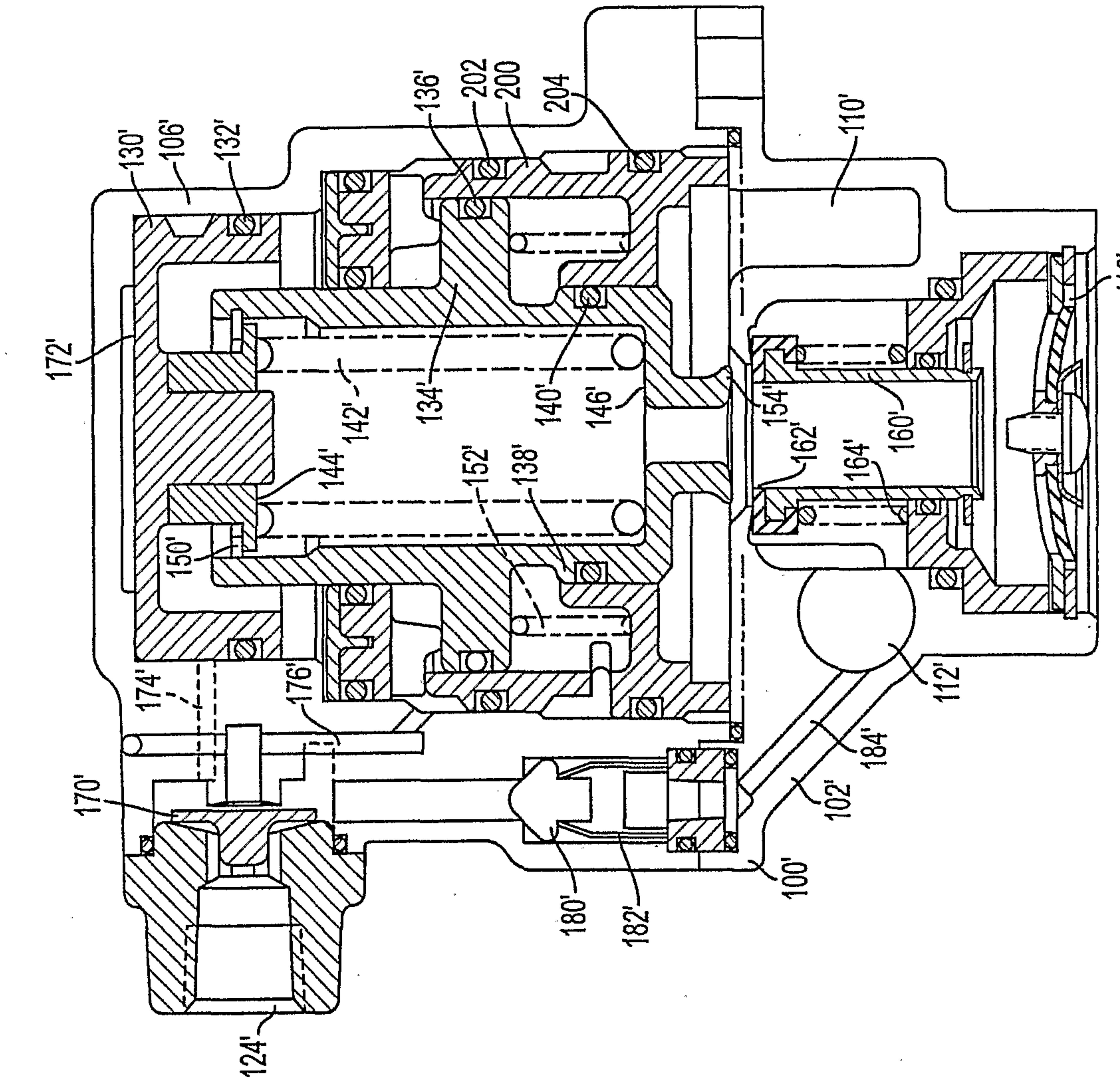
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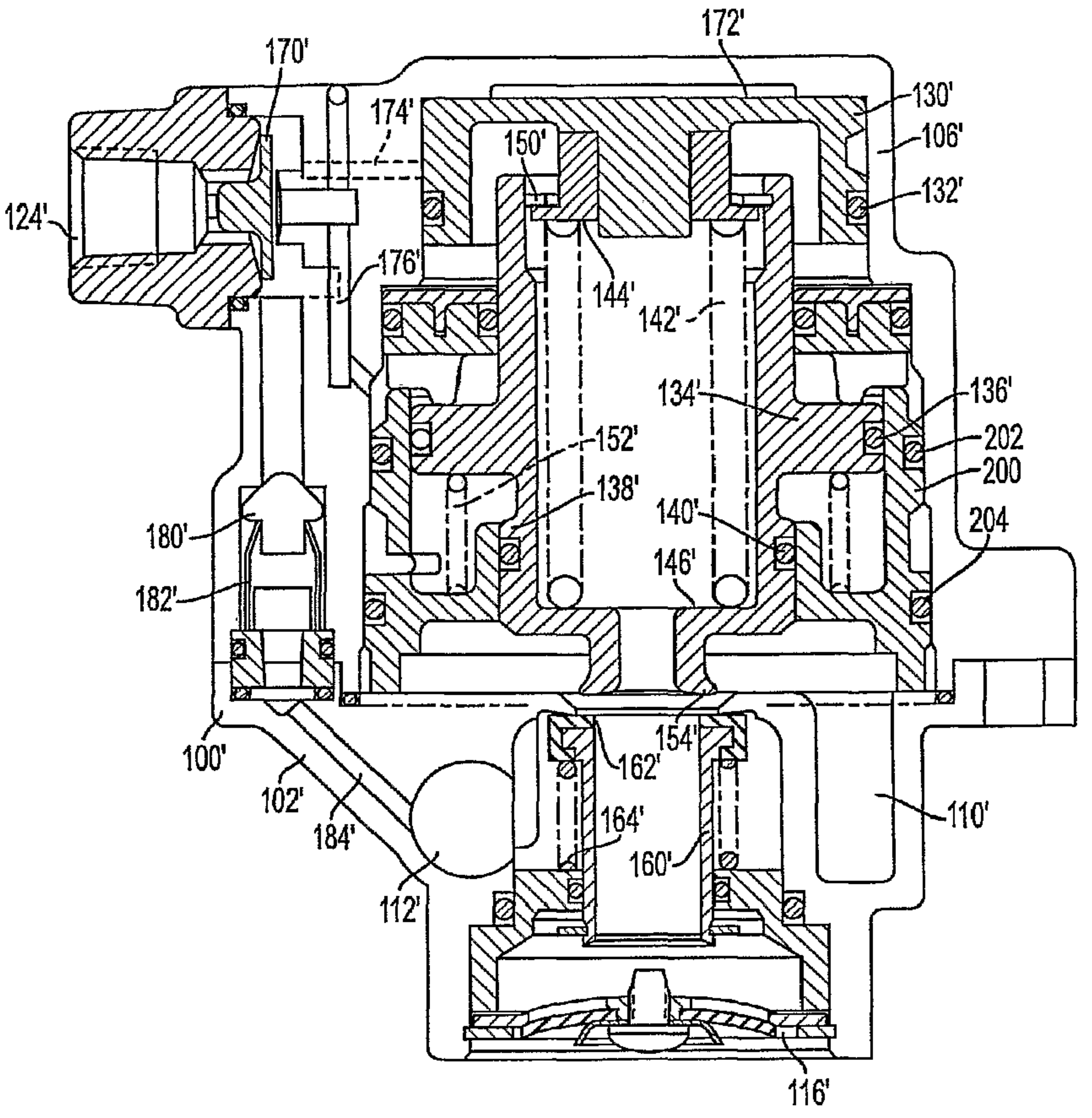
FIG. 11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