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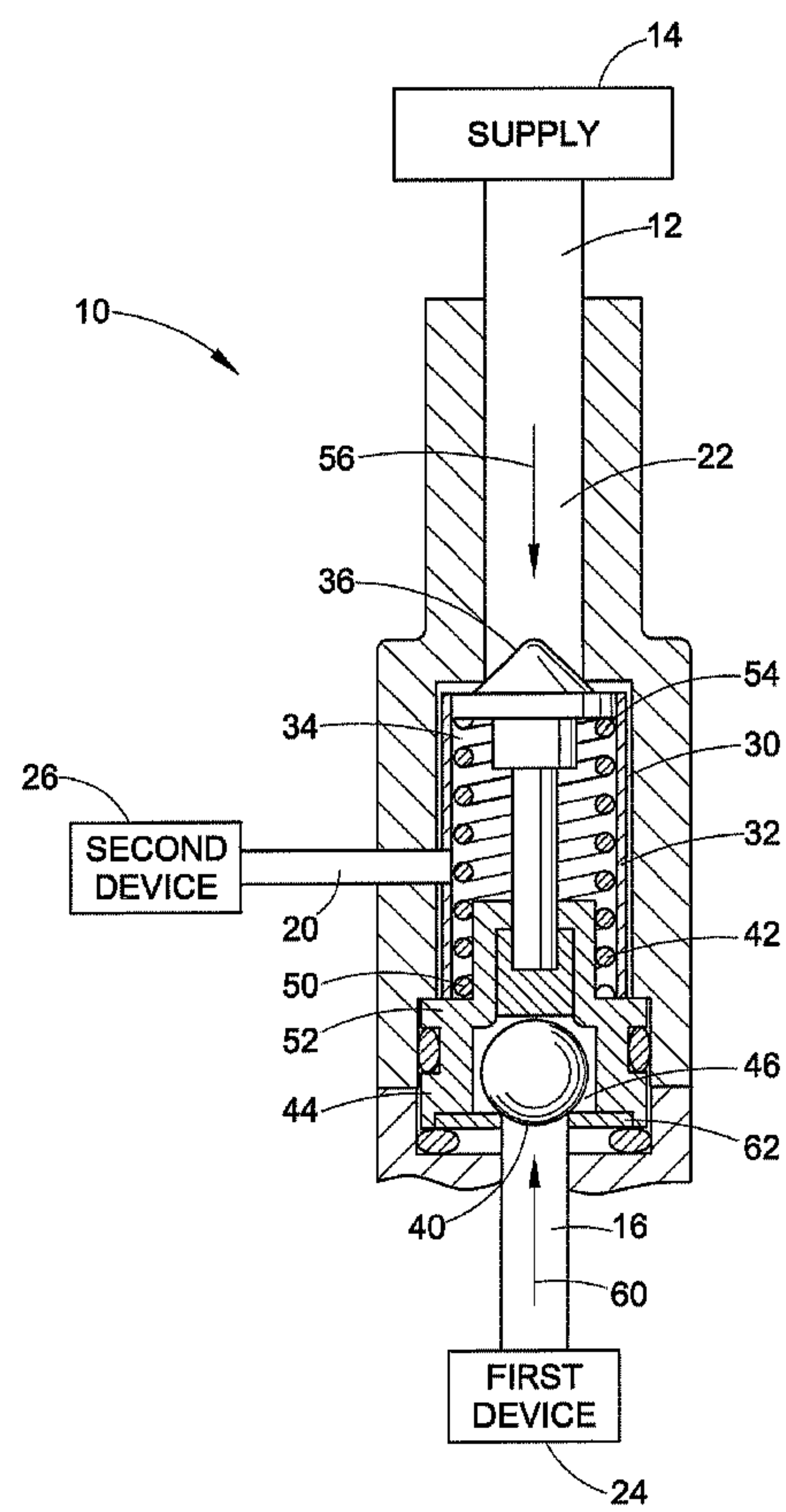
(54) **Title: CHECK VALVE**



(57) **Abrégé/Abstract:**
A valve includes a passage. A first sealing element is biased to restrict flow of a fluid in a first direction through the passage when an upstream volumetric flow rate of the fluid in the first direction is less than a first predetermined threshold. A second sealing element is biased to unrestrict flow of the fluid to a baseline unrestricted flow rate in a second direction through the passage when an upstream volumetric flow rate of the fluid in the second direction is less than a second predetermined threshold.

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(54) Title: CHECK VALVE

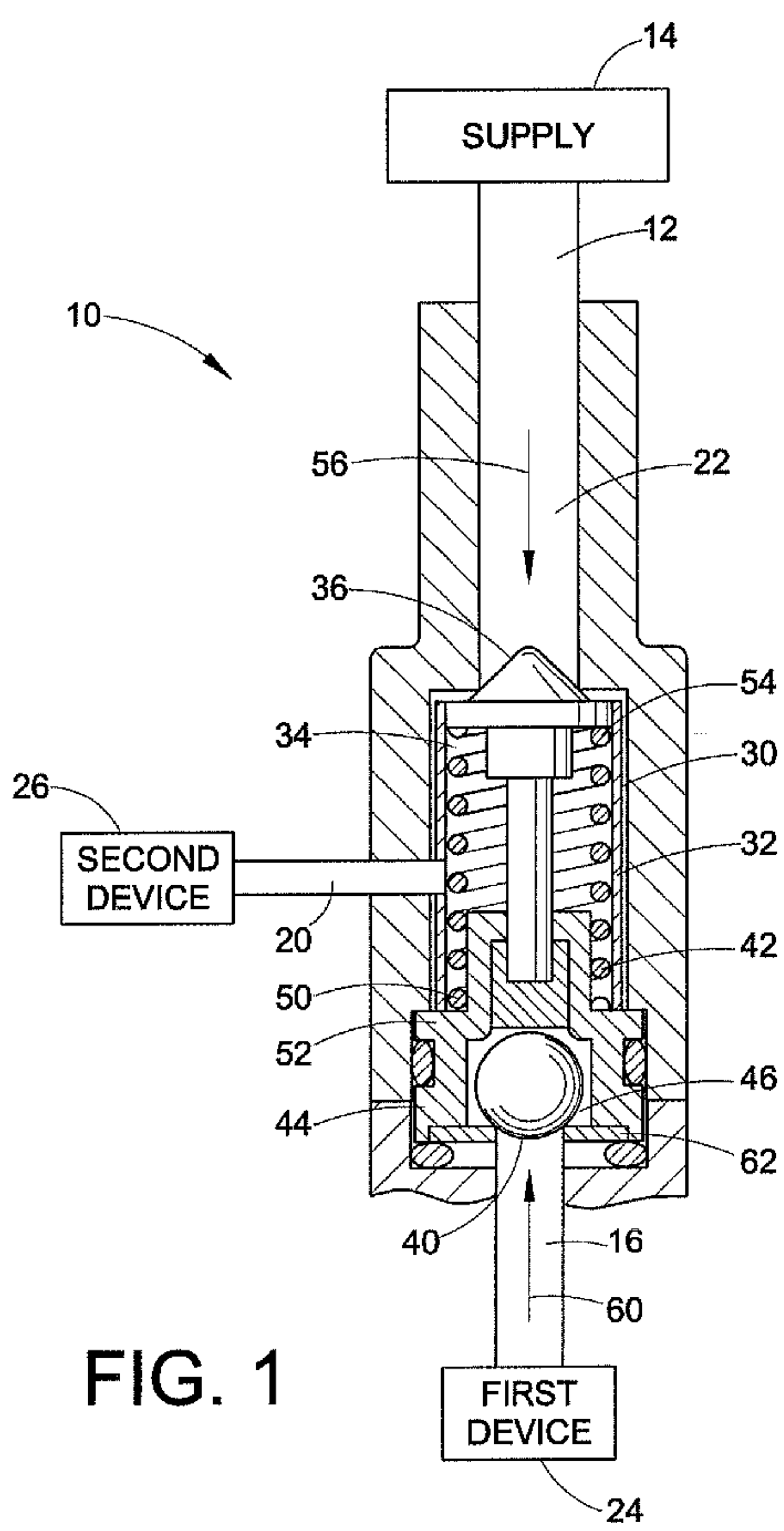

FIG. 1

(57) Abstract: A valve includes a passage. A first sealing element is biased to restrict flow of a fluid in a first direction through the passage when an upstream volumetric flow rate of the fluid in the first direction is less than a first predetermined threshold. A second sealing element is biased to unrestrict flow of the fluid to a baseline unrestricted flow rate in a second direction through the passage when an upstream volumetric flow rate of the fluid in the second direction is less than a second predetermined threshold.

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CHECK VALVE

Background

[0001] The present invention relates to a check valve. It finds particular application in conjunction with valves used in heavy vehicles and will be described with particular reference thereto. It will be appreciated, however, that the invention is also amenable to other applications.

[0002] Traditional check valves normally permit a fluid to flow through the valve in one direction. A threshold volumetric flow rate is the minimum upstream volumetric flow rate at which the valve operates to pass fluid—no fluid flows through the valve when the upstream volumetric flow rate is below the threshold volumetric flow rate. It is desirable to provide a check valve including dual threshold volumetric flow rates.

[0003] The present invention provides a new and improved apparatus and method for a dual threshold check valve.

Summary

[0004] In one aspect of the present invention, it is contemplated that a valve includes a passage. A first sealing element is biased to restrict flow of a fluid in a first direction through the passage when an upstream volumetric flow rate of the fluid in the first direction is less than a first predetermined threshold. A second sealing element is biased to unrestrict flow of the fluid to a baseline unrestricted flow rate in a second direction through the passage when an upstream volumetric flow rate of the fluid in the second direction is less than a second predetermined threshold.

[0004.1] In accordance with one aspect of the present invention, there is provided a method for controlling flow of a compressed fluid, the method comprising biasing a first sealing element to restrict flow of a fluid in a first direction through a passage when an upstream volumetric flow rate of the fluid in the first direction is less than a first predetermined threshold, and biasing a second sealing element to unrestrict flow of the fluid to a baseline unrestricted flow rate in a second direction through the passage when an upstream volumetric flow rate of the fluid in the second direction is less than a second predetermined threshold.

[0004.2] In accordance with another aspect of the present invention, there is provided a check valve, comprising a passage, means for restricting flow of a fluid in a first direction through the passage when an upstream volumetric flow rate of the fluid in the first direction is less than a first predetermined threshold, and means for restricting flow of the fluid in a second direction through the passage when an upstream volumetric flow rate of the fluid in the second direction is greater than a second predetermined threshold.

[0004.3] In accordance with a further aspect of the present invention, there is provided a check valve, comprising a passage, a first sealing element biased to restrict flow of a fluid in a first direction through the passage when an upstream volumetric flow rate of the fluid in the first direction is less than a first predetermined threshold, and a second sealing element biased by gravity to unrestrict flow of the fluid to a baseline unrestricted flow rate in a second direction through the passage when an upstream volumetric flow rate of the fluid in the second direction is less than a second predetermined threshold, the second direction being substantially opposite the first direction.

Brief Description of the Drawings

[0005] In the accompanying drawings which are incorporated in and constitute a part of the specification, embodiments of the invention are illustrated, which, together with a general description of the invention given above, and the detailed description given below, serve to exemplify the embodiments of this invention.

[0006] **FIGURE 1** illustrates a valve in accordance with one embodiment of an apparatus illustrating principles of the present invention;

[0007] **FIGURE 2** illustrates an enlarged view of the second sealing element in accordance with one embodiment of an apparatus illustrating principles of the present invention;

[0008] **FIGURE 3** illustrates an enlarged view of the grate in accordance with one embodiment of an apparatus illustrating principles of the present invention;

[0009] **FIGURE 4** illustrates a graph of delivery pressure versus leakage for the second sealing element; and

[0010] **FIGURE 5** illustrates a graph of a fluid flow to seat the second sealing element versus a weight of the second sealing element.

Detailed Description of Illustrated Embodiment

[0011] With reference to **FIGURE 1**, an exemplary valve **10** is illustrated in accordance with one embodiment of the present invention. The valve **10** includes a supply port **12**, which receives compressed fluid from a supply **14**, a first delivery port **16**, and a second delivery port **20**. A valve passage **22** ("the first passage") fluidly communicates with the supply port **12**, the first delivery port **16** which fluidly supplies the compressed fluid to a first device **24**, and the second delivery port **20** which fluidly supplies the compressed fluid to a second device **26**. A fluid control valve **30** is positioned in the first passage **22**.

[0012] The fluid control valve **30** (e.g., a check valve) includes a housing **32**, a fluid control valve passage **34** ("the second passage") defined in the housing **32**, a first sealing element **36**, a second sealing element **40**, and a biasing member **42** (e.g., a spring). A sealing element housing **44** is secured within the housing **32** and defines a volume **46** in which the second sealing element **40** is positioned. In the illustrated embodiment, a first end **50** of the biasing member **42** abuts a shoulder **52** of the sealing element housing **44**. A second end **54** of the biasing member **42** biases the first sealing element **36** to create a seal between the first and second passages **22, 34**, respectively, when an upstream volumetric flow rate of a fluid passing through the first passage **22** in a first direction (see arrow indicated at **56**) is less than a first predetermined threshold. The second sealing element **40** is biased to provide a first baseline unrestricted flow of the fluid when an upstream volumetric flow rate of the fluid passing from the first delivery port **16** to the second passage **34** through the volume **46** in a second direction (see arrow indicated at **60**) is less than a second predetermined threshold. A second baseline unrestricted flow of the fluid is achieved when the fluid flows from the second passage **34** to the first delivery port **16** via the volume **46** in the first direction **56** while the second sealing element **40** is in the biased position.

[0013] In the illustrated embodiment, it is contemplated that the first sealing element **36** is a soft, elastomeric material. The first sealing element **36** and the biasing member **42** act as a means for restricting flow of the fluid in the first direction **56** through the second passage **34**.

[0014] In addition, it is contemplated that the second sealing element **40** is a rounded object (e.g., a sphere, a ball, etc) of a non-elastomeric material. For example, it is contemplated in one embodiment that the second sealing element **40** is a stainless steel ball. It is to be understood that other embodiments in which the second sealing element **40** is a shape other than rounded and/or a material other than stainless material are also contemplated.

[0015] As discussed above, the second sealing element **40** is positioned in the volume **46** of the housing **44** of the fluid control valve **30**. A grate **62** is secured to one end of the housing **44** to secure the second sealing element **40** in the volume **46** of the housing **44**.

[0016] With reference to **FIGURES 2 and 3**, the grate **62** includes a plurality of arms **64** (e.g., four) partially extending from an inner radial edge **66** toward a center point shown at **70**. An inner region **72** (identified by the dashed line in **FIGURE 3**) of the grate **62** is open. The second sealing element **40** is sized to be seated on the arms **64** of the grate **62**—when the second sealing element **40** is in the biased position—such that the second sealing element **40** does not pass through the grate **62**. In addition, fluid flows (in both the first and second directions **56**, **60**, respectively (see **FIGURE 1**)) through intermediate regions **74** between the arms **64** regardless of whether the second sealing element **40** is seated on the arms **64**.

[0017] With reference to **FIGURES 1–3**, the grate **62** acts to cage the second sealing element **40** in the volume **46** while allowing flow of the fluid around the second sealing element **40** and through the grate **62**. The second sealing element **40** freely moves within the volume **46** as a function of at least one of a tolerance between the second sealing element **40** and an inner wall **76** of the housing **44**, a weight of the second sealing element **40** and/or a size (e.g., radius or diameter) of the second sealing element **40**. The second sealing element **40**, the volume **46**, the grate **62**, and the housing **44** act as a means for restricting flow of the fluid in the second direction **60** through the second passage **34**.

[0018] The valve **10** is oriented so that gravity biases the second sealing element **40** to rest on the arms **64** of the grate **62** (i.e., the biased position). In this position, the first and second baseline unrestricted flows of the fluid in both the first and second directions **56**, **60** through the second passage **34** are possible when the upstream volumetric flow rate of the fluid in the second direction **60** is less than the second predetermined threshold. When the upstream volumetric flow rate of the fluid in the second direction **60** becomes greater than the second predetermined threshold, the second sealing element **40** is carried by the flow of the fluid off of the arms **64** of the grate **62** and toward a seat **80** of the housing **44**. The illustrated design including a sphere **40** caged, but freely moving within, the volume **46** offers robust sealing against the seat **80** under various environmental conditions. At the same time, the design eliminates the need for a spring to bias the second sealing element **40**.

[0019] In one embodiment, once the second sealing element **40** is seated on the seat **80**, flow of the fluid is restricted to about 10,000 standard cubic centimeters per minute (sccm) or less in the second direction **60**. Therefore, the fluid is restricted from flowing from the first delivery port **16** to the supply port **12** and the second delivery port **20**. However, the fluid is still free to flow approaching the first baseline unrestricted flow rate in the first direction **56** (i.e., from the supply port **12** and/or the second delivery port **20** to the first delivery port **16**), which would fluidly push the second sealing element **40** back toward the biased position on the grate **62**. The second sealing element **40** remains seated on the seat **80** as long as the upstream volumetric flow rate of the fluid in the second direction **60** remains greater than the second predetermined threshold.

[0020] It is contemplated that at a desired pressure and opening size to operate the valve, the first predetermined threshold is about 700 sccm. In addition, it is contemplated that the second sealing element **40** moves from the grate **62** to the seat **80** on the housing **44** when the fluid flows in the second direction **60** (i.e., from the first delivery port **16** to the supply port **12**) through the second passage **34** at a rate of about 10,000 sccm. Therefore, it is contemplated that the second predetermined threshold is about 10,000 sccm. It is also contemplated that the first predetermined volumetric threshold flow may be larger than the second predetermined volumetric threshold flow. For example, if it is desired that the supply **14** acts as a primary source of fluid for larger airflow volume to the second device **26** while the first device **24** acts as a secondary source of fluid for lower airflow volume to the second device **26**, the first predetermined threshold may be 15,000 sccm and the second predetermined threshold may be 10,000 sccm.

[0021] In one embodiment, it is desirable to supply fluid from the supply **14** to the first and second devices **24**, **26**, respectively. After the first and second devices **24**, **26** are fully charged, fluid is no longer supplied from the supply **14** and the first sealing element **36** is seated in the biased position illustrated in **FIGURE 1** to create a seal between the supply port **12** and the second passage **34**. Once the first sealing element **36** is seated, flow of the fluid less than the second predetermined threshold in the second direction **60** from the first delivery port **16** to the second passage **34** does not seat the second sealing element **40** on the seat **80**. Therefore, fluid is permitted to flow from the first device **24** to the second device **26** via the second passage **34**. Once the second sealing element **40** is seated on the seat **80**, flow of the fluid from the first device **24** to the second device **26** is restricted to less than the second predetermined threshold (e.g., approaching 2,000 sccm or 4,000 sccm). Such a restricted flow may be desired if a leak develops in the second device **26**. For example, the restricted flow of fluid would slowly provide additional fluid to the second device **26** so that the leak may be repaired and/or the supply **14** reactivated before the first device **24** is depleted of fluid.

[0022] As discussed above, the second sealing element **40** freely moves within the volume **46** as a function of a tolerance between the second sealing element **40** and the inner wall **76** of the housing **44**, a weight of the second sealing element **40** and/or a size (e.g., radius or diameter) of the second sealing element **40**. In one embodiment, a diameter of the second sealing element **40** is about 0.218 inches and the inside diameter of the volume **46** is about 0.260 inches, which provides a diameter clearance of about 0.042 inches between the second sealing element **40** and the inner wall **76**. In this embodiment, the second predetermined threshold is about 13,700 sccm.

[0023] With reference to **FIGURE 4**, a graph **82** illustrating the diameter clearance (e.g., tolerance) versus a leak rate is provided. With reference to **FIGURES 1 and 4**, the leak rate represents a flow of the fluid from the first device **24** to the second passage **34** that will seat the second sealing element **40** on the seat **80**.

[0024] With reference to **FIGURE 5**, a graph **84** illustrating a fluid flow to seat the second sealing element versus a weight of the second sealing element is provided. The graph **84** shows more fluid flow is required to seat a heavier second sealing element.

[0025] In one embodiment, the housing **32** is a metal material (e.g., aluminum or steel), the housing **44** is a plastic material, and the grate **62** is a metal material (e.g., stainless steel). Therefore, in the embodiment in which the second sealing element **40** is stainless steel, a steel-against-plastic seal is created between the housing **44** and the second sealing element **40**.

[0026] While the present invention has been illustrated by the description of embodiments thereof, and while the embodiments have been described in considerable detail, additional advantages and modifications will readily appear to those skilled in the art. Therefore, the invention, in its broader aspects, is not limited to the specific details, the representative apparatus, and illustrative examples shown and described. The scope of the claims should not be limited by the preferred embodiments set forth in the examples, but should be given the broadest interpretation consistent with the description as a whole.

CLAIMS:

1. A valve, comprising:

a passage;

a first element biased to restrict flow of a fluid in a first direction through the passage when an upstream volumetric flow rate of the fluid in the first direction is less than a first predetermined threshold; and

a second element biased to unrestrict flow of the fluid to a baseline unrestricted flow rate in a second direction through the passage when an upstream volumetric flow rate of the fluid in the second direction is less than a second predetermined threshold, the second element movable to a seat when the upstream volumetric flow rate of the fluid in the second direction is greater than the second predetermined threshold, the fluid flowing through the passage in the second direction when the element is seated on the seat.

2. The valve as set forth in claim 1, wherein:

the first element is disposed at a first end of the passage; and

the second element is disposed at a second end of the passage.

3. The valve as set forth in claim 1, further including:

a spring biasing the first element.

4. The valve as set forth in claim 1, wherein:

the second element is a ball; and

gravity biases the ball to permit flow of the fluid in the first and second directions through the passage when the upstream volumetric flow rate of the fluid in the second direction is less than the second predetermined threshold.

5. The valve as set forth in claim 4, wherein the ball is stainless steel.

6. The valve as set forth in claim 4, wherein the second predetermined threshold is a function of at least one of a weight of the ball and a diameter of the ball.

7. The valve as set forth in claim 6, further including:

a housing fluidly communicating with the passage;

wherein the ball is positioned in the housing;

wherein the ball moves within the housing as a function of a tolerance between the ball and the housing; and

wherein the second predetermined threshold is also a function of the tolerance between ball and housing.

8. The valve as set forth in claim 7, wherein the housing includes:

the seat, the ball being seated against the seat and restricting flow of the fluid when the upstream volumetric flow rate of the fluid in the second direction is greater than the second predetermined threshold; and

a grate, the ball being positioned between the seat and the grate, the fluid freely flowing through the grate in both the first and second directions regardless of a position of the ball;

wherein the ball moves between the seat and the grate as a function of at least one of the upstream volumetric flow rate of the fluid in the second direction, the weight of the ball, the size of the ball, and the tolerance between the ball and the housing.

9. The valve as set forth in claim 8, wherein the grate cages the ball in the housing.

10. The valve as set forth in claim 1, wherein the first predetermined threshold is less than the second predetermined threshold.

11. A method for controlling flow of a compressed fluid, the method comprising:

biasing a first element to restrict flow of a fluid in a first direction through a passage when an upstream volumetric flow rate of the fluid in the first direction is less than a first predetermined threshold;

biasing a second element to unrestrict flow of the fluid to a baseline unrestricted flow rate in a second direction through the passage when an upstream volumetric flow rate of the fluid in the second direction is less than a second predetermined threshold; and

positioning the second element on a seat when the upstream volumetric flow rate of the fluid in the second direction is greater than the second predetermined threshold, the fluid flowing through the passage at a restricted rate in the second direction when the second element is positioned on the seat.

12. The method for controlling flow of a compressed fluid as set forth in claim 11, wherein the step of biasing the second element includes:

biasing the second element via gravity.

13. The method for controlling flow of a compressed fluid as set forth in claim 12, further including:

determining the second predetermined threshold as a function of a weight of the second element.

14. The method for controlling flow of a compressed fluid as set forth in claim 11, further including:

unseating the second element from the seat for unrestricting the flow of the fluid in the second direction when the upstream volumetric flow rate of the fluid in the second direction is less than the second predetermined threshold.

15. A check valve, comprising:

a passage;

a first element biased to restrict flow of a fluid in a first direction through the passage when an upstream volumetric flow rate of the fluid in the first direction is less than a first predetermined threshold;

a second element biased by gravity to unrestrict flow of the fluid to a baseline unrestricted flow rate in a second direction through the passage when an upstream volumetric flow rate of the fluid in the second direction is less than a second predetermined threshold, the second direction being substantially opposite the first direction; and

the second element moving to a seat to restrict flow of the fluid in the second direction through the passage when the upstream volumetric flow rate of the fluid in the second direction is greater than the second predetermined threshold, the fluid flowing through the passage in the second direction when the second element is seated on the seat.

16. The check valve as set forth in claim 15, wherein the second element is a ball.

17. The valve as set forth in claim 1, wherein the second predetermined threshold is 10,000 sccm.

18. The valve as set forth in claim 1, wherein when the upstream volumetric flow rate of the fluid in the second direction exceeds the second predetermined threshold, the flow rate in the second direction around the second element is restricted to about 10,000 sccm.

19. The method for controlling flow of a compressed fluid as set forth in claim 11, further including:

restricting the flow of the fluid in the second direction to about 10,000 sccm when the upstream volumetric flow rate of the fluid in the second direction is greater than the second predetermined threshold.

20. The check valve as set forth in claim 15, wherein the second element restricts flow of the fluid in the second direction to about 10,000 sccm.

21. A valve comprising:

a first passage for receiving supply air;

a first port for delivering supply air to a first device;

a second port for delivering supply air to a second device;

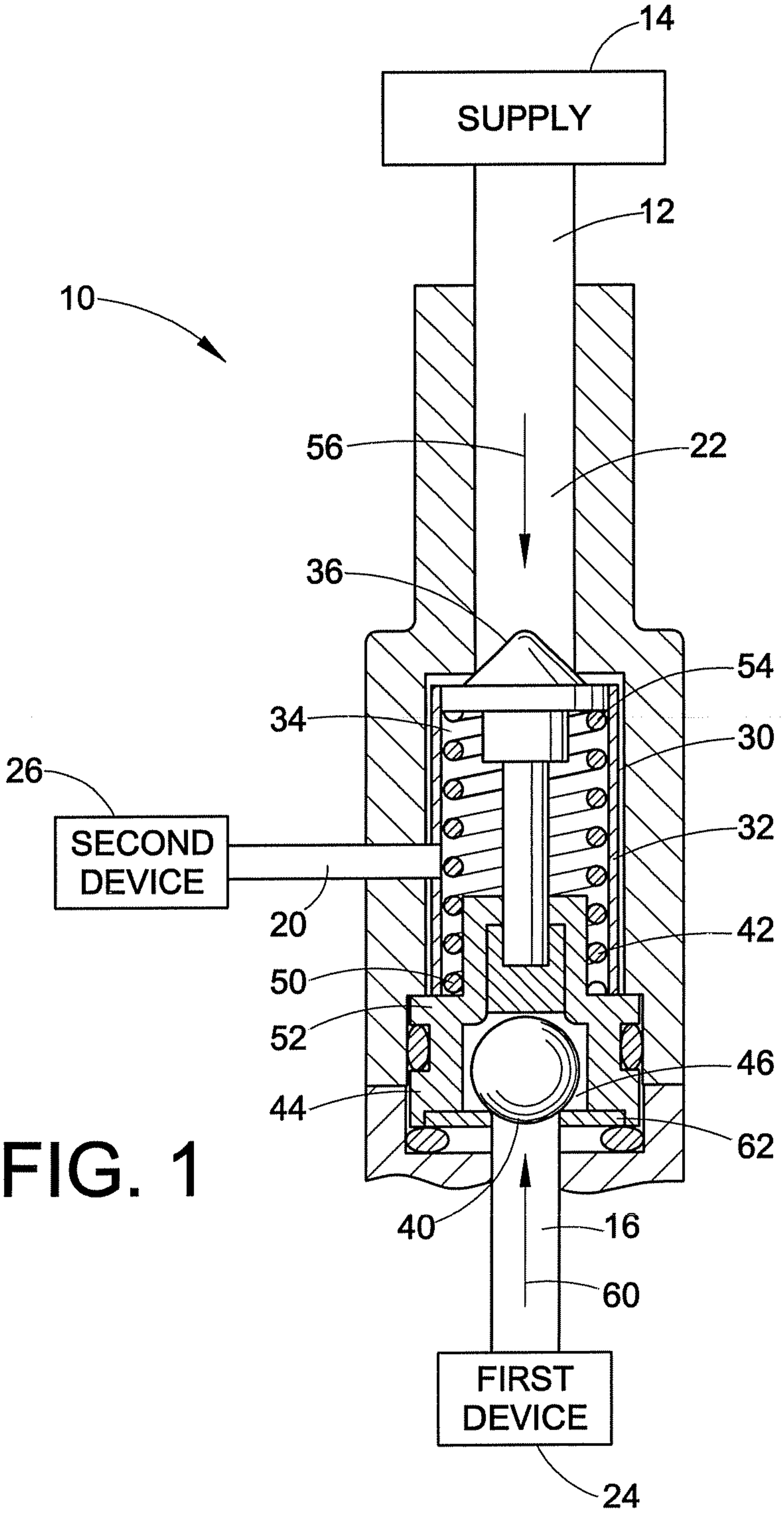
a second passage in fluid communication with the first passage, the first port and the second port;

a seat located between the second passage and the first port;

a first element positioned between the first passage and the second passage, the first element permitting the flow of supply air from the first passage to the second passage when the supply air flow rate in a first direction is greater than a first predetermined threshold; and

a second element positioned between the seat and the first port, the second element permitting unrestricted flow of the supply air in the first direction into the first device and the second element permitting unrestricted air flow in a second direction, opposite of the first direction, from the first device into the second passage when an air flow rate in the second direction is less than a second predetermined threshold and the second element permitting a restricted flow of air in the second direction when the air flow rate in the second direction is greater than the second predetermined threshold, and the second element is seated on the seat.

22. The valve as set forth in claim 21, wherein the second element permits a restricted flow rate from the first device to the second passage of 10,000 sccm.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FIRST DEVICE
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FIG. 1

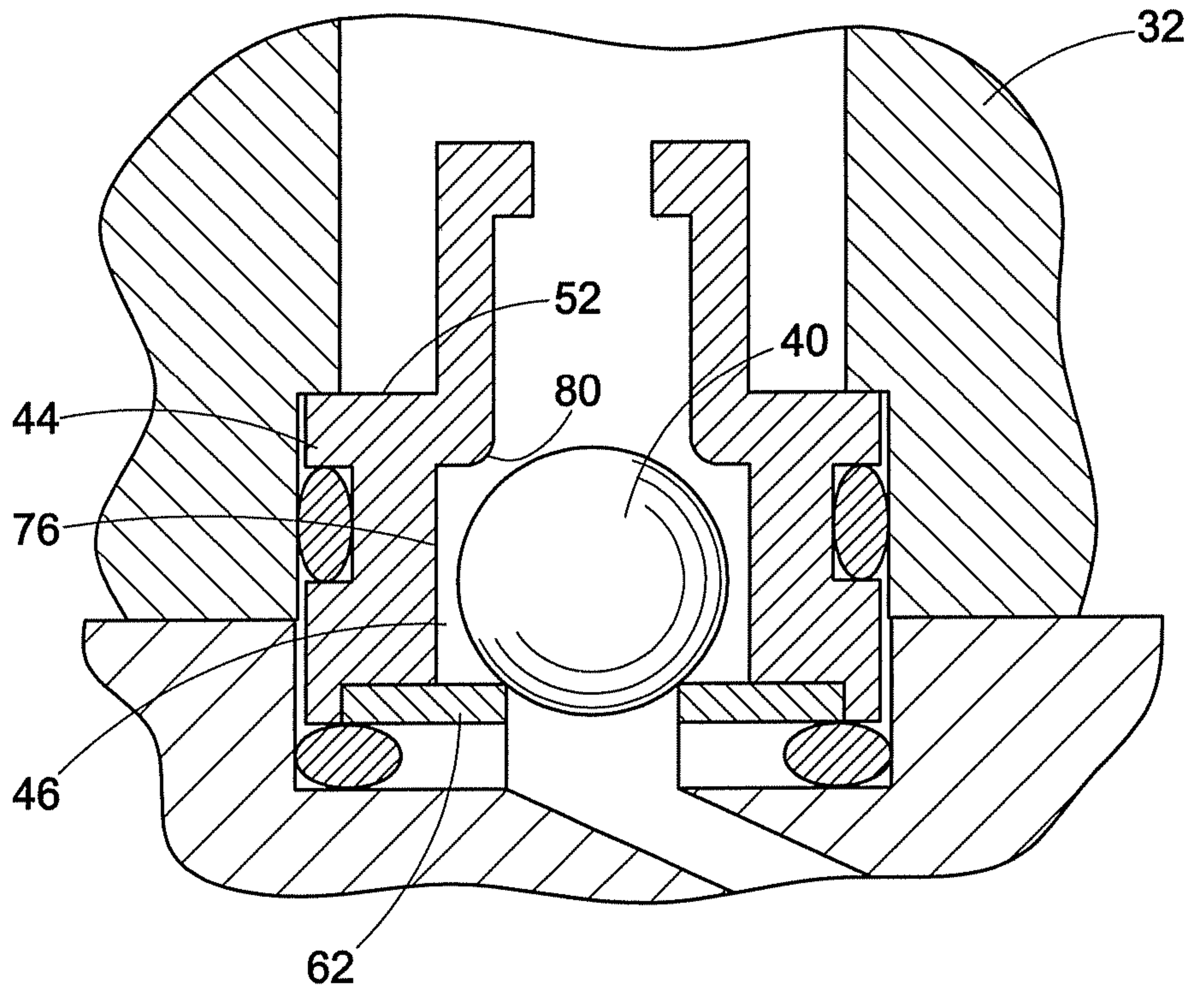


FIG. 2

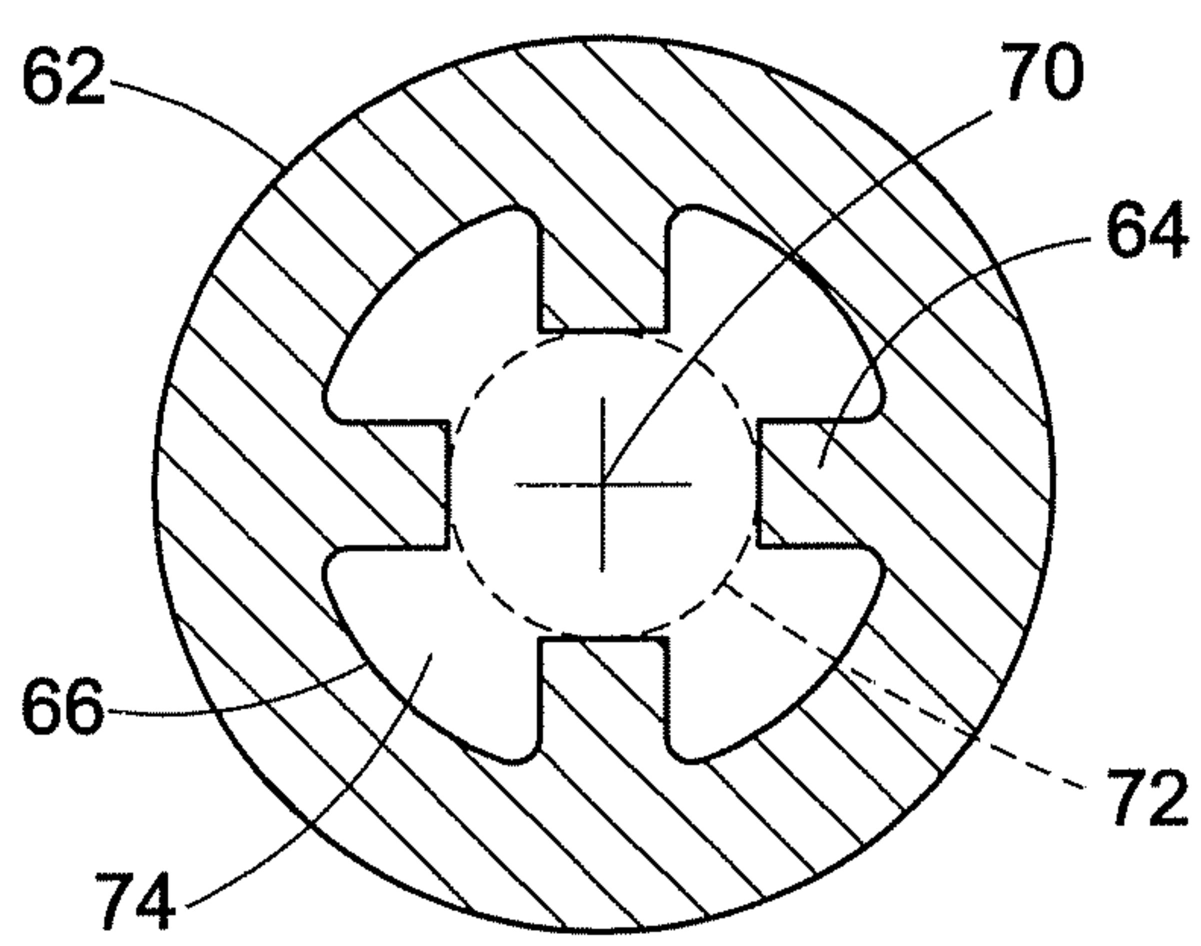


FIG. 3

BALL VALVE DIAMETER CLEARANCE VS.
REQUIRED LEAK RATE TO LIFT BALL VALVE
HEAD PRESSURE = 0.5 TO 1.0 PSI
PLASTIC GUIDE ID = 0.260 INCHES

LEAKAGE FLOW RATE AROUND THE STAINLESS STEEL BALL VALVE		
BALL DIAMETER	DIA CLEARANCE	LEAK RATE
(INCH)	(INCH)	(SCCM)
0.177	0.083	20,400
0.218	0.042	13,700
0.236	0.024	7,900

82

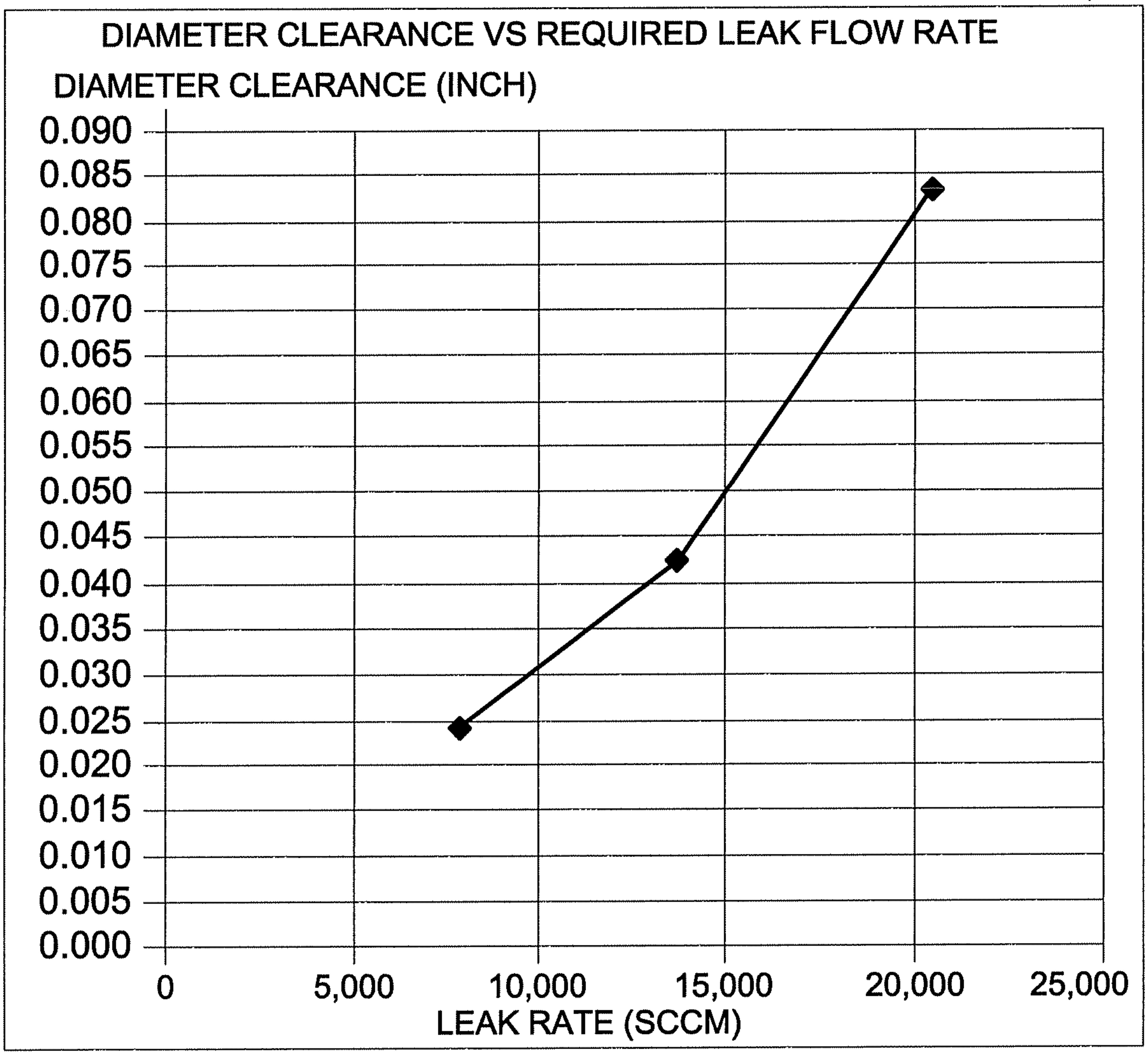


FIG. 4

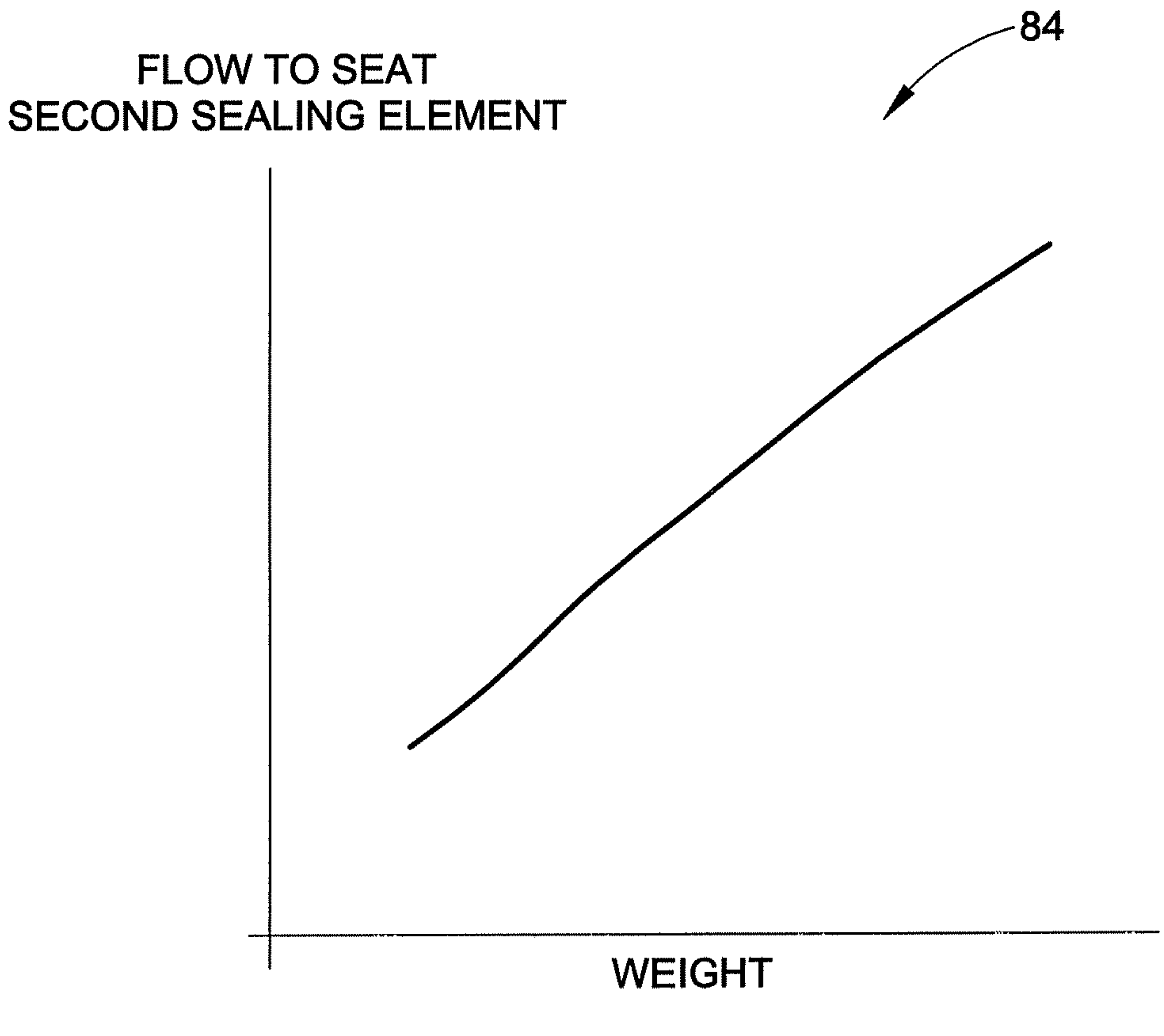
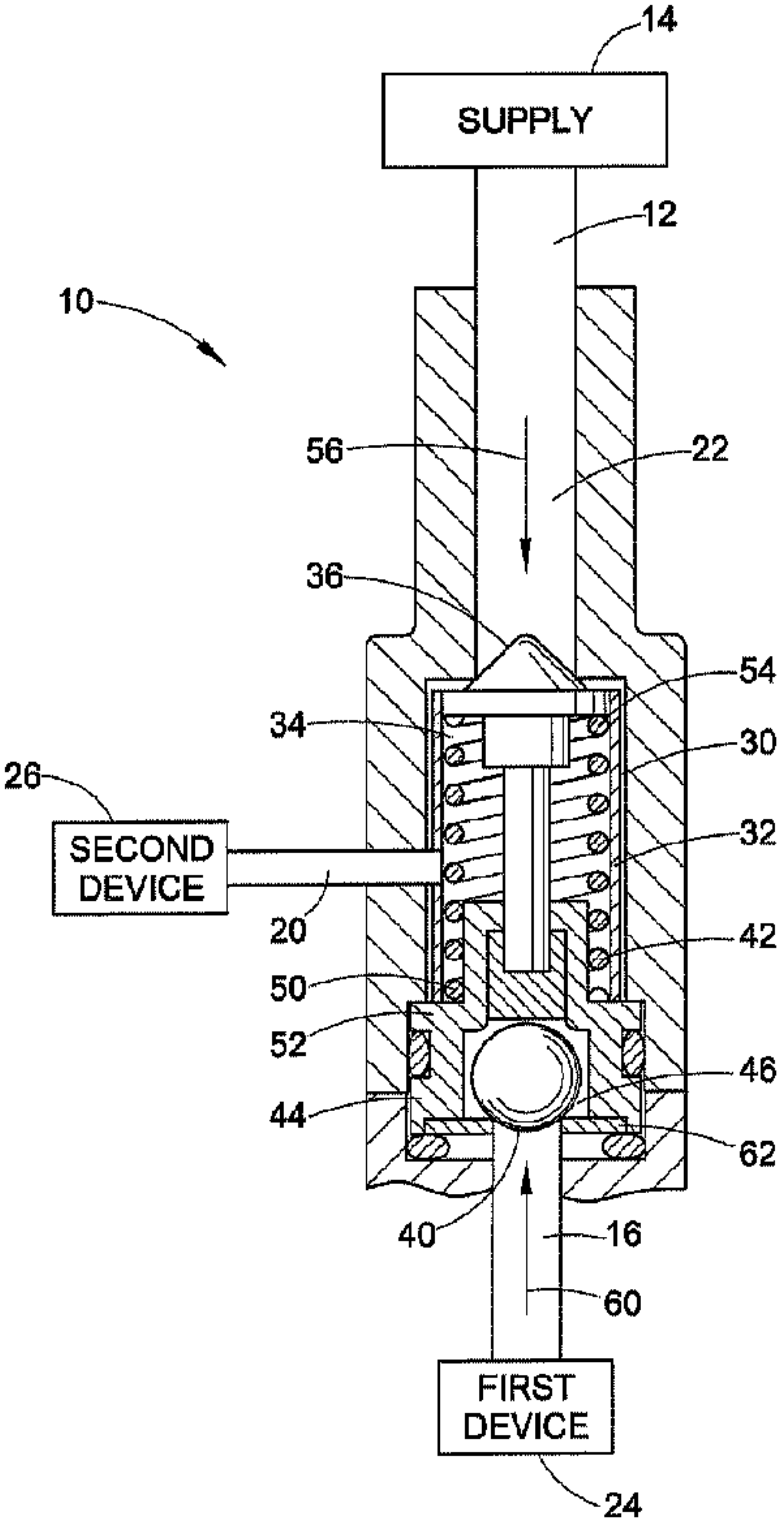


FIG. 5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