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*[Continued on next page]*

(54) Title: FLOW METERING VALVE

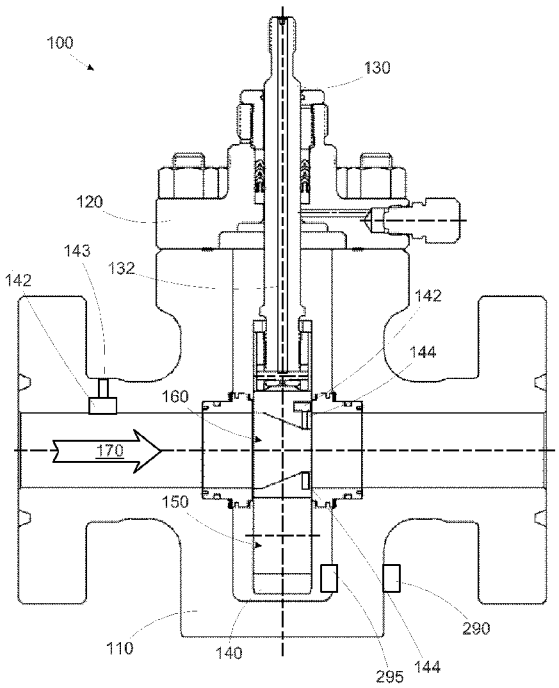



Figure 1

(57) Abstract: A valve includes a housing, a stern supported by the housing, and a valve member coupled to the stem. The valve member has a first passage defined therein with a metering flow profile, An apparatus includes a well tree having a production bore and a flow metering valve coupled to the well tree and communicating with the production bore. The flow metering valve Includes a valve member having a first passage defined therein with a metering flow profile and a second passage defined therein with an unrestricted flow profile. The second passage having a diameter substantially equal to a diameter of the production bore.

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— *with international search report (Art. 21(3))*

— *with amended claims (Art. 19(1))*

# FLOW METERING VALVE

## BACKGROUND

The disclosed subject matter relates generally to fluid systems manufacturing and, more particularly, to a flow metering valve.

In the hydrocarbon industry, meters are employed to measure large quantities of fluid, such as oil, that are transferred from one entity to another *(e.g.,* a custody transfer). One of the fundamental measurements in multiphase metering is volumetric flow rate. Typically, volumetric flow rate measurement is achieved by creating a restriction in the flow path and measuring the pressure drop across the restriction. A common instrument for creating this measurement is a venturi.

In some applications, the piping through which the volumetric flow rate is to be measured is also used to perform mechanical operations. For example, to monitor a piping section a sensor module, or "pig" may be passed through the line. The pig may seal to the inside diameter of the piping so that the pressure created propels the module through the piping. Such a module cannot pass through a flow metering section sue to the restricted cross-section. In another example, for a hydrocarbon production well, a well tree *(i.e.,* or Christmas tree) may be attached to the well head. The well tree includes various valves and instrumentation for monitoring the well and controlling flow there from. It is difficult to integrate a flow metering device with a well tree due to the length of metering section and also due to the metering profile, which reduces the inside diameter of the piping. Due to the reduction in diameter, an operator performing workover operations would be prohibited from running certain wireline tools through the metering profile. A metering package coupled to the well tree would have to be removed from the well or bypassed to allow the insertion of wireline tools through the production flow path.

This section of this document is intended to introduce various aspects of art that may be related to various aspects of the disclosed subject matter described and/or claimed below. This section provides background information to facilitate a better understanding of the various aspects of the disclosed subject matter. It should be understood that the statements in this section of this document are to be read in

this light, and not as admissions of prior art. The disclosed subject matter is directed to overcoming, or at least reducing the effects of, one or more of the problems set forth above.

## BRIEF SUMMARY

The following presents a simplified summary of the disclosed subject matter in order to provide a basic understanding of some aspects of the disclosed subject matter. This summary is not an exhaustive overview of the disclosed subject matter. It is not intended to identify key or critical elements of the disclosed subject matter or to delineate the scope of the disclosed subject matter. Its sole purpose is to present some concepts in a simplified form as a prelude to the more detailed description that is discussed later.

One aspect of the disclosed subject matter is seen in a valve including a housing, a stem supported by the housing, and a valve member coupled to the stem. The valve member has a first passage defined therein with a metering flow profile.

Another aspect of the disclosed subject matter is seen in an apparatus including a well tree having a production bore and a flow metering valve coupled to the well tree and communicating with the production bore. The flow metering valve includes a valve member having a first passage defined therein with a metering flow profile and a second passage defined therein with an unrestricted flow profile. The second passage having a diameter substantially equal to a diameter of the production bore.

## BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWINGS

The disclosed subject matter will hereafter be described with reference to the accompanying drawings, wherein like reference numerals denote like elements, and:

Figures 1 and 2 are cross-section views of a flow metering gate valve in accordance with one illustrative embodiment of the present subject matter;

Figure 3 is a cross-section view of a gate member that may be used in the valve of Figure 1 adapted for three positions;

Figure 4 is a cross-section view of a flow metering ball valve in accordance with another illustrative embodiment of the present subject matter; and

Figure 5 is a diagram of a well tree including the flow metering gate valve of Figure 1.

While the disclosed subject matter is susceptible to various modifications and alternative forms, specific embodiments thereof have been shown by way of example in the drawings and are herein described in detail. It should be understood, however, that the description herein of specific embodiments is not intended to limit the disclosed subject matter to the particular forms disclosed, but on the contrary, the intention is to cover all modifications, equivalents, and alternatives falling within the spirit and scope of the disclosed subject matter as defined by the appended claims.

## DETAILED DESCRIPTION

One or more specific embodiments of the disclosed subject matter will be described below. It is specifically intended that the disclosed subject matter not be limited to the embodiments and illustrations contained herein, but include modified forms of those embodiments including portions of the embodiments and combinations of elements of different embodiments as come within the scope of the following claims. It should be appreciated that in the development of any such actual implementation, as in any engineering or design project, numerous implementation-specific decisions must be made to achieve the developers' specific goals, such as compliance with system-related and business related constraints, which may vary from one implementation to another. Moreover, it should be appreciated that such a development effort might be complex and time consuming, but would nevertheless be a routine undertaking of design, fabrication, and manufacture for those of ordinary skill having the benefit of this disclosure. Nothing in this application is considered critical or essential to the disclosed subject matter unless explicitly indicated as being "critical" or "essential."

The disclosed subject matter will now be described with reference to the attached figures. Various structures, systems and devices are schematically

depicted in the drawings for purposes of explanation only and so as to not obscure the disclosed subject matter with details that are well known to those skilled in the art. Nevertheless, the attached drawings are included to describe and explain illustrative examples of the disclosed subject matter. The words and phrases used herein should be understood and interpreted to have a meaning consistent with the understanding of those words and phrases by those skilled in the relevant art. No special definition of a term or phrase, *i.e.*, a definition that is different from the ordinary and customary meaning as understood by those skilled in the art, is intended to be implied by consistent usage of the term or phrase herein. To the extent that a term or phrase is intended to have a special meaning, *i.e.*, a meaning other than that understood by skilled artisans, such a special definition will be expressly set forth in the specification in a definitional manner that directly and unequivocally provides the special definition for the term or phrase.

Referring now to the drawings wherein like reference numbers correspond to similar components throughout the several views and, specifically, referring to Figure 1, the disclosed subject matter shall be described in the context of a flow metering gate valve 100. The valve 100 includes a body 110, a bonnet 120, a rising valve stem 130, and a gate 140. For ease of illustration, the valve actuator is not illustrated. Various type of manual, motor-operated, or hydraulic operators are known in the art, and may be used in conjunction with the valve 100.

As illustrated in Figure 1, the gate 140 has two flow passages, an unrestricted passage 150 and a restricted passage 160 having a venturi-type profile. In the illustrated embodiment, the venturi-type profile is a Dall tube profile, which is essentially a shortened venturi tube. Of course, other types of restricted profiles may be used, such as an orifice plate, a v-cone, a flow mixer, *etc.* Such venturi-type profiles may be collectively referred to as metering profiles. Hence, the gate 140 may be referred to as a valve member having a first passage defined therein with a metering flow profile and a second passage defined therein with an unrestricted flow profile. For ease of illustration, and to avoid obscuring the present subject matter, the conventional parts of the valve 100, such as the packing, stem attachment details, bolts, seals, *etc.*, are not described in detail, as they are known to those of ordinary skill in the art.

In Figure 1, the valve 100 is shown in a seated position. In the seated position, the restricted passage 160 is aligned with the flow path 170. In this position, the valve 100 is in a flow metering position. Sensors 142 and ports 143, 144 are defined in the gate 140 for detecting the pressure across the restricted passage 160. One or more ports 132 may also be defined in the stem 130 for passing an electrical connector to communicate the sensed pressure(s). A differential pressure across the restricted passage 160 may be measured using the sensors 142 and ports 143, 144, to determine the volumetric flow rate. Both absolute pressures may be measured to determine the differential pressure, or a differential pressure sensor may be used. Increased accuracy may be obtained by measuring both differential pressure and the absolute pressure of at least the restricted flow path. The particular location of the sensors 142 and ports 143, 144 for measuring the pressures may vary. For example, ports may be provided in the gate 140 or the body 110. It is also contemplated that one or more ports or sensors may be provided in the piping upstream of the valve to measure the unrestricted pressure. Those of ordinary skill in the art are familiar with techniques for taking flow measurements across a venturi profile. For example, techniques for measuring flow parameters using a flow restricting device are described in WO2007/129897, entitled "A METHOD AND APPARATUS FOR TOMOGRAPHIC MULTIPHASE FLOW MEASUREMENTS."

In Figure 2, the valve 100 is shown in a back-seated position. In this position, the unrestricted passage 150 is aligned with the flow path 170. The use of the unrestricted passage 150 allows full flow with minimal pressure losses across the valve 100. Because the unrestricted passage 150 has substantially the same diameter as the attached piping, equipment, such as wire line tools, may be passed through the valve unhindered.

Turning now to Figure 3, a cross-section view of an alternative gate 140' is provided. The gate 140 of Figure 1 includes an open position (*i.e.*, unrestricted) and a metering position. In some instances, it may be useful to close the valve entirely. To achieve this capability, the gate 140' includes the unrestricted passage 150, the restricted passage 160, and a solid portion 180 that stops the flow through the valve 100. To accommodate the gate 140', the body 110, bonnet 120, and/or stem 130

dimensions may be modified. In the illustrated embodiment, the solid portion 180 is aligned with the flow path 170 when the gate 140' is in the seated position, the restricted passage 160 is aligned with the flow path 170 when the gate 140' is in the back-seated position, and the unrestricted passage 150 is aligned with the flow path 170 when the gate 140' is in an intermediate position. The open and metering positions are determined by hard travel limits of the valve stem 130. The valve 100 may be placed intermediate unrestricted position by providing limits on the actuator or by monitoring a pressure drop across the valve 100. If the unrestricted passage 150 is properly aligned, the pressure drop should be negligible.

The valve 100 described in Figure 1 may also be adapted for an application where a flow metering position and closed position is employed. In such an embodiment, the valve gate would have a restricted passage 160 as in Figures 1 and 2, and a solid portion 180 as in Figure 2. For this embodiment, the unrestricted passage 150 would not be defined in the gate.

Figure 4 is a cross-section of a flow metering ball valve 200 in accordance with another illustrative embodiment of the present invention. The valve 200 includes a body 210, a bonnet 220, a valve stem 230, and a ball 240. Again, various type of manual, motor-operated, or hydraulic operators are known in the art, and may be used in conjunction with the valve 200.

The ball 240 has a restricted passage 260 having a venturi-type profile. The ball 240 may be referred to as a valve member having a first passage defined therein with a metering flow profile. For ease of illustration, and to avoid obscuring the present subject matter, the conventional parts of the valve 200, such as the packing, stem attachment details, bolts, seals, *etc.*, are not described in detail, as they are known to those of ordinary skill in the art.

In Figure 4, the ball valve 200 is shown in an open position. The valve 200 may be placed in a closed position thereby preventing flow by rotating the stem 230 by 90 degrees. In the open position, the restricted passage 260 is aligned with the flow path 270. In this position, the valve 200 is in a flow metering position. Differential and or absolute pressures across the restricted passage 260 may be measured to determine the volumetric flow rate. In one embodiment, a pressure

sensor 275 may be provided in the ball 240 and a port 277 may be formed in the ball to electrically transmit the sensed pressure. A sensor 280 and port 282 may also be provided for measuring the unrestricted pressure. The particular location of the sensors and ports for measuring the differential and/or absolute pressure(s) may vary. For example, ports may be provided in the ball 240 or the body 210. It is also contemplated that one or more ports may be provided in the piping upstream of the valve to measure the unrestricted pressure.

There are various techniques for implementing the pressure sensing in the flow metering valve 100, 200. Pressure sensors may be located inside or outside the pressure boundary of the valve 100, 200. In one embodiment, the need to port the sensed pressure or route wires through the pressure boundary of the valve 100, 200 may be eliminated by using a non-penetrating cross-pressure-vessel transceiver device within the pressure environment for measuring the restricted pressure, the unrestricted pressure, or both. As shown in Figures 1, 2, and 4, a controller290housed outside the pressure environment may communicate with, and can provide power to a sensor 295 within the pressure environment. Alternatively, a battery or energy harvesting device may be provided to power the sensor 295. Although the non-penetrating sensor 295 and sensors 142 with associated penetrations are illustrated on the same drawing, it is contemplated that both need not be present for measuring the same parameter. However, they may be mixed. For example, a non-penetrating sensor 295 may be used to measure the restricted pressure, while a penetrating sensor 142 may be used to measure the unrestricted pressure.

A single transceiver device or multiple transceiver devices may be employed as needed for specific applications to transfer power and communication signals. Exemplary, non-penetrating interfaces are described in United States Patent Publication No. 2008/0070499, entitled "MAGNETIC COMMUNICATION THROUGH METAL BARRIERS," and United States Patent Publication No. 2010/0027379, entitled "ULTRASONIC THROUGH-WALL COMMUNICATION (UWTC) SYSTEM," which are in corporated herein by reference in their entireties. These publications describe communication devices that use a magnetic or ultrasonic signal to

communicate and/or provide power through the pressure boundary without actually penetrating the boundary.

Figure 5 is a simplified diagram of an illustrative well tree assembly 300 (*i.e.*, or Christmas tree) having a production bore 310 defined therein. Although a surface tree is illustrated, the concepts described herein may also be applied to a subsea installation. The well tree assembly 300 includes an upper master valve 320, a lower master valve 330, a flow metering valve 340, and a swab valve 350. A flow wing valve 360 and a kill wing valve 370 are coupled to outlets of the well tree assembly 300, and an elbow 380is coupled to the flow wing valve 360. A tree cap 390 is provided above the swab valve 350. In the illustrated embodiment, the flow metering valve 340 is the valve 100 of Figure 1.The unrestricted passage 150 shown in Figure 1 allows well intervention though the well tree 300. If the alternative gate 140' of Figure 2 were used with the valve 340, the lower master valve 330 could be omitted, as its isolation functionality could be performed using the flow metering valve 340. The valves 310-370 may be manually operated or actuated (*e.g.*, hydraulically, or motor operated) depending on the particular implementation. Moreover, as known to those of ordinary skill in the art, the relative positions of the valves 310-370 may vary, and some valves may be omitted or additional valves may be added. The orientation of the tree 300 may also vary (*e.g.*, vertical or horizontal).

The particular embodiments disclosed above are illustrative only, as the disclosed subject matter may be modified and practiced in different but equivalent manners apparent to those skilled in the art having the benefit of the teachings herein. Furthermore, no limitations are intended to the details of construction or design herein shown, other than as described in the claims below. It is therefore evident that the particular embodiments disclosed above may be altered or modified and all such variations are considered within the scope and spirit of the disclosed subject matter. Accordingly, the protection sought herein is as set forth in the claims below.

CLAIMS

WE CLAIM:

1. A valve, comprising:

a housing;

a stem supported by the housing;

a valve member coupled to the stem and having a first passage defined therein with a metering flow profile.

2. The valve of claim 1, wherein the valve member comprises a gate.

3. The valve of claim 2, wherein the gate has a second passage defined therein with an unrestricted flow profile, the second passage having a diameter substantially equal to a diameter of a flow passage defined through said housing.

4. The valve of claim 3, wherein the gate comprises a solid portion larger than a diameter of a flow passage defined through said housing.

5. The valve of claim 2, wherein the gate comprises a solid portion larger than a diameter of a flow passage defined through said housing.

6. The valve of claim 1, wherein the valve member comprises a ball.

7. The valve of claim 1, wherein the valve stem comprises a rising valve stem.

8. An apparatus, comprising:

a well tree having a production bore; and

a flow metering valve coupled to the well tree and communicating with the production bore, wherein the flow metering valve includes a valve member having a first passage defined therein with a metering flow profile and a second passage defined therein with an unrestricted flow profile, the second passage having a diameter substantially equal to a diameter of the production bore.

9. The apparatus of claim 8, wherein the valve member comprises a solid portion larger than a diameter of the production bore.

10. The apparatus of claim 8, wherein the valve member comprises a gate.

11. The apparatus of claim 1 or 8, wherein the metering profile comprises an unrestricted portion and a restricted portion, and the flow metering valve further defines a first pressure port communicating with the unrestricted portion and a second pressure port communicating with the restricted portion.

12. The apparatus of claim 11, wherein the second pressure port is defined in the valve member.

13. The apparatus of claim 11, wherein the first port is defined in a body of the flow metering valve.

14. The apparatus of claim 11, further comprising a differential pressure sensor coupled to the first and second ports.

15. The apparatus of claim 1 or 8, wherein the flow metering valve includes an unrestricted portion and the metering profile comprises a restricted portion, and the flow metering valve further comprises at least one sensor communicating with the unrestricted portion and with the restricted portion.

16. The apparatus of claim 15, further comprising a controller disposed outside a pressure boundary of the flow metering valve, wherein the at least one pressure sensor is disposed within the pressure boundary, and the controller is operable to communicate with the at least one pressure sensor through the pressure boundary without penetrating the pressure boundary.

17. The apparatus of claim 1 or 8, wherein the metering profile comprises a venturi profile.

18. The apparatus of claim 1 or 8, wherein the metering profile comprises a Dall tube profile.

19. The apparatus of claim 1 or 8, wherein the metering profile comprises an orifice plate.

**AMENDED CLAIMS**
**Received by the International Bureau on 14 March 2012 (14.03.12)**

CLAIMS

WE CLAIM:

1. A valve, comprising:

a housing;

a stem supported by the housing;

a valve member coupled to the stem and having a first passage defined therein with a metering flow profile alignable with a flow passage defined through said housing.

2. The valve of claim 1, wherein the valve member comprises a gate.

3. The valve of claim 2, wherein the gate has a second passage defined therein with an unrestricted flow profile, the second passage having a diameter substantially equal to a diameter of a flow passage defined through said housing.

4. The valve of claim 3, wherein the gate comprises a solid portion larger than a diameter of said ~~a~~ flow passage defined through said housing.

5. The valve of claim 2, wherein the gate comprises a solid portion larger than a diameter of said ~~a~~ flow passage defined through said housing.

6. The valve of claim 1, wherein the valve member comprises a ball.

7. The valve of claim 1, wherein the valve stem comprises a rising valve stem.

8. An apparatus, comprising:

a well tree having a production bore; and

a flow metering valve coupled to the well tree and communicating with the production bore, wherein the flow metering valve includes a valve member having a first passage defined therein with a metering flow profile and a second passage defined therein with an unrestricted flow profile, the second passage having a diameter substantially equal to a diameter of the production bore, wherein said first and second

passages are alignable with a flow passage defined through said flow metering valve.

9. The apparatus of claim 8, wherein the valve member comprises a solid portion larger than a diameter of the production bore.

10. The apparatus of claim 8, wherein the valve member comprises a gate.

11. The apparatus of claim 1 or 8, wherein the metering profile comprises an unrestricted portion and a restricted portion, and the flow metering valve further defines a first pressure port communicating with the unrestricted portion and a second pressure port communicating with the restricted portion.

12. The apparatus of claim 11, wherein the second pressure port is defined in the valve member.

13. The apparatus of claim 11, wherein the first port is defined in a body of the flow metering valve.

14. The apparatus of claim 11, further comprising a differential pressure sensor coupled to the first and second ports.

15. The apparatus of claim 1 or 8, wherein the flow metering valve includes an unrestricted portion and the metering profile comprises a restricted portion, and the flow metering valve further comprises at least one sensor communicating with the unrestricted portion and with the restricted portion.

16. The apparatus of claim 15, further comprising a controller disposed outside a pressure boundary of the flow metering valve, wherein the at least one pressure sensor is disposed within the pressure boundary, and the controller is operable to communicate with the at least one pressure sensor through the pressure boundary without penetrating the pressure boundary.

17. The apparatus of claim 1 or 8, wherein the metering profile comprises a venturi profile.

18. The apparatus of claim 1 or 8, wherein the metering profile comprises a Dall tube profile.

19. The apparatus of claim 1 or 8, wherein the metering profile comprises an orifice plate.

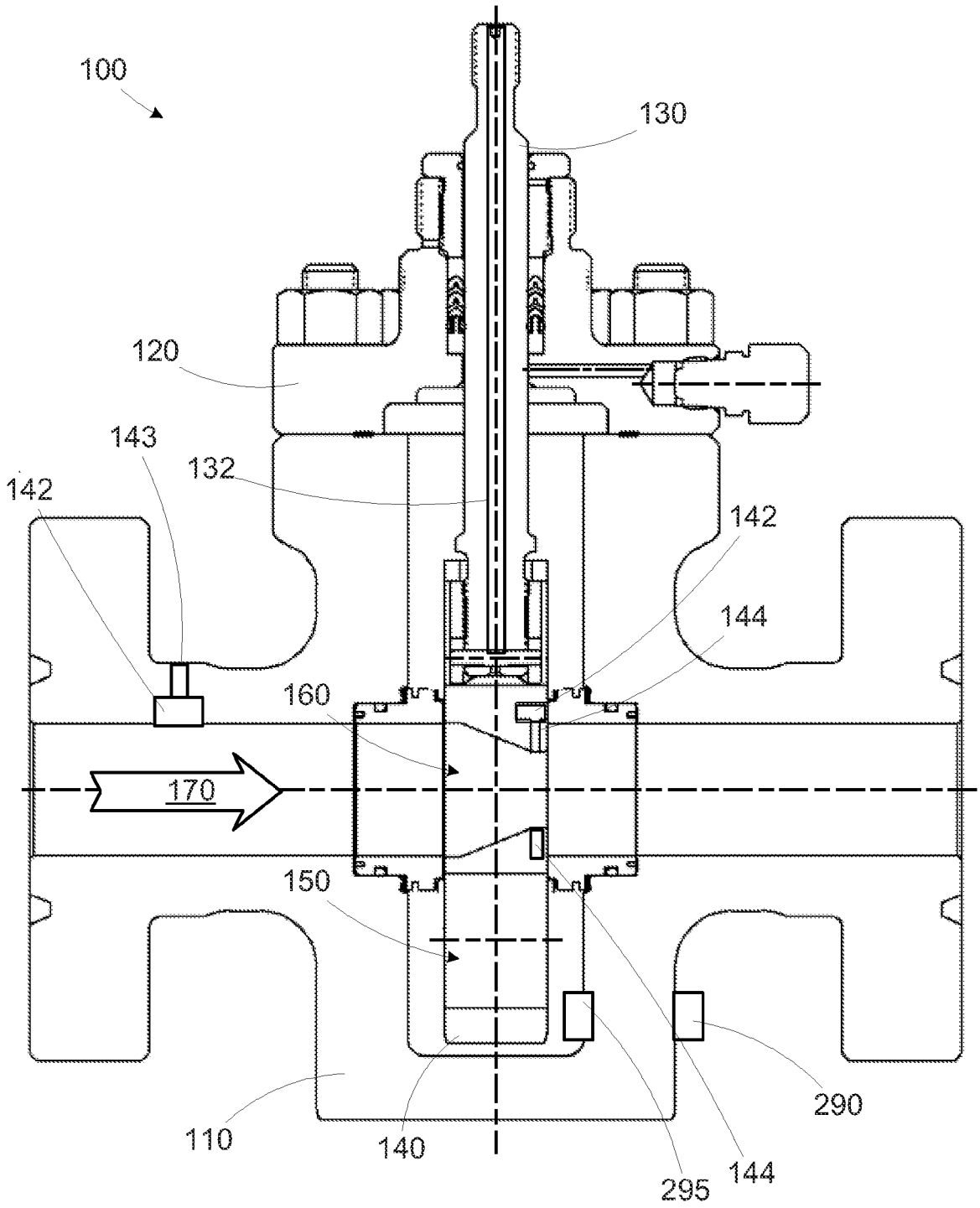



Figure 1

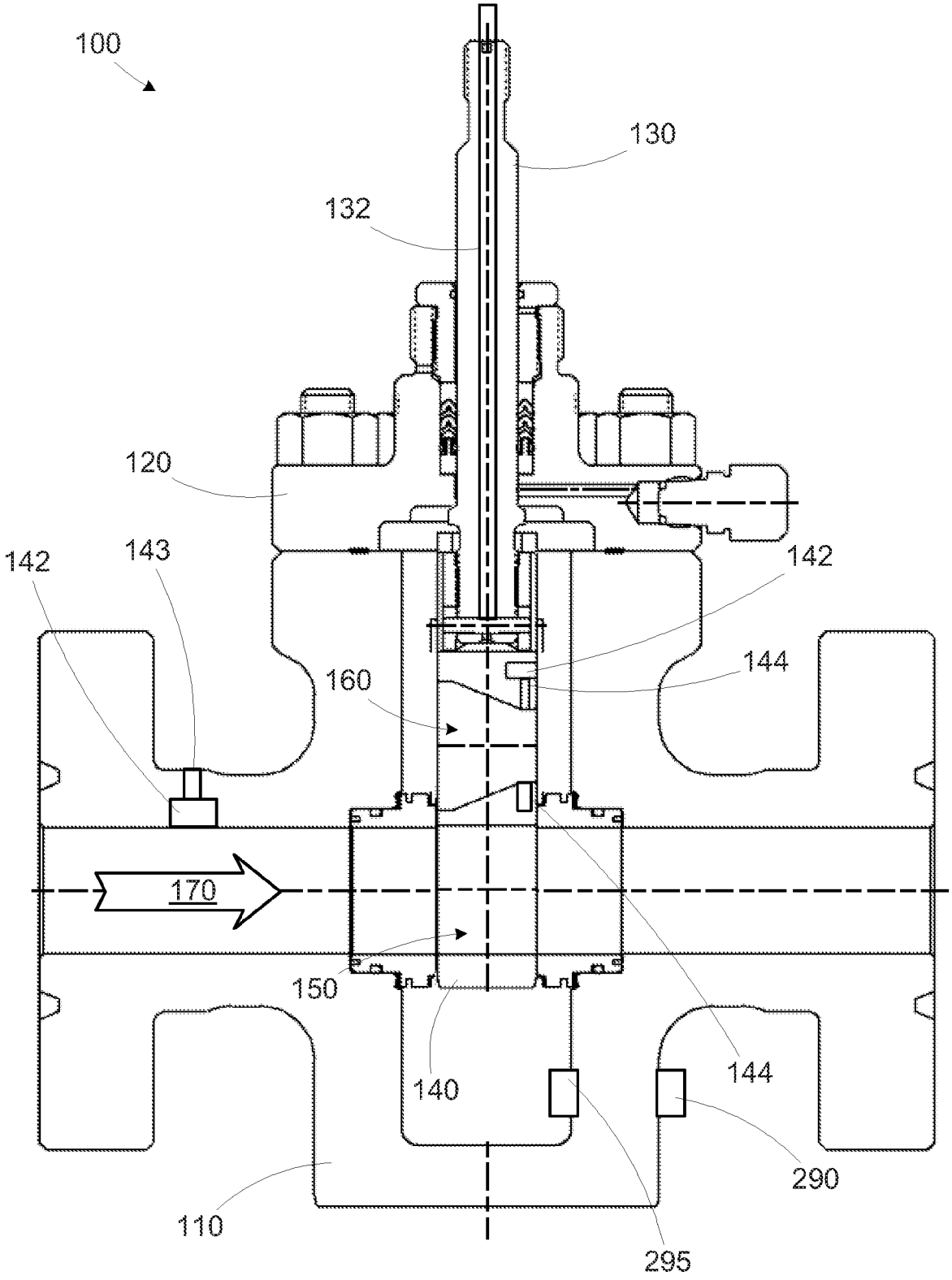



Figure 2

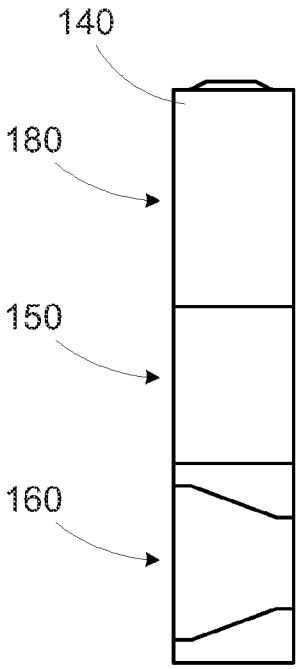



Figure 3

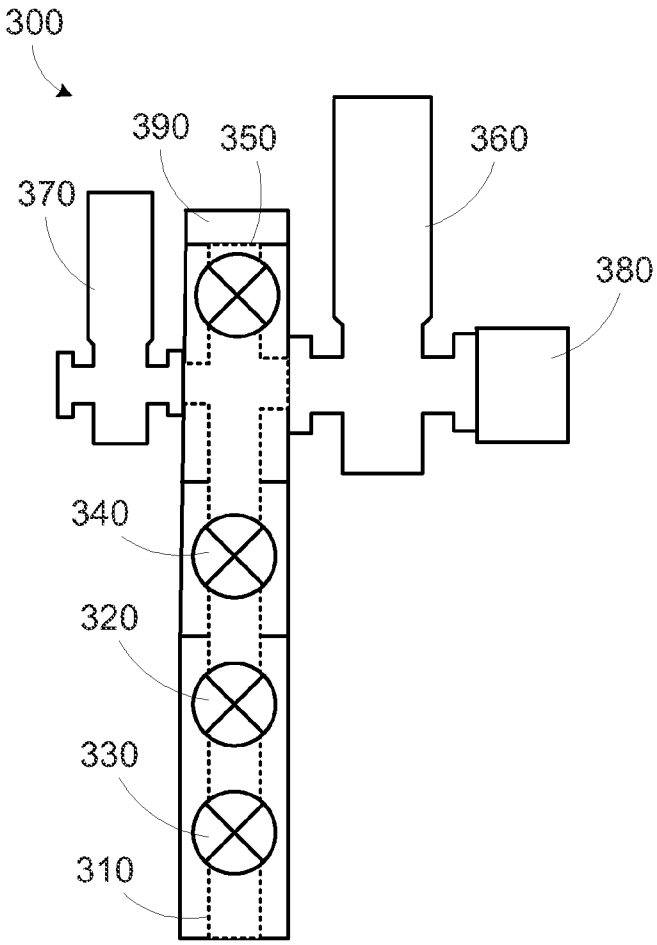



Figure 5

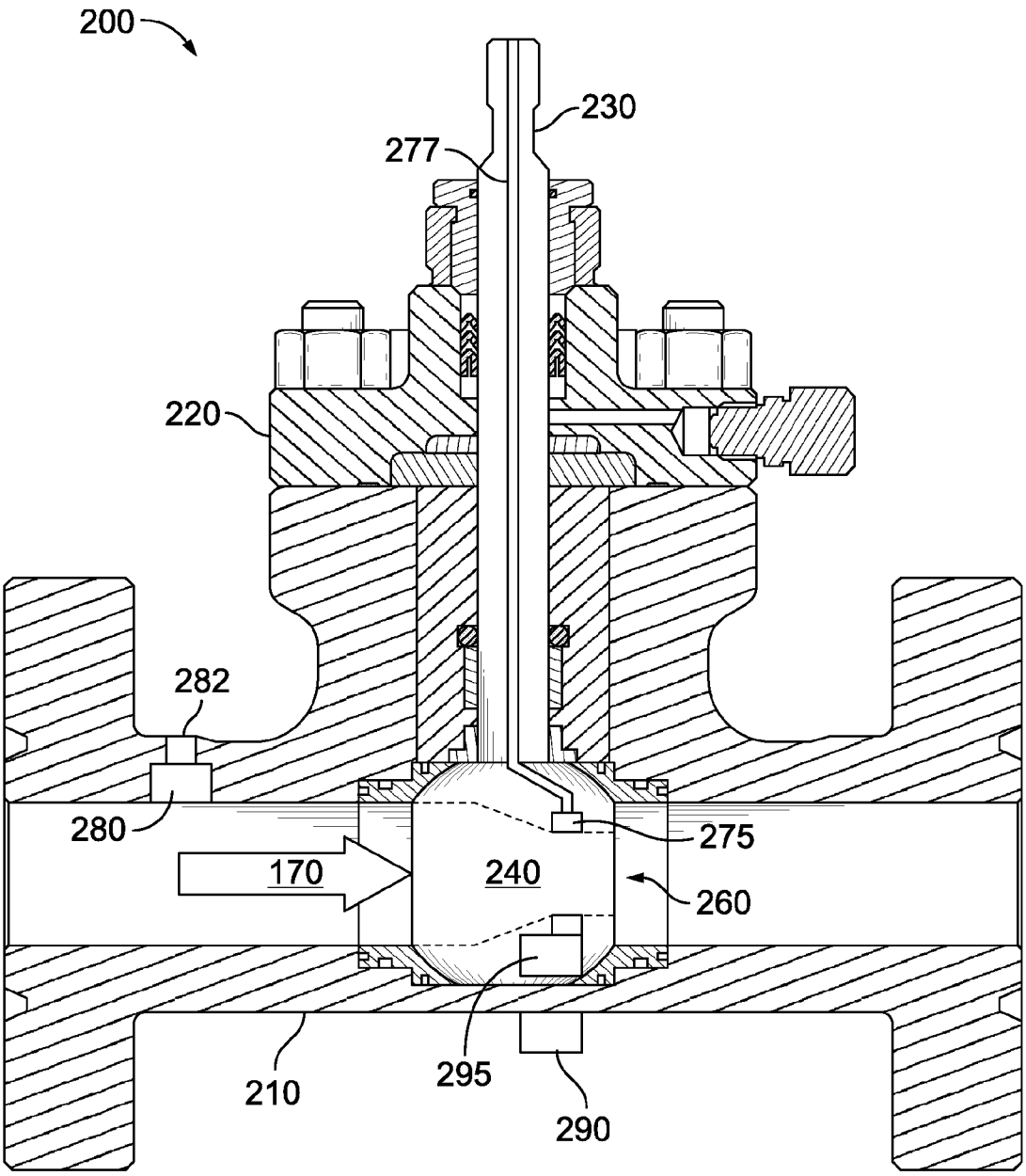



Figure 4

# INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2010/056698

A. CLASSIFICATION OF SUBJECT MATTER
IPC(8) - F16K 43/00 (2010.01)
USPC - 137/329.02
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC(8) - E21B 34/06; F16K 43/00 (2010.01)
USPC - 137/14, 329.02, 870; 166/337, 344; 251/126, 205

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
PatBase, Google Patents

C. DOCUMENTS CONSIDERED TO BE RELEVANT

| Category* | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
|---|---|---|
| X<br>----<br>Y | US 2002/0117211 A1 (CAIN et al) 29 August 2002 (29.08.2002) entire document | 1-5, 7, 11-13<br>----------<br>6, 10, 14-19 |
| X<br>----<br>Y | US 3,357,491 A (JONES et al) 12 December 1967 (12.12.1967) entire document | 8-9<br>------<br>10 |
| Y | US 2,351,775 A (MCMURRY) 20 June 1944 (20.06.1944) entire document | 6 |
| Y | US 4,646,624 A (STEARNS) 03 March 1987 (03.03.1987) entire document | 14-16 |
| Y | US 7,251,935 B2 (ZHANG et al) 07 August 2007 (07.08.2007) entire document | 16 |
| Y | US 3,410,138 A (LYNCH) 12 November 1968 (12.11.1968) entire document | 17-19 |

☐ Further documents are listed in the continuation of Box C. ☐

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| Date of the actual completion of the international search | Date of mailing of the international search report |
|---|---|
| 06 January 2011 | 14 JAN 2011 |
| Name and mailing address of the ISA/US<br>Mail Stop PCT, Attn: ISA/US, Commissioner for Patents<br>P.O. Box 1450, Alexandria, Virginia 22313-1450<br>Facsimile No. 571-273-3201 | Authorized officer:<br>Blaine R. Copenheaver<br>PCT Helpdesk: 571-272-4300<br>PCT OSP: 571-272-7774 |