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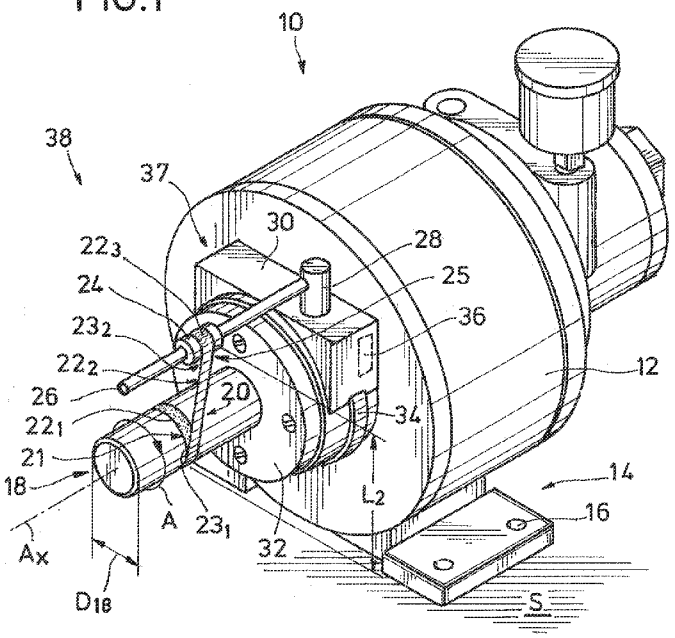
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(54) Title: RECORDER FOR SHAFT ROTATION VERIFICATION

FIG.1



(57) Abstract: A recording assembly (38) for documenting that a shaft (18) in a rotating machine (10) has been rotated while the rotating machine (10) was stored or otherwise out of service. The recording assembly (38) includes an elongated strip that is wound on a reel (24) disposed adjacent the shaft (18). The reel (24) is rotatable about an axle (26) that is spaced away from the shaft (18). A free end (21) of the strip is secured to an outer surface of the shaft (18) and spools onto the shaft (18) as the shaft (18) is rotated, and which unwinds the strip from the reel (24). Markings are on the strip representing distance from the free end (21), which visually indicate occurrence and amount of shaft (18) rotation. Types of markings include different colors or patterns, and which change at distances corresponding to shaft (18) circumference. Alternatively, the markings are metered increments illustrating linear distance.

WO 2021/225985 A1

[Continued on next page]

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PCT PATENT APPLICATION

RECORDER FOR SHAFT ROTATION VERIFICATION

BACKGROUND OF THE INVENTION

1. Field of Invention

[0001] The present disclosure relates to recording rotation of a shaft of a rotating machine. More specifically, the present disclosure relates to verifying that a shaft of a rotating machine has been rotated in compliance with recommended practice.

2. Description of Prior Art

[0002] There are a number of applications for rotating machinery, such as providing rotational drive (*i.e.*, motors and turbines), providing pressure (*i.e.*, pumps and compressors), or providing electricity (*i.e.*, generators). Rotating machinery used in industry, such as for manufacturing or processing, is often larger than in non-industry settings. Moreover, because many manufacturing and processing facilities are in continuous operation, these facilities often have redundant or spare rotating machinery on hand to replace rotating machinery taken out of service for maintenance or repair. When the spare rotating machinery is left dormant over a period of time, certain components sometimes deform due to creep, and moving parts can bind. Component deformation and binding of moving parts subjects the rotating machinery to failure when put into service. New equipment stored for a period of time while an industrial facility is under construction is also subject to dormancy induced failure.

[0003] Periodically rotating the shafts of rotating equipment while being stored or on stand-by is one technique employed to address the issues of the equipment being dormant. Machinery equipment shafts are rotated to preserve the shaft and avoid equipment failure from shaft sagging during equipment startup. The frequency and amount of shaft rotation is sometimes provided by the equipment manufacturer. Moreover, some manufacturer's warranties may not be honored without proof of shaft rotation. In some instances, operations or construction personnel record instances of shaft rotation that did not occur; and while not properly maintaining the dormant rotating machinery.

SUMMARY OF THE INVENTION

[0004] Disclosed herein is a recorder for use with a rotating machine having a shaft, the recorder having frame assembly made up of a base and a reel axle supported on the base. Also included with the recorder is a reel rotatably mounted on the reel axle and that is coaxial with the shaft, a strip of recording medium having a portion selectively wound onto the reel and a free end coupled to the shaft, and markings on a surface of the recording medium that reflect a distance from the free end and an amount of rotation of the shaft in the time since the free end was attached to the shaft. In an example, the rotating machine is dormant. Example markings include changes in color of a surface of the strip, and in an alternative the changes in color are disposed at a designated locations on the strip. Alternate markings are where a pattern of a surface of the strip changes, and optionally the changes in pattern are disposed at a designated locations on the strip. In one embodiment, the markings are metered indications of length. In an alternative, the frame assembly is secured to the rotating machinery by an attachment that is a coupling, such as a strap, a magnet, or combinations. Optionally, the frame assembly is disposed on a surface on which the rotating machine is supported.

[0005] Also included is a method of handling a rotating machine, and which includes engaging a recorder with a shaft of the rotating machine, monitoring rotation of the shaft while the rotating machine is dormant, estimating a value of the rotation of the shaft, recording the value of the rotation of the shaft to define a record of shaft rotation, and maintaining the record of shaft rotation. In one embodiment, the recorder includes a reel, a strip of a recording medium having a portion wound on the reel, a free end and markings that indicate a distance to the free end, and where the step of engaging a recorder involves securing the free end to an outer surface of the shaft, the method further including supporting the reel coaxial with the shaft. The step of estimating a value of rotation of the shaft optionally includes observing the markings on a portion of the strip wound onto the shaft and that are visible. In an alternative, the method also includes mounting the reel onto a reel axle, and coupling the reel axle to the rotating machine. Optionally included with the method is mounting the reel onto a reel axle, and supporting the reel axle on a surface on which the rotating machine is supported. In one example, the steps of monitoring, estimating, and recording are performed in compliance with API 686. The recorder of the method alternatively includes a digital device having a laser signal transmitter and receiver and reflectors spaced apart along a circumference of the shaft, that in one alternative are positioned 90 degrees apart from one

another. Further in this example is a sensor that senses light reflected from the reflectors, and a counter for registering an output from the sensor. The counter is optionally a digital device, and in which a record of the shaft rotations is stored for proof of rotation to maintain a warranty of the rotating machine. The method optionally includes installing and operating the rotating machine.

BRIEF DESCRIPTION OF DRAWINGS

[0006] Some of the features and benefits of the present invention having been stated, others will become apparent as the description proceeds when taken in conjunction with the accompanying drawings, in which:

[0007] Figure 1 is a side perspective view of a rotating machine having an example of a recording assembly for recording shaft rotation.

[0008] Figure 1A is an elevational view of an example of a recording medium for use with the recording assembly of Figure 1.

[0009] Figure 2 is a schematic example of a facility employing embodiments of a rotating machine.

[0010] Figure 3 is side perspective view of a rotating machine having an alternate example of a digital recording assembly for recording shaft rotation.

[0011] While the invention will be described in connection with the preferred embodiments, it will be understood that it is not intended to limit the invention to that embodiment. On the contrary, it is intended to cover all alternatives, modifications, and equivalents, as may be included within the spirit and scope of the invention as defined by the appended claims.

DETAILED DESCRIPTION OF INVENTION

[0012] The method and system of the present disclosure will now be described more fully hereinafter with reference to the accompanying drawings in which embodiments are shown. The method and system of the present disclosure may be in many different forms and should not be construed as limited to the illustrated embodiments set forth herein; rather, these embodiments are provided so that this disclosure will be thorough and complete, and will fully convey its scope to those skilled in the art. Like numbers refer to like elements throughout. In an embodiment, usage of the term "about" includes +/- 5% of a cited magnitude. In an embodiment, the term "substantially" includes +/- 5% of a cited magnitude, comparison, or description. In an embodiment, usage of the term "generally" includes +/- 10% of a cited magnitude.

[0013] It is to be further understood that the scope of the present disclosure is not limited to the exact details of construction, operation, exact materials, or embodiments shown and described, as modifications and equivalents will be apparent to one skilled in the art. In the drawings and specification, there have been disclosed illustrative embodiments and, although specific terms are employed, they are used in a generic and descriptive sense only and not for the purpose of limitation.

[0014] Shown in perspective view in Figure 1 is an example of a rotating machine 10 that has an outer housing 12 for covering internal components. A base 14 is formed onto a lower portion of the housing 12, and includes bolt holes 16 through which fasteners (not shown) are selectively inserted for securing the rotating machine 10 to a mounting surface S. Rotating machine 10 includes a shaft 18 shown projecting axially from within housing 12. A strip of recording medium 20 is shown having a free end 21 secured to an outer surface of the shaft 18. Example securing means include glue, adhesive tape, and fasteners (not shown). The strip of recording medium 20 is partitioned into segments 22_1, 22_2, 22_3 which are visually distinguishable from one another by markings on each of the segments 22_1, 22_2, 22_3 that differ from markings on adjacent ones of the segments 22_1, 22_2, 22_3. Example markings include a particular color or pattern. It should be pointed out that embodiments of the strip of recording medium 20 include those having more than three segments. As shown in Figure 1, segment 22_2 extends along a path that is substantially straight and with a callout identifying its length L_2. Segment 22_1 is shown spooled on shaft 18 and extending along a curved path; in the embodiment shown segment 22_1 has a length substantially

equal to the circumference of shaft 18 and based on diameter D_{18} of shaft 18. As described in more detail below, segments 22_1, 22_2, 22_3 of some embodiments of the strip of recording medium 20 have a designated length so that a distance from a portion of the strip of recording medium 20 to the free end 21 is identifiable by inspecting markings on the strip of recording medium 20 that are visible. As described in more detail below, in one example a distance from the free end 21 to visible portions of the strip of recording medium 20 provides an indication of the amount shaft 18 has rotated since the free end 21 was secured to the shaft 18. Alternatives exist where a strip of recording medium 20 has segments 22_1, 22_2, 22_3 with lengths that differ from lengths of segments 22_1, 22_2, 22_3 of other embodiments of the strip of recording medium 20. In the example of Figure 1, borders 23_1, 23_2 are optionally included on strip 20 to illustrate respective interfaces between segments 22_1, 22_2 and segments 22_2, 22_3.

[0015] Still referring to Figure 1, an example of a reel 24 is illustrated on which a reserve portion 25 of the strip 20 is spooled. Reel 24 is shown rotatingly mounted on a reel axle 26. In the embodiment shown, reel axle 26 is an elongated member and oriented substantially parallel with an axis A_X of shaft 18. One end of reel axle 26 is attached to a pedestal 28, so that reel axle 26 is supported in a cantilever like arrangement on pedestal 28. As shown, pedestal 28 has a cylinder like configuration and about an axis oriented perpendicular with reel axle 26. An end of pedestal 28 distal from its portion attached to reel axle 26 is mounted on an upper surface of a base 30. Upper surface of base 30 is rectangular with its elongate side perpendicular to axis A_X. Upper and side surfaces of base 30 are substantially planar, and its lower surface is curved to give base 30 a saddle like configuration. In the example of Figure 1, a portion of housing 12 that circumscribes shaft 18 projects axially outward to define a cylindrically shaped end plate 32, and on which base 30 couples to rotating machine 10. As shown, the curved lower surface of base 30 corresponds to curved lateral sidewalls of the end plate 32. An example means of securing the base 30 to the rotating machine 10 includes a strap 34 with opposing ends attached to lateral sides of the base 30. In between where its ends attach to the lateral sides of base 30 strap 34 extends along the outer surface of the end plate 32. An alternative means to secure base 30 to rotating machine 10 includes a magnet 36, and which is shown in dashed outline. In an alternative, the base 30, pedestal 28, and reel axle 26 define a support frame 37, and a recording assembly 38 is defined by the support frame 37, reel 24, and strip of recording medium 20.

[0016] In a non-limiting example of operation, recording assembly 38 is coupled to rotating machine 10; such as by securing strap 34 to end plate 32 or by attractive forces of magnet 36. Alternatively, instead of being coupled to rotating machine 10 recording assembly 38 is optionally supported on surface S; such as being set directly on surface S or on a stand or frame (not shown) set on surface S. Free end 21 of strip of recording medium 20 is secured to shaft 18 and a portion of strip of recording medium 20 spans between reel 24 and shaft 18. In the example of Figure 1, shaft 18 has rotated (as illustrated by arrow A) so that a portion of strip of recording medium 20 is wound around shaft 18. In one alternate example, lengths of the segments 22_1, 22_2, 22_3 is a criteria for selecting a particular strip of recording medium 20; that is the segments 22_1, 22_2, 22_3 of the strip of recording medium 20 have lengths corresponding to the circumference of shaft 18. Examples of the lengths corresponding to the circumference of the shaft 18 are where the length of each of the segments 22_1, 22_2, 22_3 ("segment lengths") equals the circumference. An optional selection criteria is that a ratio of the circumference to segment lengths is an integer value, or its reciprocal is an integer value. For example, by selecting a recording medium 20 with segment lengths corresponding to the circumference of shaft 18, a number of rotations of the shaft 18 since the free end 21 was attached can be readily obtained based on the visible color and/or pattern in combination with a knowledge of a color and/or pattern sequence of the segments 22_1, 22_2, 22_3. In an example, the configuration or position of the strip of recording medium 20 when monitoring and/or recording rotation of shaft 18 begins or is initiated ("initial position") is with the free end 21 being secured to shaft 18, and none of the strip of recording medium 20 being wound onto the shaft 18. Alternatives exist where the initial configuration is set to be after at least a portion of the strip of recording medium 20 has been spooled onto the shaft 18, such as that shown in Figure 1.

[0017] One advantage of the disclosed device and method is that clear physical evidence that the shaft 18 has been rotated is realized by observing a difference in the amount of the strip of recording medium 20 that is wrapped around or spooled onto the shaft 18 versus the initial position. In another alternative, the frequency of rotation of the shaft 18 and the amount of rotation is performed in compliance with API 686. In an example, based on records obtained and maintained with the recording assembly 38 that the shaft 18 has been rotated, along with the amount and frequency of rotation during the period of time the rotating machine 10 was dormant and/or out of operation, the rotating machine 10 is deemed to be ready for operation and is placed in service.

[0018] Referring now to Figure 1A, an alternate example of a strip of recording medium 20A is shown having markings that are in the form of increments 40A. The increments 40A are illustrated as lines extending perpendicular to a length of the strip of recording medium 20A and spaced apart from one another. Examples exist where the increments 40A are equidistant spaced apart from one another, and the respective distances are in SI or English units. Further in the example of Figure 1A is a verification field 42A in which a date, initials, and distance are to be physically input, such as by operations personnel. An example input in the verification field 42A logs a distance of the strip of recording medium 20A spooled onto the shaft 18A, the date the distance was observed, and initials of the observer. In one example, a log of information in the verification field 42A provides evidence of compliance with API 686.

[0019] Shown schematically in Figure 2 is an example of a processing facility 44 in which embodiments of the rotating machine 10 of Figure 1 are installed and in operation. Shown is a compressor 46 that pressurizes vapor or gas received from a vessel 48 through a line 50. The vapor or gas is pressurized in compressor 46 and discharged into line 52. Impellers or blades (not shown) in compressor 46 are rotated by driving an attached shaft 54 with a shaft 56 from a turbine 58. A coupling 60 is shown engaging shafts 54, 56. In an example, coupling 60 includes a gearbox. A line 62 is shown that provides a motive fluid to turbine 58 to rotate blades or impellers (not shown) inside turbine 58 and that result in rotation of its shaft 56. The motive fluid is discharged from turbine 58 through line 64. A reflux fluid is delivered to vessel 48 through line 66, and which partially flashes across a control valve 67 in line 66. Pump 68 pressurizes liquid received from tower 70 via line 72, and discharges the pressurized liquid into line 66. A shaft 74 is shown in dashed outline in pump 68. Optionally, a reboiler circuit 76 is included with tower 70. Further illustrated in Figure 2 is a tank 78 that receives a flow of liquid bottoms from vessel 48 and through line 80. An optional control valve 81 in line 80 provides a pressure drop for flashing a portion of the liquid bottoms so that a two phase flow is delivered to tank 78. Gas flowing into tank 78 through line 80 is directed into an overhead line 82 that directs the gas to a compressor 84. Rotating a shaft 86 of compressor 84 compresses the gas. A motor 88 is shown having a shaft 90 that engages shaft 86 via a coupling 92. In an alternative, energizing motor 88 rotates shaft 90, coupling 82, and shaft 86. Compressor 46, turbine 58, coupling 60, pump 68, compressor 84, motor 88, and coupling 92 are each an example of a rotating machine.

[0020] Shown in perspective view in Figure 3 is an alternate example of a recording assembly 38A for use with a rotating machine 10A. A counter system 94A is included with the recording assembly 38A, which is equipped with a sensor 96A and reflectors 98A arranged on a band 100A shown mounted to an outer surface of shaft 18A. Sensor 96A of this example is responsive to light reflected from reflectors 98A. In the example shown, the reflectors 98A are spaced angularly away from each other along a path that circumscribes shaft 18A. Alternatively, reflectors 98A are each at substantially the same axial location on axis A_X of shaft 18A. In an example, sensor 96A is strategically positioned to sense light reflected from a one of the reflectors 98A that are at a particular angular location about axis A_X. For the purposes of illustration herein, each time light from a particular reflector 98A is sensed by sensor 96A is referred to as an event. Further in this example, rotating the shaft 18A as shown by arrow A consequently moves the reflectors 98A about axis A_X to the particular angular location and reflect light that is sensed by sensor 96A. A counter 102A is also included with the recording assembly 38A and which is in communication with sensor 96A through a communication line 104A. A screen on counter 102A optionally displays a record of the number of rotations. In an alternative, sensor 96A emits a signal for each event of sensed reflected light, and which is tabulated in counter 102A. An optional controller 106A is also shown with the example of Figure 3, and that is in communication with the recording assembly 38A via communication means 108A. Examples of communication line 104A and communication means 108A include a conductive medium, fiber optic material, and wireless. The number and/or time of each event is optionally stored in counter 102A, in controller 106A, or both. In an alternative, recording assembly 38A includes a light emitter (not shown) which directs light towards the reflectors 98A that when reflected is sensed by sensor 96A. In an example of operation of recording assembly 38A (similar to operation of recording assembly 38 of Figure 1 and described above) is coupled with rotating machine 10A over a period of time when rotating machine 10A is out of service and information of rotation collected and maintained within the recording assembly 38A is consulted prior to operation of rotating machine 10A. In an alternate embodiment equipment data, date and/or time of rotation, and identity of operations personnel performing the rotation are displayed on screen of counter 102A. In a non-limiting example, name of operations personnel performing the rotation and equipment information (*i.e.* equipment number, serial number, *etc.*) are entered into the recording assembly 38A; and which are optionally stored digitally such as on a computer readable medium.

[0021] The present invention described herein, therefore, is well adapted to carry out the objects and attain the ends and advantages mentioned, as well as others inherent therein. While a presently preferred embodiment of the invention has been given for purposes of disclosure, numerous changes exist in the details of procedures for accomplishing the desired results. These and other similar modifications will readily suggest themselves to those skilled in the art, and are intended to be encompassed within the spirit of the present invention disclosed herein and the scope of the appended claims.

CLAIMS

What is claimed is.

1. A recording assembly 38 for use with a rotating machine 10 having a shaft 18, the recording assembly 38 comprising:

a frame assembly 37 comprising,

a base 30, and

a reel axle 26 supported on the base 30;

a reel 24 rotatably mounted on the reel axle 26 and that is coaxial with the shaft 18;

a strip of recording medium 20 having a portion selectively wound onto the reel 24 and a free end 21 coupled to the shaft 18; and

characterized by,

markings on a surface of the recording medium 20 that reflect a distance from the free end 21 and an amount of rotation of the shaft 18 in the time since the free end 21 was attached to the shaft 18.

2. The recording assembly 38 of Claim 1, characterized in that the rotating machine 10 is dormant.

3. The recording assembly 38 of Claims 1 or 2, characterized in that the markings comprise changes in color of a surface of the strip.

4. The recording assembly 38 of Claim 3, characterized in that the changes in color are disposed at a designated locations on the strip.

5. The recording assembly 38 of any of Claims 1 – 4, characterized in that the markings comprise a changes of a pattern of a surface of the strip.

6. The recording assembly 38 of Claim 5, characterized in that the changes in pattern are disposed at a designated locations on the strip.

7. The recording assembly 38 of any of Claims 1 – 6, characterized in that the markings comprise metered indications of length.

8. The recording assembly 38 of any of Claims 1 – 7, characterized in that the frame assembly 37 is secured to the rotating machine 10 by an attachment that comprises a coupling selected from the group consisting of a strap, a magnet, and combinations thereof.

9. The recording assembly 38 of any of Claims 1 – 8, characterized in that the frame assembly 37 is disposed on a surface on which the rotating machine 10 is supported.

10. A method of handling a rotating machine 10 comprising:

engaging a recording assembly 38 with a shaft 18 of the rotating machine 10;

monitoring rotation of the shaft 18 while the rotating machine 10 is dormant;

estimating a value of the rotation of the shaft 18;

recording the value of the rotation of the shaft 18 to define a record of shaft 18 rotation; and

characterized by,

maintaining the record of shaft 18 rotation.

11. The method of Claim 10, characterized in that the recording assembly 38 comprises a reel 24, a strip of a recording medium 20 having a portion wound on the reel 24, a free end 21 and markings that indicate a distance to the free end 21, and where the step of engaging a recording assembly 38 comprises securing the free end 21 to an outer surface of the shaft 18, the method further characterized by supporting the reel 24 coaxial with the shaft 18.

12. The method of Claim 11, characterized in that the step of estimating a value of rotation of the shaft 18 comprises observing the markings on a portion of the strip wound onto the shaft 18 and that are visible.

13. The method of Claims 11 or 12, further characterized by mounting the reel 24 onto a reel axle 26, and coupling the reel axle 26 to the rotating machine 10.

14. The method of any of Claims 11 – 13, further characterized by mounting the reel 24 onto a reel axle 26, and supporting the reel axle 26 on a surface S on which the rotating machine 10 is supported.

15. The method of any of Claims 11 – 14, characterized in that the steps of monitoring, estimating, and recording are performed in compliance with API 686.

16. The method of any of Claims 11 – 15, characterized in that the recording assembly 38 comprises a reflector 98, a sensor 96 that senses light reflected from the reflector 98, and a counter 94 for registering an output from the sensor 96.

17. The method of any of Claims 11 – 16, further characterized by installing and operating the rotating machine 10.

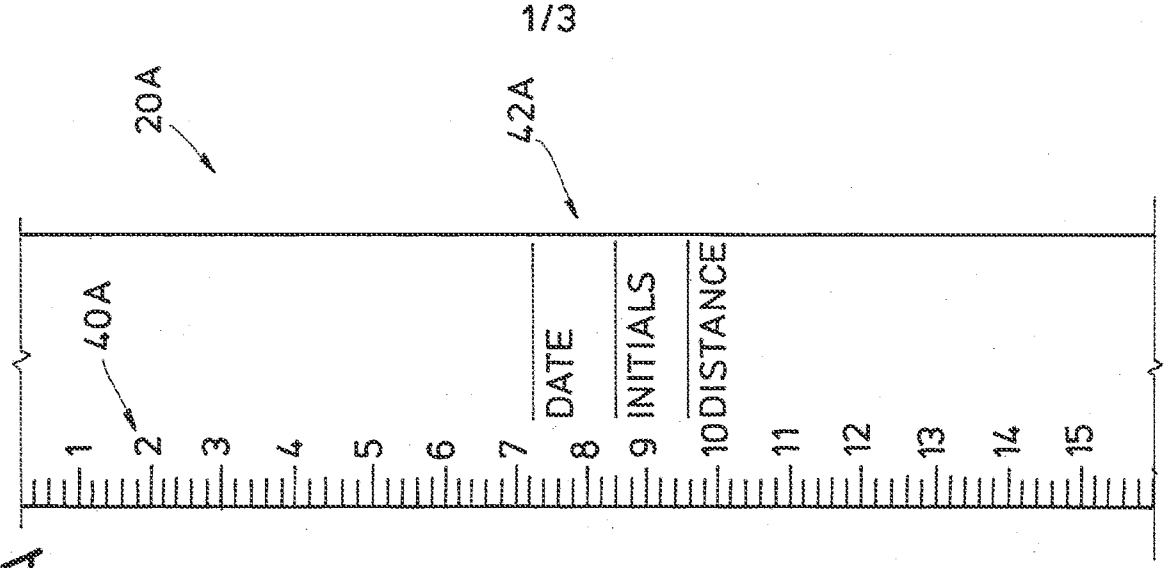

20A
42A
40A
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DATE
INITIALS
DISTANCE

FIG.1A

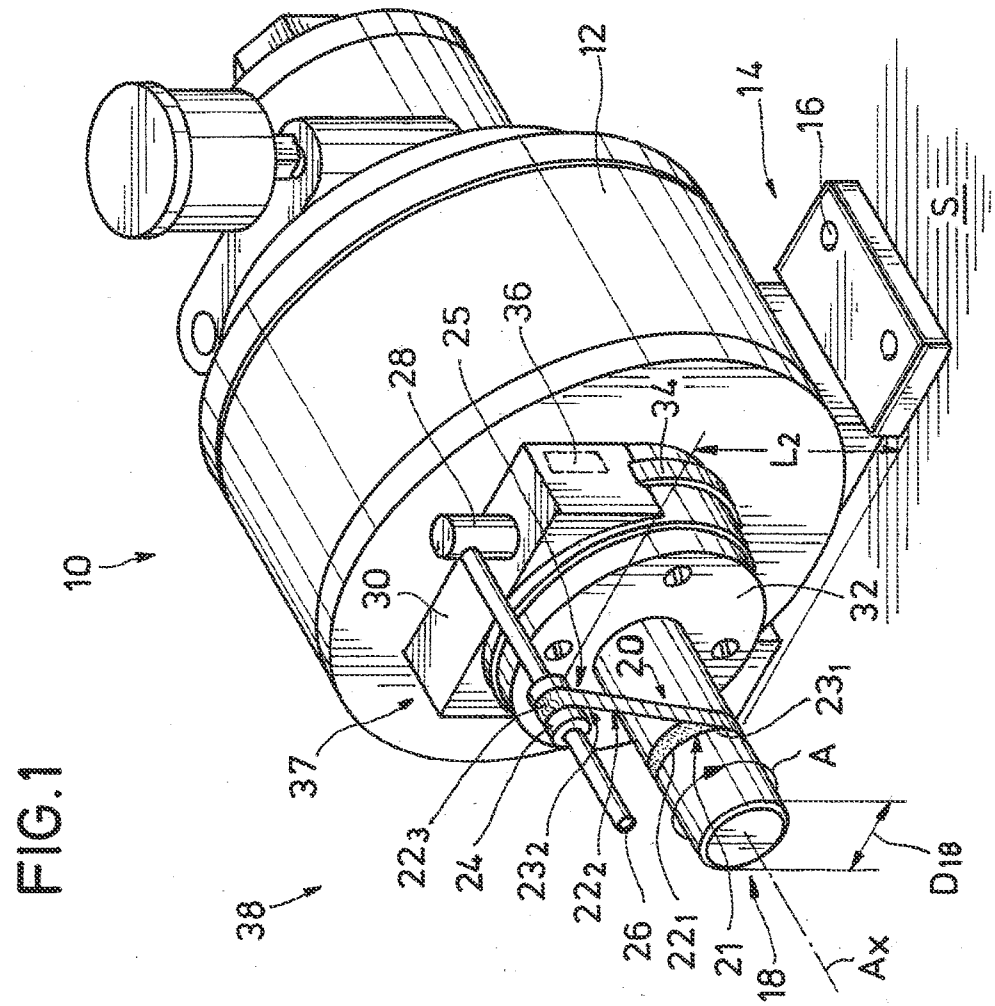

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FIG.1

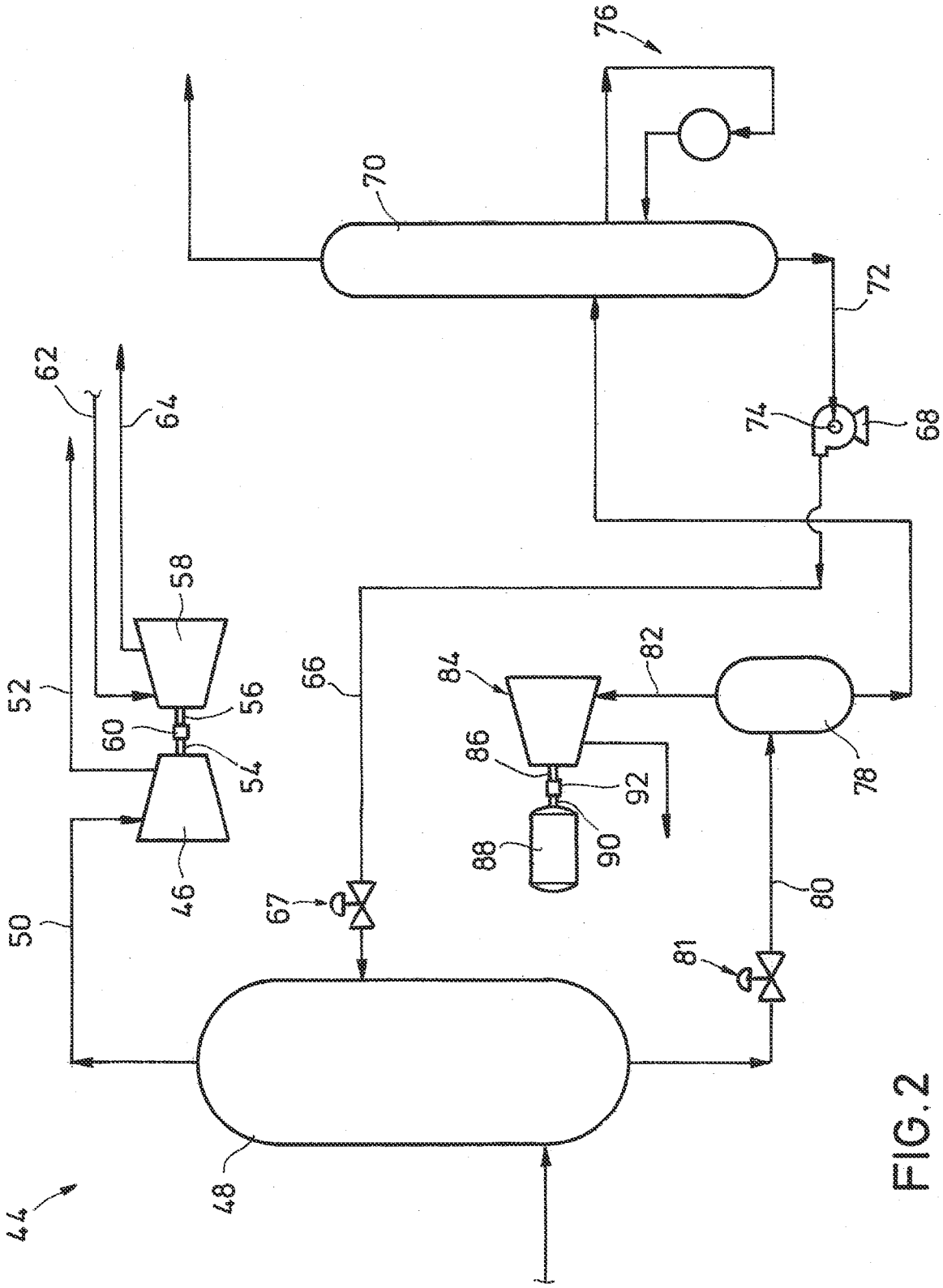

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FIG. 2

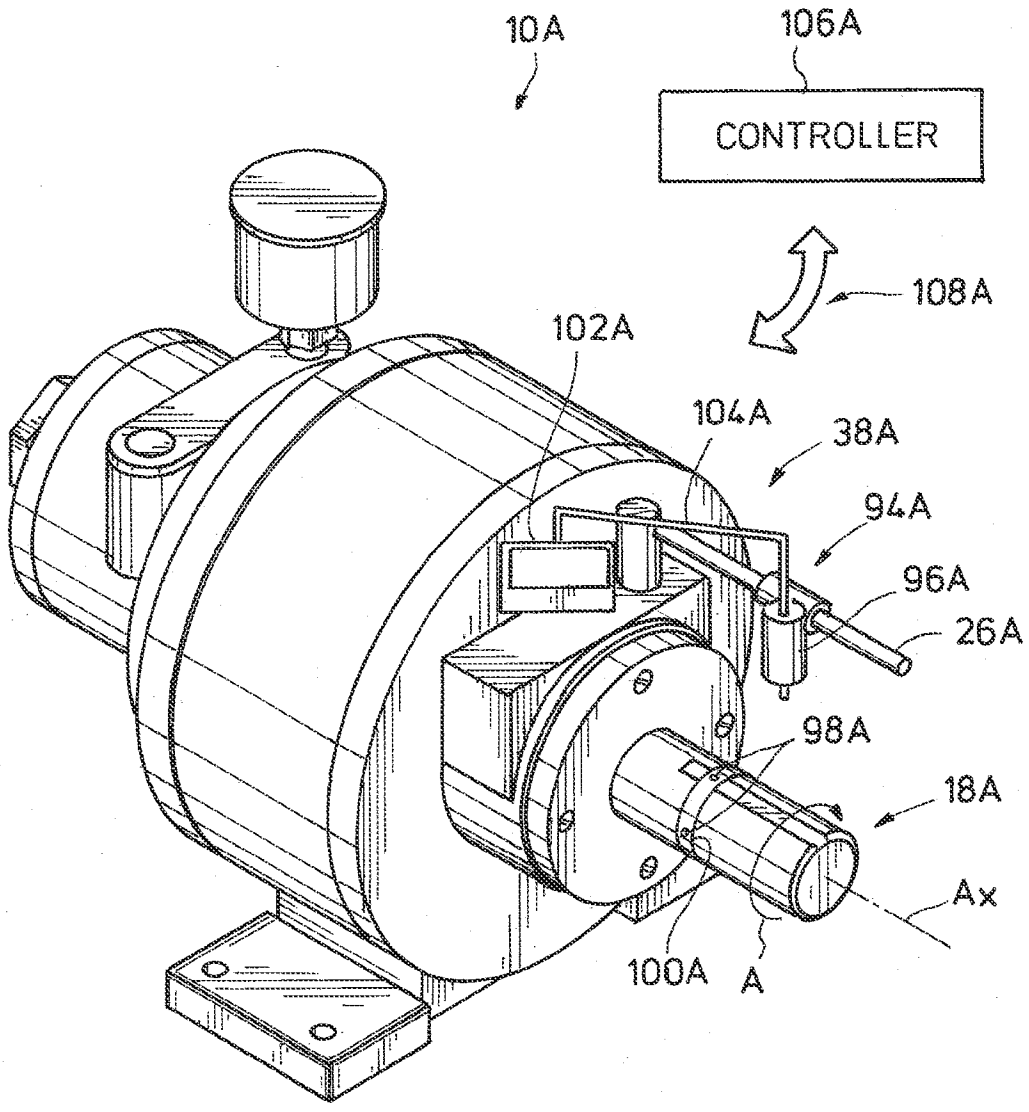

10A
106A
CONTROLLER
108A
102A
104A
38A
94A
96A
26A
98A
18A
Ax
100A
A

FIG. 3

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2021/030516

A. CLASSIFICATION OF SUBJECT MATTER
INV. G01D5/14 G01D5/347 G01P3/38
ADD.

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)
G01D G01M

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)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2010/176283 A1 (KARASIK VLADIMIR [US] ET AL) 15 July 2010 (2010-07-15) Abstract, Desc. [0001], [0014]-[0038], Figs. 1-2	1,2,5,6, 8-17
X	US 4 631 519 A (JOHNSTON JAMES S [GB]) 23 December 1986 (1986-12-23) Abstract, Fig. 8 and corresponding passage of description	1
X	US 2008/276477 A1 (ALBRECHT JOSEF [DE]) 13 November 2008 (2008-11-13) Abstract, Desc. [0017]-[0021], Figs. 1-3	1,3,4
X	US 2017/360331 A1 (BASSEZ SOPHIE [FR] ET AL) 21 December 2017 (2017-12-21) Abstract, Desc. [0058]-[0108], Fig. 1	1,7

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[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents :

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Date of the actual completion of the international search	Date of mailing of the international search report
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2

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