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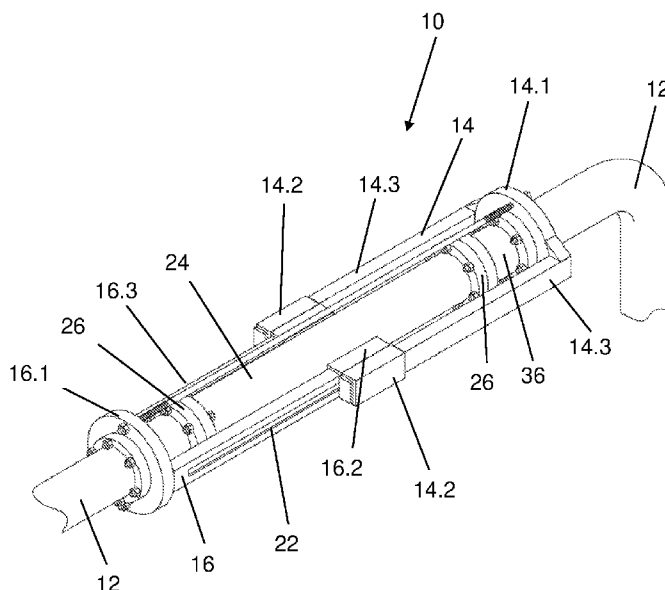


FIGURE 1

(57) Abstract: The invention provides an extendable arm (10) which is removably insertable into an irrigation pipeline (12) of a centre pivot irrigation system which includes a central tower and at least one movable tower for carrying the pipeline (12). The arm (10) comprises a first arm segment (14) which is connectable at one end thereof to the irrigation pipeline (12); a second arm segment (16) which is connectable at one thereof to the irrigation pipeline (12); and a connecting pipe (24) extending between the first and second arm segments (14, 16) to enable uninterrupted fluid flow in the irrigation pipeline (12). The first and second arm segments (14, 16) are displaceable relative to each other between a retracted and extended position to alternate radial distance between the movable tower and the central tower.



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- *as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))*
- *as to the applicant's entitlement to claim the priority of the earlier application (Rule 4.17(iii))*
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EXTENDABLE ARM FOR A CENTRE PIVOT IRRIGATION SYSTEM

5 BACKGROUND TO THE INVENTION

Irrigation systems have been used in the cultivation of crops for many years and is especially important to crop farmers in areas with little or unreliable rainfall. Centre pivot irrigation systems are well known for its precise water application to match crop requirements and soil characteristics, and therefore reduce water wastage. It may also reduce the amount of labour required for irrigating a specific field, since these systems are automated and can be operated by a single person, often times through a virtual connection.

15 A typical centre pivot irrigation system comprises a stationary central tower with a pivot mechanism and main control panel which is anchored to a small concrete base at a fixed water supply point (i.e., hydrant) at the center of a field; an irrigation pipeline of relatively large diameter, composed of high tensile galvanized light steel or aluminium pipes, radially extending from and rotatable about the central tower; and a number of sequentially spaced moving towers for supporting the irrigation pipeline in an elevated position above ground, with the moving towers being able to move slowly over a planted field to irrigate the crops through sprinklers spaced at regular intervals along the pipeline.

Depending on its design, the length of a pipeline can vary from 50m to 750m. The pipeline is placed on wheeled A-frame towers of typically 3m height above ground and spaced at 35m – 55m distance apart (i.e., the length of a span), with the common length of spans being 40m. Truss rod arches maintain an even distribution
5 of weight and loads between the moving towers. The spans are equipped with flexible joints at the ends allowing the pipeline to articulate and to allow side-to-side, up-and-down, and rotational movement with no stress on the pipeline. The whole irrigation system rotates slowly, at a typical speed (i.e., of the last span) of 2–3 m/min around the central tower, applying water in the form of overhead spray irrigation and
10 covers an irrigation area in a circular pattern. A drive system features small individual power units mounted on each wheeled tower. An automatic alignment system keeps the irrigating pipeline in straight alignment.

It will be appreciated that the wheels of the A-frame towers support a significant
15 weight consisting of the tower frames, irrigation pipeline, sprinklers, and the water running through the irrigation pipeline. Due to the system being fixed at the central tower, the wheels of each tower run the same circular track with each rotation of the system, all whilst water from the sprinklers creates muddy conditions in the soil beneath. This continual running of the moving towers at a fixed radial distance from
20 the central tower eventually causes the wheels to form ruts in the ground, causing the wheels to become stuck. This causes major problems and requires considerable labour and effort to release the wheels out of the mud, as evidenced by the different prior art, often very expensive, attempts to suggest solutions. Apart from the system becoming stuck, these ruts can cause significant damage to a particular field and
25 repairing these ruts every season is costly and labour intensive.

The applicant aims to address the above-mentioned shortcomings of centre pivot irrigation systems by providing an extender for an irrigation pipeline which can lessen or prevent the formation of ruts by the wheels of the towers.

5

SUMMARY OF THE INVENTION

According to the invention there is provided an extendable arm which is removably insertable into an irrigation pipeline of a centre pivot irrigation system which includes
10 a central tower and at least one movable tower for carrying the pipeline, the arm comprising -

a first arm segment which is connectable at one end thereof to the irrigation pipeline;

a second arm segment which is connectable at one thereof to the irrigation
15 pipeline,

with the first and second arm segments being displaceable relative to each other between a retracted and extended position to alternate radial distance between the movable tower and the central tower; and

a connecting pipe extending between the first and second arm segments to
20 enable uninterrupted fluid flow in the irrigation pipeline.

The first arm segment may include a first irrigation pipe attachment for connecting the first arm segment at one thereof to the irrigation pipe; and at least two elongate first arms extending parallel to each other and from radially opposite positions from
25 the first irrigation pipe attachment. The first arms may terminate at their free ends in

first engagement formations for slidingly engaging the second arm segment. Each of the first arms may include at least one elongate channel extending substantially the length of the arms and located in inwardly facing faces of the first arms.

5 The second arm segment may include a second irrigation pipe attachment for connecting the second arm segment at one thereof to the irrigation pipe; and at least two elongate second arms extending parallel to each other and from radially opposite positions from the second irrigation pipe attachment. The second arms may terminate at their free ends in second engagement formations for slidingly engaging
10 the first arms of the first arm segment. In one embodiment of the invention, the second arms may be arranged closer to each other compared to the distance between the first arms, such that the second arms fit between and slidingly engage the first arms. Each of the second arms may include at least one elongate channel extending substantially the length of the arms and located in outwardly facing faces
15 of the second arms such that the channels of the second arms face the channels of the first arms.

The first and second arm segments may be displaceable relative to each other between an extended position, in which the first and second engagement formations
20 are aligned; and a retracted position in which the second engagement formations press against the first irrigation pipe attachment, with the first engagement formations arranged approximate the second irrigation pipe attachment.

The first and second arms may be connected to each other through at least one
25 connecting pin connected to either one of the first or second engagement formations

and being slidable in the elongate channel of the other of the second or first arms, as the case may be. Particularly, in one embodiment of the invention, the connecting pins are connected to each of the first engagement formations of the first arms, extending inwardly and being slidable in the elongate channels of the second arms.

5 In an alternative embodiment of the invention, the connecting pins are connected to each of the second engagement formations of the second arms, extending outwardly and being slidable in the elongate channels of the first arms. It will be appreciated that the engagement formations may include more than one connecting pin each. It will also be appreciated that the first and second arm segments may be slightly
10 pivotable relative to each other at the connecting pin connection, thus allowing for a measure of flexibility over uneven ground conditions.

The connecting pipe may be a flexible pipe deformable to accommodate the extended and retracted positions of the first and second arm segments. The
15 connecting pipe may be a concertina pipe. Alternatively, the extendable arm may include at least two connecting pipes of different lengths to accommodate the extended and retracted positions of the first and second arm segments respectively. The connecting pipe may terminate at each of its opposite ends in a pipe flange which is complementarily configured for connecting the connecting pipe to the first
20 and second irrigation pipe attachments respectively.

The extendable arm may include an adjustment mechanism to adjust the arm between the retracted and the extended configurations. The adjustment mechanism may comprise at least one elongate rod terminating in two opposite threaded ends,
25 with one threaded end extending through the first irrigation pipe attachment and the

second threaded end extending through the second irrigation pipe attachment; and two nuts for engaging the threaded rod ends for securing the threaded rod in place; the arrangement being such that rotation of the nuts on the threaded rod ends displaces the arm segments between the extended and retracted positions. In a preferred embodiment of the invention the extendable arm includes two threaded rods extending parallel to each other and penetrating at radially opposite positions through the first and second irrigation pipe attachments.

The extendable arm may include two intermediate pipe connectors for connecting the connecting pipe to the irrigation pipe attachments of the first and second arm segments respectively. Each intermediate pipe connector may terminate at opposite ends thereof in a radially extending connector flange dimensioned for connecting the pipe flanges to the second connector flanges, and for connecting the first connector flanges to the irrigation pipe attachments through a number of nuts and bolts extending through the various flanges. The irrigation pipeline may be connected to opposite sides of the irrigation pipe attachments, thus completing the fluid path of the extendable arm. The extendable arm may include a series of intermediate pipe connectors of different lengths to accommodate different connector pipe lengths intermediate the first and second arm segments.

20

According to a second aspect of the invention there is provided a centre pivot irrigation system, comprising –

a central tower; an irrigation pipeline extending from the central tower; and at least one moveable tower for carrying the pipeline; and

an extendable arm which is removably insertable into the irrigation pipeline and which comprises –

a first arm segment which is connectable at one end thereof to the irrigation pipeline;

5 a second arm segment which is connectable at one thereof to the irrigation pipeline, with the first and second arm segments being displaceable relative to each other between a retracted and extended position to alternate radial distance between the movable tower and the central tower; and

10 a connecting pipe extending between the first and second arm segments to enable uninterrupted fluid flow in the irrigation pipeline.

SPECIFIC EMBODIMENT OF THE INVENTION

Without limiting the scope thereof, the invention will now further be described and
15 exemplified with reference to the accompanying drawings in which –

FIGURE 1 is an assembled perspective view of an extendable arm according to the invention, in an extended configuration;

20 **FIGURE 2** is an exploded perspective view of the extendable arm of Figure 1, illustrating construction of the arm;

FIGURE 3 is a perspective view of the first and second arm segments of the extendable arm in a retracted configuration;

FIGURE 4 is a cross section of the engagement formation between the first and second arms;

25 **FIGURE 5** is a plan view of the extendable arm in an extended position;

FIGURE 6 is a side view of the extendable arm of Figure 5; and

FIGURE 7 is a side view of the extendable arm of Figure 5, illustrating the slightly pivotable connection between the first and second arms.

5 The invention provides an extendable arm [10] which is removably insertable into an irrigation pipeline [12] of a centre pivot irrigation system (not shown). As provided for by the prior art, a centre pivot irrigation system includes a central tower (not shown), an irrigation pipeline [12] extending from the central tower, and at least one moveable tower (not shown) for carrying the pipeline [12].

10

The extendable arm [10] of the invention comprises a first arm segment [14] which is connectable at one end thereof to the irrigation pipeline [12]; a second arm segment [16] which is connectable at one thereof to the irrigation pipeline [12]; and a connecting pipe [24] extending between the first and second arm segments [14; 16]

15 to enable uninterrupted fluid flow in the irrigation pipeline [12]. The first and second arm segments [14; 16] are displaceable relative to each other between a retracted and extended position to alternate radial distance between the movable tower and the central tower.

20 The first arm segment [14] includes a first irrigation pipe attachment [14.1] for connecting the first arm segment [14] at one thereof to the irrigation pipe [12]. It also includes at least two elongate first arms [14.3] extending parallel to each other and from radially opposite positions from the first irrigation pipe attachment [14.1]. The first arms [14.3] terminate at their free ends in first engagement formations [14.2] for

25 slidingly engaging the second arm segment [16]. Each of the first arms [14.3]

includes at least one elongate channel [21] extending substantially the length of the first arms [14.3] and located in inwardly facing faces of the first arms [14.3].

The second arm segment [16] includes a second irrigation pipe attachment [16.1] for
5 connecting the second arm segment [16] at one thereof to the irrigation pipe [12]; and
at least two elongate second arms [16.3] extending parallel to each other and from
radially opposite positions from the second irrigation pipe attachment [16.1]. The
second arms [16.3] terminate at their free ends in second engagement formations
[16.2] for slidingly engaging the first arms [14.3] of the first arm segment [14]. In one
10 embodiment of the invention, the second arms [16.3] are arranged closer to each
other compared to the distance between the first arms [14.3], such that the second
arms [16.3] fit between and slidingly engage the first arms [14.3]. Each of the second
arms [16.3] include at least one elongate channel [22] extending substantially the
length of the arms [16.3] and located in outwardly facing faces of the second arms
15 [16.3] such that the channels [22] of the second arms [16.3] face the channels [21] of
the first arms [14.3].

The first and second arm segments [14; 16] are displaceable relative to each other
between an extended position (refer Figure 1), in which the first and second
20 engagement formations [14.2; 16.2] are aligned; and a retracted position (refer
Figure 3) in which the second engagement formations [16.2] press against the first
irrigation pipe attachment [14.1], with the first engagement formations [14.2] arranged
approximate the second irrigation pipe attachment [16.1].

The first and second arms [14.3; 16.3] are connected to each other through at least one connecting pin [20] connected to either one of the first or second engagement formations [14.2; 16.2] and being slidable on the elongate channel [21 or 22] of the other of the second or first arms [16.3; 14.3]. Particularly, in the illustrated
5 embodiment of the invention, the connecting pins [20] are connected to each of the second engagement formations [16.2] of the second arms [16.3], extending outwardly and being slidable in the elongate channels [21] of the first arms [14.3]. As illustrated in Figure 7, the first and second arm segments [14; 16] are slightly pivotable relative to each other at the connecting pin [20] connection.

10

The connecting pipe [24] is either a flexible pipe (for example a concertina pipe), which is deformable to accommodate the extended and retracted positions of the first and second arm segments [14; 16]; or the extendable arm [10] includes at least two connecting pipes [24] of different lengths to accommodate the extended and
15 retracted positions of the first and second arm segments [14; 16] respectively. It will of course be appreciated that the extendable arm [10] may include more than 2 connecting pipe [24] lengths to provide for more than two positions. The connecting pipe [24] terminates at each of its opposite ends in a pipe flange [26].

20 The extendable arm [10] further includes two intermediate pipe connectors [36] for connecting the connecting pipe [24] to the irrigation pipe attachments [14.1; 16.1] of the first and second arm segments [14; 16] respectively. Each intermediate pipe connector [36] terminates at opposite ends thereof in a radially extending connector flange [36.1; 36.2] dimensioned for connecting the pipe flanges [26] to the second
25 connector flanges [36.2], and for connecting the first connector flanges [36.1] to the

irrigation pipe attachments [14.1; 16.1] through a number of nuts and bolts extending through the various flanges. The irrigation pipeline [12] is connected to opposite sides of the irrigation pipe attachments [14.1; 16.1], thus completing the fluid path of the extendable arm [10].

5

The extendable arm [10] includes an adjustment mechanism [28] to adjust the arm [10] between the retracted and the extended configurations. The adjustment mechanism comprises at least one elongate rod [30] terminating in two opposite threaded ends [32], with one threaded end [32] extending through the first irrigation
10 pipe attachment [14.1] and the second threaded end [32] extending through the second irrigation pipe attachment [16.1]; and two nuts [34] for engaging the threaded rod ends [32] for securing the threaded rod [30] in place. Rotation of the nuts [34] on the threaded rod ends [32] displaces the arm segments [14; 16] between the extended and retracted positions. In a preferred embodiment of the invention the
15 extendable arm [10] includes two threaded rods [30] extending parallel to each other and penetrating at radially opposite positions through the first and second irrigation pipe attachments [14.1; 16.1]. In the illustrated embodiment the adjustment mechanism [28] is manually adjustable, but it will be appreciated that the first and second arm segments [14; 16] may be displaced relative to each other through
20 automated means, such as hydraulic, electronic or robotic adjustment means.

It will be appreciated that other embodiments of the invention are possible without departing from the spirit or scope of the invention as set out in the claims.

25

CLAIMS

1. An extendable arm [10] that is removably insertable into an irrigation pipeline [12] of a centre pivot irrigation system, which includes a central tower and at least one movable tower for carrying the pipeline [12], the arm [10] comprising –
- 5 a first arm segment [14] which is connectable at one end thereof to the irrigation pipeline [12];
- a second arm segment [16] which is connectable at one thereof to the irrigation pipeline [12],
- 10 with the first and second arm segments [14; 16] being displaceable relative to each other between a retracted and extended position to alternate radial distance between the movable tower and the central tower; and
- a connecting pipe [24] extending between the first and second arm segments [14; 16] to enable uninterrupted fluid flow in the irrigation pipeline [12].
- 15
2. The extendable arm [10] according to claim 1 wherein the first arm segment [14] includes a first irrigation pipe attachment [14.1] for connecting the first arm segment [14] at one thereof to the irrigation pipeline [12]; and at least two elongate first arms [14.3] extending parallel to each other and from radially opposite positions from the first irrigation pipe attachment [14.1].
- 20
3. The extendable arm [10] according to claim 2 wherein the first arms [14.3] terminate at their free ends in first engagement formations [14.2] for slidingly engaging the second arm segment [16].
- 25

4. The extendable arm [10] according to claim 3 wherein each of the first arms [14.3] includes at least one elongate channel [21] extending substantially the length of the arms [14.3] and located in inwardly facing faces of the first arms [14.3].
5
5. The extendable arm [10] according to claim 1 wherein the second arm segment [16] includes a second irrigation pipe attachment [16.1] for connecting the second arm segment [16] at one thereof to the irrigation pipeline [12]; and at least two elongate second arms [16.3] extending parallel to each other and from radially opposite positions from the second irrigation pipe attachment [16.1].
10
6. The extendable arm [10] according to claim 5 wherein the second arms [16.3] terminate at their free ends in second engagement formations [16.2] for slidingly engaging the first arm segment [14].
15
7. The extendable arm [10] according to claim 6 wherein each of the second arms [16.3] includes at least one elongate channel [22] extending substantially the length of the arms [16.3] and located in outwardly facing faces of the second arms [16.3].
20
8. The extendable arm [10] according to claims 2 and 5 wherein the second arms [16.3] of the second arm segment [16] are arranged closer to each other compared to the distance between the first arms [14.3] of the first arm segment

[14], such that the second arms [16.3] fit between and slidably engage the first arms [14.3].

9. The extendable arm [10] according to claims 4 and 7 wherein the channels [22] of the second arms [16.3] face the channels [21] of the first arms [14.3].
10. The extendable arm [10] according to claims 3 and 6 wherein the first and second arm segments [14; 16] are displaceable relative to each other between an extended position, in which the first and second engagement formations [14.2; 16.2] are aligned; and a retracted position in which the second engagement formations [16.2] press against the first irrigation pipe attachment [14.1], with the first engagement formations [14.2] arranged approximate the second irrigation pipe attachment [16.1].
11. The extendable arm [10] according to claims 4 and 7 wherein the first and second arms [14.3; 16.3] are connected to each other through at least one connecting pin [20] connected to either one of the first or second engagement formations [14.2; 16.2] and being slidable in the elongate channel [21 or 22] of the other of the second or first arms [16.3; 14.3], as the case be.
12. The extendable arm [10] according to claim 11 wherein the connecting pins [20] are connected to each of the first engagement formations [14.2] of the first arms [14.3], extending inwardly and being slidable in the elongate channels [22] of the second arms [16.3].

13. The extendable arm [10] according to claim 11 wherein the connecting pins [20] are connected to each of the second engagement formations [16.2] of the second arms [16.3], extending outwardly and being slidable in the elongate channels [21] of the first arms [14.3].

5

14. The extendable arm [10] according to claim 11 wherein the first and second arm segments [14; 16] are slightly pivotable relative to each other at the connecting pin [20] connection, thus allowing for a measure of flexibility over uneven ground conditions.

10

15. The extendable arm [10] according to claim 1 wherein the connecting pipe [24] is a flexible pipe deformable to accommodate the extended and retracted positions of the first and second arm segments [14; 16].

15 16. The extendable arm [10] according to claim 15 wherein the connecting pipe [24] is a concertina pipe.

17. The extendable arm [10] according to claim 1 wherein the extendable arm [10] includes at least two connecting pipes [24] of different lengths to accommodate
20 the extended and retracted positions of the first and second arm segments [14; 16] respectively.

18. The extendable arm [10] according to claim 1 wherein the connecting pipe [24] terminates at each of its opposite ends in a pipe flange [26] which is

complimentarily configured for connecting the connecting pipe [24] to the first and second arm segments [14; 16] respectively.

19. The extendable arm [10] according to claim 1 wherein the extendable arm [10]
5 includes an adjustment mechanism [28] to adjust the arm between the retracted and the extended configurations.
20. The extendable arm [10] according to claims 2, 5 and 19 wherein the
10 adjustment mechanism [28] comprises at least one elongate rod [30] terminating in two opposite threaded ends [32], with one threaded end extending through the first irrigation pipe attachment [14.1] and the second threaded end extending through the second irrigation pipe attachment [16.1]; and two nuts [34] for engaging the threaded rod ends [32] for securing the threaded rod [30] in place; the arrangement being such that rotation of the nuts
15 [34] on the threaded rod ends [32] displaces the arm segments [14; 16] between the extended and retracted positions.
21. The extendable arm [10] according to claim 20 wherein the extendable arm [10]
20 includes two threaded rods [30] extending parallel to each other and penetrating at radially opposite positions through the first and second irrigation pipe attachments [14.1; 16.1].
22. The extendable arm [10] according to claim 1 wherein the extendable arm [10]
25 includes two intermediate pipe connectors [36] for connecting the connecting pipe [24] to the first and second arm segments [14; 16] respectively, with the

irrigation pipeline [12] being connected to opposite sides of the first and second arm segments [14; 16] respectively, thus completing the fluid path of the extendable arm [10].

- 5 23. The extendable arm [10] according to claim 22 wherein the extendable arm [10] includes a series of intermediate pipe connectors [36] of different lengths to accommodate different connector pipe [24] lengths intermediate the first and second arm segments [14; 16].
- 10 24. An extendable arm [10] according to claim 1 wherein the adjustment mechanism [28] is a hydraulic, electronic, or robotic adjustment means for automated displacement of the first and second arm segments [14; 16] relative to each other.
- 15 25. A centre pivot irrigation system, comprising –
a central tower; an irrigation pipeline [12] extending from the central tower; and at least one moveable tower for carrying the pipeline [12]; and
an extendable arm [10] which is removably insertable into the irrigation pipeline [12] and which comprises –
20 a first arm segment [14] which is connectable at one end thereof to the irrigation pipeline [12];
a second arm segment [16] which is connectable at one thereof to the irrigation pipeline [12], with the first and second arm segments [14; 16] being displaceable relative to each other between a retracted and

extended position to alternate radial distance between the movable tower and the central tower; and

a connecting pipe [24] extending between the first and second arm segments [14; 16] to enable uninterrupted fluid flow in the irrigation pipeline [12].

5

26. An extendable arm [10] according to claim 1, substantially as herein illustrated and exemplified with reference to the accompanying Figures.

10

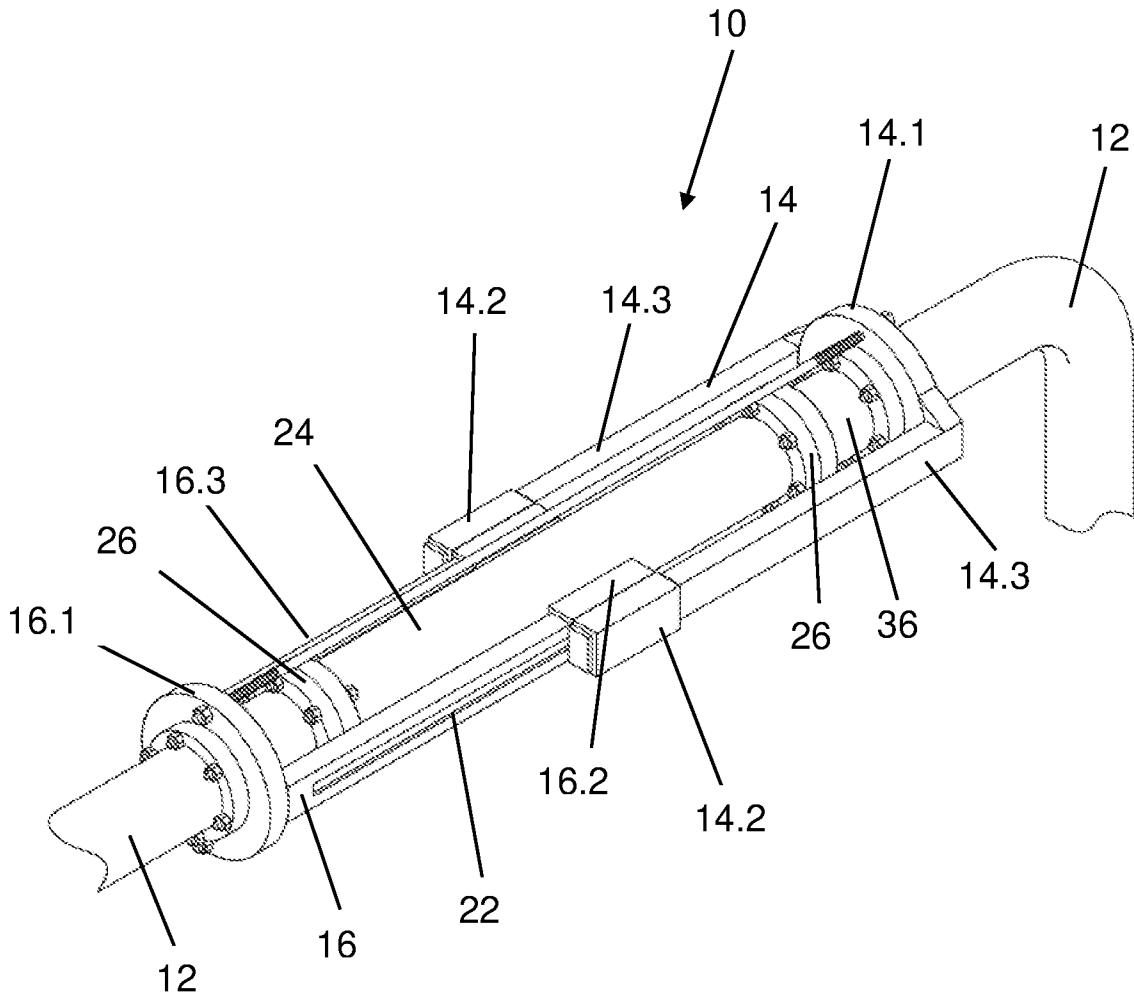


FIGURE 1

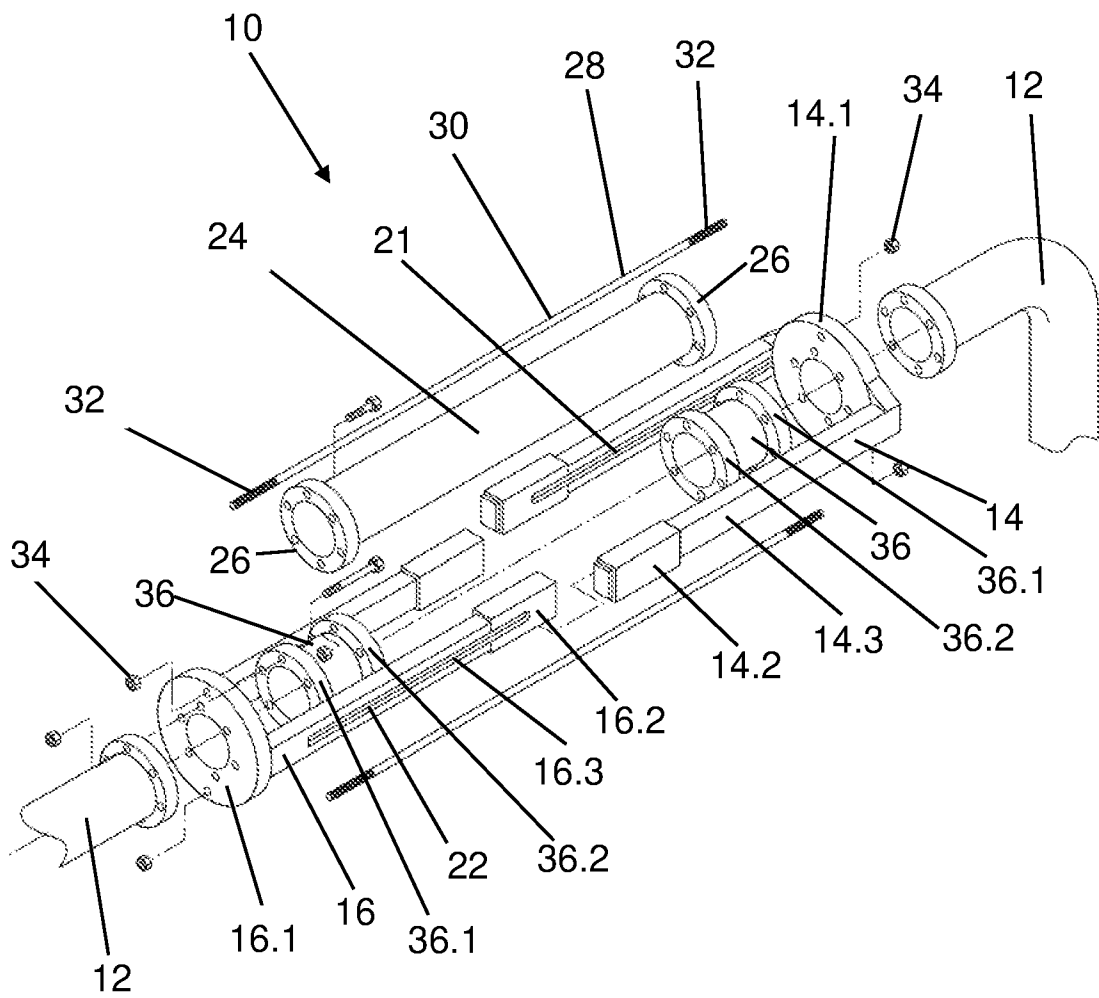


FIGURE 2

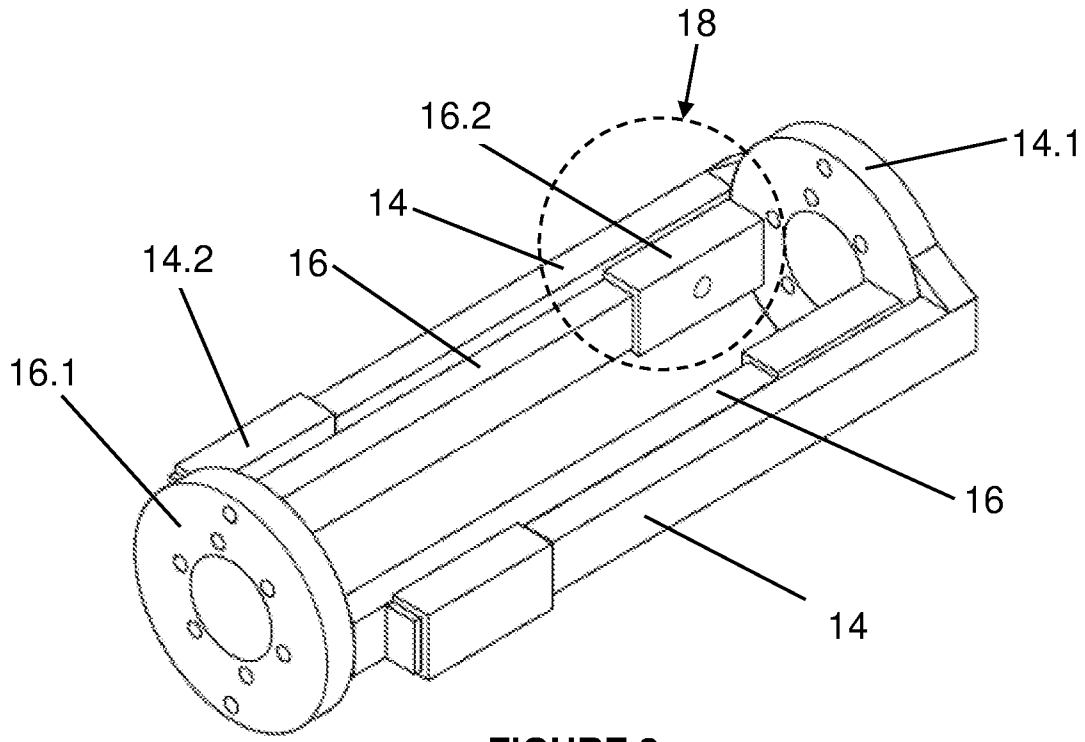


FIGURE 3

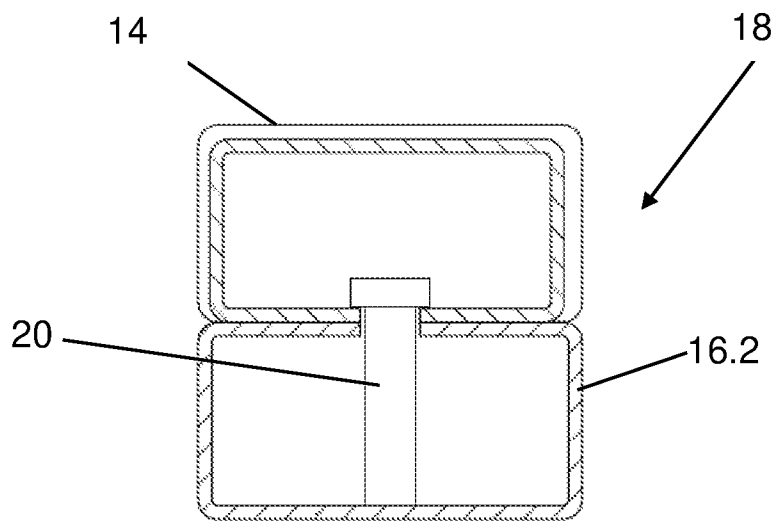


FIGURE 4

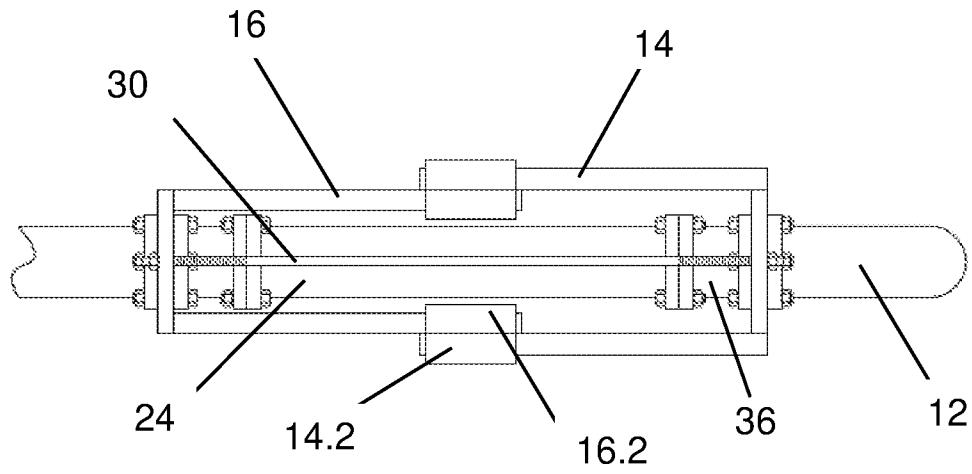


FIGURE 5

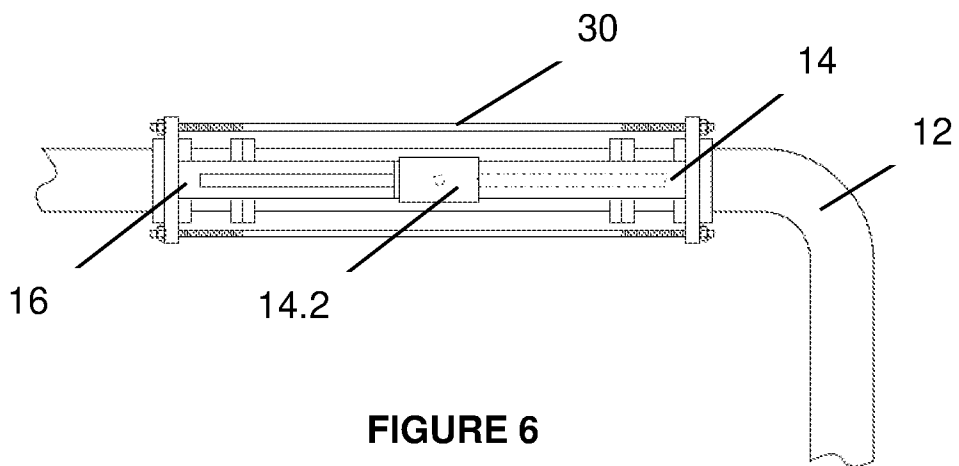


FIGURE 6

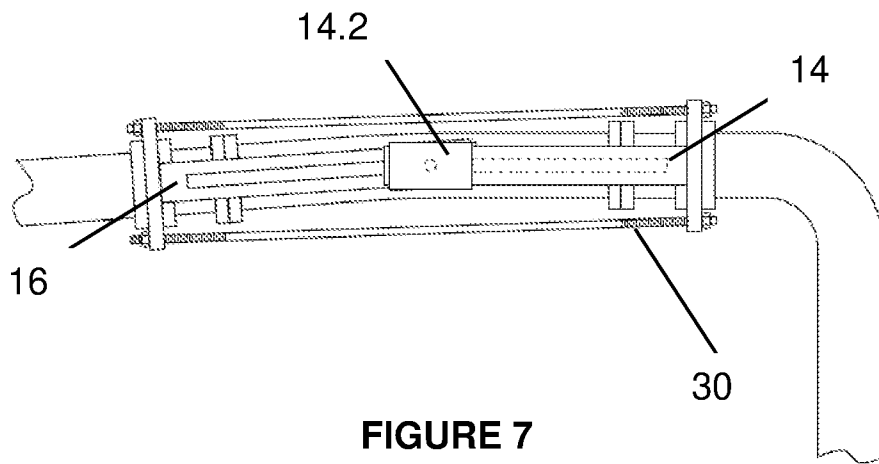


FIGURE 7

INTERNATIONAL SEARCH REPORT

International application No.
PCT/IB2022/054661

A. CLASSIFICATION OF SUBJECT MATTER IPC: A01G 25/09 (2006.01); F16L 27/12 (2006.01)		
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) A01G, F16L		
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) Full Text Databases		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2021051866 A1 (DAVENPORT ROSS, PINCH WAYNE) 25 February 2021 (25.02.2021) figs. 2-2C, abstract	1, 25
Y		15, 16
Y	US 1726483 A (GIESLER JEAN), 27 August 1929 (27.08.1929) fig. 1, pages 2-3	15, 16
A	US 6902351 B1 (MCGEE RICKY, CHRISTENSEN DALE) 07 June 2005 (07.06.2005) figs. 1-4B, column 3, line 49 - column 4, line 6	1, 25
A	US 2014097613 A1 (IKEDA SHINTARO) 10 April 2014 (10.04.2014) figs. 27-33, paragraphs 181-201	1, 25
A	US 5435495 A (DAVIS JIMMY) 25 July 1995 (25.07.1995) figs. 3-5, columns 3-5	1, 25
Further documents are listed in the continuation of Box C.		<input checked="" type="checkbox"/> See patent family annex.
* Special categories of cited documents:		
"A" document defining the general state of the art which is not considered to be of particular relevance		"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"E" earlier application or patent but published on or after the international filing date		"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)		"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"O" document referring to an oral disclosure, use, exhibition or other means		
"P" document published prior to the international filing date but later than the priority date claimed		"&" document member of the same patent family
Date of the actual completion of the international search 09 August 2022 (09.08.2022)	Date of mailing of the international search report 11 August 2022 (11.08.2022)	
Name and mailing address of the ISA/AT Austrian Patent Office Dresdner Straße 87, A-1200 Vienna Telephone No. +43 (1) 53424 342	Authorized officer Görtler Maximilian Telephone No. +43 1 534 24 365	

INTERNATIONAL SEARCH REPORTInternational application No.
PCT/IB2022/054661**Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)**

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. Claims Nos.: 26
because they relate to subject matter not required to be searched by this Authority, namely:

2. Claims Nos.: 26
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:
Claim 26 is not clear because it contains only a reference to the drawings, but no technical feature.

3. Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.

3. As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

- The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.

- The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.

- No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/IB2022/054661

Patent document cited in search report	Patent family member(s)	Publication date
US 2021051866 (A1)	US 2021051866 (A1)	2021-02-25
US 1726483 (A)	US 1726483 (A)	1929-08-27
US 6902351 (B1)	US 6902351 (B1) US 7066414 (B1)	2005-06-07 2006-06-27
US 2014097613 (A1)	CN 103635733 (A) CN 103635733 (B) JP 5738994 (B2) JP WO2013005802 (A1) KR 101878531 (B1) KR 20140062458 (A) TW 201321643 (A) TW I524022 (B) US 2014097613 (A1) US 9249911 (B2) WO 2013005802 (A1)	2014-03-12 2015-05-20 2015-06-24 2015-02-23 2018-07-13 2014-05-23 2013-06-01 2016-03-01 2014-04-10 2016-02-02 2013-01-10
US 5435495 (A)	US 5435495 (A)	1995-07-25