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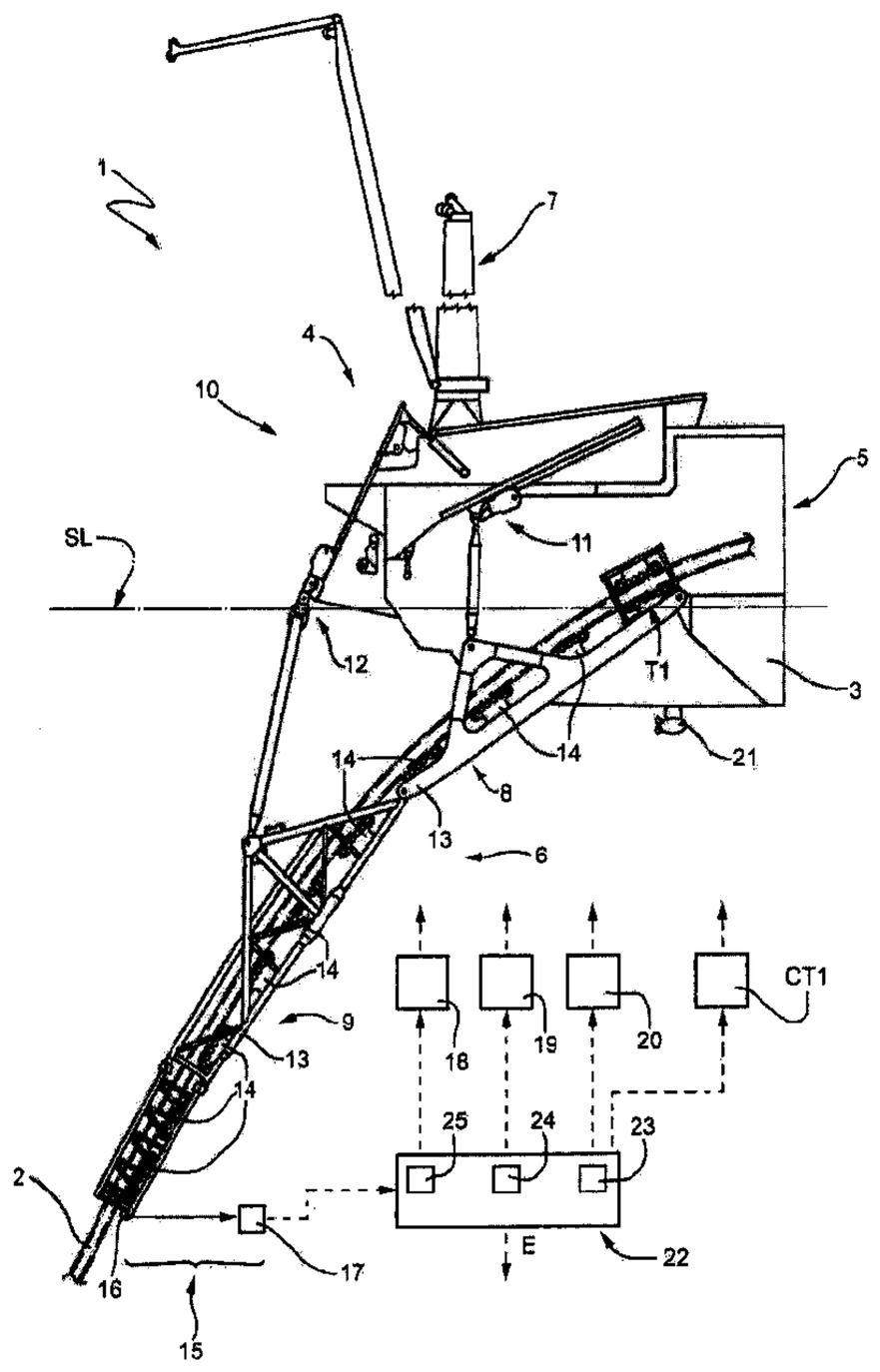
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(54) **Titre : PROCEDE DE POSE D'UN PIPELINE SUR LE FOND D'UN PLAN D'EAU A PARTIR D'UN NAVIRE POSEUR, ET NAVIRE POSEUR**

(54) **Title: METHOD OF LAYING A PIPELINE FROM A LAYING VESSEL ONTO THE BED OF A BODY OF WATER, AND LAYING VESSEL**



(57) **Abrégé/Abstract:**
A method of laying a pipeline from a laying vessel into a body of water; the method including the steps of : - guiding the pipeline (2) along a supporting structure (13) of a laying ramp (6) by means of a number of guide devices (14); - acquiring an image of the

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(57) **Abrégé(suite)/Abstract(continued):**
pipeline (2), in an acquisition plane crosswise to the axis of the pipeline (2), at the free end of the laying ramp (6); - determining whether the acquired image is within an acceptance range (AR) predetermined as a function of the configuration of the supporting structure (13) and the size of the pipeline (2); and - emitting an error signal (E) when the acquired image is not within the acceptance range (AR).

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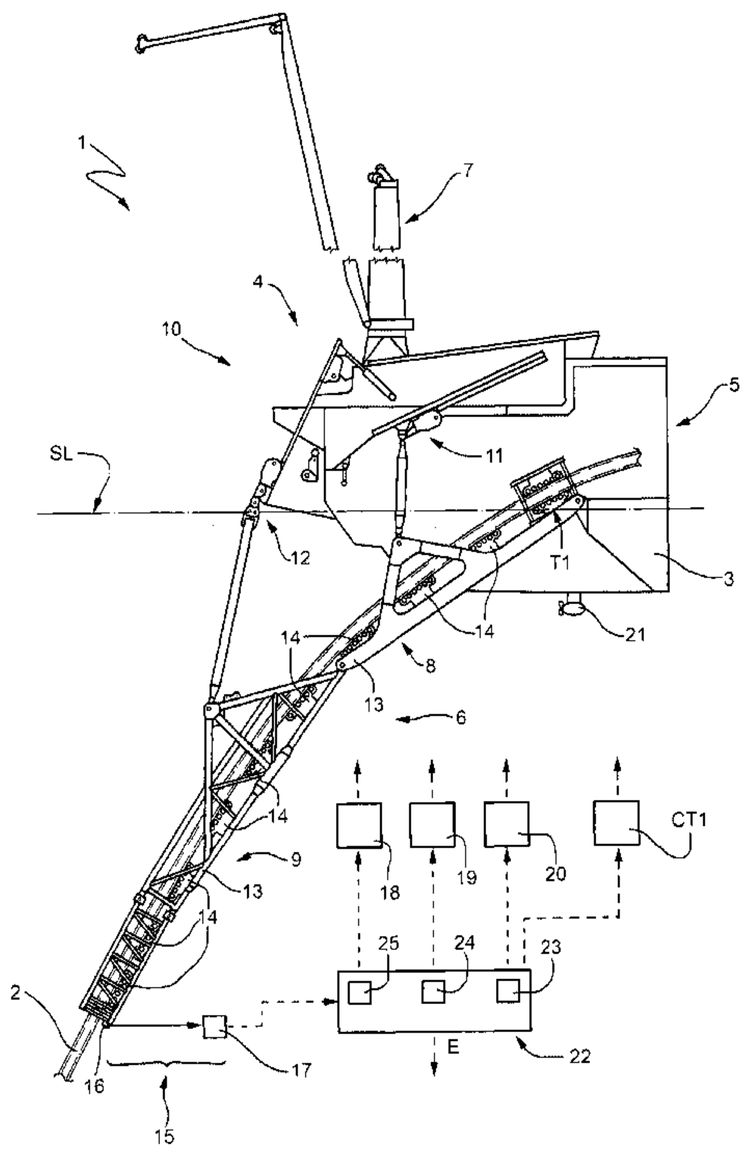
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(54) **Title**: METHOD OF LAYING A PIPELINE FROM A LAYING VESSEL ONTO THE BED OF A BODY OF WATER, AND LAYING VESSEL

FIG. 1



(57) **Abstract**: A method of laying a pipeline from a laying vessel into a body of water; the method including the steps of : - guiding the pipeline (2) along a supporting structure (13) of a laying ramp (6) by means of a number of guide devices (14); - acquiring an image of the pipeline (2), in an acquisition plane crosswise to the axis of the pipeline (2), at the free end of the laying ramp (6); - determining whether the acquired image is within an acceptance range (AR) predetermined as a function of the configuration of the supporting structure (13) and the size of the pipeline (2); and - emitting an error signal (E) when the acquired image is not within the acceptance range (AR).

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METHOD OF LAYING A PIPELINE FROM A LAYING VESSEL ONTO THE BED OF A BODY OF WATER, AND LAYING VESSEL

TECHNICAL FIELD

The present invention relates to a method of laying a pipeline from a laying vessel into a body of water.

More specifically, the present invention relates to a method which guides the pipeline along a supporting structure of a laying ramp by means of a number of guide devices spaced along the supporting structure, and releases the pipeline into the body of water at the free end of the laying ramp.

BACKGROUND ART

A laying vessel is a floating unit, which comprises a pipeline assembly line, and is equipped at the stern with a laying ramp, which is an extension of the assembly line and serves to ease the pipeline onto the bed of the body of water as the floating unit moves forward.

Laying vessels include S-lay vessels of the above type, as described for example in Patent Application WO 2009/098586 A2, and J-lay vessels of the type described in Patent EP 1,102,698 B1.

In the S-lay method, the pipeline is assembled on a substantially horizontal assembly line and laid off the laying ramp, which, in the work configuration, serves to guide and support the pipeline along a curved path

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partly above and partly below water level. Pipelines laid this way assume an S shape between the laying vessel and the bed of the body of water, with curves of a radius depending on the rigidity of the pipeline, and can be laid using various types of vessels, such as pontoons, barges, semisubmersibles, and single-hull ships.

Underwater pipeline laying calls for fairly calm water conditions, so much so that, in rough water, laying is suspended, the completed part of the pipeline is abandoned using a winch-controlled cable, and the laying ramp is raised as far as possible above water level into a so-called 'survival configuration'.

The laying ramp normally comprises an inner ramp hinged to the laying vessel, and an outer ramp hinged to the inner ramp, and can assume various work configurations, depending on the depth of the bed and the characteristics of the pipeline; a transit configuration, in which the inner and outer ramps allow unimpeded movement of the laying vessel; and said survival configuration. For which purpose, the laying ramp is connected to the laying vessel by a known actuator assembly, as described for example in the Applicants patent US 4,257,718.

To guide and move the pipeline forward, the laying ramp comprises a number of guide devices aligned to define the path of the pipeline.

In the J-lay method, the pipeline assembly line is housed at least partly in a J-lay tower hinged to the laying vessel, and the pipeline is guided by a laying ramp normally fixed to the J-lay tower. In this case, too, as described in Patent EP 1,102,698 B1, adjustable guide devices are fitted to the laying ramp supporting structure to guide the pipeline as it is being laid, and to monitor stress between the pipeline and the supporting structure.

In both the above laying methods, stress between the pipeline and the laying ramp supporting structure must be monitored to prevent damage to the pipeline and/or laying ramp. In this connection, it is important to remember that, when laying the pipeline, the laying vessel and ramp, on the one hand, and the pipeline, on the other, are subjected by the water to various forms of stress. The laying vessel, despite being maintained in position and advanced in steps along a given course by a system of mooring lines or a so-called dynamic positioning system comprising thrusters, is still subject to undesired movements caused by waves and water currents. The same wave action and currents also affect the pipeline, but, because of the difference in shape and mass of the laying vessel and the pipeline, and the fact that the pipeline is substantially flexible and rests partly on the bed, produce different movements of the laying ramp and pipeline. Pitching and rolling of

the laying vessel are especially hazardous, by causing violent contact between the pipeline and the laying ramp; and known systems of monitoring stress between the pipeline and the laying ramp supporting structure have proved poorly effective in preventing critical pipeline and laying ramp operating conditions.

DISCLOSURE OF INVENTION

It is an object of the present invention to provide a method of laying a pipeline from a laying vessel into a body of water, designed to minimize the drawbacks of the known art.

Another object of the present invention to provide a method of laying a pipeline from a laying vessel into a body of water, designed to prevent situations endangering the pipeline and/or laying ramp.

According to the present invention, there is provided a method of laying a pipeline from a laying vessel into a body of water; the method comprising the steps of :

- guiding the pipeline along a supporting structure of a laying ramp by means of a number of guide devices;

- acquiring an image of the pipeline, preferably in an acquisition plane crosswise to the axis of the pipeline, at the free end of the laying ramp;

- determining whether the acquired image is within an acceptance range predetermined as a function of the configuration of the supporting structure and the size

of the pipeline; and

- emitting an error signal when the acquired image is not within the acceptance range.

The present invention has the major advantage of identifying situations in which external agents and movement of the vessel bring the pipeline dangerously close to the supporting structure, and indicating a potential hazard at the free end of the laying ramp, where movements between the pipeline and the supporting structure are greatest.

Preferred embodiments of the present invention may provide for automatically adjusting the guide devices with respect to the supporting structure according to the error signal, and/or adjusting the supporting structure according to the error signal, and/or controlling the position of the laying vessel and/or adjusting the pull on the pipeline by the laying vessel according to the error signal.

All the above steps can prevent hazard situations from getting worse, and prevent accidents.

Another object of the present invention is to provide a laying vessel.

According to the present invention, there is provided a laying vessel for laying a pipeline in a body of water; the laying vessel comprising :

- a laying ramp comprising a supporting structure and a number of guide devices for guiding the pipeline;

- an image acquisition device for acquiring an image of the pipeline, preferably in an acquisition plane crosswise to the axis of the pipeline, at the free end of the laying ramp; and

- a control unit for determining whether the acquired image is within an acceptance range predetermined as a function of the configuration of the supporting structure and the size of the pipeline, and for emitting an error signal when the acquired image is not within the acceptance range.

BRIEF DESCRIPTION OF THE DRAWINGS

A number of non-limiting embodiments of the present invention will be described by way of example with reference to the accompanying drawings, in which :

Figure 1 shows a partly sectioned side view, with parts removed for clarity, of a laying vessel equipped with a laying ramp and in accordance with the present invention;

Figure 2 shows a schematic cross section, with parts removed for clarity, of the Figure 1 laying ramp;

Figure 3 shows a partly sectioned side view, with parts removed for clarity, of a laying vessel equipped with a laying ramp and in accordance with a further embodiment of the present invention;

Figure 4 shows a schematic cross section, with parts removed for clarity, of the Figure 3 laying ramp.

BEST MODE FOR CARRYING OUT THE INVENTION

Number 1 in Figure 1 indicates a laying vessel for laying a pipeline 2 on the bed (not shown) of a body of water of level SL. In the example shown, laying vessel 1 is a single-hull S-lay ship, and comprises a hull 3; an aftercastle 4; and a assembly line 5 for assembling pipeline 2 from pipes (not shown). Laying vessel 1 is equipped with a laying ramp 6, which defines an extension of assembly line 5 in the Figure 1 operating configuration, and serves to guide and support pipeline 2 along a path having at least one curved portion, a first portion above water level SL, and a second portion below water level SL.

Laying vessel 1 is equipped, at aftercastle 4, with a crane 7 for performing auxiliary pipeline 2 laying operations.

Laying ramp 6 is hinged to laying vessel 1, and comprises an inner ramp 8 hinged to laying vessel 1, and an outer ramp 9 hinged to inner ramp 8. And laying vessel 1 comprises a drive assembly 10 for setting laying ramp 6 to a number of operating configurations (only one shown in Figure 1); a transit configuration (not shown), in which both inner and outer ramps 8, 9 are positioned above water level SL; and a survival configuration (not shown in Figure 1), in which inner and outer ramps 8, 9 are locked as far as possible above water level SL.

Drive assembly 10 comprises two actuators 11, 12 for supporting, controlling, and setting respective inner and outer ramps 8, 9 to the above configurations. In the Figure 1 laying configuration, inner ramp 8 and outer ramp 9 define respective supporting portions for pipeline 2.

Laying ramp 6 comprises a supporting structure 13, and a number of guide devices 14 spaced along supporting structure 13. In the example shown, inner ramp 8 comprises an inner portion of supporting structure 13, and outer ramp 9 comprises an outer portion of supporting structure 13 hinged to the inner portion of supporting structure 13.

T1 in Figure 1 indicates a tensioning device, which exchanges a force, preferably a gripping force, with pipeline 2 to exert pull on pipeline 2 to release pipeline 2 from laying vessel 1 in controlled manner, or pull back pipeline 2, or lock pipeline 2 with respect to laying vessel 1.

With reference to Figure 2, supporting structure 13 extends along three sides defining a space housing pipeline 2. More specifically, Figure 2 shows the free end of supporting structure 13, where the relative movements between pipeline 2 and laying ramp 6 are greatest. The guide device 14 at the free end of supporting structure 13 does not usually contact pipeline 2, and serves to absorb any shock. Each guide

device 14 is damped with respect to supporting structure 13, and has actuators (not shown) for adjusting its active position with respect to supporting structure 13 to optimize load distribution between pipeline 2 and laying ramp 6.

With reference to Figure 1, laying vessel 1 comprises an image acquisition device 15, in turn comprising a sensor 16, and a processing unit 17 associated with sensor 16.

Laying vessel 1 comprises a control device 18 for controlling drive assembly 10 of laying ramp 6; a control device 19 for controlling guide devices 14; a control device 20 for controlling the position of laying vessel 1 - in the example shown, for controlling the dynamic positioning system comprising a number of thrusters 21 (only one shown in Figure 1); a control device CT1 for controlling tensioning device T1 to adjust the force exchanged between pipeline 2 and tensioning device T1 and, therefore, the pull exerted on the pipeline; and a control unit 22 connected to image acquisition device 15 and control devices 18, 19, 20, and in turn comprising a display 23, a control panel 24, and a memory 25.

With reference to Figure 2, sensor 16 is fitted to supporting structure 13, at the free end of laying ramp 6, is positioned facing the outer face of pipeline 2, and is designed to define a fan-shaped image acquisition

range lying substantially in an acquisition plane perpendicular to the axis of pipeline 2. Sensor 16 is defined by an optical sensor, so image acquisition device 15 preferably comprises a light source 26 fixed to supporting structure 13 to illuminate pipeline 2 in the image acquisition range of sensor 16; and an image processing unit 17 for processing optical images. In a variation, sensor 16 is defined by a sonar, and image processing unit 17 is designed to process acoustic images, so light source 26 is not needed.

Light source 26 is preferably designed to emit a laser beam clearly showing pipeline 2 in the acquisition plane. More specifically, the laser beam is positioned and designed to sweep the whole face of the pipeline in the acquisition plane.

With reference to Figure 1, the images acquired by image acquisition device 15 are transmitted to control unit 22, where they are compared with images stored in memory 25. The stored images are acceptable real images of the known pipeline 2, or image models reconstructed on the basis of the known dimensions of pipeline 2. In a first comparison mode, the acquired images are compared with the stored images to determine the position of pipeline 2 with respect to the supporting structure, and to determine the X and Y coordinates, which are in turn compared with an acceptance range AR expressed in coordinates.

In a second mode, the stored images define acceptance range AR.

In both modes, control unit 22 emits an error signal E when pipeline 2 does not fall within the acceptance range AR defined substantially by the dash line in Figure 2. With reference to Figure 1, the error signal E may be used to correct the configuration of laying ramp 6 and/or guide devices 14, and/or the position of laying vessel 1, and/or the pull exerted on pipeline 2 by tensioning device T1. In other words, control unit 22 is able to automatically control control devices 18, 19, 20, CT1 as a function of error signal E and other incoming signals relating to the load transmitted by pipeline 2 to guide devices 14, and to dynamic positioning of laying vessel 1.

Control unit 22 may be set to only operate automatically on some of control devices 18, 19, 20, CT1.

As shown in Figure 2, laying ramp 6 is also equipped with a further image acquisition device 15 comprising a sensor 16, an image processing unit 17, and a light source 26 in the event sensor 15 is defined by an optical sensor. The further image acquisition device 15 is positioned to acquire images of pipeline 2 in the same acquisition plane as the other image acquisition device 15, but from a different angle. The images acquired by both image acquisition devices 15 are sent

to control unit 22 for comparison with respective acceptance ranges, and an error signal E is emitted when the images acquired by at least one image acquisition device 15 do not fall within the respective acceptance range AR. As a result, image acquisition is made more dependable, and the range within which reliable images can be acquired is increased.

The images acquired by both image acquisition devices 15 may also be combined to reconstruct the position of pipeline 2 with respect to laying ramp 6, and determine the distance of the pipeline from laying ramp 6 in the acquisition plane.

Number 27 in Figure 3 indicates as a whole a semisubmersible laying vessel comprising a double-hull floating structure 28; a hinge assembly 29; a J-lay tower 30 hinged to floating structure 28 by hinge assembly 29; and a drive assembly 31 for orienting J-lay tower 30 about the hinge axis into a number of configurations. The top part of J-lay tower 30 houses a assembly line 32 for assembling pipes (not shown); and the bottom part houses a tensioning device T2 for exchanging a force, preferably a gripping force, with the pipeline, to exert pull on pipeline 2 to release pipeline 2 in controlled manner, or pull back pipeline 2, or lock the pipeline with respect to laying vessel 27.

The bottom end of J-lay tower 30 is connected to a

laying ramp 34, which defines an extension of J-lay tower 30 and, in use, is immersed in the body of water. Laying ramp 34 is connected rigidly to J-lay tower 30, so the configuration of J-lay tower 30 determines the configuration of laying ramp 34.

Laying ramp 34 comprises a supporting structure 35 extending about pipeline 2; and a number of guide devices 36, which are fitted to supporting structure 35, are spaced about pipeline 2 and along supporting structure 35, and are preferably adjustable and controllable by actuators not shown in the drawings.

Laying ramp 34 is equipped with an image acquisition device 15 located at the free end of supporting structure 35 to determine any risk positions of pipeline 2 with respect to laying ramp 34.

Images are acquired in the same way as described for laying ramp 6.

Laying vessel 27 comprises a control unit 37; a control device 38 for controlling drive assembly 31; a control device 39 for controlling guide devices 36; a control device 40 for controlling the movement of laying vessel 27 - in this case, dynamic positioning by means of thrusters 41 (only one shown in Figure 2); and a control device CT2 for controlling the force exchanged between tensioning device T2 and pipeline 2, and therefore the pull exerted on the pipeline. As described with reference to Figure 1, the acquired images are

compared with an acceptance range AR, and control unit 37 emits an error signal E when the acquired images do not fall within acceptance range AR. Control unit 37 comprises a display 42, a control panel 43, and a memory 44, and is designed to both automatically and manually control the position of J-lay tower 30, and/or the position of guide devices 36, and/or the movement of laying vessel 27, and/or the pull exerted on pipeline 2, as a function of error signal E.

As shown in Figure 4, sensor 16 is fitted to supporting structure 35, at the free end of laying ramp 34, and positioned facing the outer face of pipeline 2. In this case, supporting structure 35 completely surrounds pipeline 2, and sensor 16 defines a fan-shaped image acquisition range lying substantially in an acquisition plane perpendicular to the axis of pipeline 2. Sensor 16 is defined by an optical sensor, so image acquisition device 15 preferably comprises a light source 26 fixed to supporting structure 35 to illuminate pipeline 2 in the image acquisition range of sensor 16; and an image processing unit 17 for processing optical images. In a variation, sensor 16 is defined by a sonar, and image processing unit 17 is designed to process acoustic images, so light source 26 is not needed.

As shown in Figure 4, laying ramp 34 is also equipped with a further image acquisition device 15

comprising a sensor 16, an image processing unit 17, and a light source 26 in the event sensor 15 is defined by an optical sensor. The further image acquisition device 15 is positioned to acquire images of pipeline 2 in the same acquisition plane as the other image acquisition device 15, but from a different angle. The images acquired by both image acquisition devices are processed in the same way as in the previous embodiment.

The main advantages of the present invention lie in preventing the pipeline from assuming critical positions with respect to the laying ramp; enabling immediate intervention to counteract any critical situations; and fairly accurately determining the position of the pipeline with respect to the laying ramp, both in and out of the water.

Clearly, changes may be made to the embodiments of the present invention described herein without, however, departing from the protective scope of the accompanying Claims. For example, ramp 6 may be formed in one rigid piece, or comprise any number of hinged portions.

CLAIMS

1. A method of laying a pipeline from a laying vessel into a body of water; the method comprising the steps of:

- guiding the pipeline along a supporting structure of a laying ramp by means of a number of guide devices;

- acquiring an image of the pipeline at the free end of the laying ramp;

- determining whether the acquired image is within an acceptance range predetermined as a function of the configuration of the supporting structure and the size of the pipeline; and

- emitting an error signal when the acquired image is not within the acceptance range.

2. A method as claimed in claim 1 wherein the image of the pipeline is acquired in an acquisition plane crosswise to the axis of the pipeline at the free end of the laying ramp.

3. A method as claimed in claim 2, and comprising the step of altering the configuration of the guide devices with respect to the supporting structure, as a function of the error signal.

4. A method as claimed in claim 2 or claim 3, and comprising the step of altering the configuration of the supporting structure as a function of the error signal.

5. A method as claimed in any one of claims 2 to 4 and comprising the step of controlling the position of the laying vessel as a function of the error signal.

6. A method as claimed in any one of claims 2 to 5 and comprising the step of controlling the force exchanged between a tensioning device and the pipeline so as to control the pull exerted on the pipeline as a function of the error signal.

7. A method as claimed in any one of claims 2 to 6, and comprising the step of determining the distance between the pipeline and the supporting structure at the free end of the laying ramp.

8. A method as claimed in any one of claims 2 to 7, wherein the image is an acoustic image of a face of the pipeline.

9. A method as claimed in claim 8, and comprising the step of acquiring a further acoustic image in the same acquisition plane as the acoustic image and along a further face of the pipeline.

10. A method as claimed in any one of claims 2 to 7, wherein said image is an optical image of a face of the pipeline.

11. A method as claimed in claim 10 comprising illuminating the pipeline along the acquisition plane.

12. A method as claimed in claim 10 comprising illuminating the pipeline along the acquisition plane with a laser beam which sweeps a whole face of the pipeline along the acquisition plane.

13. A method as claimed in any one of claims 10 to 12, and comprising the step of acquiring a second optical image in the same acquisition plane as the first optical image and along a further face of the pipeline.

14. A method as claimed in any one of claims 1 to 13, wherein the acceptance range is defined by information stored in a memory.

15. A laying vessel for laying a pipeline in a body of water; the laying vessel comprising:

- a laying ramp comprising a supporting structure and a number of guide devices for guiding the pipeline;

- an image acquisition device for acquiring an image of the pipeline at the free end of the laying ramp; and

- a control unit for determining whether the acquired image is within an acceptance range predetermined as a function of the configuration of the supporting structure and the size of the pipeline, and for emitting an error signal when the acquired image is not within the acceptance range.

16. A laying vessel as claimed in claim 15 wherein the image of the pipeline is acquired in an acquisition plane crosswise to the axis of the pipeline at the free end of the laying ramp.

17. A laying vessel as claimed in claim 16, and comprising a control device for controlling the variable configuration of the guide devices, and which is connected to the control unit and designed to alter the configuration of the guide devices with respect to the supporting structure as a function of the error signal.

18. A laying vessel as claimed in any one of claims 16 to 17, and comprising a drive assembly for altering the configuration of the laying ramp; and a control device for controlling the drive assembly as a function of the error signal.

19. A laying vessel as claimed in any one of claims 16 to 18, and comprising a floating structure; a J-lay tower hinged to the floating structure; a drive assembly for altering the configuration of the J-lay tower; and a control device for controlling the drive assembly and the configuration of the J-lay tower as a function of the error signal.

20. A laying vessel as claimed in any one of claims 16 to 19, and comprising a control device for controlling the position of the laying vessel and which is connected to the control unit and designed to control the position of the laying vessel as a function of the error signal.

21. A laying vessel a as claimed in any one of claims 16 to 20, and comprising a tensioning device designed to exchange a force with the pipeline and exert pull on the pipeline; and a control device connected to the control unit and designed to control the force exchanged

between the tensioning device and the pipeline, so as to control the pull exerted on the pipeline as a function of the error signal.

22. A laying vessel as claimed in any one of claims 16 to 21, wherein the control unit is designed to determine the distance between the pipeline and the supporting structure at the free end of the laying ramp.

23. A laying vessel as claimed in any one of claims 16 to 22, wherein the image acquisition device comprises a sensor fitted to the laying ramp to define a fan-shaped acquisition range extending along the acquisition plane perpendicular to the axis of the pipeline; and an image processing unit.

24. A laying vessel as claimed in Claim 23, and comprising a number of image acquisition devices fitted to the laying ramp to acquire images of different faces of the pipeline in the same acquisition plane perpendicular to the axis of the pipeline.

25. A laying vessel as claimed in Claim 23, wherein said sensor is an optical sensor for acquiring optical images, or a sonar sensor for acquiring acoustic images.

26. A laying vessel as claimed in Claim 25, wherein the image acquisition device comprises a light source designed to emit a laser beam that sweeps a whole face of the pipeline along the acquisition plane.

FIG. 1

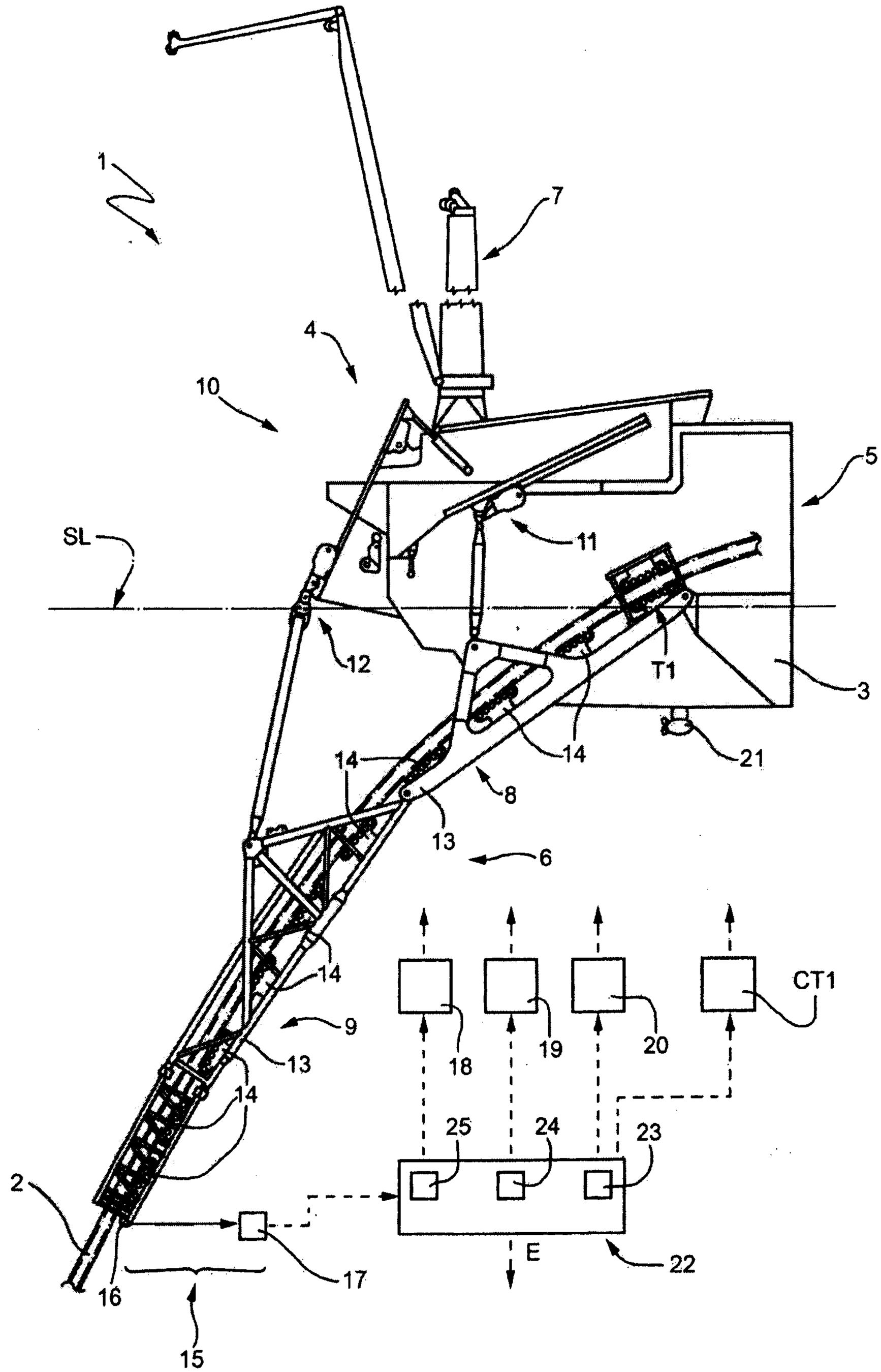
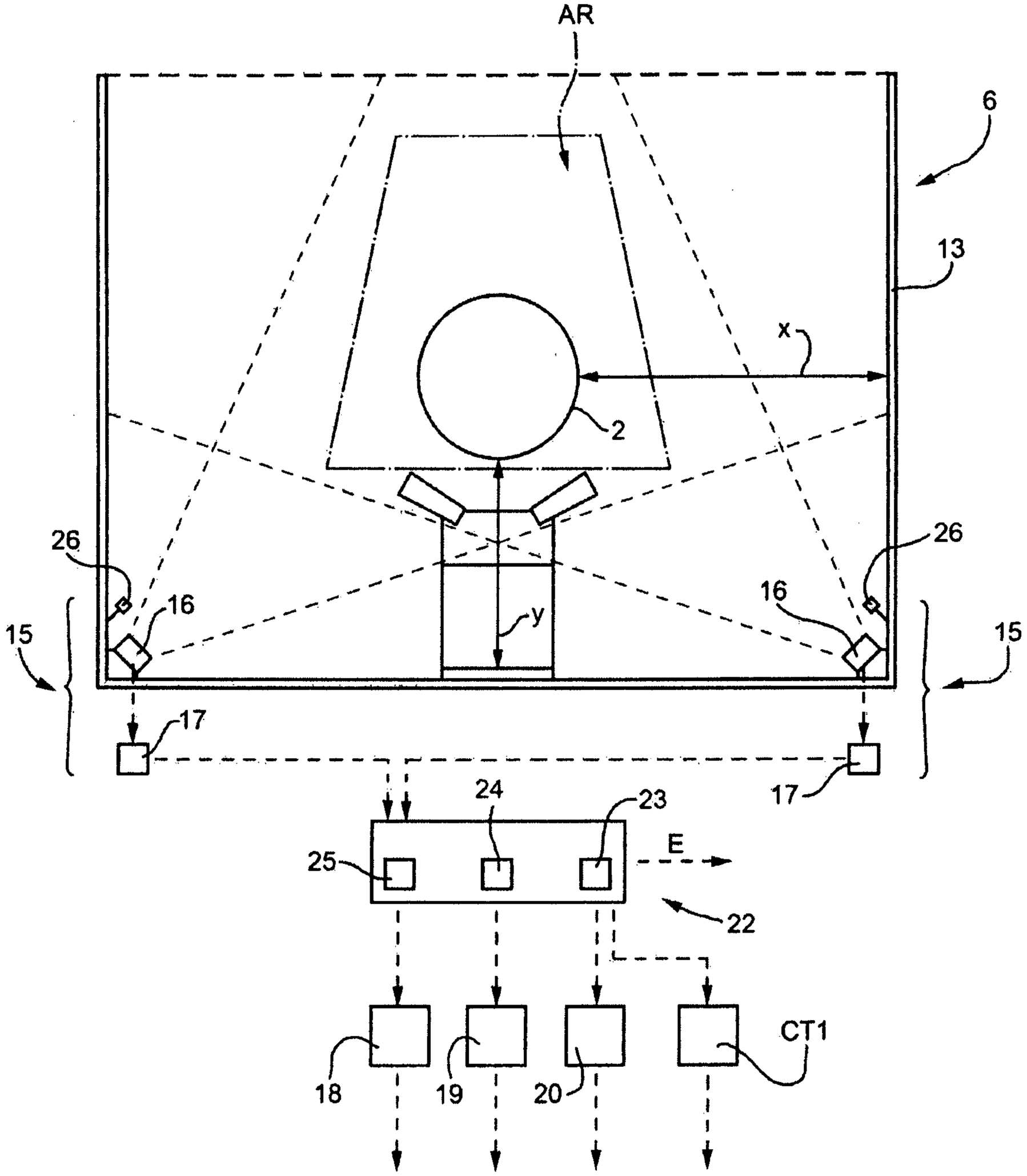

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SL
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E
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FIG. 2



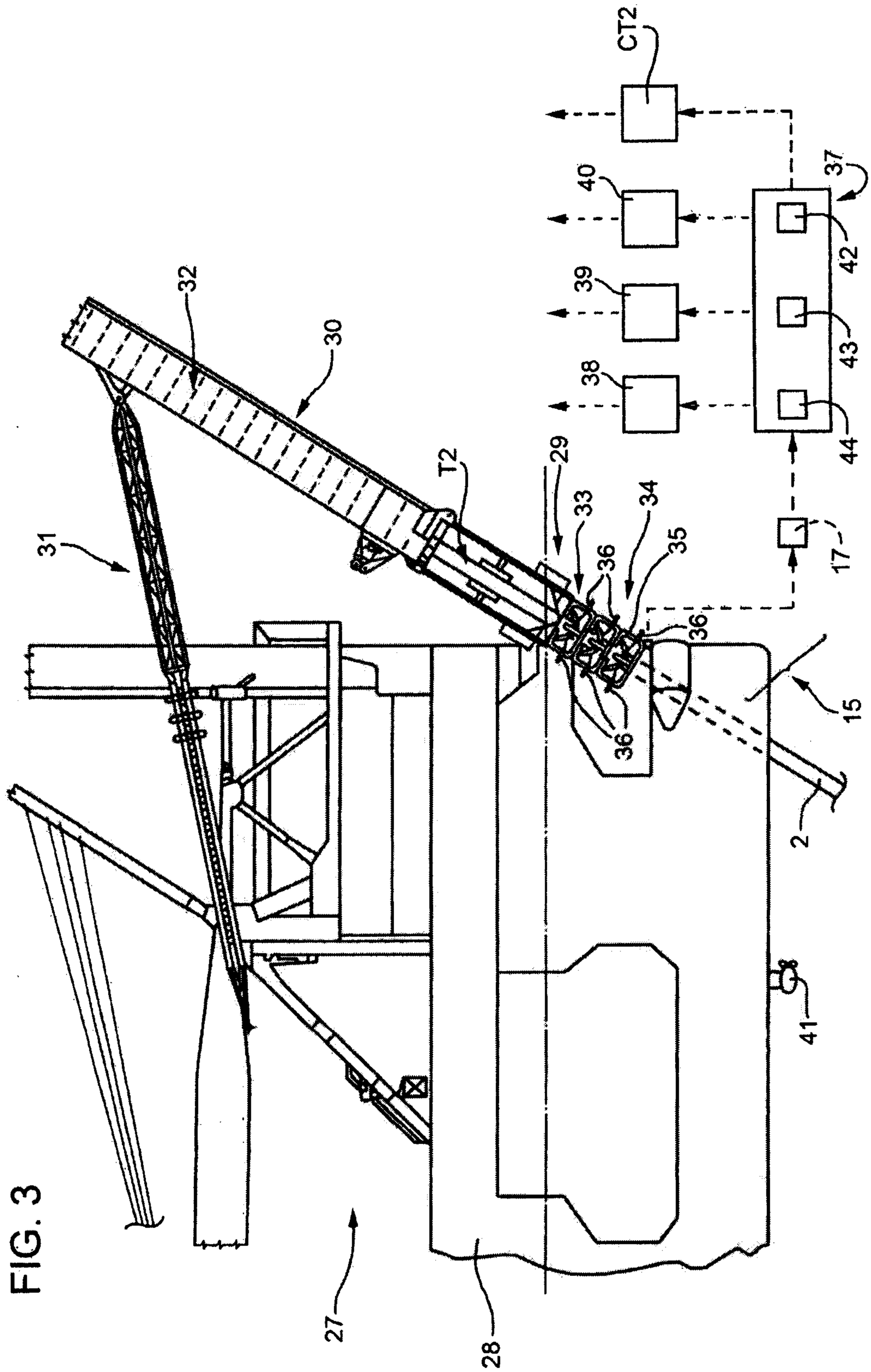
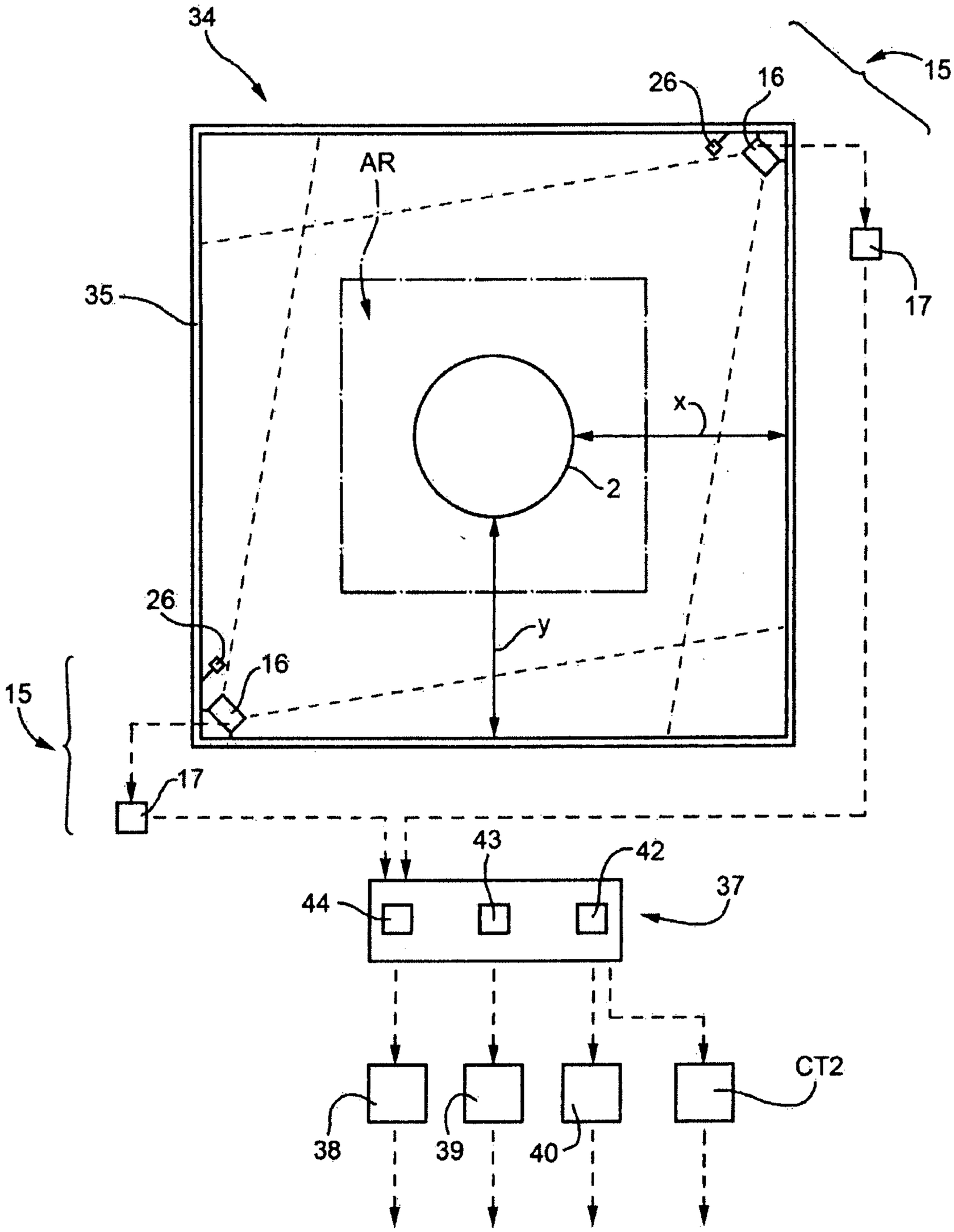
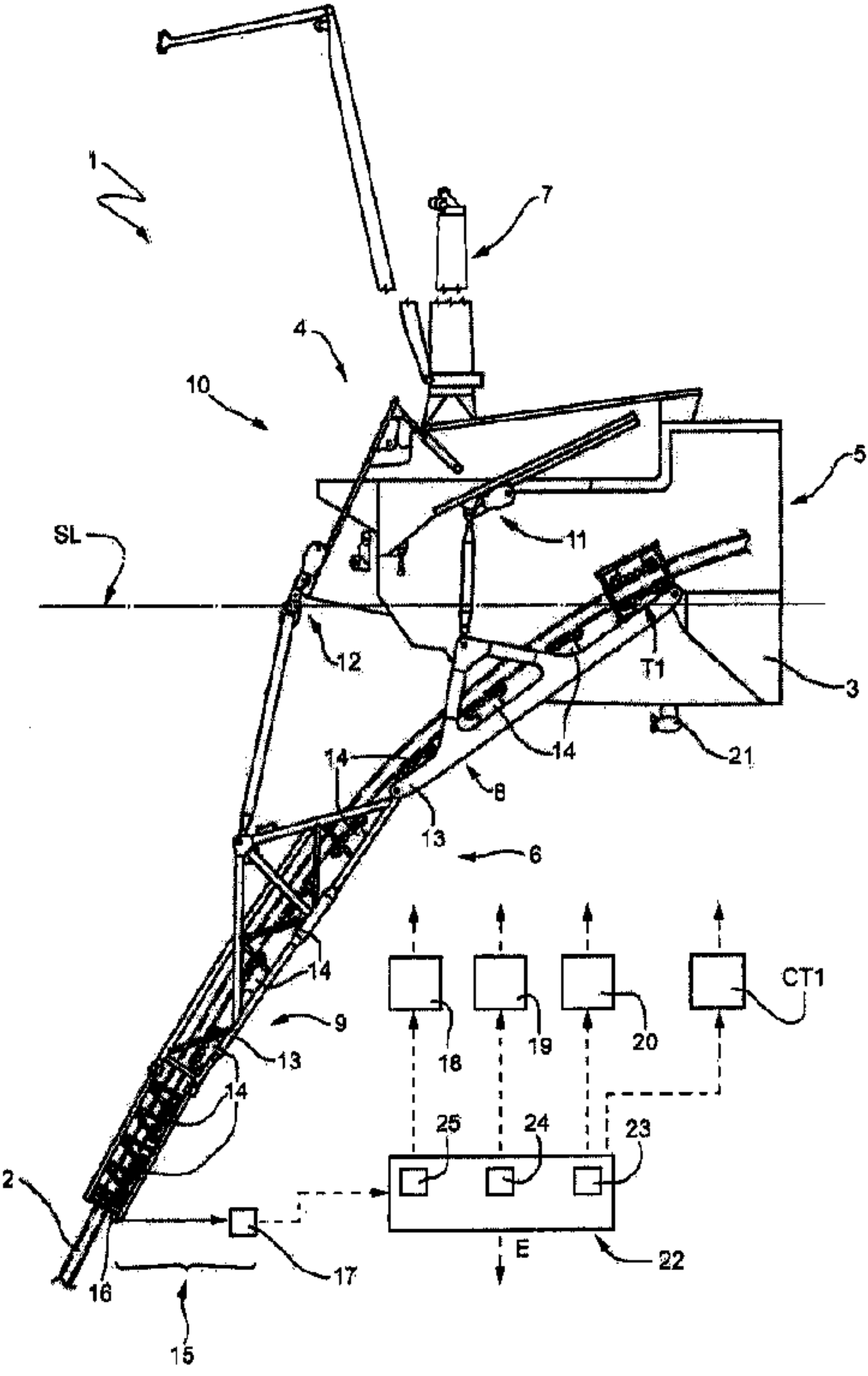


FIG. 3

FIG. 4




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