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(54) **APPARATUS AND PLANT FOR PRODUCING RENEWABLE ENERGY**

(57) An apparatus (100) for the production of renewable energy is described, comprising a tank (10) configured to be immersed in a free-flowing stream and comprising two side walls (12) and a bottom wall (14), at least three blades (20), each blade 20 having dimensions such as to close the passage area of the water in the tank (10), guide means (33) of an upper side (23) of the blade (20) configured to guide the side upper (23) during the thrust phase of the water on the blade (20), lower guide means (34) and upper guide means (44) to guide a bottom side (24) of the blade (20) during a phase recovery mechanism of the blade (20), motion transmission means (50) for transmitting the motion from the blade (20) which is pushed by the water pressure to the other blades (20), driving means (60) configured to guide the motion transmission means (50); further described is a plant for the production of renewable energy comprising said apparatus (100).

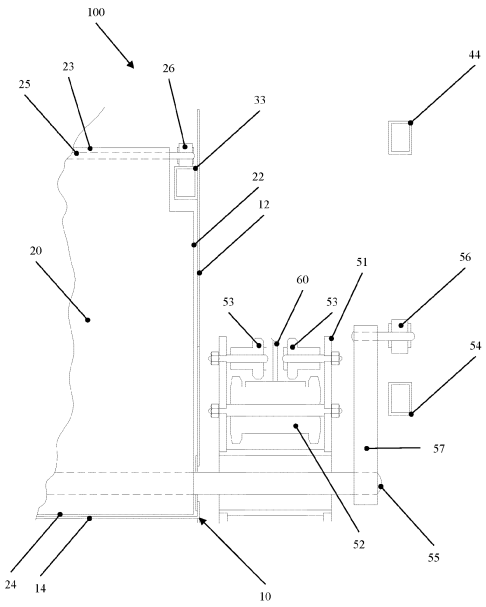

FIG. 1

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Description

[0001] The present invention generally refers to an apparatus and plant for the production of renewable energy.

[0002] In particular, the present invention relates to an apparatus and a plant for the production of renewable energy starting from the hydraulic energy deriving from a water flow rate of a free surface channel, for example an irrigation channel, or even a water course with large flow rates, in consideration of the fact that it can work completely submerged.

[0003] To produce electrical or mechanical energy starting from the kinetic energy of a flow of water in a free-flowing canal, it is necessary to exploit limited head and water flow; for this purpose, the use of Banki turbines or augers is known, which, although simple to build and inexpensive, however require building works for installation and have the problem of having reduced yields.

[0004] Apparatuses and plants are also known for the production of renewable energy starting from the water flow rate of a free-surface canal which withdraw a water flow rate from the canal through pipes and hydraulic works and introduce it into a turbine, to then return it to the channel.

[0005] These known apparatuses and plants have the problem of being expensive to manufacture, having a high environmental impact, and requiring the release of authorizations to be put into operation.

[0006] Document DE-U1-2007 002848 discloses an apparatus for the production of renewable energy which constitutes the most relevant prior art superseded by the present invention.

[0007] Object of the present invention is solving the aforesaid prior art problems, by providing an apparatus and a plant for the production of renewable energy starting from a water flow rate of an open-surface channel which are simple to construct, cost-effective, without having an impact on the environment and which remains within the canal, without requiring the construction of building or hydraulic works.

[0008] The above and other objects and advantages of the invention, as will appear from the following description, are achieved with an apparatus and plant for the production of renewable energy such as those described in the respective independent claims. Preferred embodiments and non-trivial variants of the present invention are the subject matter of the dependent claims.

[0009] It is understood that all attached claims form an integral part of the present description.

[0010] It will be immediately obvious that innumerable variations and modifications may be made to what is described (for example relating to shape, dimensions, arrangements and parts with equivalent functionality) without departing from the scope of the invention as appears from the attached claims.

[0011] The present invention will be better described by some preferred embodiments, provided by way of non-limiting example, with reference to the attached drawings, in which:

Figure 1 is a schematic partial sectional view of an apparatus for the production of renewable energy according to the present invention;
Figures 2-5 are schematic partial sectional views of an apparatus for the production of renewable energy according to the present invention in different working positions;
Figure 6 is a schematic partial sectional view of a component of an apparatus for the production of renewable energy according to the present invention;
Figure 7 is a partial schematic view in side section of an apparatus for the production of renewable energy according to the present invention; and
Figure 8 is a partial schematic top view of an apparatus for the production of renewable energy according to the present invention.

[0012] Referring to the Figures, the apparatus 100 for the production of renewable energy according to the present invention comprises:

- a tank 10 configured to be immersed in a stream, preferably in a free-surface channel and comprising two side walls 12 and a bottom wall 14 which delimit an area for the passage of water in the tank 10; preferably, the walls 12, 14 have dimensions such as to allow the tank 10 to be immersed in a channel, with the bottom wall 14 near the bottom of the channel and the side walls 12 near the edges of the channel,
- at least three blades 20, each blade 20 having dimensions such as to close the passage area of the water in the tank 10 and comprising a bottom side 24, preferably having a length substantially equal to that of the bottom wall 14 of the tank 10, configured to operate in contact (substantially watertight) with said bottom wall 14 during a thrust phase in which the water exerts pressure on the blade 20 moving it, an upper side 23 and two sides 22, preferably having length substantially equal to the height of the side walls 12 of the tank 10, configured to operate in contact (substantially watertight) with said side walls 12 during the thrust phase of the water on the blade 20,
- guide means 33 of the upper side 23 of the blade 20 arranged at the upper part of the tank 10, preferably connected to the side walls 12 inside the tank 10, configured to guide the upper side 23 during the water thrust phase on the blade 20 (substantially vertical lower blade of Fig. 2) so as to keep the blade 20 in a transverse position to the flow of water in the tank 10; preferably, said guide means 33 of the upper side 23 of the blade 20 are arranged inside the side wall 12 and comprise a rail 33 inside the tank 10, for example a rail 33 inside at each of the two side walls 12, having a the curved end at which the upper side 23 of the blade 20 leaves the guide means 33,
- lower guide means 34 arranged in correspondence

with the lower part of the tank 10, preferably connected to a support structure 110 of the tank 10, configured to guide the bottom side 24 of the blade 20 during a first recovery phase of the blade 20 (Fig. 3) in which the upper side 23 of the blade 20 is not guided by the guide means 33; preferably, said lower guide means 34 are arranged outside the side wall 12 and comprise a lower rail 34, for example a lower rail 34 at each of the two side walls 12, having a curved end configured to guide the side of bottom 24 by rotating the blade 20 to bring it into a position in which the upper side 23 rests on a support element 64, for example a support rail 64,

- upper guide means 44 arranged at the top of the tank 10, preferably connected to the support structure 110 of the tank 10, configured to guide the bottom side 24 of the blade 20 during a second recovery phase of the blade 20 (Fig. 4, substantially horizontal upper blade of Fig. 2), in which the upper side 23 of the blade 20 is not guided by the guide means 33 and the blade 20 is free to float, so as to return it to the position in which the water exerts a pressure on the blade 20 to start the thrust phase; preferably, said upper guide means 44 are arranged outside the side wall 12 and comprise an upper rail 44, for example an upper rail 44 at each of the two side walls 12, having a curved end configured to guide the side bottom 24 by rotating the blade 20 to bring it into a transversal position to the flow of water in the tank 10 so as to start the thrust phase,
- motion transmission means 50 connected in a rotating manner to the bottom side 24 of the blade 20 and configured to transmit the motion from the blade 20 which is pushed by the water pressure to the other blades 20 which in the recovery phase are not pushed by the pressure some water; in a preferred way, the means for transmitting the motion 50 comprise a carriage 51 connected in a rotating way to the bottom side 24 of the blade 20, preferably connected in a rotating way to a pin 55 connected to the bottom side 24 of the blade 20, said carriage 51 being slidably connected to guide means 60 and via connection means, for example the links 54 of a chain 58, to other carriages 51 which may or may not be connected to respective blades 20;
- guide means 60 of the motion transmission means 50, preferably connected to the support structure 110 of the tank 10, configured to guide, preferably with an annular motion, the motion transmission means 50 connected to the blades 20 from the position in which, in the thrust phase, the water exerts a pressure on the blade 20 (substantially vertical lower blade of Fig. 2) to the position in which, in the recovery phase of the blade 20, the blade 20 is free to float (Fig. 4, blade substantially horizontal top of Fig. 2) to then return said motion transmission means 50 to the starting position in which the water exerts pressure on the blade 20 and repeat the succession of motion phases; preferably, the guide means 60 comprise an annular rail 60 outside the tank 10 arranged along a side wall 12, for example a rail 60 at each of the two side walls 12.

[0013] In a preferred embodiment of the invention, the upper side 23 of the blade 20 is connected to a wheel or roller 26 rotating on the guide means 33 arranged at the upper part of the tank 10; for example, the wheel 26 is connected to a pin 25 connected to the upper side 23 of the blade 20 and rotates on the rail 33 inside the tank 10; preferably, the upper side 23 of the blade 20 is connected to two wheels 26 connected to the ends of the pin 25, rotating on respective rails 33 inside the tank 10 and each placed outside one of the sides 22 of the blade 20.

[0014] Preferably, the bottom side 24 of the blade 20 is connected to a wheel or roller 56 rotating on the lower 34 or upper 44 guide means; for example the wheel 56 is connected, preferably via an arm 57, to the pin 55 connected to the bottom side 24 of the blade 20 and rotates on the lower 34 or upper 44 rail; preferably, the bottom side 24 of the blade 20 is connected to two wheels 56 connected to the ends of the pin 55, rotating on respective lower rails 34 or upper rails 44 each placed outside each of the two side walls 12, in correspondence with the bottom 14 of tank 10.

[0015] Preferably, the trolley 51 comprises wheels or rollers 52 rotating on the guide means 60, for example pairs of antagonistic wheels 52, 53 arranged on the two sides of the rail 60 external to the tank 10 and rotating on the rail 60; in a preferred way, the motion transmission means 50 comprise two trolleys 51, each connected to one of the sides 22 of the blade 20, placed outside the side walls 12 of the tank 10 and sliding on the guide means 60.

[0016] Preferably, the trolley 51 comprises two wheels or rollers 52 rotating on the guide means 60 and two pairs of opposing wheels 53, in particular a pair of opposing wheels 53 for each wheel 52, the wheels 52 and the pairs of wheels 53 being arranged opposite sides of the outer rail 60 and rotating thereon.

[0017] In a preferred embodiment of the invention, the wheels 52, 53 rotating on the outer rail 60 and the wheels 56 rotating on the lower 34 or upper rails 44 are made of plastic material, for example polyurethane to reduce noise and wear; the opposing wheels 53, when the carriages are in the overturned position, keep the wheels 52 of the carriage 51 resting on the external rail 60, avoiding misalignment of the carriages 51 and limiting the wear of the wheels 52 and the noise when they return to rest on the outer rail 60. Preferably, the opposing wheels 53 are closer to each other than the wheels 52 of the trolley 51, to reduce friction and wear when the trolleys 51 travel along the curved part of the outer rail 60.

[0018] In a preferred embodiment of the invention, the chain 58 is formed by three carriages 51 each connected to a blade 20 by means of the pin 55, said carriages 51 being furthermore connected by means of the connecting

links 54 to other carriages 51 comprising the wheels 52, 53 rotating on the outer rail 60 but not connected to the blades 20; preferably, the apparatus 100 for the production of renewable energy of the invention comprises two chains 58 each at one of the side walls 12.

[0019] In the operation of the apparatus 100 for the production of renewable energy according to the invention, during the thrust phase of the water on the blade 20 (substantially vertical lower blade of Fig. 2) the upper side 23 of the blade 20 slides on the guide 33 arranged at the top of the tank 10, with the wheel 26 connected to the pin 25 which rotates on the rail 33 inside the tank 10.

[0020] At the end of the thrust phase of the water on the blade 20 (Fig. 3) the upper side 23 of the blade 20 is no longer guided by the guide means 33, and the wheel 26 connected to the pin 25 leaves the guide means 33, preferably after traveling the curved end of the rail 33, while the bottom side 24 of the blade 20 begins to be guided by the lower guide means 34 during the first recovery phase of the blade 20 (Fig. 3), with the wheel 56 connected to the arm 57 which comes into contact with the lower rail 34 and the blade 20 which tends to rotate, so as to generate a force which drags the trolley 51 downstream and facilitates the positioning of the next blade 20 which is located upstream. In summary, by adding the combined actions of the downstream blade 20 which rotates on the lower rail 34 and the initial thrust of the upstream blade 20, a force is developed similar to that exerted by the blade 20 when it is in the thrust phase, transversal to the flow of the water in the tank 10.

[0021] At the end of the first recovery phase of the blade 20 (Fig. 3), the upper side 23 of the blade 20 is no longer guided by the guide means 33, and the wheel 26 connected to the pin 25 leaves the guide means 33 to arrive in a position in which the upper side 23 of the blade 20; preferably, the wheel 26 rests on a support element 64, for example a support rail 64.

[0022] Subsequently, during the second recovery phase of the blade 20 (Fig. 4, substantially horizontal upper blade of Fig. 2) the upper side 23 of the blade 20 is no longer guided by the guide means 33 and the blade 20 is free to float, while the bottom side 24 of the blade 20 slides on the upper guide means 44; preferably, the wheel 56 connected to the arm 57 rotates on the upper rail 44 arranged in correspondence with the upper part of the tank 10.

[0023] In the operation of the apparatus 100 for the production of renewable energy according to the invention, the motion transmission means 50 connected to the bottom side 24 of the blade 20 and guided by the driving means 60, preferably, the carriage 51 including the wheels 52, 53 rotating on the rail 60 external to the tank 10, transmit the motion from the blade 20 which is pushed by the water pressure to the other blades 20 which in the recovery phase are not pushed by the water pressure, preferably with an annular motion.

[0024] The apparatus 100 for the production of renewable energy according to the invention comprises a wheel 61 equipped with hooking teeth 62 on which the connecting links 54 rest to transfer, by rotating the wheel 61, the power generated by the apparatus 100 to a device for the production of electricity, for example through a kinematic chain comprising belts 77, pulleys 76 and a transmission shaft 75.

[0025] Preferably, the hooking teeth 62 comprise inserts 63 made of plastic material, for example polyurethane, at the points of support of the joining links 54 to the hooking teeth 62 which have the function of avoiding noise during hooking and reducing usury; moreover, the polyurethane deforming slightly allows the simultaneous support of all the links to the hooking teeth 62 of the wheel 61.

[0026] Preferably, the transmission shaft 75 is arranged in a direction parallel to the upper sides 23 and the bottom 24 of the blade 20 and perpendicular to the sides 22 and, in addition to transmitting the motion, has the function of keeping the blades 20 aligned in the event that the forces of the water acting on the right and left side of the immersed blade 20 are of different intensities, for example after a bend in the canal, preventing a rotation of the blade 20 itself caused by the difference in thrust which would produce an anomalous inclination of the pin 55 of the blade, which would affect all the carriages 51 making them work obliquely with a relative increase in friction, loss of power and unwanted and excessive wear of the side parts of the wheels 52, 53 of the carriages 51.

[0027] In a preferred embodiment of the invention, the apparatus 100 for the production of renewable energy comprises a control system comprising a microcontroller and sensors 71, 74, for example a water level meter 71 in the channel, which control the lifting and lowering of the apparatus 100 to intercept the maximum flow rate and avoid overflowing, so as to manage water flow rates which are highly variable over time; the support structure 110 is actuated by lifting means 70, for example comprising motor means of known type which actuate a screw-nut type mechanism connected to columns 111, to lift the apparatus 100 for the production of renewable energy when necessary free the channel, while in normal operation the apparatus 100 can be sunk so as not to have an environmental impact.

[0028] Preferably, the apparatus 100 for the production of renewable energy also comprises a protection and debris storage element 72, for example a plane 72 arranged above the apparatus 100 to prevent foreign bodies from falling into the tank 10 and for depositing debris loaded by a cleaner 73 installed upstream of the apparatus 100, and load sensors 74, for example load cells, to monitor the weight weighing on the protection element 72 and on the cleaner 73.

[0029] In a preferred embodiment of the invention, the apparatus 100 comprises four load cells 74 arranged under the debris protection and storage surface 72 and two load cells 74 on which the cleaner 73 rests.

[0030] The four load cells 74 arranged under the pro-

tection and debris storage surface 72 have the function of constantly monitoring the weight of the objects, debris or animals weighing on said surface 72. When the weight gradually increases, it means that the cleaner 73 is loading and depositing waterborne debris; the weight value will be read, memorized and updated by the control system after each activation of the cleaner 73: once the programmed weight has been reached, the control system will issue a warning to the system manager. If the system detects, in a short time interval, a weight variation between one load cell and another with the cleaner 73 stopped, it will interpret it as the presence of a live animal or a foreign body on the protection plane and will instantly send an alarm.

[0031] The two load cells 74 on which the cleaner 73 rests have the function of constantly monitoring the weight affecting the cleaner 73 itself and, should said weight suddenly increase, it would be interpreted by the control system as the presence of a deposited debris with consequent activation of the cleaner 73 to remove it.

[0032] Preferably, the control system constantly monitors the operation of the apparatus 100 by means of sensors of the known type, for example noise, vibration, water level measurement sensors and controls the lifting of the apparatus 100, automatically or piloted by an operator, when he detects anomalies with an increase in noise, vibrations, water level or in the case of exceptional or periodic maintenance, to lift the apparatus 100 so that both the tank and the blades are no longer lapped by the water flow water and thus stop the apparatus 100.

[0033] Preferably, upstream of the cleaner 73, another water level gauge is installed which has the function of detecting the water level in the channel to raise the apparatus 100 and the cleaner 73 above the surface of the water if its level should reach the limits of overflow, for example in the event that significant quantities of debris are discharged into the channels with an accumulation speed greater than the removal speed of the cleaner 73.

[0034] The plant for the production of renewable energy according to the invention comprises at least one apparatus 100, preferably a plurality of apparatuses 100 installed in a channel, connected to a device for the production of electric energy; preferably the apparatus 100 is not connected directly to the device for the production of electric energy but via a hydraulic circuit, preferably hydraulic, comprising an accumulator of fluid (preferably oil) under pressure placed in fluid communication with a hydraulic motor which drives a alternator for the production of electricity.

[0035] Each apparatus 100 installed in the channel puts the oil in the circuit under pressure, preferably a plurality of apparatuses 100 connected in parallel, substantially at the same pressures they increase the oil flow rate until the desired pressure and flow rate are obtained to operate the hydraulic motor connected to the alternator.

[0036] The hydraulic accumulator allows the impulse produced by the apparatuses 100 to be dampened and the alternator revolutions to be adjusted to put it in phase with the electric mains. Alternatively, it is possible to exploit the hydraulic energy produced by the apparatus 100 of the invention with an electrolyser, hydrogen and oxygen tanks usable in fuel cells including those of the PEM type (fuel cells with proton exchange membranes), given the high degree of purity (about 99.99%).

[0037] Advantageously, the apparatus and plant for the production of renewable energy starting from a water flow rate of a free-flowing channel according to the invention are simple to construct, cost-effective, have no impact on the environment and remain outdoors. inside the channel in which they are installed, without requiring the construction of specific building or hydraulic works.

Claims

1. Apparatus (100) for the production of renewable energy including:

   - a tank (10) configured to be immersed in a free-flowing stream and comprising two side walls (12) and a bottom wall (14) which delimit an area for the passage of water in the tank (10),
   - at least three blades (20), each blade 20 having dimensions such as to close the passage area of the water in the tank (10) and comprising a bottom side (24) configured to operate in contact with said bottom wall (14) during a thrust phase in which the water exerts pressure on the blade (20) by moving it, an upper side (23) and two sides (22) configured to operate in contact with said side walls (12) during the thrust phase of the water on the blade (20),
   - guide means (33) of the upper side (23) of the blade (20) arranged in correspondence with the upper part of the tank (10) and configured to guide the upper side (23) during the thrust phase of the water on the blade (20) so as to keep the blade (20) in a transverse position to the water flow in the tank (10),
   - lower guide means (34) arranged in correspondence with the lower part of the tank (10) and configured to guide the bottom side (24) of the blade (20) during a first recovery phase of the blade (20) in which the side top (23) of the blade (20) is not guided by the guide means (33),
   - upper guide means (44) arranged in correspondence with the upper part of the tank (10) and configured to guide the bottom side (24) of the blade (20) during a second recovery phase of the blade (20), in which the upper side (23) of the blade (20) is not guided by the guide means (33) and the blade (20) is free to float, so as to return it to the position in which the water exerts pressure on the blade (20) to start the push phase,

- motion transmission means (50) rotatably connected to the bottom side (24) of the blade (20) and configured to transmit the motion from the blade (20) which is pushed by the water pressure to the other blades (20) which in the recovery phase are not pushed by the water pressure,
- guide means (60) configured to guide the motion transmission means (50) connected to the blades (20) from the position in which, in the thrust phase, the water exerts pressure on the blade (20) to the position in which, in the recovery phase of the blade (20), the blade (20) is free to float, to then return said motion transmission means (50) to the starting position in which the water exerts pressure on the blade (20).

2. Apparatus (100) for the production of renewable energy according to claim 1, **characterized in that** the motion transmission means (50) comprise a carriage (51) connected in a rotating manner to the bottom side (24) of the blade (20), connected in a sliding manner to the guide means (60) and through connection means (54, 58) to other carriages (51) connected to respective blades (20).

3. Apparatus (100) for the production of renewable energy according to claim 2, **characterized in that** the carriage (51) comprises wheels (52, 53) rotating on the guide means (60).

4. Apparatus (100) for the production of renewable energy according to any one of the preceding claims, **characterized in that** the guide means comprise an annular rail (60) external to the tank (10) disposed along a lateral wall (12).

5. Apparatus (100) for the production of renewable energy according to any one of the preceding claims, **characterized in that** the upper side (23) of the blade (20) is connected to a wheel (26) rotating on the guide means (33) arranged at the top of the bowl (10) and the bottom side (24) of the blade (20) is connected to a wheel (56) rotating on the lower (34) or upper (44) guide means.

6. Apparatus (100) for the production of renewable energy according to any one of the preceding claims, **characterized in that** said guide means (33) of the upper side (23) of the blade (20) are arranged inside the side wall (12) and comprise a rail (33) inside the tank (10) having a curved end at which the upper side (23) of the blade (20) leaves the guide means (33).

7. Apparatus (100) for the production of renewable energy according to any one of the preceding claims, **characterized in that** said lower guide means (34) are arranged outside the side wall (12) and comprise a lower rail (34) having a curved end configured to guide the bottom side (24) by rotating the blade (10) to bring it into a position in which the top side (23) abuts a rest (64).

8. Apparatus (100) for the production of renewable energy according to any one of the preceding claims, **characterized in that** said upper guide means (44) are arranged outside the side wall (12) and comprise an upper rail (44) having a curved end configured to guide the bottom side (24) by rotating the blade (10) to bring it into a position transverse to the flow of water in the tank (10) so as to start the thrust phase.

9. Plant for the production of renewable energy comprising at least one apparatus (100) according to any one of claims 1 to 8 connected to a device for the production of electric energy.

10. Plant for the production of renewable energy according to claim 9, **characterized in that** it has a hydraulic circuit comprising a pressurized fluid accumulator placed in fluid communication with a hydraulic motor which drives the device for the production of electric energy.

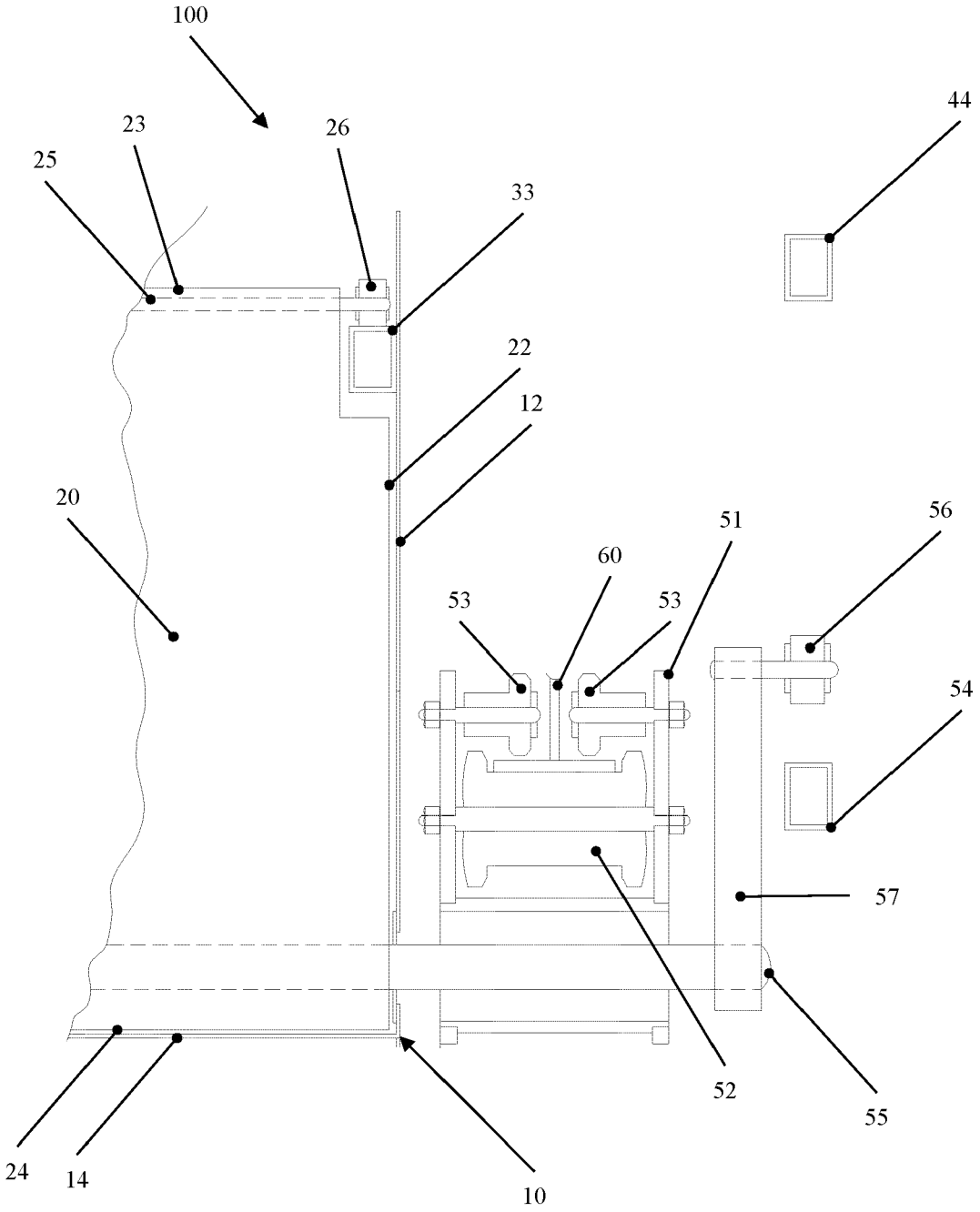

FIG. 1

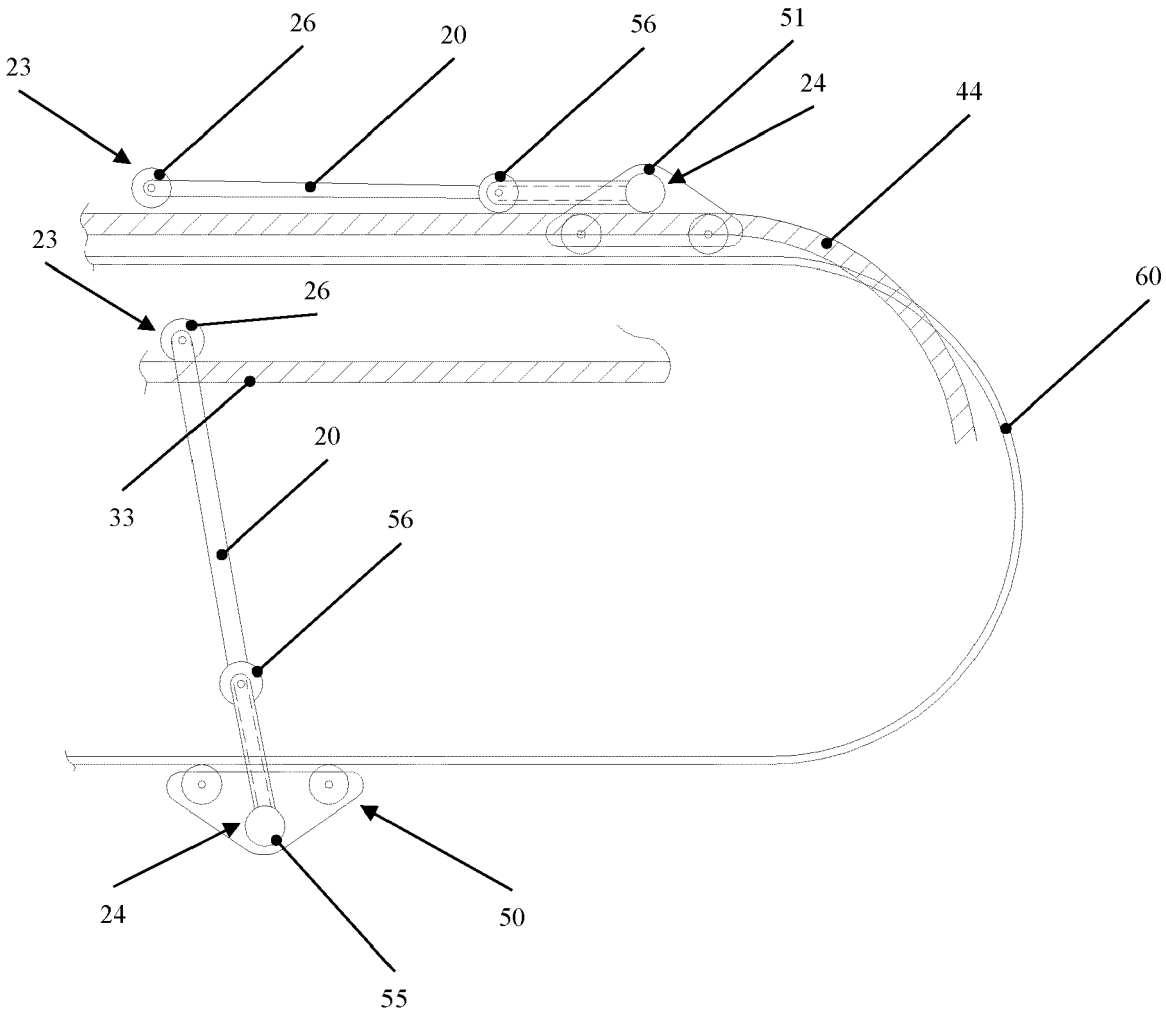

FIG. 2

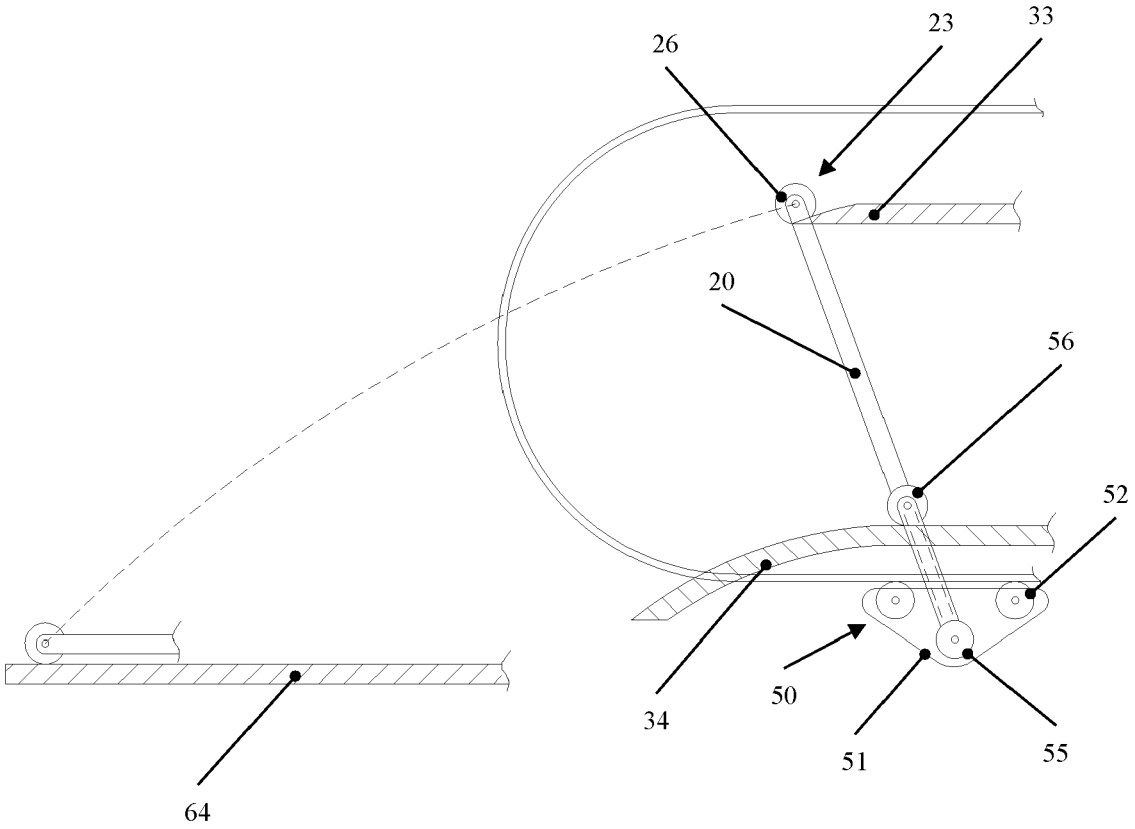

FIG. 3

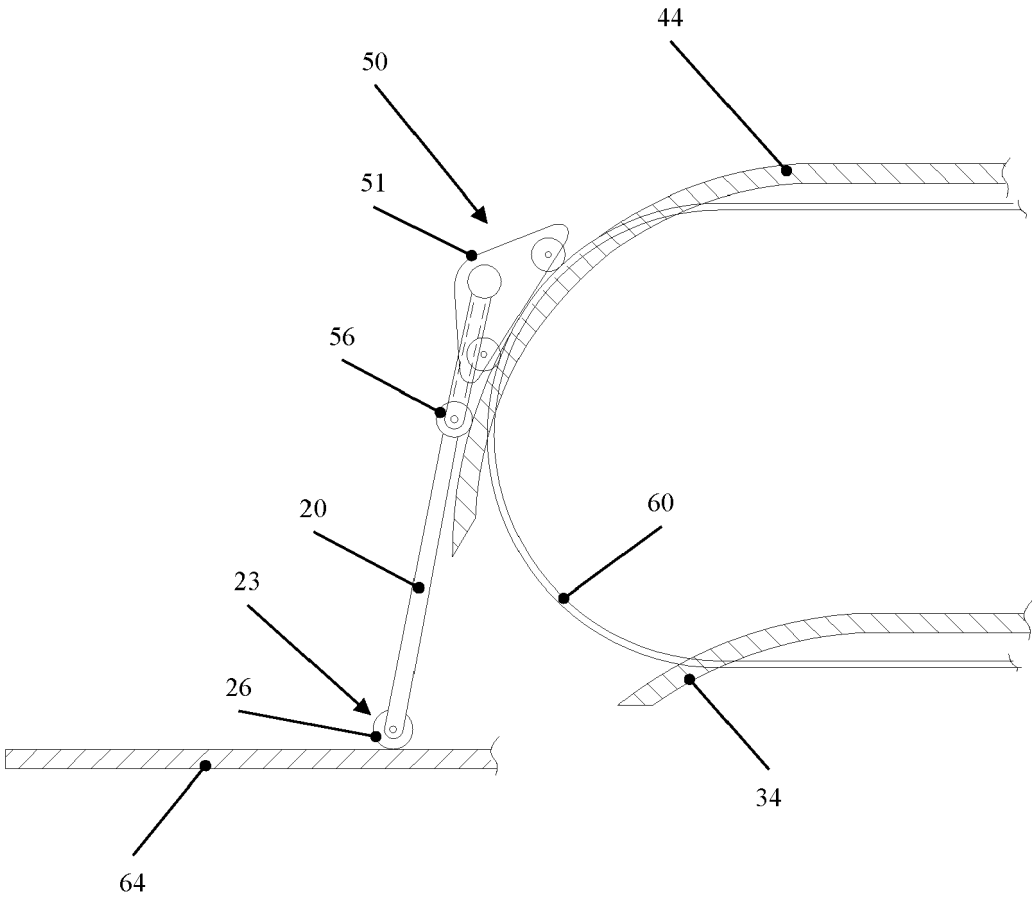

FIG. 4

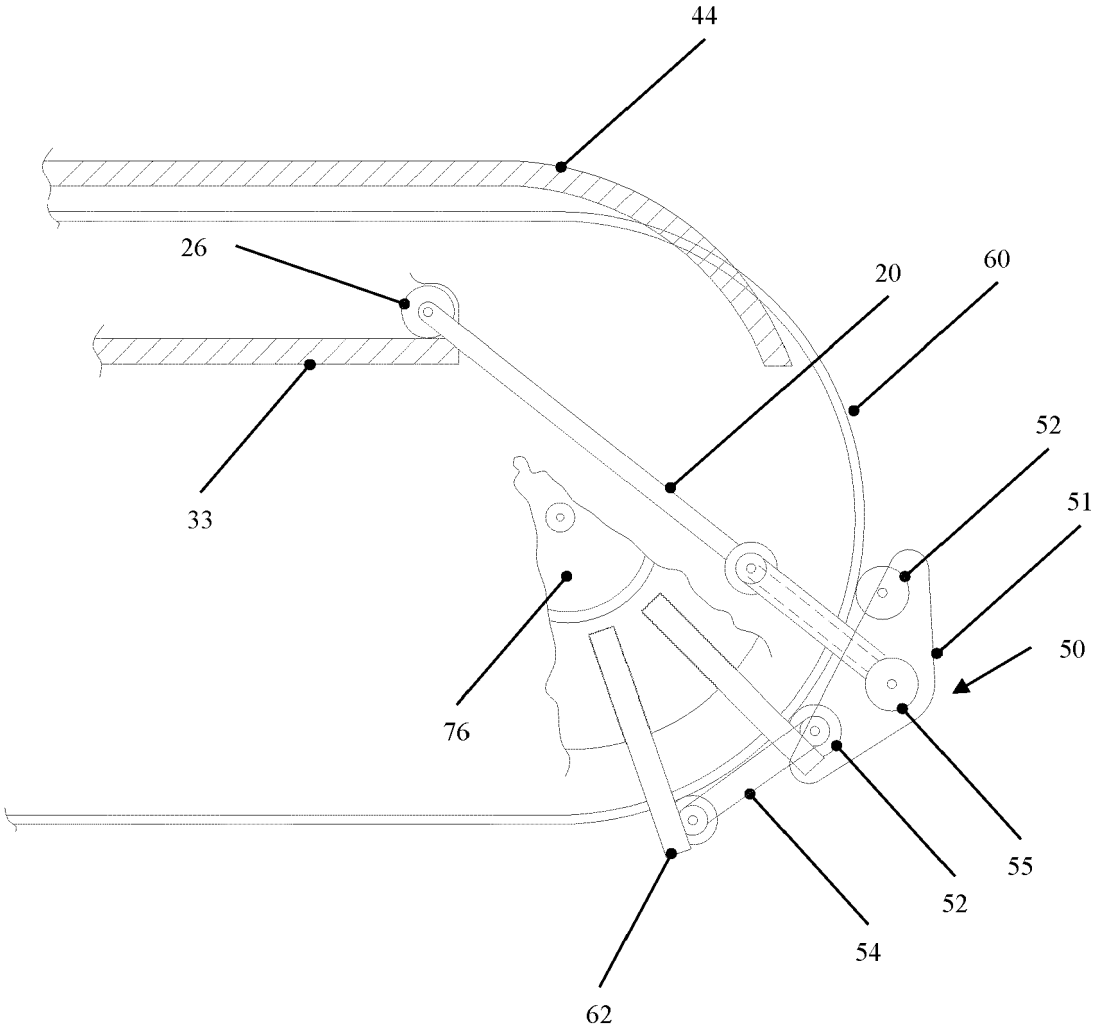

FIG. 5

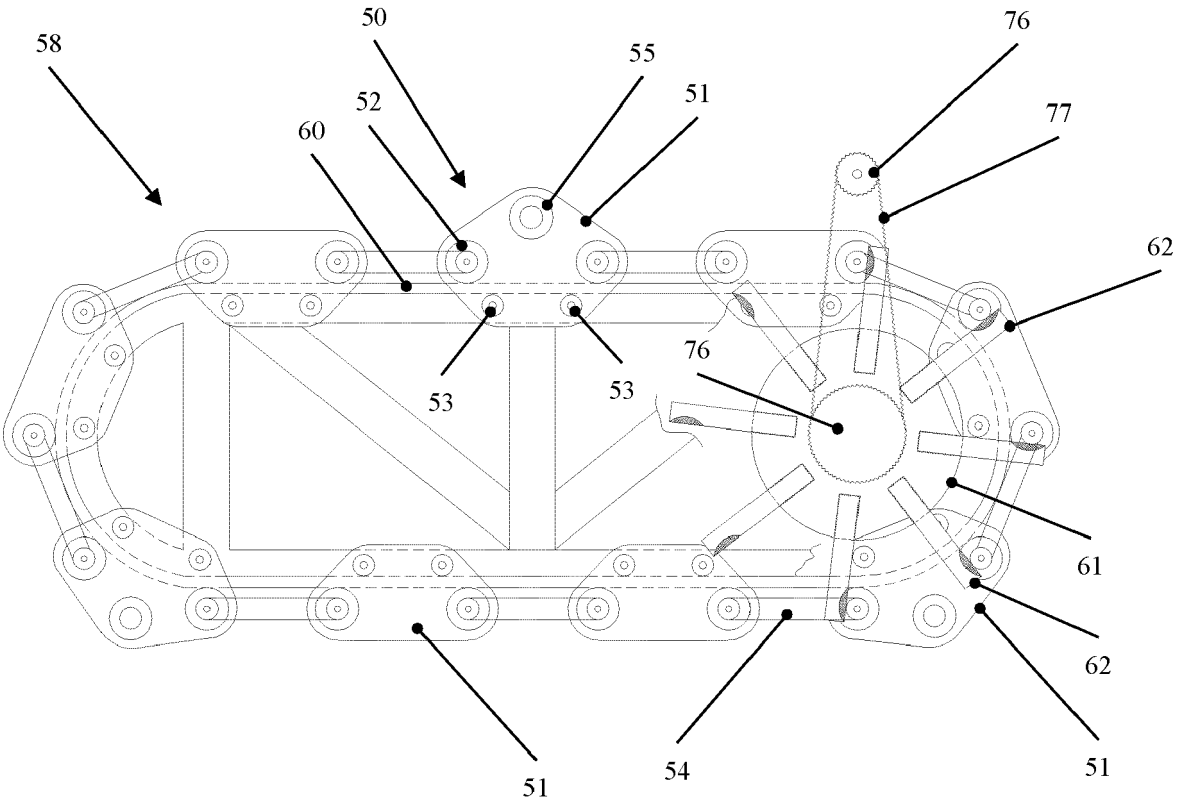

FIG. 6

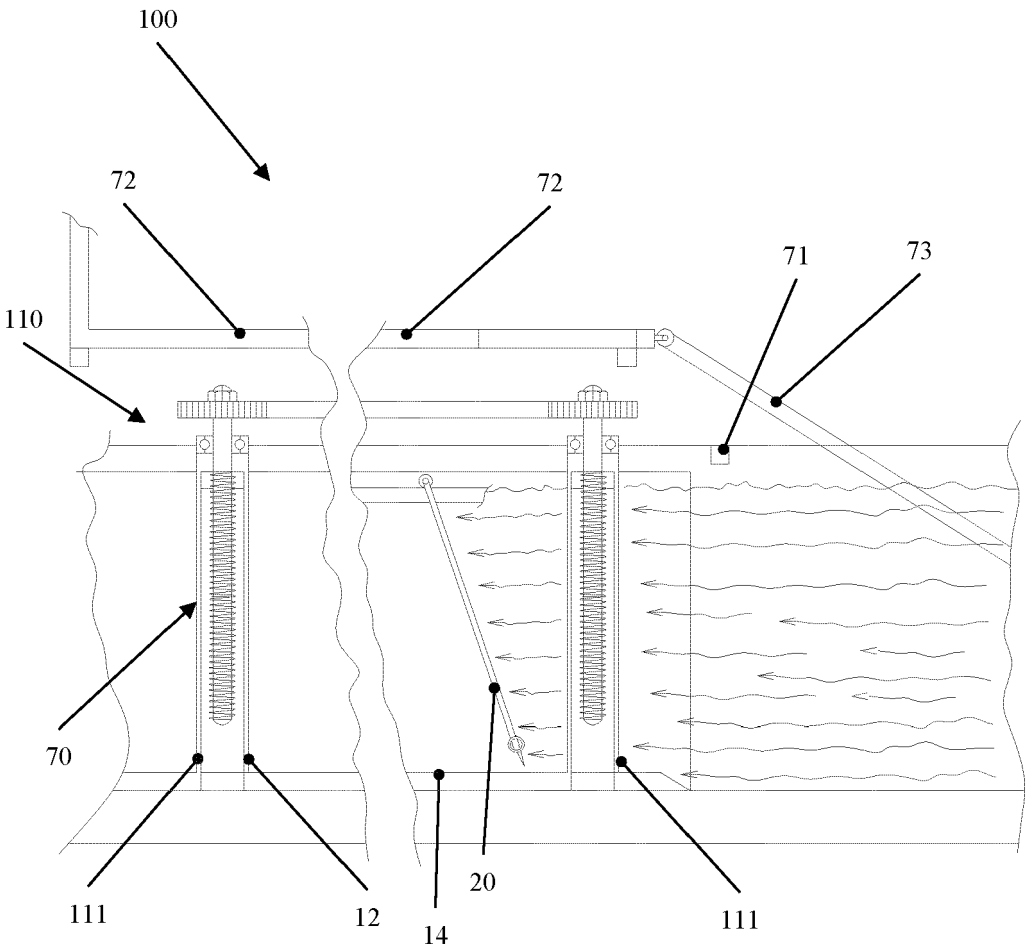

FIG. 7

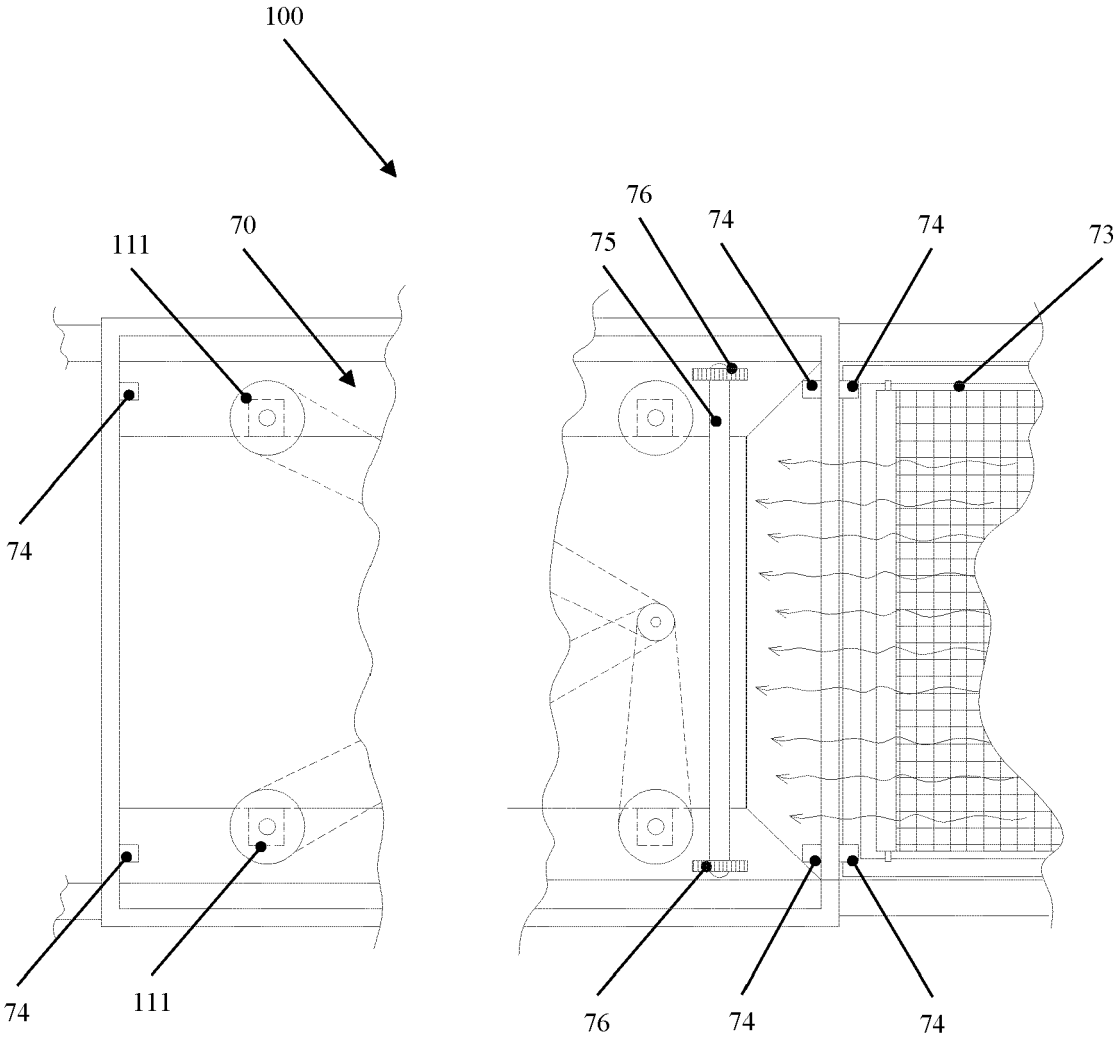

FIG. 8

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EUROPEAN SEARCH REPORT

Application Number
EP 23 15 7561

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
A	DE 20 2007 002848 U1 (POSORSKI HANS [DE]) 26 April 2007 (2007-04-26) * paragraph [0026] - paragraph [0036]; figures *	1-10	INV. F03B17/06
A	US 1 457 927 A (EDWARD EBEL FREDERICK) 5 June 1923 (1923-06-05) * page 1, line 49 - page 2, paragraph 46; figures *	1-10	
A	WO 2011/101693 A1 (HIDRA FORCE D O O [HR]; KORAC IVAN [HR]) 25 August 2011 (2011-08-25) * figures 1-6 *	1-10	

TECHNICAL FIELDS SEARCHED (IPC)

F03B

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	20 June 2023	Di Renzo, Raffaele

CATEGORY OF CITED DOCUMENTS

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EPO FORM 1503 03.82 (P04C01)

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 23 15 7561

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