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[0001] The invention relates to a device and a method for the high-pressure cleaning of tubes of heat exchangers. Heat exchangers are also called tube-bundle devices or heat transformers. They have a large number of tubes arranged parallel to one another, which are arranged between an inlet area and an outlet area. For cleaning, cleaning devices are attached in one of these areas; a cleaning nozzle located on the free end of a lance is inserted into the tube to be cleaned. In the process, high-pressure water streams out of the nozzle. The nozzle generally has a plurality of, mostly varying, nozzle openings. Some of these are oriented forwards, in the working direction, and others backwards, contrary to the direction of insertion of the lance.

[0002] By high pressure, water with a pressure of at least 800 bar, preferably higher, for example above 1,000 or even above 1,500 bar is generally understood.

[0003] A high-pressure cleaning device for tubes of heat exchangers in accordance with the preamble of claim 1 is known from WO 2006/021164 A1.

[0004] In the cleaning device according to DE 2807121 B2, the direction of the stream of the nozzle jets is constantly changed. Due to the position of the nozzle jets, a rotational movement results, which can cause a rotation of the nozzle. In order to avoid rotating the lance as well, a rotational passage between the nozzle and the lance is necessary and provided.

[0005] A high-pressure cleaning device for tubes of heat exchangers for the simultaneous cleaning of at least three tubes is known from JP S63 294497 A; the high-pressure cleaning device has, connected to a drive motor, a reel on which high-pressure hoses are wound up. The drive motor has two operating states. In one operating state, namely when the high-pressure hoses are introduced into the tubes, the reel can rotate freely. In the other operating state, namely when the cleaning has ended, the drive motor pulls the high-pressure hoses out of the tubes. The high-pressure tubes are wound on the reel in the process.

[0006] Special and stringent safety regulations must be observed in high-pressure cleaning, in particular in the industrial field. Without sufficient protection, water jets in the high-pressure area can endanger the life of an operator. The Federal Trade Association Regulation BGR 500 thus stipulates, *inter alia*, the wearing of special protective clothing for persons located in the direct vicinity of the cleaning procedure. However, even with protective clothing, the operation of a high-pressure equipment is always associated with high risk and injuries can never be completely ruled out. In addition, as a result of the enormous forces exerted by the released jets of water, the operation of a high-pressure cleaning device is heavy manual labour, which represents a strain on personnel, in particular for personnel in protective clothing. The protective clothing is a hindrance when performing manual labour. Cleaning devices are thus increasingly being used which do not require the presence of a person in the immediate vicinity, but rather can be controlled remotely. In this case, the operator no longer has to wear a protective suit; he or she can work and carry out all necessary steps protected in a booth and far enough away from the actual cleaning procedure.

[0007] A high-pressure cleaning device for cleaning radioactively contaminated tube bundles is known from DE 34 18 835 A1. A high-pressure hose, bearing an injection nozzle at its front end for the cleaning water, is slid through the tubes. A frame is provided as a positioning device, in which two sliding rollers, which receive the hose between them, can be driven over the plane of the frame, for which purpose drive means are provided. The device is intended for automatic operation; as the tube bundles to be cleaned are radioactively contaminated, the presence of a person in the vicinity of the cleaning procedure is a health hazard. The transport of the hose by means of the sliding rollers is disadvantageous; contaminations on the hose can lead to the hose not being transported.

[0008] A high-pressure cleaning device for tubes of heat exchangers is known from DE 297 23 349 U1 in which a high-pressure hose is connected to a lance having a nozzle at its front end. By means of a positioning device, it is possible to position and guide the device.

[0009] An inside bundle cleaner is sold by the company Peinemann, Netherlands, which has five parallel lances, each connected to high-pressure hoses that are wound on a reel associated with a drive motor. The lances are equipped with a nozzle on their free end. For forward propulsion, the high-pressure hoses each catch a rotating chain with guide means from above and below, the chain carrying along every single high-pressure hose in the forward and rearward direction. This way, the lances are moved into and analogously pulled out of the tubes to be cleaned. However, it has proven difficult during normal operation with all the contaminations that occur to move the high-pressure hoses back and forth mechanically by means of the chains. In the event of the contamination of the hoses, a sufficient transport does not materialize, for example when a hose is slippery. In addition, the high-pressure hoses are subjected to severe strain and are worn down by the chains.

[0010] This device is also disadvantageous in that it is a relatively large unit, which is normally only assembled once and then operated on site. It is not suitable to be transported as a mobile device for use at different sites.

[0011] This is where the invention comes in. It is the object of the invention to improve a cleaning device of the type described above so that it is possible to work faster with it and, preferably, a forward motion of the nozzles can occur in a controlled manner.

[0012] This object is achieved by a high-pressure cleaning device in accordance with the features of claim 1.

[0013] A nozzle is respectively connected directly to a high-pressure hose. A part of the high-pressure hose inserted into the tube. Forward propulsion is achieved in a known manner by means of jet propulsion. In any case, nozzle jets are respectively discharged from the nozzles, rearward and contrary to the working direction, which cause a recoil and propels the nozzle forward like a rocket. The high-pressure hose located on the nozzle is thus constantly pulled into the tube. It is awash in water from the rearward-oriented nozzles and thus protected and lubricated. Removed contaminations are essentially displaced rearward and not forward so that blockages cannot form in the forward direction. A part of the jet streams of a nozzle is preferably oriented forward in order to attain a cleaning effect there. The main part of the jet streams is, however, oriented rearward so that overall a forward propulsion is achieved.

[0014] Due to the recoil principle, mechanical transport means, such as, for example, chains, can be omitted. As no lances are used either, the cleaning device has a relatively short construction and is composed of fewer components than in the prior art. The reel can be arranged in the vicinity of the heat exchanger to be cleaned without the length of the lances determining a distance between the two here.

[0015] The guiding unit has guiding tubes for the individual high-pressure hoses. The guiding tubes have a lower end dimensioned so that in particular the nozzle cannot enter the guiding tubes; preferably, a connecting piece of the nozzle is so thick that it does not fit into the guiding tube. The guiding tubes form a catch device for the high-pressure hoses or their nozzles.

[0016] When the nozzle is retracted as far as possible, i.e. to the hard stop or shortly before the hard stop in a guiding tube, it is still located far enough away from the mouths of the tubes and thus from the plane so that it can be moved over the plane in any position.

[0017] The guiding tubes are far enough inside that they receive the high-pressure hose with play. The high-pressure hose can preferably glide very well inside the guiding tubes; the inner surfaces preferably have an anti-friction coating. The outer diameter of the high-pressure hoses is adapted to the interior inner diameter of the tubes so that an annular cross-section area remains free, the area of which is at least as big as the area of the interior inner cross section of the high-pressure hoses. The high-pressure hoses are preferably structurally identical. Structurally identical nozzles are preferably used.

[0018] The object of the guiding unit is first to position and then to align the flexible high-pressure hoses. The guiding tubes take on the role of arranging the high-pressure hoses so as to be coaxial and aligned with the respective individual tubes. The distance of the guiding tubes from one another can be varied so that the guiding unit can be adjusted to various geometries of mirrors of heat transformers. For this purpose, it is also advantageous to provide a transverse guide and to configure a guiding unit with a carriage that can be slid along the transverse guide. This way, different locations in a direction can be reached. When at least one longitudinal guide and preferably two lateral longitudinal guides are additionally also provided which have fixation means for their fixation on the heat exchanger, wherein the longitudinal guides are arranged perpendicular to the transverse guide and respectively have a guide carriage which carries the transverse guide, a movement can also occur in a second direction perpendicular to the first. This way, all tubes of the mirror can be reached.

[0019] The high-pressure hoses are essentially arranged in a line in the guiding unit. The guiding tubes are preferably arranged parallel to one another and in a plane.

[0020] The drive motor is rotationally connected to the reel via a gear mechanism. Preferably, this gear mechanism is self-locking in the path of the return force and/or a brake is additionally provided, which prevents a rotational movement of the reel in an undesired direction of rotation.

[0021] The drive motor drives the reel optionally in one rotational direction or in the other. In the first operating state of the motor, the motor supplies sufficient torque to the reel that the high-pressure hoses can be jointly pulled out of the tubes during operation against the forward propulsion. In this case, the drive motor drives the reel in the winding direction. The drive motor can also drive the reel in the unwinding direction. As the forward motion is attained through the forward propulsion of the nozzles, the drive motor is not responsible for driving the nozzles into the individual tubes. Rather, the insertion into the tubes occurs because of the recoil. The motor determines the speed at which the nozzles advance in the tubes.

[0022] The drive motor is operated so that the high-pressure hoses advance at the determined speed in the tubes. In the process, the drive motor brakes the winding-up process of the reel. It works against the forward propulsion. If the drive motor did not brake the forward motion, the nozzles would move through the tubes at a higher speed. Accordingly, the uninhibited speed at which a nozzle with a high-pressure hose moves through a tube during operation is greater than the speed at which the motor lets the nozzle advance in the tube. As a result of the drive motor working against the forward propulsion, the high-pressure hoses remain subjected to a certain tension. They deviate as little as possible from an extended arrangement.

[0023] If one of the nozzles gets stuck in the tube, it is still pushed ahead by the drive motor, which is in the second operating state. The high-pressure hose in question is no longer subjected to a tensile force, but rather can buckle, for example on the reel. By this means, one can detect a defective operational state. The tube in question is then cleaned by other means.

[0024] It is advantageous if the high-pressure hoses extend in as linear a fashion as possible from the guiding unit to the reel. The high-pressure hoses enter the winding on the reel at a tangent. When there is a redirection of the high-pressure hoses between the guiding unit and the reel, e.g. a 90° arc, it is advantageous to reinforce the arc, for example to provide a deflector pulley there. It should be avoided that, when there is tension in the high-pressure hoses, the form of the arc changes appreciably.

[0025] The motor is stopped in a third operating state. Even if the nozzles are still working, they cannot advance further in the tubes. The forward propulsion is thus stopped.

[0026] The object in accordance with the method is achieved by the method in accordance with claim 7. Water streams constantly through each nozzle during the cleaning procedure as well as during the transition from the cleaning of one tube to another tube. The high-pressure water is thus normally not turned off during the cleaning of a heat exchanger. By this means, downtimes resulting from the water being turned on and off are avoided.

[0027] It is also advantageous in this scenario that the noise of the stream hitting the mirror is changed characteristically when a guiding tube is positioned over the mouth of a tube. By this means, an operator has a clear acoustic indicator that the position is correct and the nozzle can now be inserted into the tube.

[0028] In practical tests, it has been shown that the cleaning of tubes can be carried out with considerable speed. While forward propulsion speeds of 0.5 m/ are typically reached when working with the Peinemann device, forward propulsion speeds of 2 m/s and higher can be achieved with the invention.

[0029] Further advantages and features of the invention resulting from the remaining claims as well as the following description of an embodiment of the invention, which is not to be understood as limiting, will now be explained in the following with reference to drawings. This drawings show:

Fig. 1: a side view of a cleaning device with a drive motor, a reel and a guiding unit, which is located above a mirror of a heat exchanger

with vertical tubes, the perspective is the y-direction

Fig. 2: a top view of the cleaning device according to Fig. 1, the perspective is the z-direction,

Fig. 3: a view of the guiding unit with a perspective in the x-direction III in Fig. 2,

Fig. 4: a top view of a guiding unit according to Fig. 3, the perspective is the x-direction,

Fig. 5: a perspective illustration of the guiding unit, which is supported by a transverse guide, which is in turn supported by two longitudinal guides and

Fig. 6: a perspective illustration of the reel unit.

[0030] A right-handed x-y-z coordinate system is used for the following description.

[0031] The invention is in particular suitable for heat exchangers the tubes of which extend in a vertical direction. It is, however, also suitable for heat exchangers with tubes extending in a different direction, for example tubes extending horizontally.

[0032] Figures 1 and 2 show a heat exchanger 20 in principle. In Figure 2, the view is of a plane 22 or mirror, from which tubes 24 of the heat exchanger 20 extend. They extend downward, in the z-direction. The plane 22 lies in the x-y-plane. A high-pressure cleaning device is associated with the heat exchanger 20. It has five parallel high-pressure hoses 26, each of which support a nozzle 28 at one end. Such nozzles 28 are known in the art. As one can see from Figure 1, the nozzle 28 is slightly beneath the plane 22. In this state, it can move over the individual tubes 24 and be positioned in any orientation.

[0033] A guiding unit 30 of the high-pressure cleaning device is located above the plane 22. It has a total of five guiding tubes 32, which are arranged parallel and in a plane 22, specifically in the y-z-plane here. Arrangements other than in a plane 22 are possible, for example along a zigzagging line. The guiding tubes 32 end in a lower end 34. The guiding tubes 32 each receive a high-pressure hose 26 with play and guide it. The nozzle 28 and/or a coupling of the nozzle to the high-pressure hose 26 have large enough dimensions that they do not fit into a guiding tube 32.

[0034] The guiding unit 30 has an adjustment device 36. It makes it possible to set the distance of the individual guiding tubes 32. For this purpose, long holes and screws are provided, cf. Figure 4; specifically, the distance is set in the y-direction. The guiding tubes 32 have tube axes extending in the z-direction. They thus run in the same direction as the tubes 24.

[0035] A transverse guide 38 is provided and extends at least over the diameter of the mirror 22. The guiding unit 30 has a carriage and can be moved along the transverse guide 38 in the y-direction by means of the carriage. The transverse guide 38 can be positioned in any manner; in the embodiment, it is positioned parallel to the y-direction.

[0036] An angular displacement 40 is further provided; it is arranged between the carriage and the actual guiding unit 30 and makes it possible to pivot the actual guiding unit 30 vis-à-vis the carriage about the z-direction as its axis, for example at an angle of ±15°. This way, it can then be aligned parallel to the rows of tubes 24, when the transverse guide 38 is not, as shown in Figure 2, aligned exactly parallel to these tube rows.

[0037] Two longitudinal guides 42 are further provided, which are, for example, configured as rails, as is the transverse guide 38. The transverse guide 38 has guide carriages 44 at its ends, with which it is guided in a displaceable manner in the longitudinal guides 42. The two longitudinal guides 42 run in the example embodiment parallel to the x-axis. The transverse guide 38 and longitudinal guide 42 lie in the x-y plane. As Figure 2 shows, the longitudinal guides 42 are located outside the mirror 22. All in all, the tubes 24 can all be reached via the transverse guide 38 and the longitudinal guide 42, if applicable, the angular displacement 40.

[0038] When the terms "above" and "below" are used in the description, these relate to the z-direction. A positive z-direction is oriented downward, a negative z-direction is oriented upward. A first element is thus located below a second element when the first element is in a positive z-direction below the second element.

[0039] Five guide means 46 for the high-pressure hoses 26 are located above the guiding unit 30. These are essentially Teflon hoses in which the high-pressure hoses 26 are guided. They extend up to a reel unit, which will be described in the following. It has a reel 48, on which the five high-pressure hoses 26 are wound up. Feed openings 49 for high-pressure water at the other end of the high-pressure hoses 26 are formed there. High-pressure water is fed through these to the high-pressure hoses 26, the high-pressure water reaching the nozzles 28.

[0040] The reel 48 is rotatable about an axis that is parallel to the y-direction. It is rotationally driven by a drive motor 50. Associated with the drive motor 50 is a control device (not illustrated) by means of which it is possible to switch the drive motor 50 into a plurality of operating states. In a first operating state, the drive motor 50 drives the reel 48 in the winding direction, i.e. counter-clockwise in Figure 1, while the high-pressure hose is transported in the guide means 46 in a positive x-direction and pulled away from the tubes 24. In this first operating state, the drive motor 50 supplies sufficient torque to the reel 48 that overall the high-pressure hoses 26 can be jointly pulled out of the tubes 24 during operation against the forward propulsion.

[0041] In a second operating state, the drive motor 50 works in the opposite direction, i.e. in the unwinding direction. The reel 48 then feeds the high-pressure hoses 26 at a controlled speed determined by the engine speed of the drive motor 50. This is the speed at which the nozzles 28 advance inside the tubes 24. During this process, the drive motor 50 has a braking effect on the forward motion of the nozzles 28. Without the braking effect, the nozzles 28 together with their high-pressure hoses 26 would travel faster through the tubes 24. They would also not all advance at the same speed.

[0042] In the second operating state, the high-pressure hoses 26 are not conveyed by the drive motor 50. Their forward motion occurs exclusively through the forward propulsion due to the nozzle jets oriented rearward. The forward motion of the nozzles 28 is brought about by the force of propulsion acting on the nozzles 28 by the recoil and not by the drive motor 50. Typical speeds of forward propulsion are around 2 m/s plus or minus 50%.

[0043] It is advantageous to arrange a self-locking gearing mechanism in the path of the return force, for example a worm gear, between the drive motor 50 and the reel 48. By this means, it is avoided that the reel 48 can turn faster than the speed determined by the drive motor 50. It is also advantageous to provide a brake for the reel 48 that is always controlled in such a way that the reel 48 cannot run at a higher speed than the drive motor 50.

[0044] Hydraulic, pneumatic and electric motors are conceivable drive motors 50. Pneumatic motors are advantageous, in particular in connection with pneumatically controlled brakes.

[0045] The high-pressure cleaning device for tubes of heat exchangers is configured for the simultaneous cleaning of at least three tubes and has a) at least three high-pressure hoses, b) a nozzle at each free first end of each high-pressure hose, wherein the nozzle has nozzle openings from which nozzle jets are discharged during operation, wherein the nozzle jets predominantly generate a recoil during operation and bring about a forward propulsion of the high-pressure hose, c) a guiding unit having a guiding tube for each high-pressure hose, wherein a guiding tube respectively receives one of the high-pressure hoses with play, the guiding tubes being aligned parallel to one another, wherein a free space remains between a lower end of a guiding tube and a mouth of the tube, d) a reel on which the high-pressure hoses coming from the guiding unit are wound up and feed openings for high-pressure water on every second end of every single high-pressure hose and e) a drive motor, which is rotationally connected to the reel and has a plurality of operating states, wherein, in a first operating state, the drive motor supplies the reel with sufficient torque for the high-pressure hoses to be pulled out of the tubes contrary to the forward propulsion.

List of references

[0046]

20 Heat exchanger
22 Plane, Mirror
24 Tubes
26 High-pressure hose
28 Nozzle
30 Guiding unit
32 Guiding tubes
34 Lower end (of 32)
36 Adjustment device
38 Transverse guide
40 Angular displacement
42 Longitudinal guide
44 Guide carriage
46 Guide means
48 Reel
49 Feed openings
50 Drive motor

PATENTKRAV

1. Anordning til højtryksrensning af varmeveksleres rør (24) til samtidig rengøring af mindst tre rør (24), hvor højtryksrenseanordningen har

- mindst tre højtryksslanger (26)
- en dyse (28) i hver frie første ende af hver højtryksslange (26), hvor dysen (28) har dyseåbninger hvorfra dysestråler kommer ud under brug, hvor dysestrålerne overvejende producerer rekyl og forårsager fremdrift af højtryksslangen (26) under brug og, hvor højtryksslangerne (26) trækkes ind i rørene (24) på grund af fremdriften under brug,
- en styreenhed (30) og
- en tromle (48), hvorpå højtryksslangerne (26), der kommer fra styreenheden (30) er viklet, hvor tilførselsåbninger til højtryksvand er tilvejebragt i hver anden ende af hver individuelle højtryksslange (26), **kendetegnet ved,**
- at styreenheden (30) har et styrerør (32) for hver højtryksslange, i hvert tilfælde et styrerør (32) der modtager en af højtryksslangerne (26) i hvert tilfælde med spillerum, hvor styringsrørene (32) justeres parallelt med hinanden, og hvor hvert styringsrør (32) placeres på den samme akse som et rør, hvor der er et frit rum tilbage mellem en nedre ende af hvert styrerør (32) og en munding af røret,
- og **ved at** der er tilvejebragt en drivmotor (50), som er drejeligt forbundet til tromlen (48) og har en flerhed af driftstilstande, hvor drivmotoren leverer tilstrækkeligt drejningsmoment til tromlen (48) i en første driftstilstand, så tromlen (48) roterer i viklingsretningen, og højtryksslangerne (26) trækkes ud af rørene (24) under drift mod fremdriften.

2. Højtryksrenseanordning ifølge krav 1, **kendetegnet ved, at** drivmotoren i en anden driftstilstand roterer tromlen (48) i afviklingsretningen og bestemmer den hastighed, hvormed højtryksslangerne (26), der trækkes ind i rørene (24) under drift som et resultat af fremdriften, løber ind i rørene (24), og højtryksslangerne (26) løber ikke ind i rørene (24) med en højere hastighed end den bestemt af drivmotoren.

3. Højtryksrenseanordning ifølge et af de foregående krav, **kendetegnet ved, at** styreenheden (30) omfatter en justeringsanordning (36) til justering af afstanden af de individuelle styrerør (32) fra hinanden.

4. Højtryksrenseanordning ifølge et af de foregående krav, **kendetegnet ved, at** den har en tværgående styring (38), og at styreenheden (30) har en vogn, der kan forskydes justerbart langs den tværgående styring (38).

5. Højtryksrenseanordning ifølge det foregående krav, **kendetegnet ved, at** styreenheden (30) har en vinkelforskydning (40), som er anbragt mellem vognen og resten af styreenheden (30) og muliggør en vinkelforskydning (40) af styringsrørene (32) i forhold til den tværgående styrings (38) længderetning.

6. Højtryksrenseanordning ifølge et af kravene 4 og 5, **kendetegnet ved, at** den omfatter mindst en langsgående styring (42) med fastgørelsesmidler til dens fastgørelse til varmeveksleren (20), strækkende sig på tværs i forhold til den tværgående styring (38) og med en styringsvogn (44), bærende den tværgående styring (38).

7. Fremgangsmåde til drift af en højtryksrenseanordning med trækkene ifølge et af kravene 1-6, **kendetegnet ved, at** vand kontinuerligt strømmer gennem højtryksslangerne (26), hvor trukket via drivmotoren (50) og tromlen (48) er dyserne (28) placeret under de nedre ender af styringsrørene (32) og uden for et rør (24), hvor styreenheden (30) bevæges, indtil dyserne (28) er placeret ovenfor rør (24) der skal rengøres, hvor drivmotoren skiftes til den anden driftstilstand, hvorved dyserne (28) og højtryksslangerne (26), der er fastgjort til dem, nedsænkes i rørene (24) og renser dem.

8. Fremgangsmåde ifølge krav 7, **kendetegnet ved, at** drivmotoren (50), efter rengøring af rørene (24), hvori højtryksslangerne (26) er nedsænket, er afsluttet, bringes til den første driftstilstand og højtryksslangerne (26) trækkes ud af rørene (24) mod fremdriften.

9. Fremgangsmåde ifølge krav 7 eller 8, **kendetegnet ved, at** drivmotoren (50), i en tredje driftstilstand, stopper enhver bevægelse af dyserne (28) inde i rørene (24), også når der tilføres vand.

Fig. 1

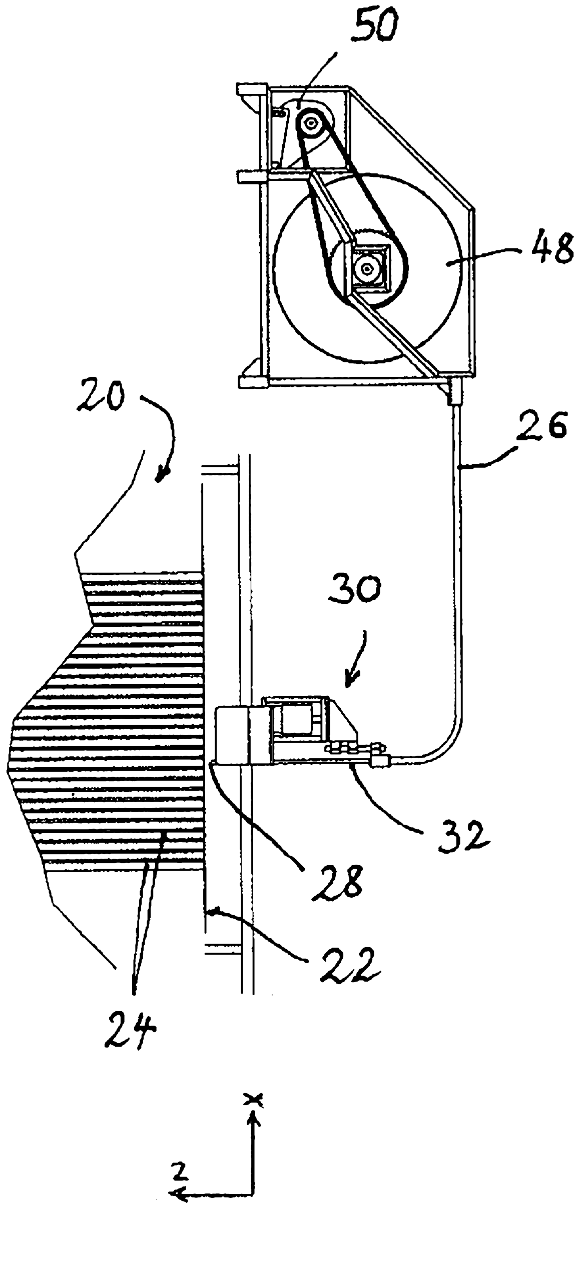

Fig. 2

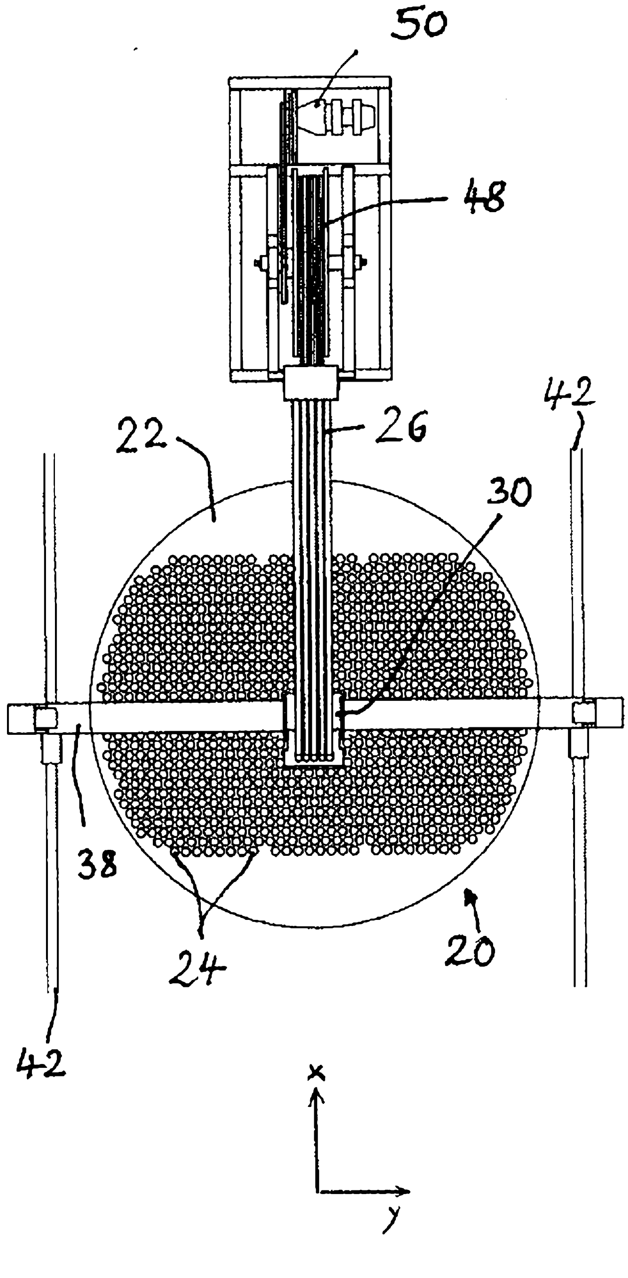

Fig. 3

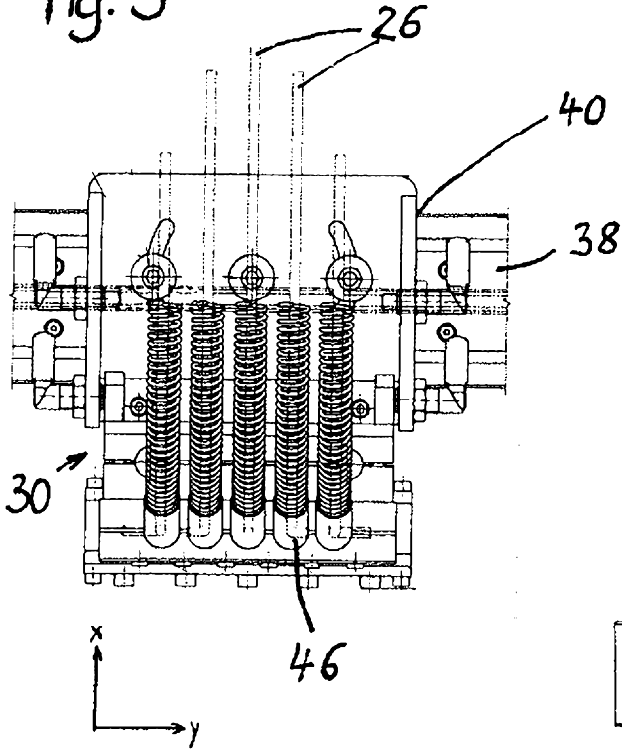

Fig. 4

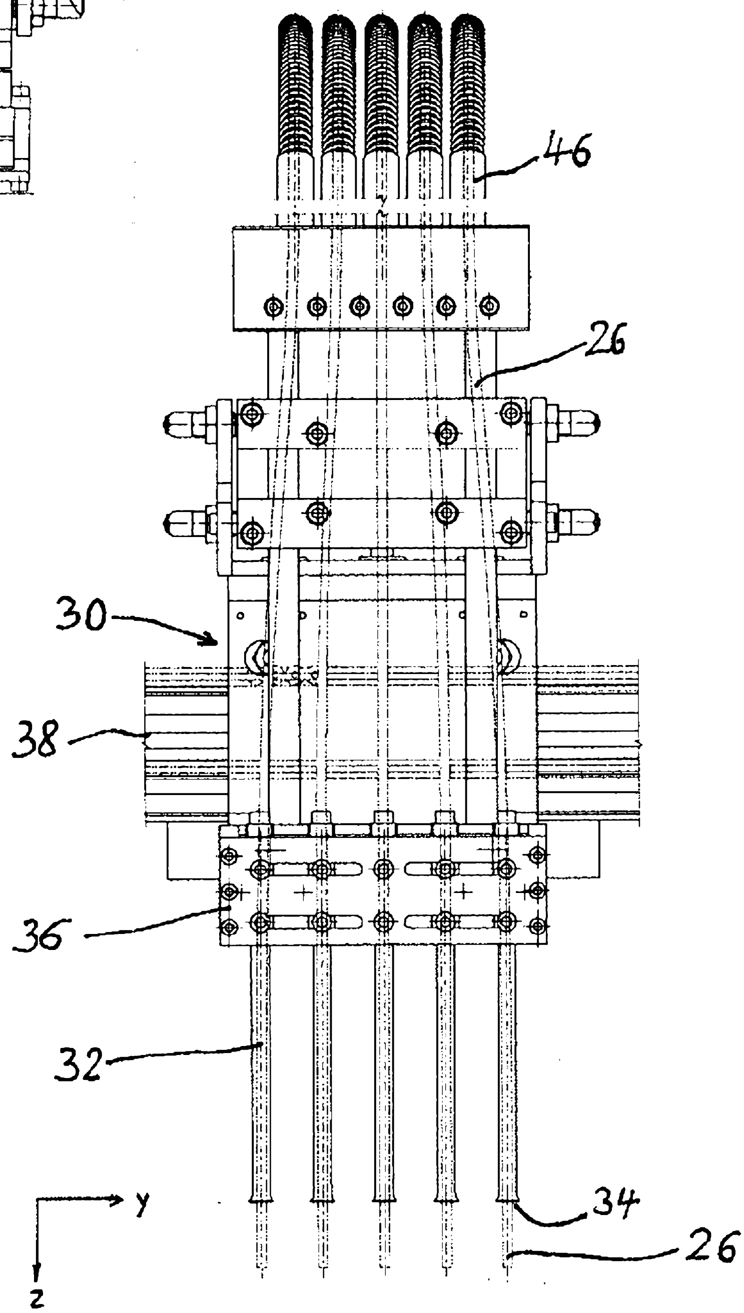

Fig. 5

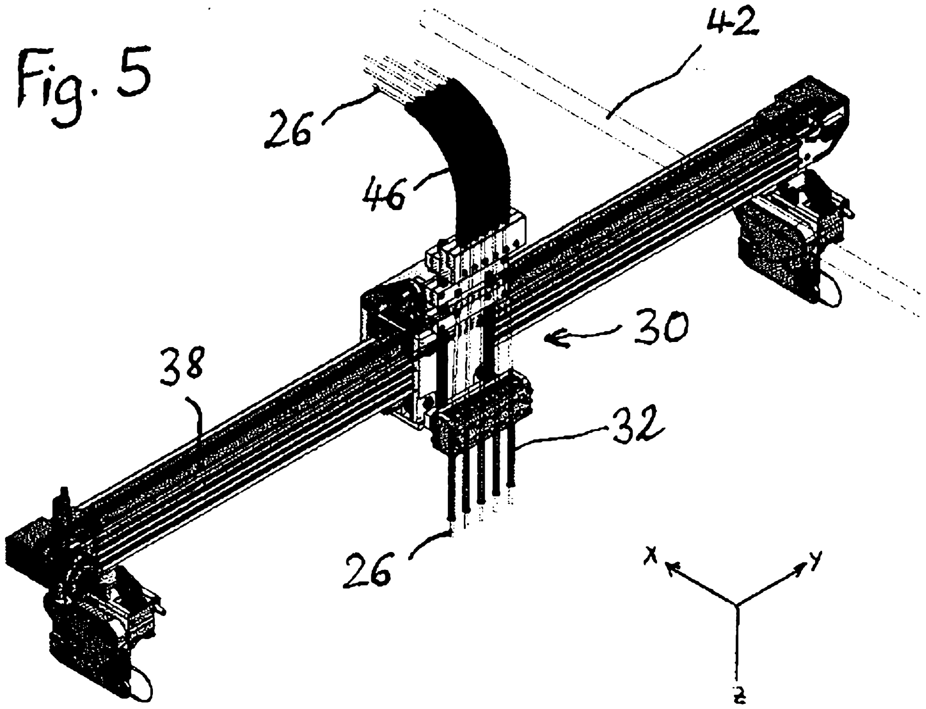

Fig. 6