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**Ottenhues**

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[54] **VACUUM LIFTING DEVICE**


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[51] **Int. Cl.** ..... **B66c 1/02**

[58] **Field of Search** ..... 294/64 R, 64 A, 65, 86; 214/1 BS, 1 BT, 1 P, 1 PA, 8.5 D, 650 SG



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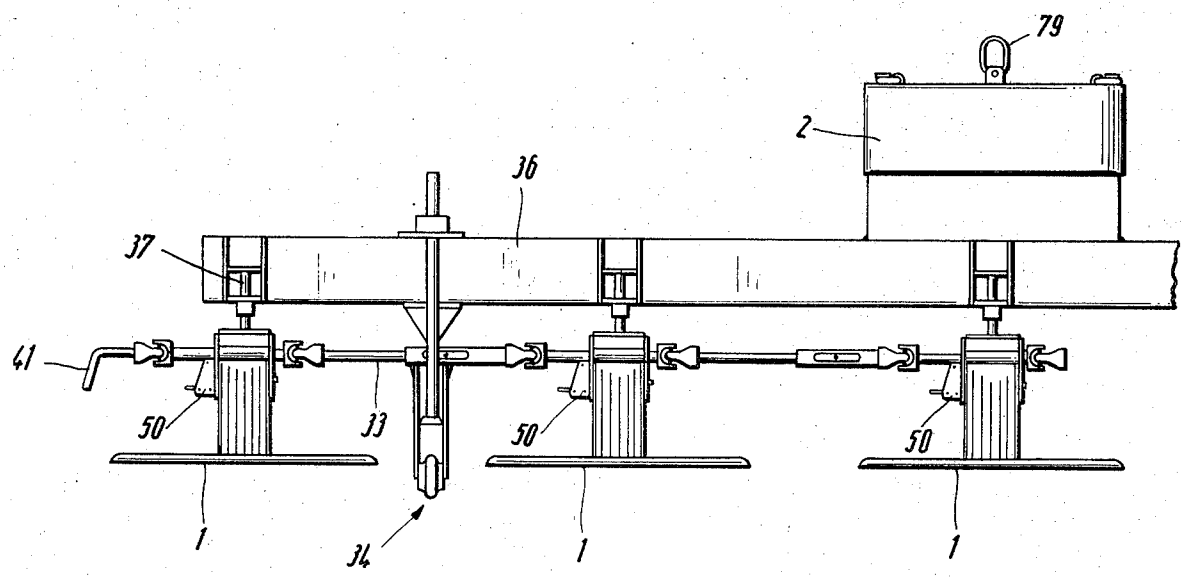
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[57] **ABSTRACT**

A vacuum lifting apparatus is composed of a plurality of side-by-side elongated segments which engage an article to be lifted by collectively conforming to the surface of the article through the force of gravity. The segments are connected by a plurality of seals which project from a main plate and a resilient rim encircles the segments and seals. Tie rods extend from each segment to a common hub and are immovably clamped together after the article has been engaged, thereby locking the segments in position while defining a desired curved configuration.


**9 Claims, 10 Drawing Figures**



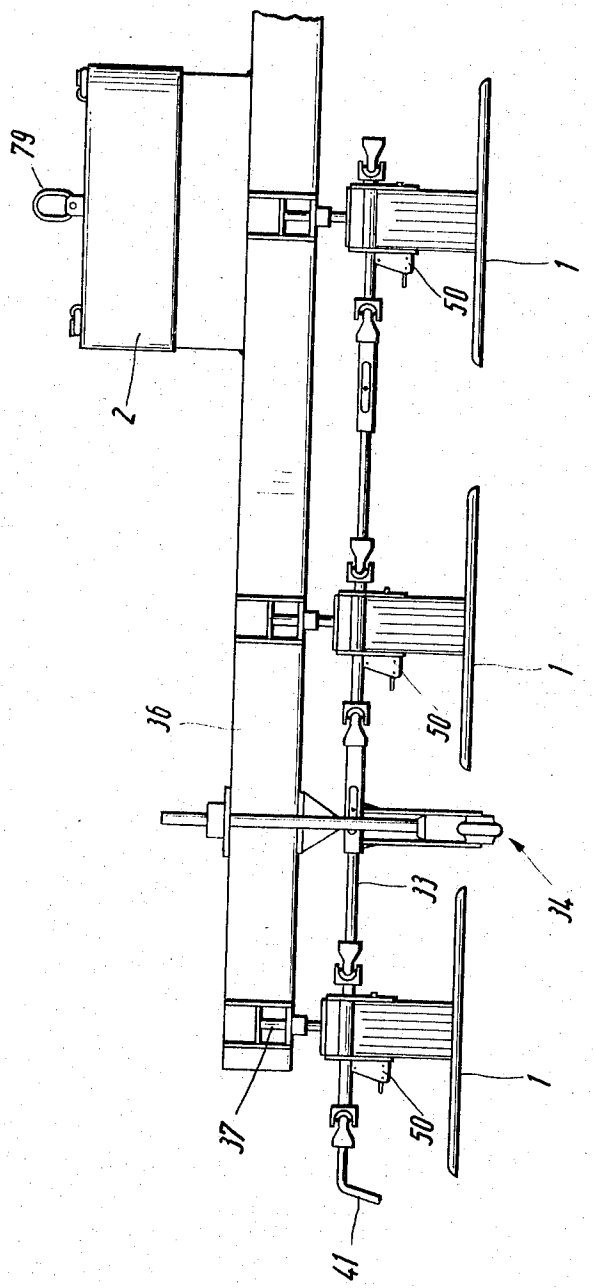



Fig. 1

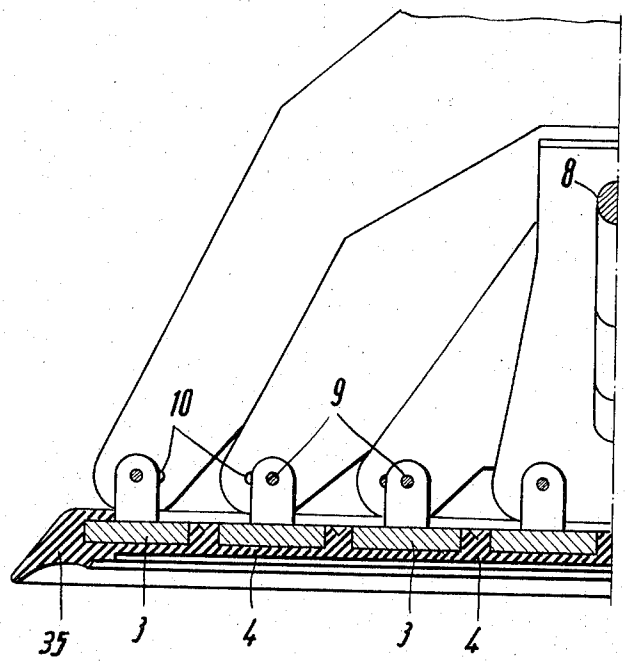



Fig. 2

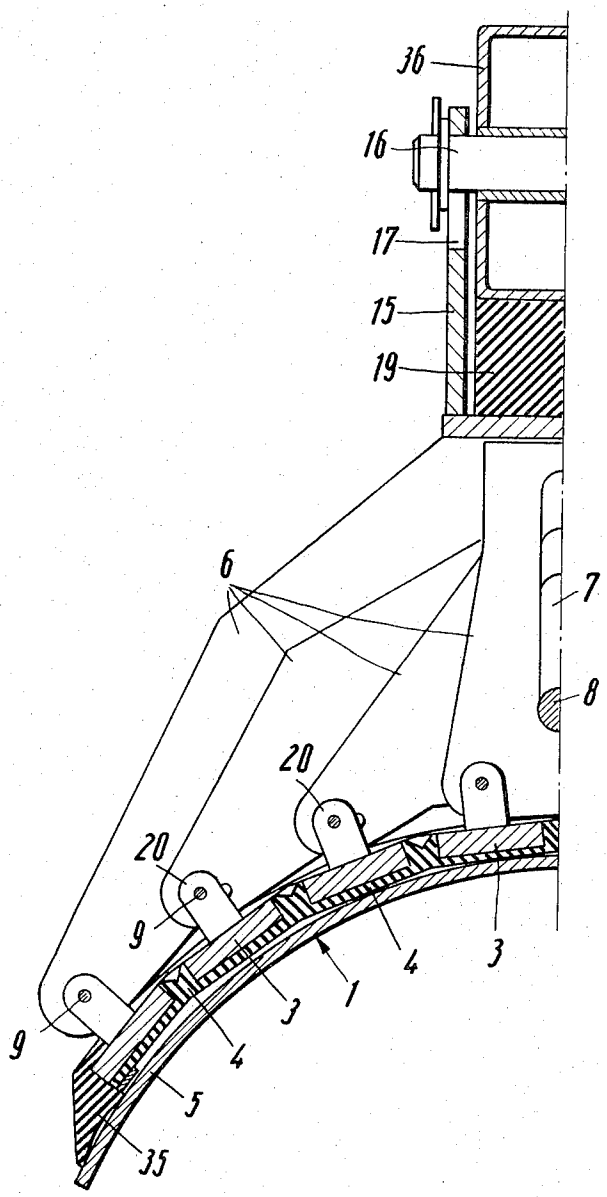



Fig. 3

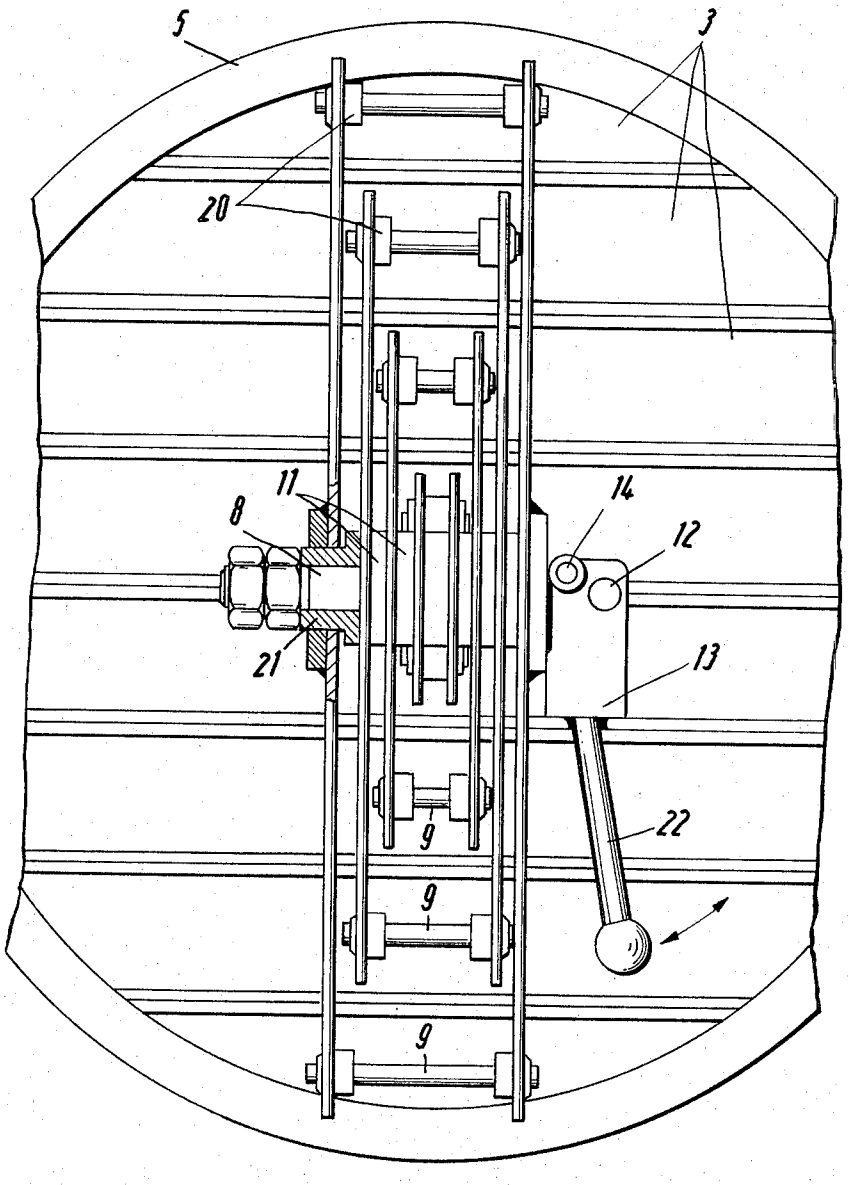



Fig. 4

Fig. 5

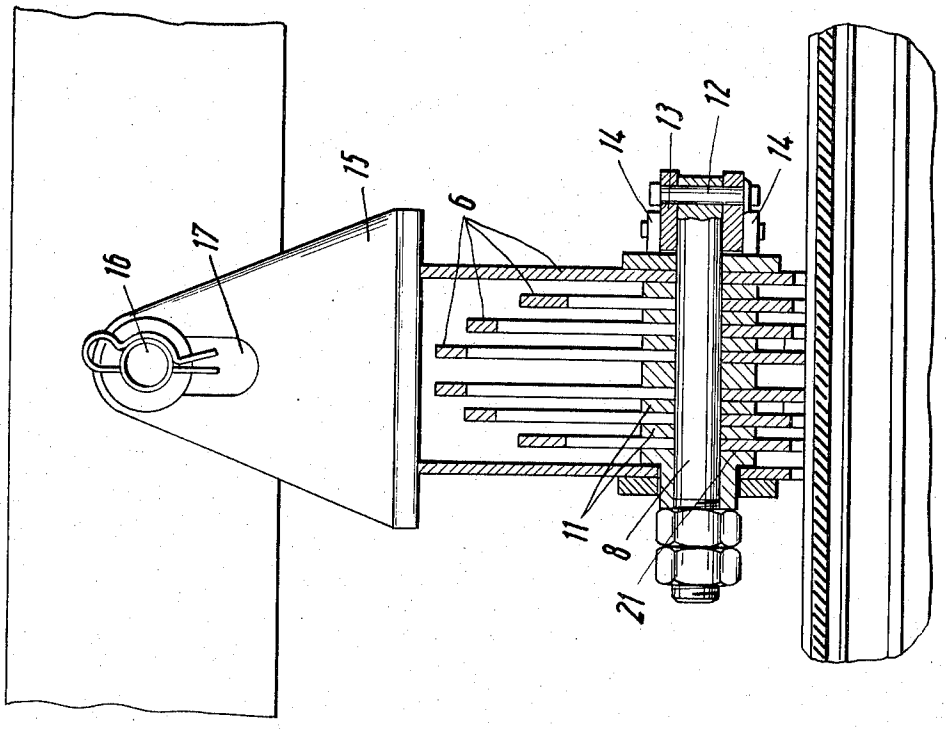
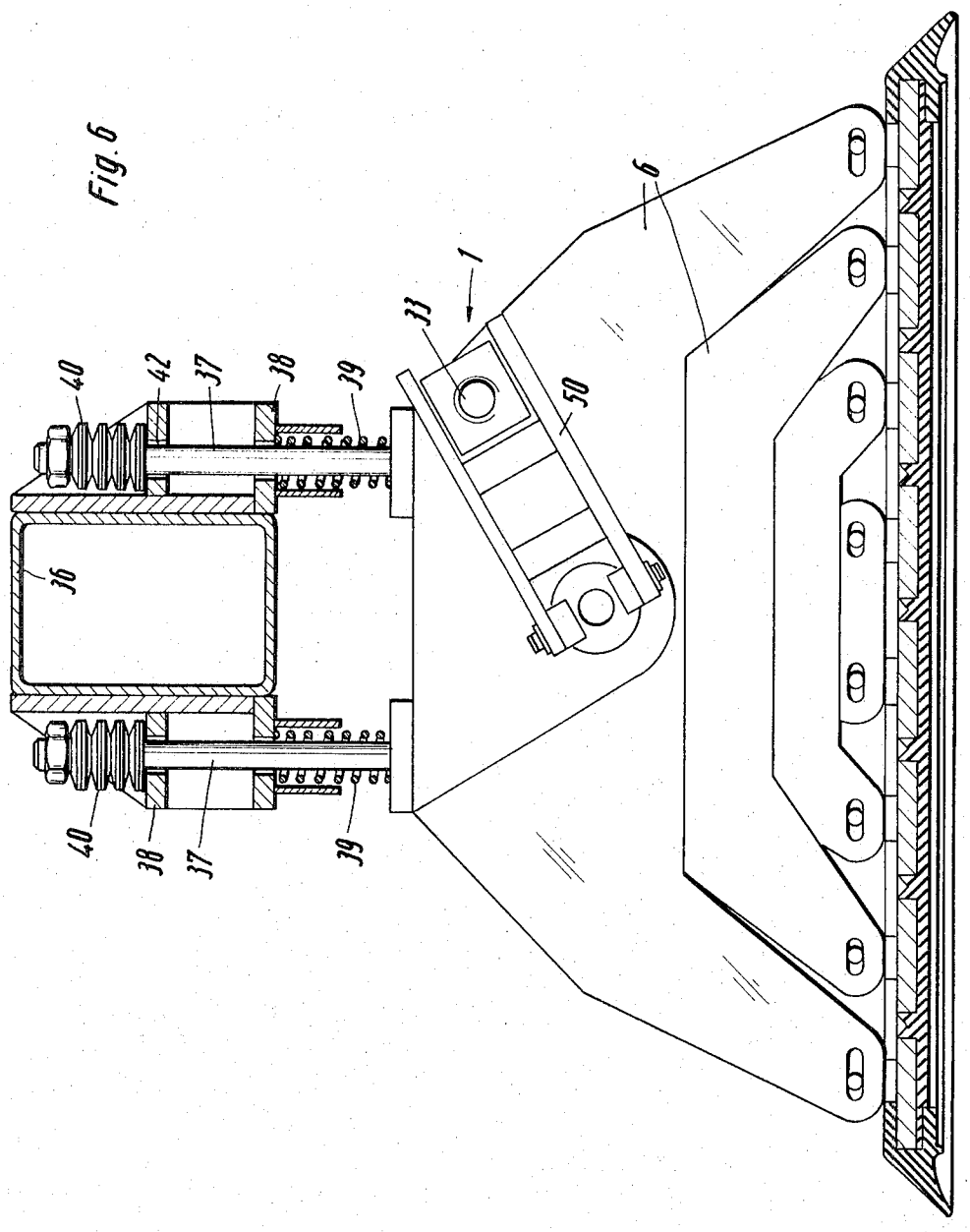


Fig. 6



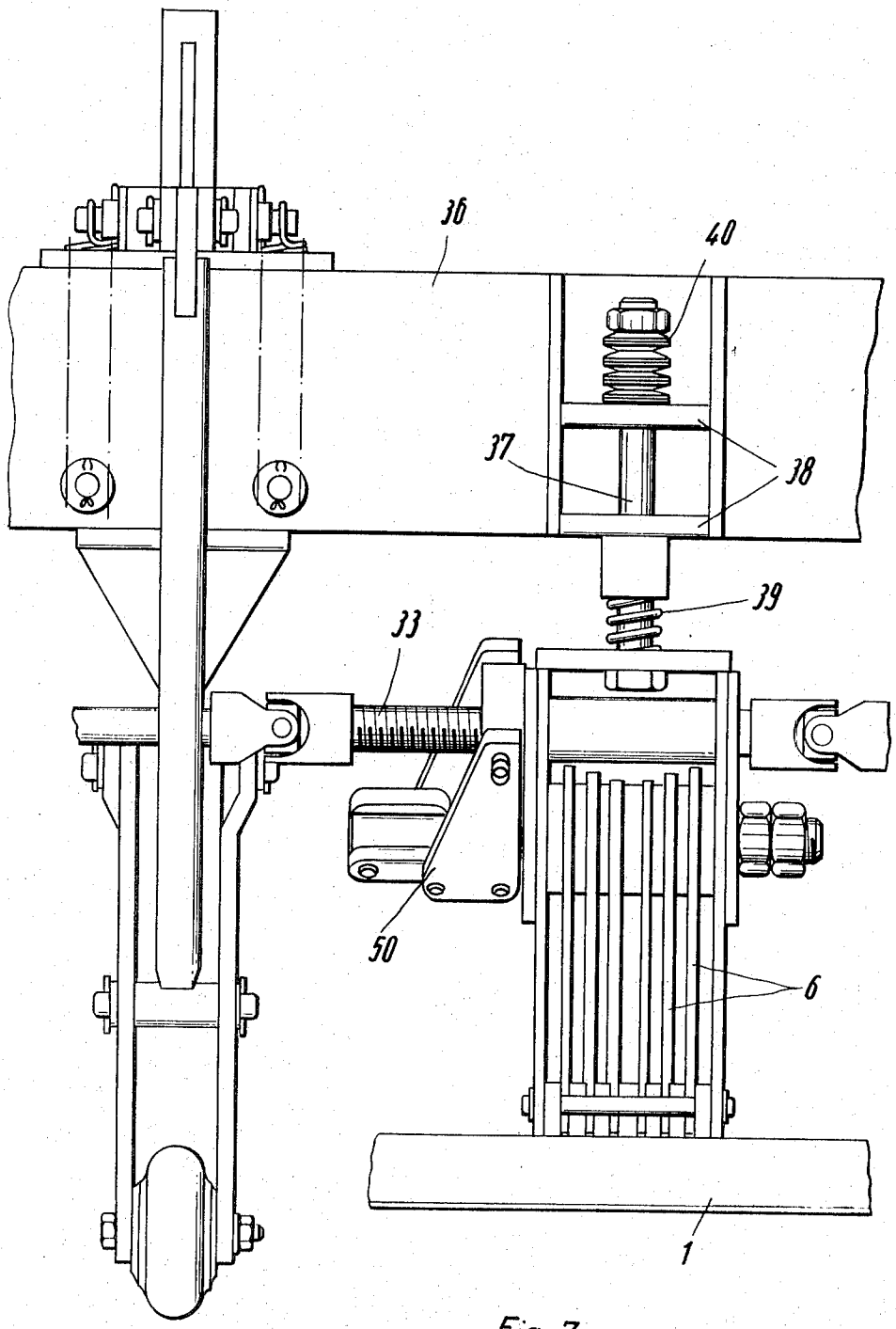



Fig. 7

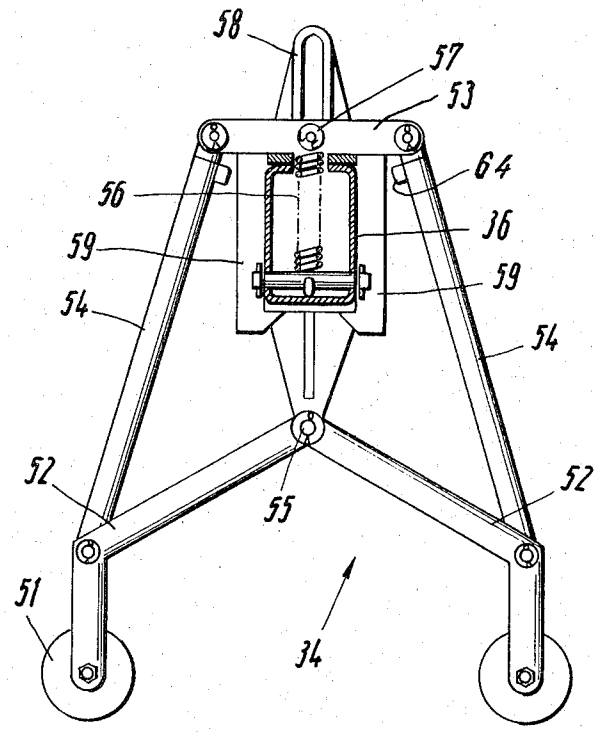
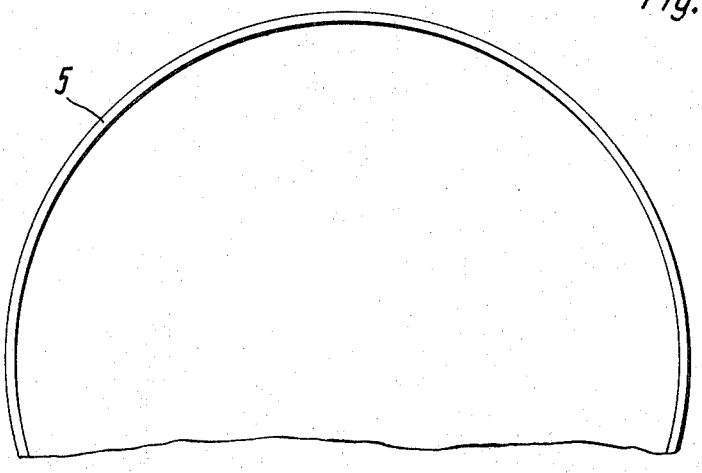



Fig. 8



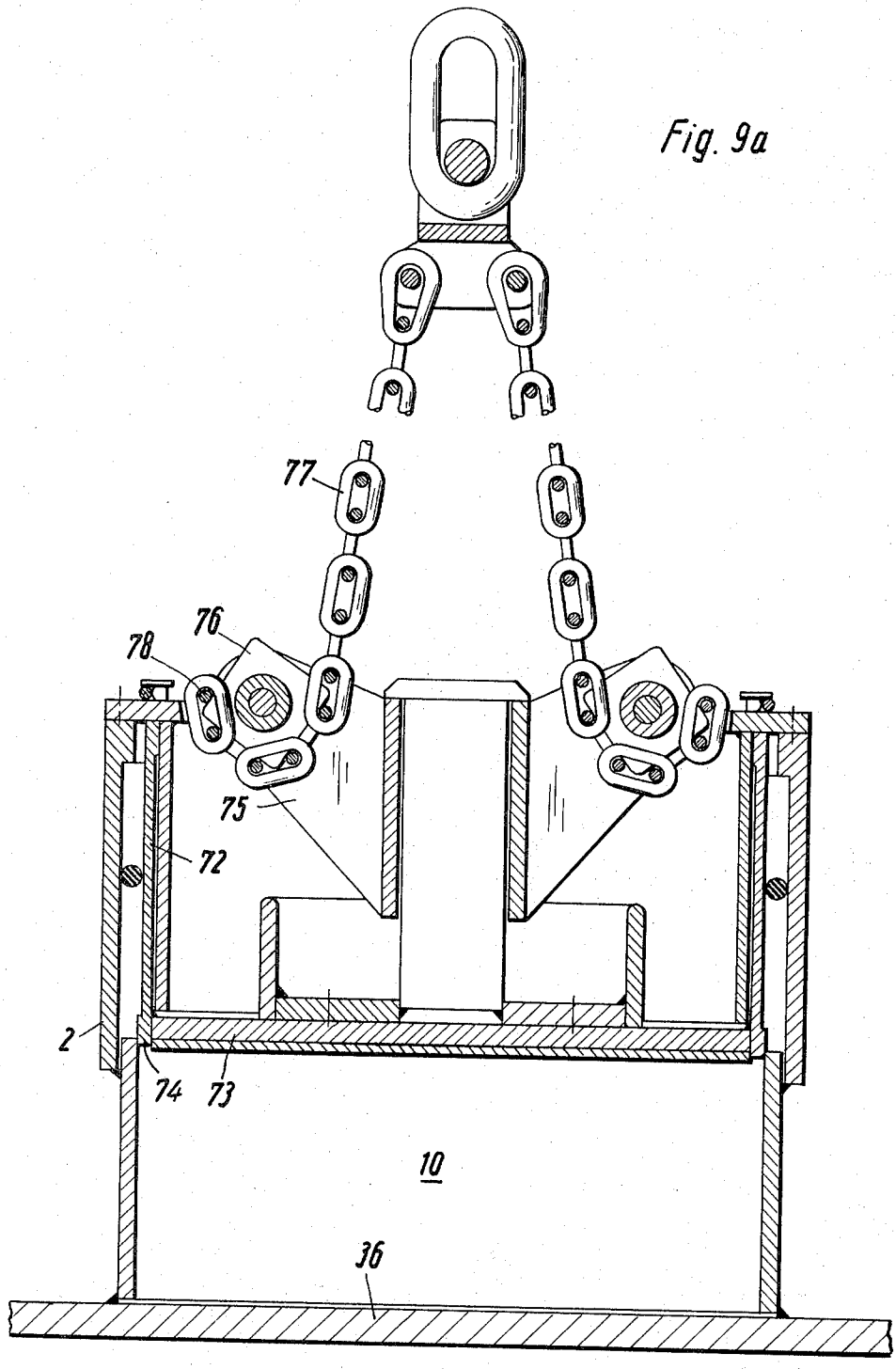
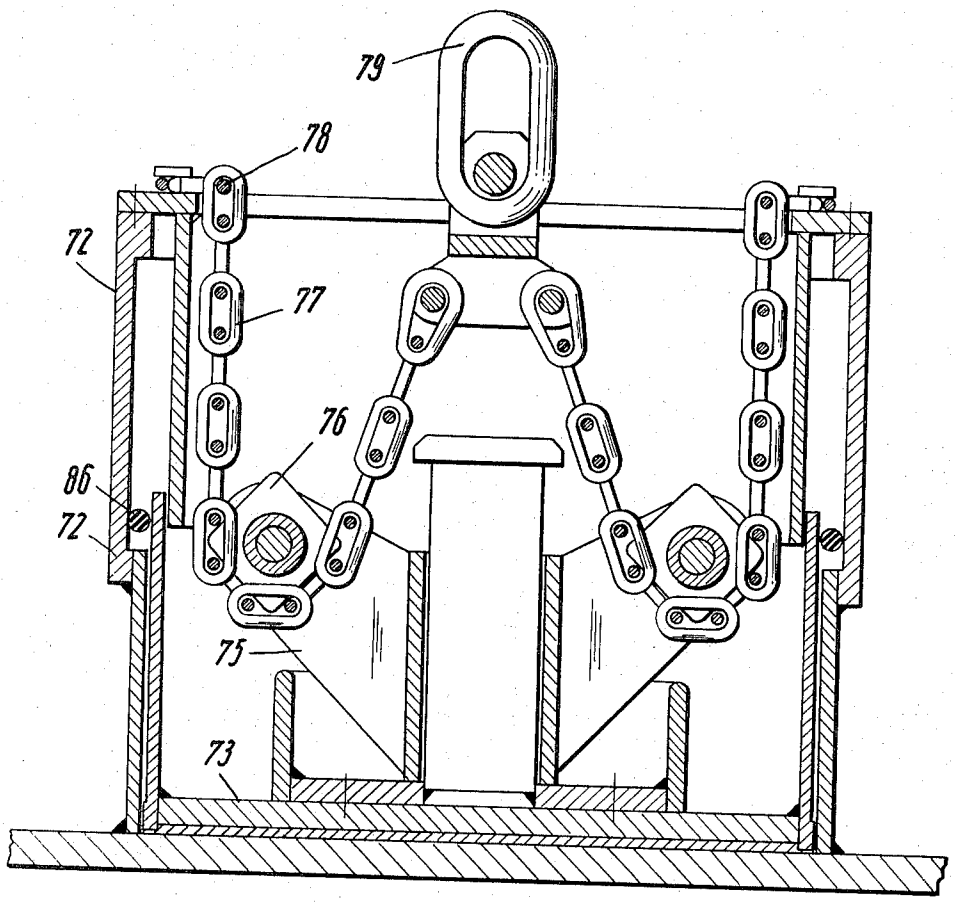



Fig. 9a

Fig. 9b



# VACUUM LIFTING DEVICE

The present invention relates to a vacuum lifting device for the lifting of articles having an axially symmetrically curved surface, by means of a holding vacuum.

Vacuum lifting devices for the lifting of articles having planar surfaces are known. Heretofore, the lifting of articles having a curved surface was always unsuccessful for the reason that the holding or suction cup could not be given a shape which would adapt itself to various curvatures.

It is the object of the present invention to provide a vacuum lifting device for the lifting of articles having curved surfaces, which device, in particular, renders it possible to safely lift articles having axially symmetrically surfaces of most varied radii of curvature, and to safely hold such articles in the lifted position.

The lifting device according to the invention should be of simple construction, easy to operate and economical in manufacture. It should be of light weight and adapted to fit equally well to articles having an inner or concave curvature and such having an outer or convex curvature, and it should be capable of lifting even extremely heavy articles.

According to the present invention, this object is solved in that in the vacuum lifting device a suction cup is placed upon the surface of the article to be lifted, whereby the suction cup curves under the action of gravity and conforms itself to the surface of the article such that segments of the suction or holding cup rest uniformly on the curved surface, the configuration of the suction cup is fixed in this position, a holding vacuum is produced between the suction cup and the surface, and the article to be lifted is raised by applying a pulling force onto the suction cup.

Accordingly, the device according to the invention comprises the following components: A suction cup comprising a plurality of side-by-side extending, flat and elongated segments and a seal positioned underneath and/or between them; a sealing lip extending around the segments; lower tie rods pivoted to each segment and each having an elongated hole in the end remote from the segment; and a hub passing through said elongated holes and permitting the tie rods to be clamped.

For the uniform take-up of load of the separate segments during the curving of the suction cup, the tie rods engaging on the individual segments are moved such that they are shifted relative to each other and retained against each other in immovable condition after the application of the suction cup.

In order to compensate for minor irregularities, at least the outermost tie rods are pivoted to the segments through bolts guided within elongated holes. In order to facilitate the clamping of the tie rods after the application of the suction cup, spacers may be fitted between the tie rods, and the hub may be traversed by a transverse bolt which is secured on a pivot arm. The end of the pivot arm is supported by rollers, whereby the axis of rotation of the rollers is movable somewhat beyond the center axis of the hub.

In order that a number of suction cups according to the invention can be arranged in side-by-side relation for the lifting of heavy loads, a pair of the tie rods engaging on corresponding segments are secured to a dog or claw, whereby the dog through a bolt and elongated holes engages on a transverse rail which has positioned thereon a plurality of suction cups in side-by-side relation. Rubber cushions are provided between the bolts of the dog and the transverse rail.



In order to render possible a good sealing action of the continuous sealing lip, the suction cup is preferably of circular configuration, while the segments arranged in side-by-side relation become increasingly shorter in outward direction.

In the case of articles of great length, such as pipes, it has been found that a single suction cup does not always provide a sufficient suction force. Accordingly, it is contemplated to provide a lifting device capable of safely lifting and retaining even very long tubular bodies of high weight and having great wall thicknesses. Nevertheless, the lifting device according to the invention should be of simple construction, universally useful and economical in operation.

In particular, the vacuum lifting device also should be adapted to be automatically aligned with tubular bodies or articles, such that each separate suction cup can be applied precisely along the axis of the cylindrical article. Hereby, the suction cup should adjust itself automatically, i.e., without any manual aid, to the cylindrical surface when the cup is lowered.

This additional object is solved according to the invention by a lifting device comprising means as described in greater detail in claim **6**.

Advantageously, the suction cups by means of stay bolts may be suspended from a transverse rail having protruding flanges, and the stay bolts may be supported relative to the transverse rail by coiled springs from below and by dished springs from above.

In order to align the vacuum lifting device precisely along the center axis of the cylindrical article, preferably the vacuum lifting device according to the invention comprises at least a pair of orienting devices mounted on the transverse rail and having laterally protruding adjustment arms carrying rollers at the lower ends thereof, which arms are pivoted at their upper ends on a pivot point being stationary with respect to the transverse rail, and pivotally connected to pushrods between their ends, the upper ends of said pushrods being connected to a two-piece transverse web adapted to be lifted off the transverse rail under the force of a spring and adapted to be collapsed about a center joint guided within an eye of the transverse rail, said transverse web having attached to its two legs a downwardly directed hook including an inwardly extending tip, which hook engages around the lower outer edge of the transverse rail.

Generally, chains or cables are used for lifting the vacuum devices including vacuum cylinders. This results in the disadvantage that the angle of inclination of the chains or cables relative to the cylinder increases such that the pressure force applied to the cylinder decreases.

Therefore, it is proposed to have the chains or cables pass around guide rollers or sheaves at the cylinder, which sheaves are mounted on the cylinder, whereby the draw gear (chains or cables) extends parallel to the direction of movement of the piston in the region between the pivot points on the cylinder and guide sheaves.

In the following, exemplary embodiments of the invention are explained in greater detail by referring to the accompanying drawings, wherein:

FIG. **1** is a part elevational view of a vacuum lifting device according to the present invention;

FIG. 2 shows a first embodiment of a suction cup in relieved condition;

FIG. 3 shows the suction cup of FIG. 2 in its curved condition;

FIG. 4 is a plan view of the suction cup of FIG. 2;

FIG. 5 is a cross-sectional view through the suction cup of FIG. 2;

FIG. 6 shows a part elevational view of a modified embodiment of a suction cup;

FIG. 7 is a cross-sectional view through a suction cup suspended from a transverse rail;

FIG. 8 is a cross-sectional view through an orienting device connected to the transverse rail and

FIGS. 9*a* and 9*b* are sectional views of a vacuum cylinder in two different positions.

As shown in FIG. 1, the vacuum lifting device according to the invention comprises a plurality of vacuum suction cups 1 which are mounted in series and in side-by-side relation on a transverse rail 36 which, in turn, is adapted to be raised by means of a vacuum cylinder 2 through a hoist. The hoist is connected to a piston of the vacuum cylinder 2 through singly sheaved chains (FIGS. 9*a*,*b*). When the hoist is raised the piston is drawn upwards within the cylinder 2 so as to produce a high vacuum. During the raising operation, the vacuum generated within the cylinder is transmitted through not illustrated hoses to the individual suction cups where such vacuum produces the requisite suction force.

In its operational condition (FIG. 3), the suction cup 1 contacts a cylindrical article 5, e.g., a pipe. In its relieved condition, the suction cup has the configuration shown in FIG. 2.

The suction cup comprises a plurality of adjacently disposed, flat segments 3 which are parallel to each other and of which the outermost segments are shorter than the inner segments, such that the segments in their curved condition jointly form a circular disc.

Sealing elements 4 are secured or vulcanized between and/or below the segments, such that a sealing and flexible plate is formed under the suction cup.

The segments 3 and the seal 4 are surrounded by a continuous sealing lip 35 which prevents air from penetrating into the vacuum space under the sealing elements 4.

The individual segments 3 carry webs 20 which have fitted into them bolts 9 extending along the respective segment. Lower tie rods 6 are pivoted to the bolts 9, which tie rods extend from the bolts 9 to a central hub 8 being movable within an elongated hole of the lower tie rods 6. A normal circular hole is provided for the inner tie rods only because the inner tie rods 6 are the only members which need not shift relative to the hub 8.

Spacer discs 11 (FIG. 4) are provided between the separate tie rods 6 which are arranged symmetrically on either side of the center line of the suction cup. By the provision of a thrust sleeve 21 which acts against the next inner tie rod 6, the hub is held stationary relative to one of the outer tie rods 6. At its opposite end, the hub 8 carries a clamping device 50 by means of which the tie rods 6, with the exception of the tie rod on the left side in FIG. 4, may be clamped together as a stack. The clamping device 50 comprises a pivot lever 13 which is pivoted to the end of the hub 8 through a bolt 12.

The flanges of the lever 13 carry rollers 14 which press against the outermost one of the tie rods 6.

When the hand lever 13 is pivoted in the direction of the arrow by means of the handle 22, the lever 13 cams on the rollers 14 and thereby draws the hub 8 outwardly, such that the tie rods 6 are immovably clamped or locked to each other as a stack. When the pivot lever 13 is pivoted beyond the outermost tension point, it is automatically jammed since in this condition the transverse joint between the flanges abuts the hub 8.

In the manner described above, it becomes possible to lock the tie rods in most simple manner in their position adapted to the surface of the curved article. The locking can be effected also by other means, e.g., by remote control, hydraulically, pneumatically, or by electromotoric or mechanical means. Hereby, the hydraulic or pneumatic energy may be produced also by the extension movement of the piston from the vacuum cylinder 2 if, for instance, a hydraulic or pneumatic cylinder is mounted parallel to the vacuum cylinder 2 and connecting conduits are provided between the transmitting and the receiving pistons on the suction cups. Also, the expert is aware of a number of other measures for the clamping operation.

It has been found to be advantageous to pivot the tie rods 6 to the bolts 9 by means of elongated holes the longitudinal direction of which extends parallel to the segments 3 in their horizontal position. These elongated holes provide for an improved force transmission to the individual segments and, at the same time, provide a compensation for slight surface irregularities.

In order to lift heavy loads, it is necessary to arrange a number of suction cups serially in side-by-side relation. In this case (FIG. 3), a transverse rail 36 carries the suction cups through bolt 16, whereby the respectively outermost tie rods 6 which are secured to the innermost one of the segments 3, are attached to a dog 15. The bolt 16 passes through an elongated hole in the vertically extending flanges of the dog 15 so as to be able to compensate for minor distance irregularities between the separate suction cups. Rubber cushions 19 are positioned between the horizontal bottom wall of the dog 15 and the transverse rail 36, which cushions transmit the power to the transverse rail 36 while compensating for a certain clearance.

In the space confined under the seal 4, a vacuum is produced either by an additional vacuum pump or by the vacuum cylinder 2 via conduits. The vacuum cylinder which is positioned above the transverse rail 36, is expanded when the hoist is raised and thereby produces the vacuum required for the lifting of the article. An additional vacuum pump is required in the case that the device is to be accommodated to the lifting of extremely heavy loads. The additional pump is driven by external means, i.e., by an electric motor or the like, but not through the linkage.

Surprisingly, with the device described above it is not only possible to lift the articles, but also to safely hold or suspend them for an extended period of time. To this end, it is necessary that the suction cup conforms itself to the surface from its horizontal position as shown in FIG. 1, when it is applied to the article 5 to be raised, whereby the tie rods adjust themselves to their respective position. Hereby, the hub 8 is shifted within its elongated holes 7. As soon as such adjustment has been effected, the tie rods are clamped against each other in immovable condition so as to uniformly take up the lift-

ing force. Thereafter, the device is evacuated and the article is lifted.

A rough calculation and a test show that the suction cups according to the invention are capable of lifting even pipes having wall thicknesses of from 20 to 30 centimeters.

In the modified embodiment shown in FIGS. 6 to 8, the modification resides particularly in the suspension and orientation of the suction cup. The construction of the suction cups per se is substantially identical to that according to FIGS. 2 to 5.

The embodiment according to FIG. 6 uses other suspensions than in the example of FIG. 3. At the point of attachment of the suction cup 1, the transverse rail 36 includes laterally protruding flanges 38 having bores 42, whereby stay bolts 37 are supported relative to the flanges 38 at their upper ends by means of dished springs 40 and at their lower ends by means of coiled springs 39. In this way, the suction cups 1 may be adjusted relative to the transverse rail 36 without causing the applied lifting power to become non-uniform, since the dished springs 40 are of substantially greater stiffness than the coiled springs 39.

Upon placing the vacuum lifting device upon a tubular body or article, the suction cups - as described above - conform themselves to the surface configuration of the article to be lifted In this position, in the illustrated embodiment a common shaft 33 extending from one suction cup 1 to the other through universal joints is rotated by means of a handcrank 41, which shaft is mounted with threaded portions within the individual clamping devices 50 of the suction cups 1. When the shaft is rotated, the clamping devices 50 are pivoted in the clamping or locking direction, and the individual tie rods 6 of the suctions cups 1 are clamped together.

In order to release the clamping engagement, the shaft 33 is rotated in the opposite direction. Thereby, the clamping device 50 again moves through its dead center and relieves the clamping force applied to the tie rods 6.

In view of the fact that most frequently a number of articles of identical curvatures are lifted one after the other, the rapidly performed clamping and releasing does not involve any substantial expenditure of work.

In order that a tubular article may be properly lifted by means of the suction cups 1, the suction cups during their placement must be precisely aligned axially over the tubular article. In order to effect such precise axial alignment, both arms of the transverse rail 36 have adjacent the outer ends thereof one orienting device 34 each for the adjustment or orientation of the lifting device.

As shown in FIG. 8, each orienting device 34 has a pair of adjusting arms 52 carrying rollers 51 at the lower ends thereof and having their upper ends pivoted to a common pivot point 55. The adjustment arms 52 are angled at their lower ends. At this point, push rods 54 are pivoted the upper ends of which are pivotally mounted on a transverse beam 53.

The transverse beam 53 comprises a pair of arms which are pivotable relative to each other about a center joint 57. Each of these arms has secured thereto a downwardly projecting hook 59 which engages under the lower side of the transverse rail 36.

The axle of the center joint 57 is adpated to be moved vertically upwards and downwards within an eye 58 secured to the transverse rail 36. The center joint 57 is retained by a spring 56 in its position abutting the transverse rail 36.

The aligning or orienting operation by employing the orienting device 34 is effected as follows:

During the normal placement of the vacuum lifting device, one of the adjustment arms 52 will first contact the surface and be deflected thereby. This deflections is transmitted via the pushrod 54 to the transverse beam 53 such that its arm remote from the pushrod 54 is raised and moves the hook 59 away from the transverse rail 36. Now, the movement of the transverse beam 53 is limited by the fact that a lug 64 mounted to the inner upper end of the pushrod 54 contacts the hook 59 thereby preventing further upward movement of the adjustment arm 52.

Now, the system which has been rendered stiff in this way aligns the transverse rail 36 with the center axis of the tubular article 5. Then, the roller 51 opposite the first roller 51, and, thus, the adjustment arm 52 opposite the first adjustment arm 52, tend to act, with a slight swinging movement, against the surface of the article 5, thereby to effect a re-alignment towards the opposite side, whereby, with the swinging motions becoming increasingly smaller, the transverse rail 36 will be gradually aligned exactly axially with the article 5.

After such alignment, both adjustment arms 52 are simultaneously engaged on both sides. During the further lowering of the vacuum lifting device, the two pushrods 54 are simultaneously moved in upward direction, whereby both hooks 59 are concurrently released from the underside of the transverse rail 36. It is only in this aligned condition that the center joint 57 can be moved upwards within the eye 58 against the force of the spring 56. The suction cups 1 being aligned as a whole, can then be placed onto the tubular article 5.

Under these circumstances, the force of the spring 56 may be very small because it need only perform a fixing function of the center joint 57 until alignment is obtained, whereby the thrust force proper is taken up by the hook 59 in each case.

It has been found that a simple pivoting, acting with a spring force, of the adjusting arms on the transverse rail does not require so high a spring force for the alignment that the sucking function of the suction cups would be affected or the lifting force exerted by the suction cups would be removed in part. In a manner being surprising to the expert, with the proposed orienting device 34 it is possible with very low spring forces only, to obtain a proper alignment of the complete system of the suction cups 1 on the tubular article 5. In another embodiment of the invention, a single suction cup may be mounted under the vacuum cylinder, which suction cup carries on both sides thereof an orienting device each, e.g., on the transverse rail.

FIG. 9 shows in detail a vacuum cylinder 2 by means of which the complete arrangement may be lifted and the suction cup may be supplied with a vacuum. The vacuum cylinder comprises a cylinder in which a piston 72 is sealingly guided. The sealing can be effected either by smooth or grooved circular cord rings 86 or by a diaphragm or membrane. The lower end of the piston 72 includes a piston face 73 on which support arms 75 including guide sheaves 76 engage through intermediate members. The cylinder 2 has sealing lips 74 at its lower end in order to protect the cylinder space against the penetration of air from the outside when the piston

72 is moved upwards to thereby produce a vacuum. A draw gear, e.g., a chain 77, a cable, a rope, a steel belt or the like, is passed around the guide sheaves, which draw gear is pivoted to the cylinder at 78. The pull is transmitted to the chain 77 through a support ring 79 by a hoist, for example a crane.

Now, when the crane pulls up the support ring 79, the chain is placed under tension and thereby draws the piston 72 in upward direction via the guide sheaves 76. The tension of the chain 77 is transmitted to the cylinder via the point 78, thereby urging the cylinder in the opposite, vertical direction. This pressure action provides an extremely good sealing function. The ends of the chain between the pivot point 78 and the guide sheaves 76 extend parallel to the direction of movement of the piston and, therefore, do not change their direction with respect to the cylinder during a movement of the piston. Accordingly, the magnitude of the force exerted by the chain on the cylinder is independent of the already effected piston stroke of the stroke which may still be performed.

In a further embodiment of the cylinder, it is possible to pass the draw gear repeatedly between the piston and the cylinder, thereby to obtain a multiplication of the pressure force.

In an alternative embodiment of the method according to the invention, the power transmission from the support ring to the cylinder may be effected through levers which have a draw bar pivoted thereto e.g., in the mid portion thereof, which draw bar, again, is secured with its lower end to the piston and through which the pull is transmitted to the piston.

In a further embodiment, the support ring is connected to racks which, in turn, are in engagement with gears secured to the draw bar of the piston. The gears are each in engagement with further racks of the cylinders. Retraction of the racks results in rotation of the gears and thereby produces a force which acts upon the racks of the cylinder in pressing direction. In this embodiment, too, an exactly vertically directed pressure force relative to the cylinder is provided. By means of a plurality of gears (at least two gears), any desired gear ratio of the force to be exerted can by obtained.

What we claim is:

1. In a vacuum lifting apparatus for lifting articles having an axially symmetrically curved surface, a vacuum lift device comprising: a flexible main plate, a plurality of rigid side-by-side elongated segments carried on said main plate for angular movement relative to each other to define a curved configuration adapted to the curved surface of the article, a plurality of seals associated with said segments and projecting from said main plate, a sealing rim of resilient material projecting from said main plate to engage said article and to form an air seal therewith and encircling said segments and said seals, tie rod means pivotally connected to the outer side of segments at first ends thereof, opposite ends of said tie rod means extending toward a common location from said segments for positioning relative to one another with angular movement of said segments, and means for locking said tie rod means at said common location at given positions to hold said segments at said angular relationships while defining a desired curved configuration.

2. A vacuum lifting apparatus in accordance with claim 1 in which said opposite ends of said tie rod means have elongated holes therein and in which said locking means comprises a stationary hub and a bolt extending through said hub and elongated holes in said tie rod means for clamping said tie rod means in an immovable condition relative to said hub.

3. A vacuum lifting apparatus in accordance with claim 2 in which spacer discs are provided between adjacent tie rod means, and which said means for locking said tie rod means comprises a pivot arm connected to said bolt, rollers secured to said pivot arm for engagement with said hub for engagement therewith during turning said pivot arm between a locking and unlocking position.

4. A vacuum lifting apparatus in accordance with claim 1 in which said vacuum lifting device is circular in shape, said segments being arranged with segments of decreasing length in an outward direction from the center of said circular configuration.

5. A vacuum lifting apparatus in accordance with claim 1 comprising a plurality of said vacuum lift devices aligned in a row, a common vacuum cylinder for producing for each of said lift devices and an orienting device for aligning said row of lift devices relative to the axis of said axially symmetrically curved surface.

6. A vacuum lifting apparatus in accordance with claim 5 including an additional vacuum pump connected to said vacuum lifting devices.

7. A vacuum lifting apparatus in accordance with claim 5 in which a transverse rail is provided for supporting said row of vacuum lift devices, a plurality of bolts are provided for connecting said lift devices to said transverse rail, upper springs are provided between the upper ends of the bolts and said rail and lower springs apply a biasing force between said rail and said tie rod means.

8. A vacuum lifting apparatus in accordance with claim 1 including a transverse rail, a plurality of orienting devices mounted on said transverse rail, each of said orienting devices comprising laterally protruding adjusting arms, rollers mounted on the lower ends of said adjusting arms, the upper ends of said adjusting arms being pivoted to a stationary point with respect to said transverse rail, a plurality of push rods, each of said adjusting arms being connected by one of said push rods to an adjusting arm at first end thereof, a two-piece transverse web, each of said webs being connected to the other ends of one of said rods and adapted to be lifted from said transverse rail by its associated push rod, a spring means applying a force to hold said transverse webs against said transverse rail, an elongated guide slot extending vertically on said transverse rail, a pin means guided within said guide slot and connected to said transverse rail, and a downwardly directed hook on each of said transverse webs including an inwardly directed tip to engage around the lower outer edge of the transverse rail.

9. A vacuum lifting apparatus in accordance with claim 1 in which a cylinder means provides a vacuum for said lift device, a piston is mounted in said cylinder means for pulling by a hoist, a flexible strand means is connected at a fixed end to said cylinder means and is connected at its opposite end to said hoist, guide sheaves carried by said piston and having said flexible strand means extending parallel to the direction of movement of the piston between the ends fastened to said cylinder and said guide sheaves.

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