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ABSTRACT

A method of servicing a bucket-wheel machine 1. The bucket-wheel machine includes a boom 5, a bucket-wheel 3 and a pivotal mounting arrangement 13 by which the bucket-wheel is mounted to pivot relative to the boom and a weight of the bucket-wheel is transmitted to the boom. The method includes loading one or more load paths, from the bucket-wheel to the boom, to relieve the pivotal mounting arrangement of the weight of the bucket-wheel; servicing the pivotal mounting arrangement; and unloading the one or more load paths to reload the pivotal mounting arrangement.

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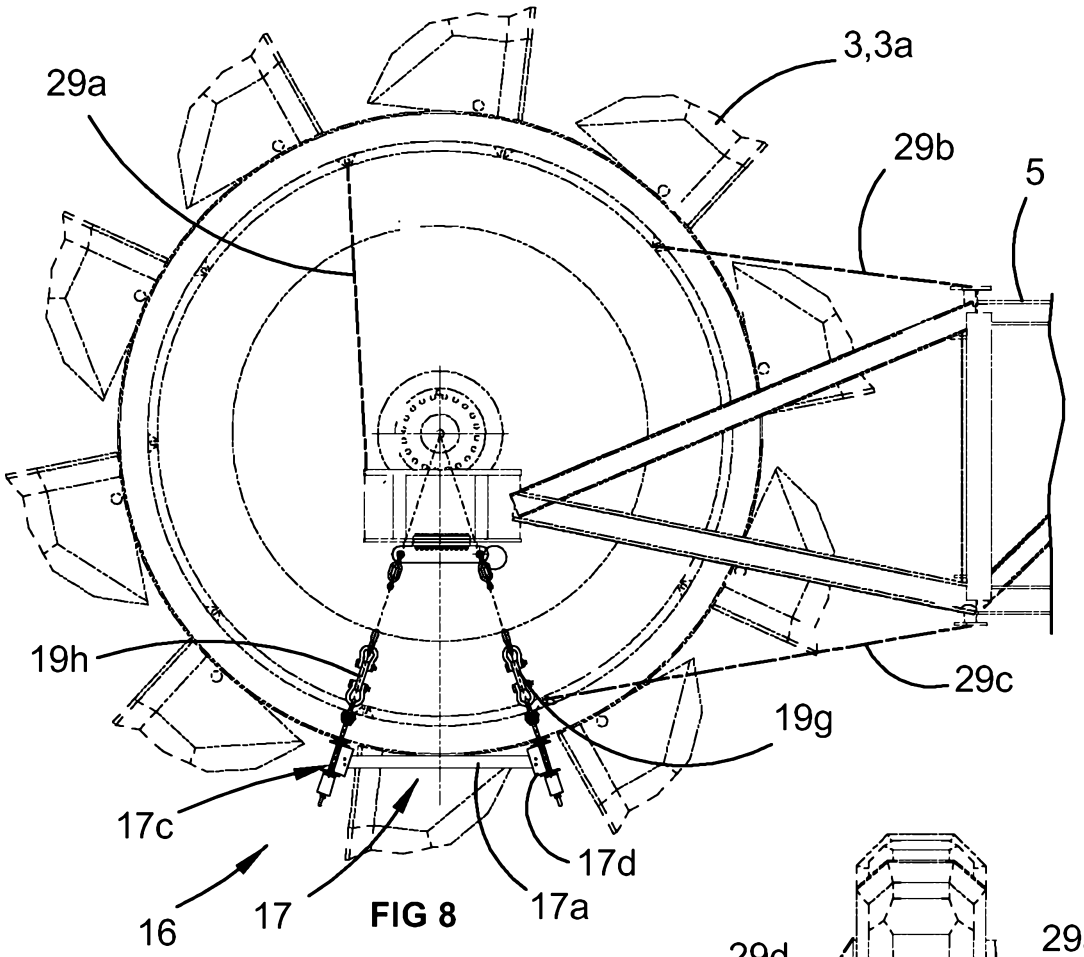

FIG 8

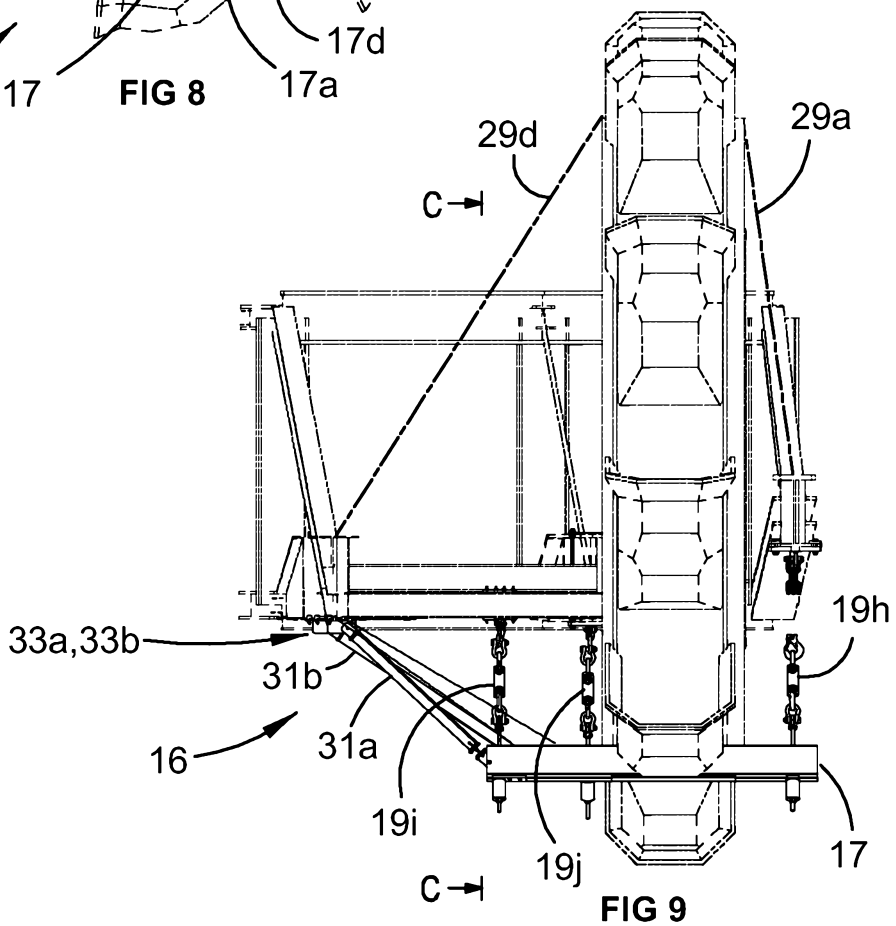

FIG 9

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BUCKET-WHEEL MACHINES

FIELD

The invention relates to methods and apparatus for servicing bucket-wheel machines.

BACKGROUND

Bucket-wheel machines are machines for moving bulk material. Bucket-wheel excavators move virgin materials such as iron ore, soil, coal and mineral sands. Bucket-wheel reclaimers 'reclaim' materials that have previously been processed and handled.

Figure 1 illustrates a bucket-wheel reclaimer 1 incorporating a bucket-wheel 3, a boom 5 carrying the bucket-wheel 3, and a counterweight 7. A superstructure 9 incorporating cables interconnects the counterweight 7 and boom 5. Components 3, 5, 7, 9 are balanced atop a track base 11.

The bucket-wheel 3 has buckets mounted about its periphery such that, when rotated in the direction suggested by arrow A, the material to be reclaimed is scooped into the buckets as the buckets move upwardly. As the buckets move over the top of the wheel, the bulk material falls downwardly towards the centre of the wheel whereat it is collected and conveyed along a conveyor 5a along the boom 5.

The wheel 3 is connected to the boom 5 via a pivotal mounting arrangement 13 that includes a shaft 13a passing horizontally through the centre of the wheel 3. The shaft has a radial bolting flange through which bolts 13b (Figure 3) are passed to secure the wheel to the shaft 13a.

The pivotal mounting arrangement 13 further includes plummer blocks 13c, 13d on opposite sides of the wheel 3 by which the shaft 13a is pivotally mounted. The plummer blocks 13c, 13d are bolted down to suitable portions of the boom 5a.

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On the drive side of the wheel 3, a portion of the shaft 13a extends outwardly beyond the plummer block 13d whereat it is engaged by a drive unit 15.

The drive unit 15 is evident in Figure 2. Figure 3 shows the end of the boom with the gearbox removed, whereby the drive-receiving splines 13e of the shaft 13a are evident.

From time to time, the pivotal mounting arrangement 13 may require servicing. By way of example, the shaft 13a may be in need of replacement if it is damaged. Typically this entails removing the drive unit 15 (to arrive at the configuration of Figure 3) before bringing in a pair of heavy-lift cranes. One of the cranes operates on the wheel 3 whilst the other crane operates on the counterweight 7 so that the reclaimer 1 does not fall over.

Typically the plummer blocks will be unbolted from the boom 5, then the wheel 3, shaft 13a and plummer blocks 13c, 13d are lifted away from the boom 5 and moved off to where they can be efficiently serviced. A reconditioned or replacement sub-assembly 3, 13a, 13c, 13d is then fitted to the boom.

The cranes can then be taken away and the drive unit 15 refitted.

This servicing operation typically takes in the vicinity of 240 hours or so. At the time of writing, a typical bucket-wheel reclaimer operating in Australia's Pilbara region could move in the vicinity of 12,000 tonnes of iron ore per hour, and the iron ore price was in the vicinity of A$60 per tonne. Thus, replacing the shaft had the potential to lead to lost production costing in the vicinity of A$172,800,000. The cost of the heavy-lift cranes necessary to move the 40 tonne wheel 3 and apply corresponding forces to (or remove) the counterweight 7 contributes to the expense of servicing the pivotal mounting arrangement. Moreover, co-ordinating the work of these two cranes is challenging and there is always a risk of damage to the bucket-wheel machine.

With the foregoing in mind, the present invention aims to provide improvements in and for servicing the pivotal mounting arrangements of bucket-wheel machines, or at least to provide alternatives for those concerned with such servicing.

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It is not admitted that any of the information in this patent specification is common general knowledge, or that the person skilled in the art could be reasonably expected to ascertain or understand it, regard it as relevant or combine it in any way before the priority date.

SUMMARY

One aspect of the invention provides a method for a bucket-wheel machine;

the bucket-wheel machine including

a boom;

a bucket-wheel; and

a pivotal mounting arrangement by which the bucket-wheel is mounted to pivot relative to the boom and a weight of the bucket-wheel is transmitted to the boom;

the method including

loading one or more load paths, from the bucket-wheel to the boom, to relieve the pivotal mounting arrangement of the weight of the bucket-wheel;

servicing the pivotal mounting arrangement; and

unloading the one or more load paths to reload the pivotal mounting arrangement.

The servicing may include replacing a shaft and/or a bearing.

The loading may comprise controlling one or more linear actuators. Optionally at least one of the one or more linear actuators is hydraulic. Preferably the controlling is remotely controlling from at least 10 metres from the bucket-wheel.

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The loading may be based on feedback from one or more load sensors. Preferably the loading is based on feedback from four or more load sensors.

The method may include positioning a cradle under the bucket-wheel. The positioning may be to place a respective cross-member of the cradle fore and aft of a lowermost bucket of the bucket-wheel. Preferably the loading includes tensioning chains by which the cradle is tethered relative to the boom.

The method may include defining on each side of bucket-wheel at least one load path, extending downwardly from an upper third of the bucket wheel to the boom, to laterally support the bucket-wheel.

Another aspect of the invention provides a bucket-wheel machine serviced in accordance with the method.

Another aspect of the invention provides rigging for a bucket-wheel machine;

the bucket-wheel machine including

a boom;

a bucket-wheel; and

a pivotal mounting arrangement by which the bucket-wheel is mounted to pivot relative to the boom and a weight of the bucket-wheel is transmitted to the boom;

the rigging including

a cradle defining an opening to receive a lowermost bucket of the bucket-wheel;

elements for transmitting a weight of the bucket-wheel from the cradle to the boom.

The elements may be chains.

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BRIEF DESCRIPTION OF DRAWINGS

Figure 1 is a perspective view of a prior art bucket-wheel machine;

Figure 2 is a plan view of an outer end of a boom of a prior art bucket-wheel machine;

Figure 3 is a perspective view of the end of the boom (drive unit removed);

Figure 4 is a perspective view of a portion of a boom and a clamp clamped thereto;

Figure 5 is a side view of a body of the clamp;

Figure 6 is a bottom view of the body of the clamp;

Figure 7 is a perspective view of a cradle;

Figure 8 is a drive-side view of a wheel supported by rigging at the end of a boom;

Figure 9 is an end view of the wheel, boom end and rigging;

Figure 10 is an enlargement of the rigging from the non-drive side; and

Figure 11 is a plan view of the wheel, the boom end and the rigging.

DESCRIPTION OF EMBODIMENTS

According to preferred implementations of the method, the pivotal mounting arrangement is serviced whilst the wheel 3 is substantially at (i.e. within a few centimetres of) its position (relative to the boom 5) when in operation. Figures 8 to 11 illustrate the wheel 3 supported relative to the boom 5 by rigging 16 and with the pivotal mounting removed.

The rigging 16 incorporates a cradle 17 (Figure 7). The cradle 17 includes a pair of runners 17a, 17b running parallel to a plane of rotation of the wheel 3. The runners 17a, 17b mutually connect cross-members 17c, 17d.

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The cradle defines (or more specifically the members 17a to 17d frame) an opening 17e into which a lowermost of the buckets 3a is receivable.

The cross-members 17c, 17d act on the body of the wheel (as opposed to the buckets of the wheel) to support the wheel during the servicing operation. In this example, the cross-members 17c, 17d are respectively inclined to present tangential surfaces to the body of the wheel. Advantageously, the cradle may have compliant material to engage the wheel 3. In this example, the cradle 17 incorporates rubber pads 17f.

The cradle 17 further includes a set of mounting points 17g to 17j to which length-adjustable load-bearing arrangements are mountable.

Figure 10 illustrates a length-adjustable load-bearing arrangement 19i attached to the mounting point 17i. The length-adjustable load-bearing arrangement 19i incorporates a hydraulically-operated linear actuator 21i connected to a length of chain 23i which is in turn connected to the boom 5 via a suitable mounting arrangement. In this example, the mounting arrangement takes the form of a clamping arrangement 25i. The assembly 19j is likewise connected between mounting arrangement 25j and mounting point 17j.

On the drive side of the wheel 3, load-bearing arrangements 19h, 19g connect the cradle to the boom 5 via a clamping arrangement 25hg. The clamping arrangement 25hg incorporates the body 25hg', a pair of rectangular cleats 25hg" (Figure 4) and a set of bolts. In this example, there are 22 Ø27 mm bolts.

Figure 4 illustrates the clamping arrangement 25hg in situ on a drive-side portion 27 of the boom 5. The drive-side portion 27 incorporates a vertical flange 27a, a transverse bottom flange 27b and a transverse top flange 27c.

The clamping arrangement 25g clamps on to the transverse bottom flange 27b. The top flange 27d has a set of bolt holes 27d by which the plummer block 13d is mountable.

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Stabilising chains 29a to 29d are placed to act between the wheel 3 and the boom 5. The chains 29a, 29d extend downwardly from a top third of the wheel 3 at respective oblique angles. The illustrated version of the invention enables the boom to be lowered to about 13 degrees below horizontal whereat the pivotal mounting arrangement 13 is close to ground level, to enable the pivotal mounting arrangement to be serviced more safely and more efficiently. Other modes of restraining the wheel 3 to enable the boom to be lowered are possible.

The rigging further includes length-adjustable rigid stabilising members 31a, 31b (Figures 9 and 10) extending upwardly at oblique angles from the non-drive side of the cradle 17 to suitable mounting arrangements 33a, 33b on the boom 5. Each of the members 31a, 31b incorporates a portion of all-thread and nuts co-operable therewith whereby the length of the member is screw-adjustable. Other modes of screw-adjustment are possible.

The chains 29a, 29c, 29d and members 31a, 31b serve to laterally stabilise the wheel 3, e.g. against the wind.

To service the pivotal mounting arrangement 13, the drive unit 15 is removed in conventional fashion, leaving the drive end of the shaft 13a exposed as in Figure 3.

The rigging 16 is then installed. The mounting points 25i, 25j, 25hg are installed on the boom 5, the cradle 17 is placed under the wheel 3, and the length-adjustable load-bearing arrangements 19g to 19j are installed between the cradle and the mounting points.

The load-bearing arrangements can then be tensioned to take the weight of the wheel 3 and thereby relieve the pivotal mounting arrangement 13 of that weight.

According to a preferred variant, each of the load-bearing arrangements 19i to 19j incorporates a respective load sensor 35i to 35j to provide an indication of the load borne by that arrangement.

More preferably the output is provided in a form that enables a user to interpret the output from a safe distance, e.g. from 10 or more metres away from the bucket-wheel

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3. Preferably the linear actuators, such as the actuator 21i, are remotely controllable from this distance to enable an operator to control the loading of the load-bearing members and corresponding unloading of the pivotal mounting arrangement 13. Wired and wireless modes of remote control are possible.

A preferred implementation of the method entails 'proof-loading' the rigging whilst leaving some load on the pivotal connection 13. The plummer blocks 13c, 13d can then be unbolted whilst all of the components have some degree of preload therebetween to avoid unexpected movement. With the bolts removed, the actuators can be controlled to take substantially all of the weight of the wheel 3, e.g. to lift the plummer blocks 13c a few millimetres clear of the boom 5. The loading of the rigging 16, and corresponding unloading of the pivotal mounting 13, can be monitored by the load sensors 35i to 35j. The weight borne by the rigging substantially corresponds to the summation of the output from those load sensors adjusted to compensate for the inclination of the chains.

At this juncture, the pivotal mounting 3 is substantially unloaded to enable the mounting arrangement 13 to be serviced. By way of example, one or both of the plummer blocks 13c, 13d might be removed and replaced by replacement items awaiting immediate fitment (thereby minimising downtime). The bolts 13b (Figure 3) might be released to break the connection between the shaft 13a and the wheel 3. Of course, other modes of connection, and modes of making and breaking connections, are possible.

This service of the pivotal mounting is facilitated without a heavy-lift crane to lift the wheel 3. Moreover, the weight of the wheel is not removed from the boom – rather, only the load paths from the wheel 3 to the boom are changed whereby there is no need to make any adjustment to the ballast 7, thus eliminating the need for the other heavy-lift crane.

The rigging 17 is only one implementation of the concept. Whilst the cradle and chains wrap around an underside of the wheel 3, other arrangements for wrapping around the underside to support the wheel 3 are possible. Indeed, some implementations of the method may lift the wheel from the top rather than from

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below – e.g. a suitable arrangement of lifting struts on each side of the wheel 3 might act between an upper portion of the wheel 3 and the boom 5.

The invention is not limited to the described examples. Rather, the invention is defined by the claims.

The term 'comprises' and its grammatical variants has a meaning that is determined by the context in which it appears. Accordingly, the term should not be interpreted exhaustively unless the context dictates so.

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CLAIMS

1. A method for a bucket-wheel machine;

the bucket-wheel machine including

a boom;

a bucket-wheel; and

a pivotal mounting arrangement by which the bucket-wheel is mounted to pivot relative to the boom and a weight of the bucket-wheel is transmitted to the boom;

the method including

loading one or more load paths, from the bucket-wheel to the boom, to relieve the pivotal mounting arrangement of the weight of the bucket-wheel;

servicing the pivotal mounting arrangement; and

unloading the one or more load paths to reload the pivotal mounting arrangement.

2. The method of claim 1 wherein the loading is based on feedback from one or more load sensors.

3. The method of claim 1 or 2 including positioning a cradle under the bucket-wheel;

wherein the positioning is to place a respective cross-member of the cradle fore and aft of a lowermost bucket of the bucket-wheel.

4. The method of claim 3 wherein the loading includes tensioning chains by which the cradle is tethered relative to the boom.

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5. Rigging for a bucket-wheel machine;

the bucket-wheel machine including

a boom;

a bucket-wheel; and

a pivotal mounting arrangement by which the bucket-wheel is mounted to pivot relative to the boom and a weight of the bucket-wheel is transmitted to the boom;

the rigging including

a cradle defining an opening to receive a lowermost bucket of the bucket-wheel;

elements for transmitting a weight of the bucket-wheel from the cradle to the boom.

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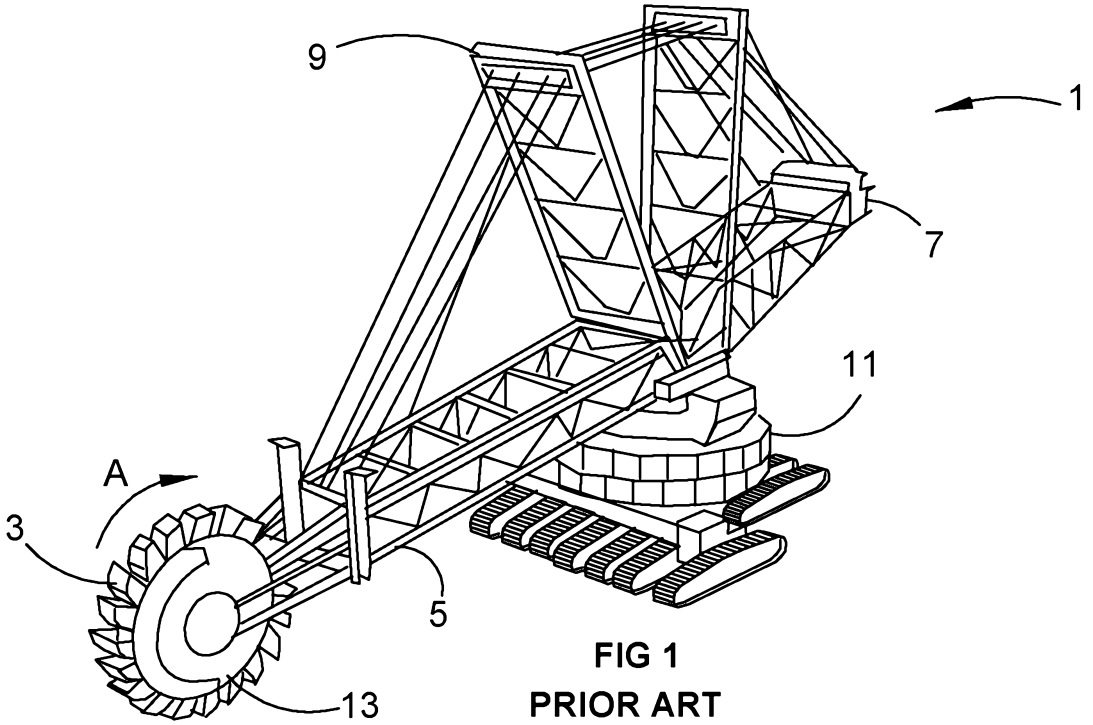

FIG 1
PRIOR ART

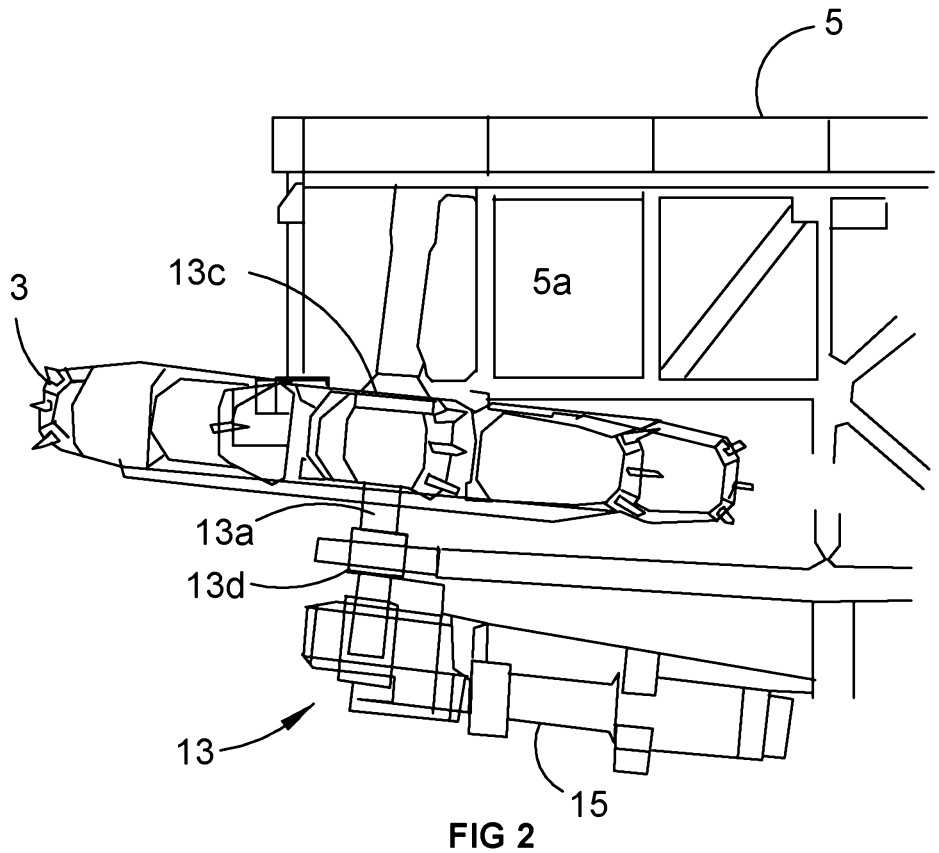

FIG 2
PRIOR ART

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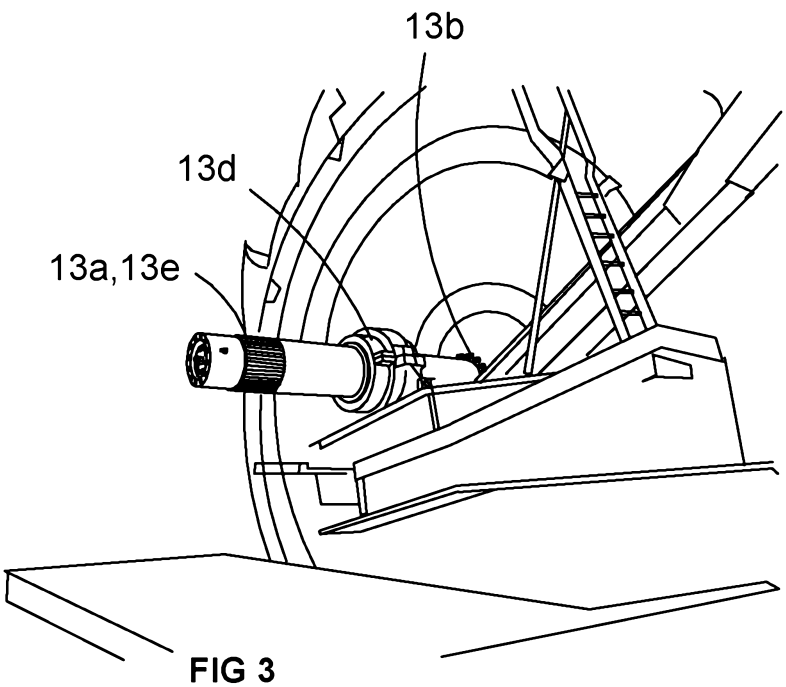

FIG 3
PRIOR ART

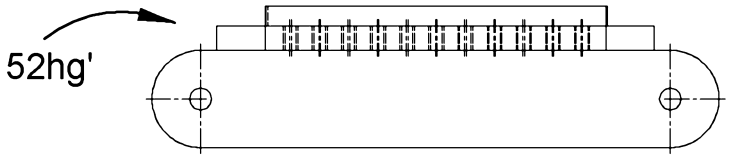

FIG 5

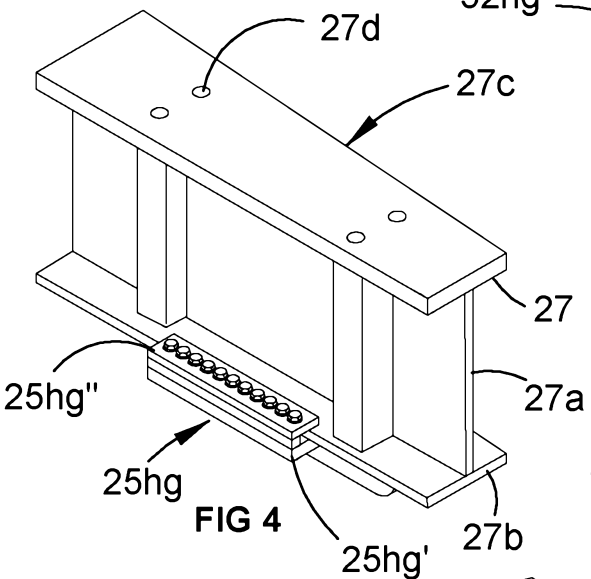

FIG 4

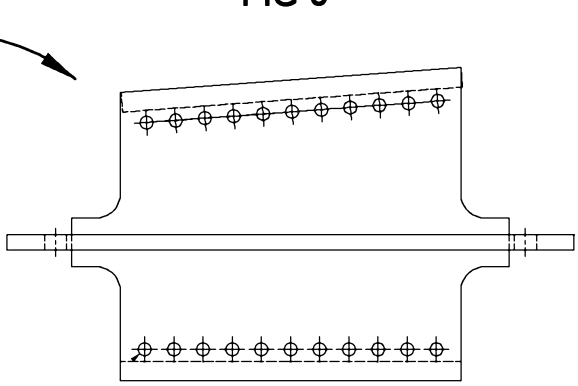

FIG 6

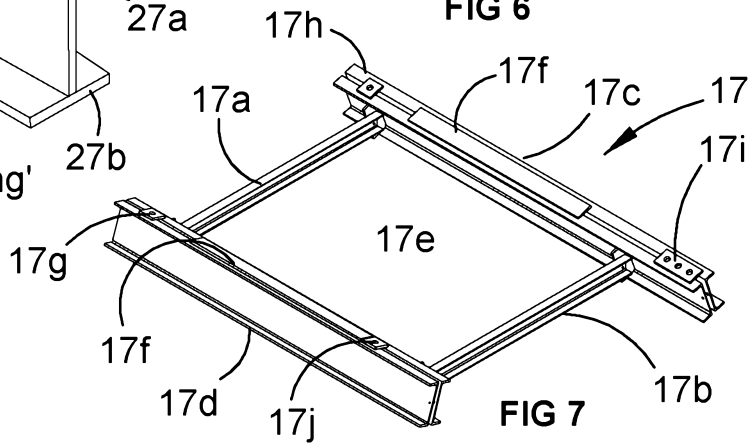

FIG 7

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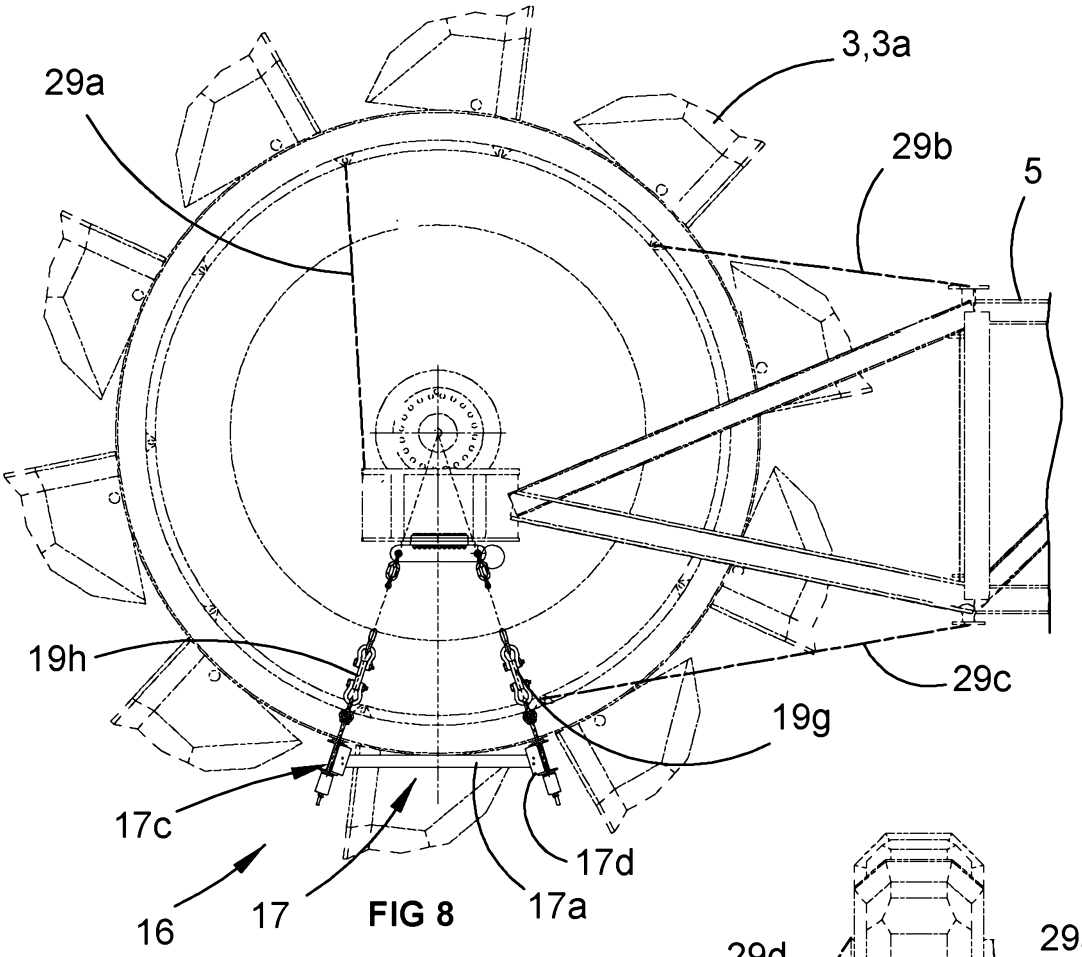

FIG 8

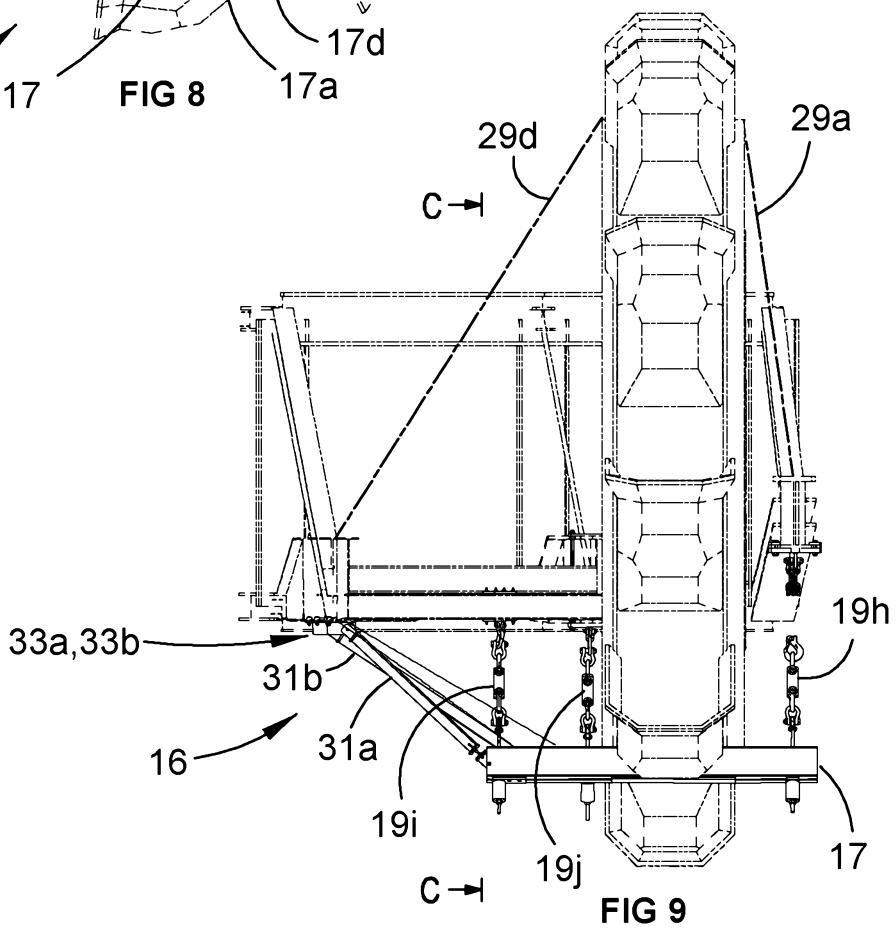

FIG 9

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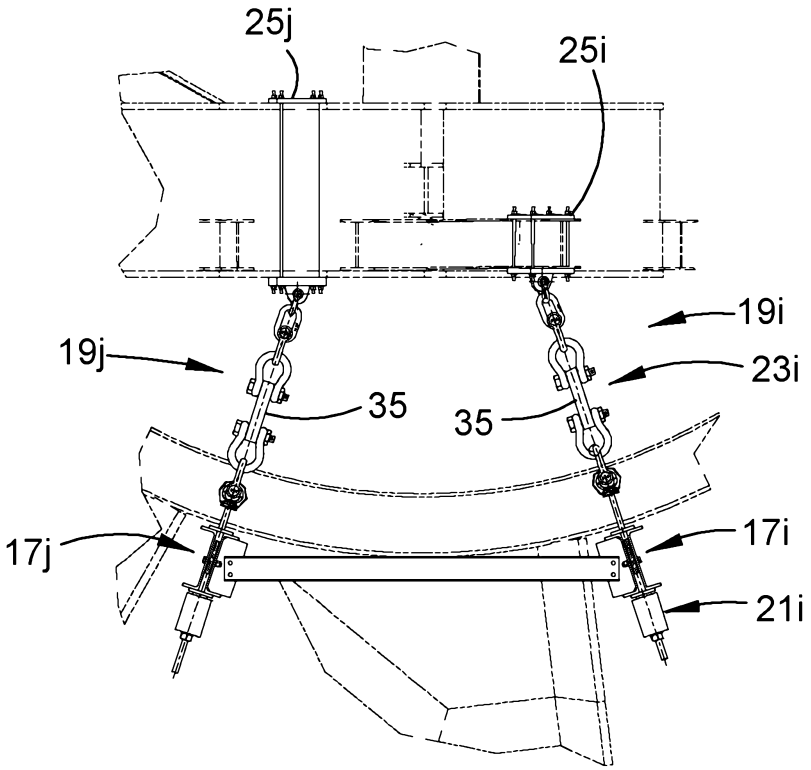

FIG 10

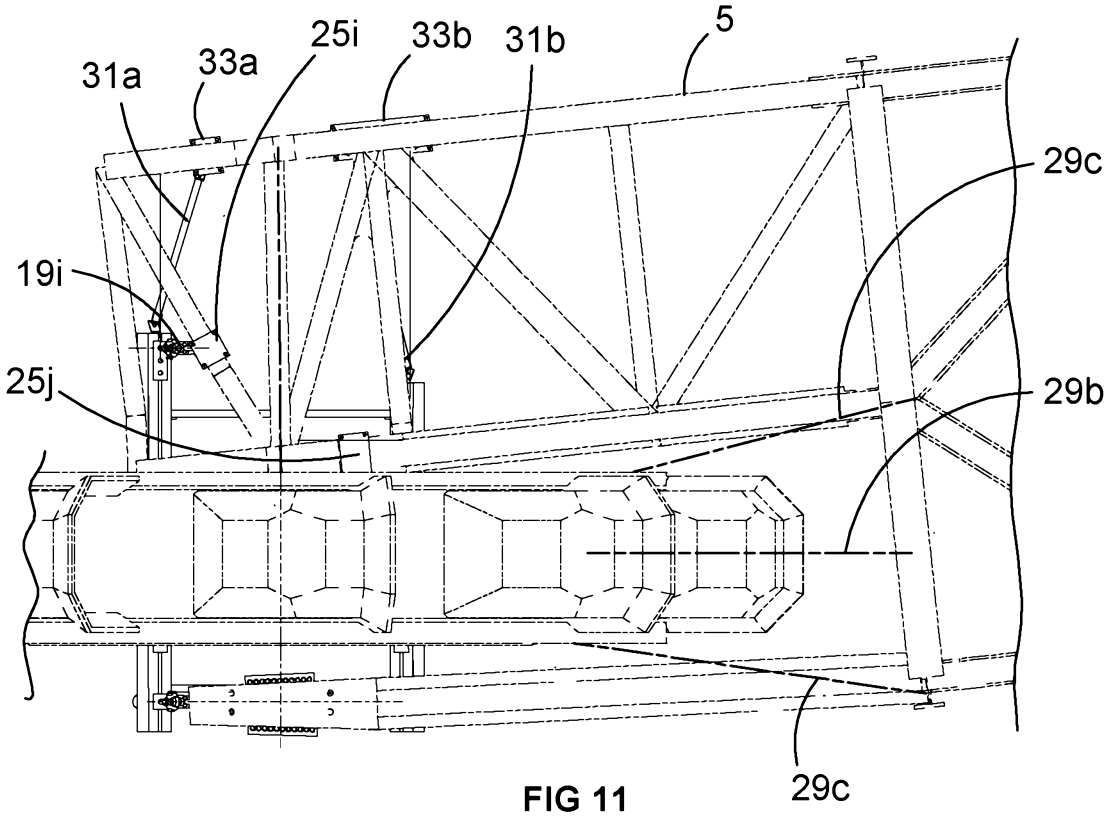

FIG 11