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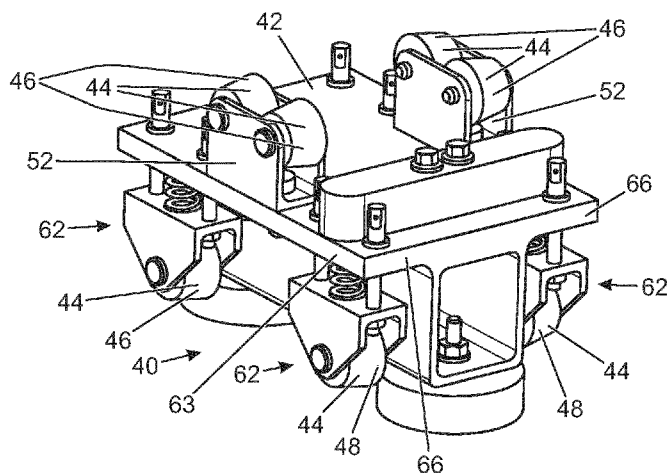


Fig. 3a

(57) Abstract: Disclosed is a measurement carriage configured to run on a track comprising a pair of c-beams. Each c-beam comprises first and second flanges having opposed interior surfaces and a connecting wall joining the flanges. The c-beams are oriented such that the flanges of the c-beams are positioned between the connecting walls. The measurement carriage comprises a main body and at least one running wheel configured to run on the interior surface of each flange of the track. At least one of those running wheels is a measurement wheel arranged to run on the interior surface of one of the first flanges. Each measurement wheel is mounted to the main body via a moveable mount permitting its movement with respect to the main body towards and away from the interior surface of the second flange opposing the flange surface on which the measurement wheel runs. The moveable mount biases the measurement wheel away from the interior surface of that second flange with respect to the main body such that its movement on the moveable mount follows variation in the distance between the respective opposed interior surfaces as the measurement carriage moves along the track. The measurement carriage comprises a measurement wheel sensor arranged to monitor movement of the measurement wheel on the moveable mount, and to output a signal comprising data indicative of the distance between the respective opposed interior surfaces.

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MEASUREMENT CARRIAGES AND SYSTEMS INCLUDING MEASUREMENT CARRIAGES

5 TECHNICAL FIELD

The present disclosure relates to measurement carriages and systems including measurement carriages, measurement apparatuses and systems including measurement apparatuses. In particular, but not exclusively, the present disclosure relates to measurement carriages that can inspect for c-beam flange wear in a c-beam based track and/or to measurement apparatuses that can inspect for c-beam separation in a c-beam based track. Aspects of the invention relate to a measurement carriage, to a system including a measurement carriage, to a measurement apparatus and to a system including a measurement apparatus. The disclosure may have particular application to overhead production line conveyors (e.g. for automotive vehicles). Though not intended to be limiting the following background is, for simplicity, provided in the context of such a production line conveyor.

20 BACKGROUND

Overhead production line conveyors may comprise a pair of c-beams forming a track. Wheels of a carrier assembly running gear may run on the lower flanges of the c-beams, supporting the weight of the carrier assembly suspended from the track and any product or product component it carries. Multiple carrier assemblies may be mounted to an associated drive system such as a chain drive in order that they can be shifted along the track.

As will be appreciated the track may carry a significant load, especially where for instance the product and/or product parts carried are heavy. Over time the running gear of the carrier assemblies may erode the lower flanges of the track, reducing their thickness. Additionally or alternatively the separation between the lower flanges may increase over time under the force exerted by the carrier assemblies. Both of the wear mechanisms may be exacerbated in particular areas of the track (known as squeeze down sections) e.g. where load forces are enhanced/concentrated and/or the track is inherently weaker. Such track sections may for instance be curved, cambered or sloped. Either in isolation or in combination, these wear mechanisms may ultimately result in failure of the track and partial or full collapse of one or

more carrier assemblies. Such a failure may cause an interruption to track use and/or damage to carried items and surrounding equipment.

With a view to avoiding such an failure the track may be visually inspected at intervals.

- 5 Nonetheless the track may be of considerable length and so the inspection may take considerable time and cause interruption to track use. Additionally conducting a thorough inspection may be difficult where for example the track is awkward to access.

- 10 It is an object of embodiments of the invention to at least mitigate one or more of the problems of the prior art.

SUMMARY OF THE INVENTION

- 15 Aspects and embodiments of the invention provide measurement carriages and systems as claimed in the appended claims.

- According to an aspect there is provided a measurement carriage configured to run on a track comprising a pair of c-beams, each c-beam comprising first and second flanges having
20 opposed interior surfaces and a connecting wall joining the flanges, the c-beams being oriented such that the flanges of the c-beams are positioned between the connecting walls, the measurement carriage comprising a main body and a measurement wheel arranged to run on the interior surface of one of the first flanges, the measurement wheel being mounted to the main body via a moveable mount permitting its movement with respect to the main
25 body towards and away from the interior surface of the second flange opposing the flange surface on which the measurement wheel runs and where the measurement carriage comprises a measurement wheel sensor arranged to monitor movement of the measurement wheel on the moveable mount, and to output a signal comprising data indicative of the distance between the respective opposed interior surfaces.

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- According to another aspect there is provided a measurement carriage configured to run on a track comprising an I-beam, the I-beam comprising a pair of ledges joined by a connecting wall, where to each side of the connecting wall the ledges define first and second flanges having opposed interior surfaces, the measurement carriage comprising a main body and at
35 least one running wheel configured to run on the interior surface of each flange of the track, at least one of those running wheels being a measurement wheel arranged to run on the interior surface of one of the first flanges, each measurement wheel being mounted to the

main body via a moveable mount permitting its movement with respect to the main body towards and away from the interior surface of the second flange opposing the flange surface on which the measurement wheel runs, the moveable mount biasing the measurement wheel away from the interior surface of that second flange with respect to the main body such that its movement on the moveable mount follows variation in the distance between the respective opposed interior surfaces as the measurement carriage moves along the track, and where the measurement carriage comprises a measurement wheel sensor arranged to monitor movement of the measurement wheel on the moveable mount, and to output a signal comprising data indicative of the distance between the respective opposed interior surfaces.

According to another aspect there is provided a measurement carriage configured to run on a track comprising a pair of c-beams, each c-beam comprising first and second flanges having opposed interior surfaces and a connecting wall joining the flanges, the c-beams being oriented such that the flanges of the c-beams are positioned between the connecting walls, the measurement carriage comprising a main body and at least one running wheel configured to run on the interior surface of each flange of the track, at least one of those running wheels being a measurement wheel arranged to run on the interior surface of one of the first flanges, each measurement wheel being mounted to the main body via a moveable mount permitting its movement with respect to the main body towards and away from the interior surface of the second flange opposing the flange surface on which the measurement wheel runs, the moveable mount biasing the measurement wheel away from the interior surface of that second flange with respect to the main body such that its movement on the moveable mount follows variation in the distance between the respective opposed interior surfaces as the measurement carriage moves along the track, and where the measurement carriage comprises a measurement wheel sensor arranged to monitor movement of the measurement wheel on the moveable mount, and to output a signal comprising data indicative of the distance between the respective opposed interior surfaces.

Thus as the measurement carriage moves along the track each measurement wheel may move in and out on its moveable mount such that to maintain its own contact with the interior surface of the first flange and may also optionally maintain or contribute to the maintenance of contact of one or more other running wheels with the opposed interior surface. These contacts may be maintained regardless of variation (within tolerance) in the distance of the relevant opposed surfaces in view at least in part of the biasing action of the moveable mounts. The variation in distance may be brought about by wear (which may be uneven along the track) to the c-beam flanges. At any location along the track the measurement

wheel sensor may take a measurement that indicates the distance between the opposed interior surfaces at that location. This distance can then be compared to a nominal distance for unworn track to understand the degree of wear that has occurred. Where the wear is deemed to create a risk or to be otherwise undesirable, remedial action may be taken. As will be appreciated, where it may be reliably assumed that wear to one of the first or second flanges in an opposed pair will be negligible (e.g. because that flange is not weight bearing) the wear calculated may be assumed to have occurred in only the other flange of the opposed pair.

In some embodiments at least another of the running wheels (which may be referred to as a secondary wheel) is arranged to run on the first flange on which the measurement wheel is also arranged to run, and is mounted to the main body by a mount which is independent of the moveable mount of the measurement wheel. The use of at least two wheels running on the first flange may assist with stabilisation of the measurement carriage as it runs on the track. Additionally, the provision of a separate mount for each of these wheels may be more stable than the use of a single mount for multiple wheels running on the first flange. Specifically, the likelihood of twisting and/or canting of a mount and/or improper/no contact for one of the wheels on the first flange, may be reduced where independent mounts are used. Twisting and/or canting of a mobile mount and/or improper/no contact of the measurement wheel, may lead to inaccuracies in the distance indicated by the data in the signal. The use of independent mounts may alleviate such difficulties, because the moveable mount of the measurement wheel may be free to move with respect to the main body independently of the mount for the second running wheel. As will be appreciated, the mount of the second running wheel may also be moveable (e.g. in a similar manner to the moveable mount of the measurement wheel) or may be fixed. As will be further appreciated, the arrangement described above may also be repeated for the other first flange.

For simplicity and except when otherwise indicated the remaining statements of invention that discuss measurement wheels and/or moveable mounts for such measurement wheels do so in the context of provision of a single measurement wheel with associated moveable mount. Nonetheless it will be appreciated that two or more measurement wheels, each mounted by an associated moveable mount, may be provided. Further that for any feature/relationship of or relevant to the single measurement wheel and/or associated moveable mount discussed, it is expressly intended that such features and/or relationships may also be applicable and are disclosed with respect to any additional measurement wheels and/or associated moveable mounts that may be present.

In some embodiments the measurement wheel is weight bearing for the measurement carriage. This may mean that the measurement wheel runs on a flange that is also weight bearing for other assemblies running on the track. This flange may therefore be the most likely to experience material levels of wear.

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In some embodiments the measurement wheel sensor comprises a transducer arranged to output a signal comprising data indicative of the position of the measurement wheel with respect to the main body.

10 In some embodiments the transducer is a linear transducer.

In some embodiments the transducer is a strain gauge load cell driven by a contact portion of the measurement wheel sensor that travels in response to position changes of the measurement wheel with respect to the main body towards and away from the interior surface of the second flange opposing the surface on which the measurement wheel runs.

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In some embodiments the moveable mount comprises a main body mount which is static with respect to the main body and a measurement wheel carrier which carries the measurement wheel, the measurement wheel carrier being constrained to movement towards and away from the main body mount by a guide portion. As will be appreciated at least part of the main body mount may be part of the main body e.g. a flange thereof.

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In some embodiments the guide portion comprises one or more projections from one of the main body mount and the measurement wheel carrier, and the other of the main body mount and measurement wheel carrier engages with the one or more projections during movement of the measurement wheel towards and away from the main body mount to guide the travel of the measurement wheel carrier.

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In some embodiments the moveable mount comprises a spring acting between the main body mount or contact portion and the measurement wheel carrier to bias the measurement wheel carrier away from the main body mount. This may at least contribute to ensuring that all running wheels continue to run on their respective flanges despite variation in the distance between the first and second flange surfaces caused by wear.

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In some embodiments at least two of the running wheels are measurement wheels and for each interior surface of each first flange of each of the c-beams there is at least one measurement wheel configured to run on that interior surface.

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In some embodiments the running wheels that are not measurement wheels are idler wheels configured to support and/or position the measurement carriage within the track. At least one of the idler wheels may be mounted to the main body via a moveable mount similar to those previously described with respect to measurement wheels. Where however such a moveable mount has a spring as previously described, it would act between an idler wheel carrier (similar to the measurement wheel carrier) and a main body mount and not optionally a contact portion of a measurement wheel sensor (which would not be provided in the case of an idler wheel). Use of a moveable mount may be particularly appropriate for idler wheels running on a flange upon which a measurement wheel also runs, potentially assisting in maintaining running wheel flange contact and main body orientation and stability. Additionally or alternatively at least one of the idler wheels may be mounted to the main body via a fixed mount which maintains the idler wheel at a fixed distance from the main body of the measurement carriage. This may be particularly appropriate for idler wheels running on a flange upon which no measurement wheel runs.

In some embodiments at least one of the running wheels has a tapered running surface which substantially matches a taper on the interior surface of the flange on which it is configured to run. Tapered running wheels may help to securely seat the measurement carriage within the track and reduce lateral drift/oscillation as it moves along the track.

In some embodiments the measurement carriage comprises a laser apparatus comprising a laser emitter and a laser receiver, the laser emitter being configured to scan a separation between the c-beams and the laser receiver being configured to sense laser light emitted by the laser emitter if it is reflected from the c-beams, and to output a signal comprising data indicative of the separation measured. The signal may for instance contain one or more characteristics of the sensed laser light such as the shape of the detected beam and/or the fringe pattern properties of the detected laser light.

In some embodiments the apparatus is arranged to scan a separation between points on the c-beams, the separation of which is indicative of the extent of one or both of any rotation of one or both of the c-beams and the extent of any deformation of one or both of the c-beams. In particular, the apparatus may be arranged to scan a separation between points on the c-beams, the separation of which is indicative of the extent of any rotation and/or deformation of one or both of the c-beams arising from the weight of one or more objects suspended from the track acting to tend to force weight bearing flanges of the respective c-beams apart. It may be for instance that the apparatus is arranged to scan points which in use are

substantially free from other wear mechanisms (e.g. they are not eroded by contact with a moving part). Thus it may be that the separation is measured in accordance with the extent of any rotation and/or deformation of one or both of the c-beams with reference to a nominal configuration, the rotation and/or deformation having resulted from loading the c-beams after installation. Further it may be that the signal outputted comprises data that with reference to a nominal configuration is indicative of the deviation of the separation from nominal, and indeed may comprise data that is indicative of this deviation arising substantially exclusively from any rotation and/or deformation of one or both of the c-beams.

In some embodiments the laser apparatus is configured to scan a separation between opposed edges of the c-beam flanges, where the flanges belong to different c-beams.

In some embodiments the separation scanned is that between opposed edges of the first flanges.

In some embodiments the first flanges are configured to bear the weight of the measurement carriage.

In some embodiments the laser emitter and the laser receiver are positioned outside of the track formed by the c-beams. This may be advantageous because the laser apparatus components may need to be at least a certain distance from the parts of the c-beam which are to be scanned. A further advantage of positioning the laser apparatus outside of the track and away from the main body is that it may be desirable/necessary to reduce the number and/or size of components on the main body such that it can fit within the track and further not interfere or be fouled by surrounding systems (e.g. an anti-roll back system). Still further the laser emitter and receiver may be subject to less contamination exposure (e.g. dust and oils/grease) if outside of the track formed by the c-beams.

In some embodiments the measurement carriage is configured to be coupled to a carrier assembly which is configured to be shifted along the track. The carrier assembly may for instance be arranged to carry a product and/or product components along the track. The measurement carriage may therefore be towed by the carrier assembly negating the need for it to be separately powered or separately driven. The measurement carriage may be configured to be removably mounted to the carrier assembly. In this way the carrier assembly may be used without the measurement carriage and without therefore incurring unnecessary wear on the measurement carriage between desired track inspection intervals.

In some embodiments the laser emitter and the laser receiver are configured to be coupled to the carrier assembly that is suspended from the track. They may for instance be mounted on a shelf of the carrier assembly. Alternatively the laser emitter and laser receiver may be mounted to part of the measurement carriage that is provided outside of the track formed by the c-beams.

In some embodiments a power source of the measurement carriage is mounted on the carrier assembly. The power source may be used to power one, some or all of the components (such as the measurement wheel sensor) provided on the measurement carriage. The power source could for instance be a battery and could be mounted on the same shelf as the laser emitter and laser receiver. This may again allow for a reduction in the combined size of the main body and components mounted directly thereon and may also help to reduce contamination build-up on the power source.

In some embodiments the measurement carriage comprises a measurement processor arranged to conduct the measurements of opposed flange interior surface distance at intervals as the measurement carriage progresses along the track. Where present the measurement processor may also conduct c-beam separation measurements at intervals as the measurement carriage progresses along the track.

In some embodiments the opposed flange interior surface distance measurements and c-beam separation measurements are conducted at the same time.

In some embodiments the measurement carriage comprises a locality scanner configured to detect when the measurement carriage is at a particular location and/or is within a particular section of the track. These locations and/or sections may for instance be known to be at enhanced risk of flange wear and/or c-beam separation, such as curved, cambered or sloping track zones. The locality scanner may for instance be a radio frequency identification (RFID) scanner arranged to read one or more RFID tags positioned along the track (e.g. RFID tags positioned at the beginning and end of a track section indicating respectively entry and exit from that section).

In some embodiments the locality scanner is configured to send a signal to the measurement processor comprising data indicative of the measurement carriage being at a particular location and/or within a particular section and in response the measurement processor alters the interval at which opposed flange interior surface distance and/or c-beam separation measurements are taken thereafter. It may be for instance that frequency of

measurements is increased in enhanced risk sections. By way of further example it could be that frequency of measurements is decreased in sections where there are elements (e.g. back stops to prevent carrier assembly run away) that may disrupt measurement performance and/or accuracy.

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In some embodiments the measurement carriage comprises an encoder wheel configured to roll on the track as the measurement carriage travels and output a signal comprising data indicative of the location of the measurement carriage on the track. The encoder wheel data may allow determination of the location of a particular opposed flange interior surface distance and/or c-beam separation measurement.

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In some embodiments data in the signal sent from the encoder wheel is combined with the opposed flange interior surface distance and/or c-beam separation data to indicate where on the track the measurements were taken. This combination may be performed by the measurement processor but could alternatively be performed by a different processor.

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In some embodiments the measurement carriage comprises a wear processor arranged to receive the signal outputted by the measurement wheel sensor and calculate flange wear in accordance with the signal.

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In some embodiments the measurement carriage comprises a c-beam separation processor arranged to receive the signal outputted by the laser receiver and calculate a separation of the c-beams in accordance with the signal.

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In some embodiments any combination of the wear processor, separation processor and measurement processor may be the same processor. Alternatively however they may be separate processors.

In some embodiments the measurement carriage comprises a memory in which data from the measurement wheel sensor signal, laser receiver signal and encoder wheel signal and/or any one or more of flange wear data calculated by the wear processor, c-beam separation data calculated by the separation processor and combined encoder wheel and opposed flange interior surface distance and/or c-beam separation data produced by the measurement processor or another processor, is sent to and stored on the memory. The memory may for instance be provided by an SD card, which may ultimately be retrieved from the measurement carriage following a period of measurement carriage running, and the data thereon analysed.

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According to yet another aspect there is provided a measurement apparatus comprising a measurement carriage configured to run on a track comprising a pair of c-beams, each c-beam comprising first and second flanges having opposed interior surfaces and a connecting wall joining the flanges, the c-beams being oriented such that the flanges of the c-beams are positioned between the connecting walls, the measurement apparatus comprising a laser apparatus comprising a laser emitter and a laser receiver, the laser emitter being configured to scan a separation between the c-beams and the laser receiver being configured to sense laser light emitted by the laser emitter if it is reflected from the c-beams, and to output a signal comprising data indicative of the separation measured.

In some embodiments the measurement carriage comprises a main body and at least one running wheel configured to run on the interior surface of one of the flanges of the track.

In some embodiments for each interior surface of each flange of the track there is at least one running wheel configured to run on that interior surface.

In some embodiments at least one of the running wheels is a measurement wheel arranged to run on the interior surface of one of the first flanges, each measurement wheel being mounted to the main body via a moveable mount permitting its movement with respect to the main body towards and away from the interior surface of the second flange opposing the flange surface on which the measurement wheel runs, the moveable mount biasing the measurement wheel away from the interior surface of that second flange with respect to the main body such that its movement on the moveable mount follows variation in the distance between the respective opposed interior surfaces as the measurement carriage moves along the track, and where the measurement carriage comprises a measurement wheel sensor arranged to monitor movement of the measurement wheel on the moveable mount, and to output a signal comprising data indicative of the distance between the respective opposed interior surfaces.

According to a further aspect a system is provided comprising a measurement carriage according to any of the previously described aspects and embodiments and a track comprising an I-beam, the I-beam comprising a pair of ledges joined by a connecting wall, where to each side of the connecting wall the ledges define first and second flanges having opposed interior surfaces.

According to a further aspect, a system is provided comprising a measurement carriage according to any of the previously described aspects and embodiments and a track comprising a pair of c-beams, each c-beam comprising first and second flanges having opposed interior surfaces and a connecting wall joining the flanges, the c-beams being oriented such that the flanges of the c-beams are positioned between the connecting walls.

In some embodiments the system comprises a carrier assembly which is configured to be shifted along the track. The carrier assembly may for instance be arranged to carry a product and/or product components along the track.

In some embodiments the measurement carriage is configured to be coupled to the carrier assembly so that the measurement carriage is shifted along the track by the carrier assembly.

In some embodiments the system comprises a chain drive system arranged, when the carrier assembly is engaged therewith, to shift the carrier assembly along the track.

In some embodiments the track is supported by a rail to which it is attached by arms, each arm being connected to the track at an exterior surface of one of the c-beam connecting walls.

In some embodiments identification tags are provided on the rail that are detectable by a locality scanner of the measurement carriage and indicate a particular track location and/or entry to or exit from a particular track section.

In some embodiments the track comprises one or more sections at enhanced risk of flange wear and/or c-beam separation by comparison with other track sections.

In some embodiments the track is an overhead production line conveyor. The track may be for conveying automotive vehicles and/or their parts for assembly.

Within the scope of this application it is expressly intended that the various aspects, embodiments, examples and alternatives set out in the preceding paragraphs, in the claims and/or in the following description and drawings, and in particular the individual features thereof, may be taken independently or in any combination. That is, all embodiments and/or features of any embodiment can be combined in any way and/or combination, unless such features are incompatible. The applicant reserves the right to change any originally filed

claim or file any new claim accordingly, including the right to amend any originally filed claim to depend from and/or incorporate any feature of any other claim although not originally claimed in that manner.

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BRIEF DESCRIPTION OF THE DRAWINGS

One or more embodiments of the invention will now be described by way of example only, with reference to the accompanying drawings, in which:

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Figure 1 shows a perspective view of elements of a system in accordance with an embodiment of the invention;

Figure 2 shows a front view of a track according to an embodiment of the invention;

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Figure 3a shows a perspective view of a measurement carriage in accordance with an embodiment of the invention;

Figure 3b; shows a side view of the measurement carriage of Figure 3a;

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Figure 3c shows a front view of the measurement carriage of Figure 3a;

Figure 3d shows a top view of the measurement carriage of Figure 3a;

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Figure 3e shows a cross-sectional view through the plane A-A in Figure 3d;

Figure 3f shows a cross section view through the plane B-B in Figure 3e;

Figure 3g shows a running wheel in accordance with an embodiment of the invention;

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Figure 4a shows a top view of a track and measurement carriage in accordance with embodiments of the invention;

Figure 4b shows a cross sectional view through the plane A-A of Figure 4a;

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Figure 4c shows a cross sectional view through the plane B-B of Figure 4b;

Figure 5 shows a perspective view of a laser emitter and a track in accordance with embodiments of the invention;

Figure 6 shows a perspective view of a system according to embodiments of the invention;

Figure 7 shows a schematic illustrating data handling in accordance with an embodiment of the invention;

Figure 8 shows a top view of a measurement carriage in accordance with embodiments of the invention;

Figure 9 shows a perspective view of a system according to an embodiment of the invention.

Figure 10 shows a graph of first flange wear in millimetres against position along a section of track in meters according to an embodiment of the invention.

DETAILED DESCRIPTION

Referring to Figure 1 a track, in this case an overhead production line conveyor for vehicle assembly, is generally shown at 10. The track 10 comprises a pair of c-beams 12, each c-beam 12 comprising first 14 and second 16 flanges having opposed interior surfaces 18 and a connecting wall 20 joining the flanges 14, 16. The c-beams 12 face one another so as the flanges 14, 16 of the c-beams 12 are positioned between the connecting walls 20. Furthermore the c-beams 12 are separated and this separation gives rise to a separation gap 22 (see Figure 2) between opposed edges 24 of the respective first flanges 14 of the c-beams 12.

The track 10 is supported by a rail (in this case an I-beam 26) to which it is attached by arms 28. Pairs of arms 28 are provided at intervals along the track 10, one in each pair connecting one each of the c-beams 12 to the I-beam 26. Each arm 28 connects to the relevant c-beam 12 at an exterior surface 30 of its connecting wall 20.

Referring now to Figure 2, the c-beams 12 are shown in greater detail. In particular the first 14 and second 16 flanges of each c-beam 12 are tapered from a greater thickness proximal the connecting wall 20 to a lesser thickness distal from it.

Figure 2 also highlights two wear mechanisms for the track 10 caused by the passage along it of carrier assemblies 32 suspended therefrom. The carrier assemblies are used to transport products or product components and are attached to a chain drive system that shifts them along the track 10 path. A first of the wear mechanisms comprises the erosion of the thickness 34 of the first flanges 14 through the action of wheels (not shown) of the carrier assemblies 32 as they rest and run on the track 10 (and specifically on the lower, weight bearing first flanges 14). A second wear mechanism comprises alteration in the separation of the c-beams 12 and in particular an increase in the separation of the first flanges 14. As they rest and run on the first flanges 14 the load presented by the carrier assemblies 32 tends to separate those first flanges 14, increasing the separation gap 22.

Turning to Figures 3a-4c a measurement carriage is generally shown at 40. The measurement carriage 40 is connected to one of the carrier assemblies 32 to facilitate its shifting along the track 10. It may therefore be considered parasitic to a carrier assembly 32. The measurement carriage 40 is configured to run on the track 10 described above. It has a main body 42 and a plurality of running wheels 44, some of which are idler wheels 46 and some of which are measurement wheels 48.

On a top side 50 of the measurement carriage 40 are four idler wheels 46, arranged in pairs, one pair on either side of the measurement carriage 40. Each pair is mounted to the main body 42 via its own static mount 52. The pairs of idler wheels 46 on either side of the measurement carriage 40 are separated by a distance so as to facilitate their running on respective interior surfaces 54 of the second flanges 16.

On an underside 58 of the measurement carriage 40 are two measurement wheels 48 and two idler wheels 46. When the measurement carriage 40 is in use these two measurement wheels 48 and two idler wheels 46 are in contact with the track. One of the measurement wheels 48 is provided on either side of the measurement carriage 40 at front corners thereof. One of the idler wheels 46 is provided on either side of the measurement carriage 40 at rear corners thereof. The measurement wheels 48 on either side of the measurement carriage 40 are separated by a distance so as to facilitate their running on respective interior surfaces 60 of the first flanges 14. The same is also true of the idler wheels 46 on the underside 58.

Each idler wheel 46 and measurement wheel 48 on the underside 58 is mounted to the main body 42 via its own moveable mount 62 that permits movement of the relevant wheel 46, 48 towards and away from the interior surface 54 of the second flange 16 opposing the interior

surface 60 of the first flange 14 on which that wheel runs. Each moveable mount 62 has a main body mount 63 that is static with respect to the main body 42, in this case comprising a pair of passages 64 and a flange 66 of the main body 42 through which the passages 64 pass. Each moveable mount 62 also comprises a carrier 68 that is mobile with respect to the main body 42 and moves with the relevant wheel 46, 48 which it mounts with an axle 70. The carrier 68 is constrained to movement towards and away from the passages 64 by a guide portion comprising a pair of projections 72 extending from the carrier 68. Each projection 72 passes through one of the passages 64 in a sliding fit, the projections 72 thereby acting as guide runners for the carrier 68 and relevant wheel 46, 48 in their movements.

In the case of the moveable mounting of the relevant idler wheels 46, the moveable mount 62 has a spring 74 which acts between the flange 66 and the carrier 68, biasing the carrier 68 to move away from the interior surface 54 of the second flange 16 opposing the interior surface 60 of the first flange 14 on which the idler wheel 48 runs.

In the case of the moveable mounting of the measurement wheels 48, the moveable mount 62 has a spring 74 which acts between the carrier 68 and a contact portion 76 of a measurement wheel sensor generally provided at 78. The spring 74 applies varying pressure to the contact portion 76 in accordance with the distance of the measurement wheel 46 from the interior surface 54 of the second flange 16 opposing the interior surface 60 of the first flange 14 on which the measurement wheel 46 runs. The measurement wheel sensor 78 comprises a strain gauge load cell 80 which is driven by movement of the contact portion 76 in response to variation in pressure on it exerted by the spring 74. Because the strain gauge load cell 80 is statically mounted on the main body 42 the spring 74 also biases the carrier 68 to move away from the interior surface 54 of the second flange 16 opposing the interior surface 60 of the first flange 14 on which the measurement wheel 46 runs.

Each running wheel 44 has a tapered running surface 82 (as best seen in Figure 3g) that substantially matches the camber of the respective interior surface 54, 60 on which it runs as created by the tapering of the relevant flange 14, 16.

The underside 58 of the measurement carriage 40 also has a pair of spacer rollers 84, rotatably mounted to the main body 42 perpendicularly with respect to the measurement wheels 48. The spacer rollers 84 (one front mounted and one rear mounted) are positioned so as in use they sit between the first flanges 14, with a running surface 86 of each spacer roller 84 opposing the edges 24 of the first flanges 14. In use the running surfaces 86

contact both opposing edges 24 where the separation between the opposing edges 24 is nominal.

Referring now to Figures 5 and 6 the measurement carriage 40 is also provided with a laser apparatus 90. The laser apparatus 90 comprises a laser emitter and a laser receiver in this case combined in a laser transceiver 92. The laser transceiver 92 is mounted to a shelf 94 of one of the carrier assemblies 32 suspended from the track. The shelf 94 and laser transceiver 92 are positioned below the track 10. The measurement carriage 40 as a whole is connected to the same carrier assembly 32. The laser emitter is arranged to scan the separation gap 22 and the laser receiver is arranged to receive laser light emitted by the laser emitter if it is reflected from the first flanges 14.

The measurement carriage 40 also has a locality scanner, in this case an RFID reader 96 (see Figures 6 and 9). Then RFID reader 96 is configured to read RFID tags 98 located at entry and exit from track sections known to be susceptible to increased wear (e.g. curved, cambered and sloped zones). The RFID tags 98 are positioned on the I-beam 26 that supports the track 10 from where they are read by the RFID reader 96.

The measurement carriage 40 also has an encoder wheel 99 mounted on a spring loaded arm (not shown) biasing the encoder wheel 99 against a surface of the track 10. The encoder wheel 99 rolls on the track 10 as the measurement carriage 40 travels and is used to indicate the location of the measurement carriage 40 as opposed flange interior surface distance data is collected.

The measurement carriage also has a power source (in this case a battery 100) that powers the strain gauge load cell 80 of each measurement sensor 78, the laser transceiver 92, the RFID reader 96, the encoder wheel 99 and the memory and various processors discussed below. The battery 100 is mounted on the shelf 94.

In use the measurement carriage 40 is periodically attached to a carrier assembly 32 and the running wheels 44 engaged with respective flanges of the track 10. Engagement of the running wheels 44 may be achieved by the application of force to temporarily overcome the biasing of the idler 46 and measurement 48 wheels that are mounted with moveable mounts 62 in order to reduce the distance spanned by the running wheels 44 mounted on the top side 50 and underside 58. The carrier assembly 32 is shifted along the track 10 by the chain drive and carries the measurement carriage 40 with it.

As the measurement carriage 40 moves along the track 10 a processor 102 mounted on the main body 42 conducts measurements, at regular intervals, of first flange 14 wear for both first flanges 14. The processor 102 receives signals comprising data indicative of the position of the measurement wheels with respect to the main body 42 outputted by the strain gauge load cells 76. Because this data will reflect the distance between the opposed interior surfaces 18 of pairs of first 14 and second 16 flanges, the processor 102 can calculate a remaining thickness of each first flange 14 at the location where the measurements were taken and this can be compared to a nominal thickness to give a wear measurement. As will be appreciated some error may be introduced where there is erosion to a second flange 16, though it is believed such wear if present would be likely insignificant given that the second flanges 16 are not load bearing and are unlikely to be significantly worn. The processor 102 assigns each calculated first flange 16 thickness a track 10 location based on signals outputted from the encoder wheel 99 and received by the processor 102 that are indicative of the location of the measurement carriage 40 on the track 10. The processor 102 then saves the combined first flange 14 thickness and location data points to a memory provided on the measurement carriage 40, in this case a selectively removable SD card 104.

As the processor 102 takes first flange 14 opposed flange interior surface distance measurements, it also conducts a measurement of the separation gap 22 between the opposed edges 24 using the laser apparatus 90. The laser receiver outputs a signal, received by the processor 102, comprising data indicative of the size of the separation gap 22 at the location where the measurement was taken. The processor 102 calculates the separation gap 22 for the location in question using the data received. It further assigns the separation gap 22 calculated a track 10 location based on the signals outputted from the encoder wheel 99. The processor 102 then saves the combined separation gap 22 and location data point to the SD card 104.

In some sections of the track 10, the interval at which the processor 102 conducts opposed flange interior surface distance and separation gap 22 measurements may be temporarily reduced. The processor 102 increases the measurement frequency in response to receipt of a signal sent by the RFID reader 96 comprising data indicative of the measurement carriage 40 being at a particular track 10 location. Such a signal is sent by the RFID reader 96 when it scans an RFID tag 98 indicating that the measurement carriage 40 is entering an area of the track 10 that has been determined to be at enhanced risk of wear. The processor 102 returns to a nominal regular measurement interval for opposed flange interior surface distance and separation gap 22 measurements in response to a subsequent signal sent by

the RFID reader 96 when it scans an RFID tag 98 indicating that the measurement carriage 40 is exiting the area of the track 10 that is at enhanced risk of wear.

As will be appreciated the processor 102 combines functions of a) measurement processor arranged to determine intervals for opposed flange interior surface distance and c-beam separation measurements and instigate those measurements; b) a wear processor arranged to receive the signals outputted by the measurement wheel sensors and calculate and record first flange 14 wear in accordance with the signals, b) a c-beam separation processor arranged to receive the signals outputted by the laser receiver and calculate and record a separation gap 22 in accordance with the signal. Nonetheless in other embodiments these processors may be provided separately or combined in any combination. By way of example a c-beam separation processor could be incorporated with the laser transceiver 92. Such a c-beam separation processor could send separation gap 22 measurements to a wear processor that also performs the wear processor functionality described above for saving to memory (e.g. the SD card 104) or could save such data directly to the memory.

As shown in Figure 7, once the measurement carriage 40 has completed a run of the track 10, the SD card 104 is retrieved and the data stored thereon is accessed by a computer 106 and presented (for example) in a spreadsheet 108 which may be used to create a graph 110. Such a graph 110 may for instance indicate first flange 14 wear in a unit of distance as a plot against track location and or the separation gap 22 in a unit of distance as a plot against track location with reference the one or both c-beams nominal configuration. Referring now to Figure 10 an example graph 110 is shown plotting first flange 14 wear in mm against position along a section of track in m. The section of track happens to be a squeeze down section (i.e. a section known to be at enhanced risk of wear). Measurement points are denoted by s_n numbers. Overlaid on the plot is with reference to the nominal configuration for the section of track a threshold wear line selected as the maximum permitted first flange 14 wear before the section of track 10 must be replaced. Based on the position of the first flange 14 wear plot with respect to the threshold, the graph 110 is colour coded to indicate whether a particular track region is below threshold (OK), is on threshold (prompting a check) or over the threshold (requiring replacement action).

In an alternative embodiment (not shown) the data used could be the deviation from a nominal configuration with reference to a nominal configuration for the section of the track measured, rather than the values measured with reference to the nominal configuration for the section of the track measured.

As will be appreciated this detailed description provides an example in which opposed flange interior surface distance and c-beam separation measurements are both performed, and are performed by a single measurement carriage. Nonetheless in alternative embodiments it will be appreciated that only one of these may be performed and that a measurement carriage is provided equipped only with the features and functionalities associated with that measurement type.

All of the features disclosed in this specification (including any accompanying claims, abstract and drawings), and/or all of the steps of any method or process so disclosed, may be combined in any combination, except combinations where at least some of such features and/or steps are mutually exclusive.

Each feature disclosed in this specification (including any accompanying claims, abstract and drawings), may be replaced by alternative features serving the same, equivalent or similar purpose, unless expressly stated otherwise. Thus, unless expressly stated otherwise, each feature disclosed is one example only of a generic series of equivalent or similar features.

The invention is not restricted to the details of any foregoing embodiments. The invention extends to any novel one, or any novel combination, of the features disclosed in this specification (including any accompanying claims, abstract and drawings), or to any novel one, or any novel combination, of the steps of any method or process so disclosed. The claims should not be construed to cover merely the foregoing embodiments, but also any embodiments which fall within the scope of the claims.

CLAIMS

1. A measurement carriage configured to run on a track comprising a pair of c-beams,
each c-beam comprising first and second flanges having opposed interior surfaces
and a connecting wall joining the flanges, the c-beams being oriented such that the
flanges of the c-beams are positioned between the connecting walls, the
measurement carriage comprising a main body and at least one running wheel
configured to run on the interior surface of each flange of the track, at least one of
those running wheels being a measurement wheel arranged to run on the interior
surface of one of the first flanges, each measurement wheel being mounted to the
main body via a moveable mount permitting its movement with respect to the main
body towards and away from the interior surface of the second flange opposing the
flange surface on which the measurement wheel runs, the moveable mount biasing
the measurement wheel away from the interior surface of that second flange with
respect to the main body such that its movement on the moveable mount follows
variation in the distance between the respective opposed interior surfaces as the
measurement carriage moves along the track, and where the measurement carriage
comprises a measurement wheel sensor arranged to monitor movement of the
measurement wheel on the moveable mount, and to output a signal comprising data
indicative of the distance between the respective opposed interior surfaces.
2. A measurement carriage according to claim 1 where at least another of the running
wheels is arranged to run on the first flange on which the measurement wheel is also
arranged to run, and is mounted to the main body by a mount which is independent
of the moveable mount of the measurement wheel.
3. A measurement carriage according to claim 1 or claim 2 where the measurement
wheel is weight bearing for the measurement carriage.
4. A measurement carriage according to any preceding claim where the moveable
mount comprises a main body mount which is static with respect to the main body
and a measurement wheel carrier which carries the measurement wheel, the
measurement wheel carrier being constrained to movement towards and away from
the main body mount by a guide portion.

5. A measurement carriage according to any preceding claim where the measurement wheel sensor comprises a transducer arranged to output a signal comprising data indicative of the position of the measurement wheel with respect to the main body.
- 5 6. A measurement carriage according to claim 5 where the transducer is a strain gauge load cell driven by a contact portion of the measurement wheel sensor that travels in response to position changes of the measurement wheel with respect to the main body towards and away from the interior surface of the second flange opposing the surface on which the measurement wheel runs.
- 10 7. A measurement carriage according to claim 6 where the moveable mount comprises a spring acting between the main body mount or contact portion and the measurement wheel carrier to bias the measurement wheel carrier away from the main body mount.
- 15 8. A measurement carriage according to any preceding claim where at least two of the running wheels are measurement wheels and for each interior surface of each first flange of each of the c-beams there is at least one measurement wheel configured to run on that interior surface.
- 20 9. A measurement carriage according to any preceding claim where the running wheels that are not measurement wheels are idler wheels configured to support and/or position the measurement carriage within the track.
- 25 10. A measurement carriage according to any preceding claim where at least one of the running wheels has a tapered running surface which substantially matches a taper on the interior surface of the flange on which it is configured to run.
- 30 11. A measurement carriage according to any preceding claim comprising a laser apparatus comprising a laser emitter and a laser receiver, the laser emitter being configured to scan a separation between the c-beams and the laser receiver being configured to sense laser light emitted by the laser emitter if it is reflected from the c-beams, and to output a signal comprising data indicative of the separation measured.
- 35 12. A measurement carriage according to claim 11 arranged to scan a separation between points on the c-beams, the separation of which is indicative of the extent of

one or both of any rotation of one or both of the c-beams and the extent of any deformation of one or both of the c-beams.

5 13. A measurement carriage according to claim 11 or 12 where the laser apparatus is configured to scan a separation between opposed edges of the c-beam flanges, where the flanges belong to different c-beams.

10 14. A measurement carriage according to any of claims 11 to 13 where the separation scanned is that between opposed edges of the first flanges.

15 15. A measurement carriage according to any of claims 11 to 14 where the laser emitter and the laser receiver are positioned outside of the track formed by the c-beams.

16. A measurement carriage according to any of claims 11 to 15 where the opposed flange interior surface distance measurements and c-beam separation measurements are conducted at the same time.

20 17. A measurement carriage according to any preceding claim where the measurement carriage is configured to be coupled to a carrier assembly which is configured to be shifted along the track.

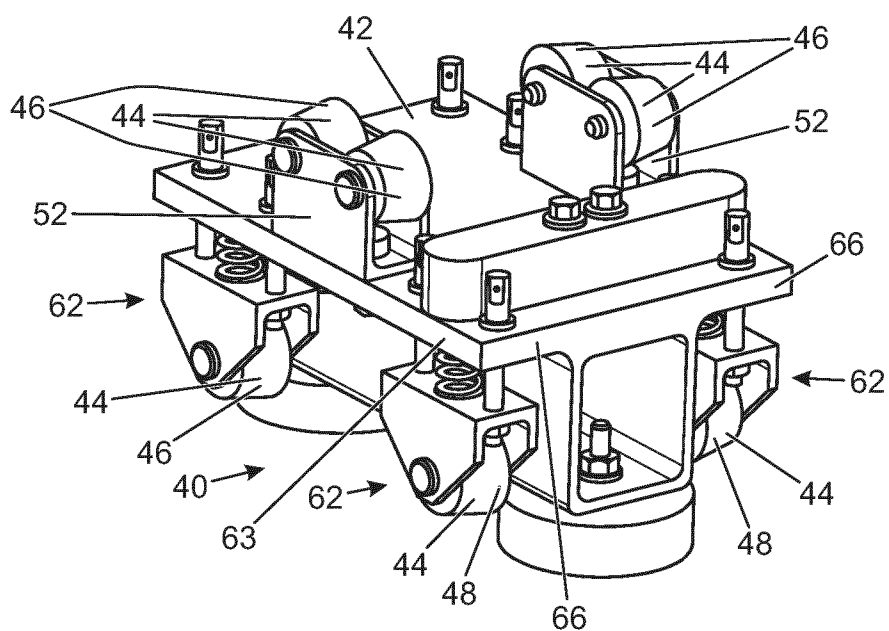
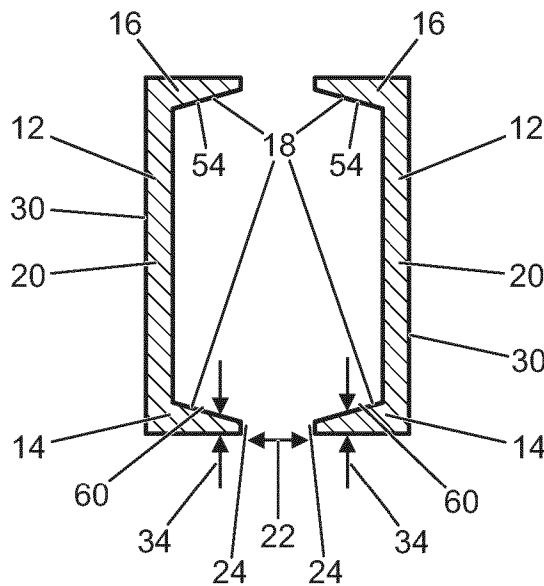
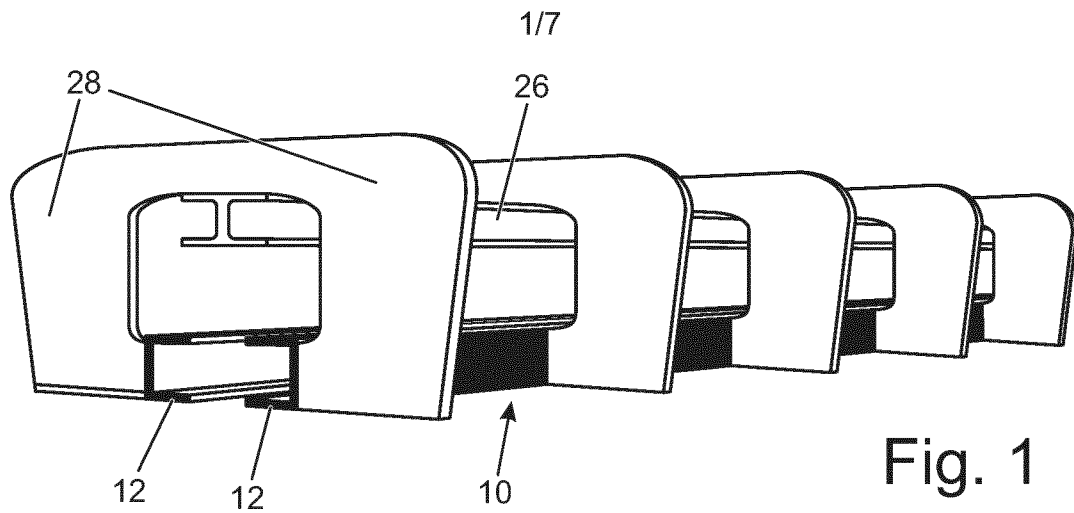
25 18. A measurement carriage according to any preceding claim comprising a locality scanner configured to detect when the measurement carriage is at a particular location and/or is within a particular section of the track.

30 19. A measurement carriage according to any preceding claim comprising an encoder wheel configured to roll on the track as the measurement carriage travels and output a signal comprising data indicative of the location of the measurement carriage on the track.

35 20. A system is provided comprising a measurement carriage according to any of claims 1 to 19 and a track comprising a pair of c-beams, each c-beam comprising first and second flanges having opposed interior surfaces and a connecting wall joining the flanges, the c-beams being oriented such that the flanges of the c-beams are positioned between the connecting walls.

21. The system according to claim 20 comprising a carrier assembly which is configured to be shifted along the track.
22. The system according to claim 21 where the measurement carriage is configured to be coupled to the carrier assembly so that the measurement carriage is shifted along the track by the carrier assembly.
23. The system according to claim 21 or claim 22 comprising a chain drive system arranged, when the carrier assembly is engaged therewith, to shift the carrier assembly along the track.
24. The system according to any of claims 21 to 23 where the track is supported by a rail to which it is attached by arms, each arm being connected to the track at an exterior surface of one of the c-beam connecting walls.
25. The system according to claim 24 where identification tags are provided on the rail that are detectable by a locality scanner of the measurement carriage and indicate a particular track location and/or entry to or exit from a particular track section.
26. A system according to any of claims 20 to 25 where the track comprises one or more sections at enhanced risk of flange wear and/or c-beam separation by comparison with other track sections.
27. A system according to any preceding claim where the track is an overhead production line conveyor.
28. A measurement apparatus comprising a measurement carriage configured to run on a track comprising a pair of c-beams, each c-beam comprising first and second flanges having opposed interior surfaces and a connecting wall joining the flanges, the c-beams being oriented such that the flanges of the c-beams are positioned between the connecting walls, the measurement carriage being coupled to a laser apparatus comprising a laser emitter and a laser receiver, the laser emitter being configured to scan a separation between the c-beams and the laser receiver being configured to sense laser light emitted by the laser emitter if it is reflected from the c-beams, and to output a signal comprising data indicative of the separation measured.
29. A system comprising a measurement apparatus according to claim 28 and a track comprising a pair of c-beams, each c-beam comprising first and second flanges

having opposed interior surfaces and a connecting wall joining the flanges, the c-beams being oriented such that the flanges of the c-beams are positioned between the connecting walls.



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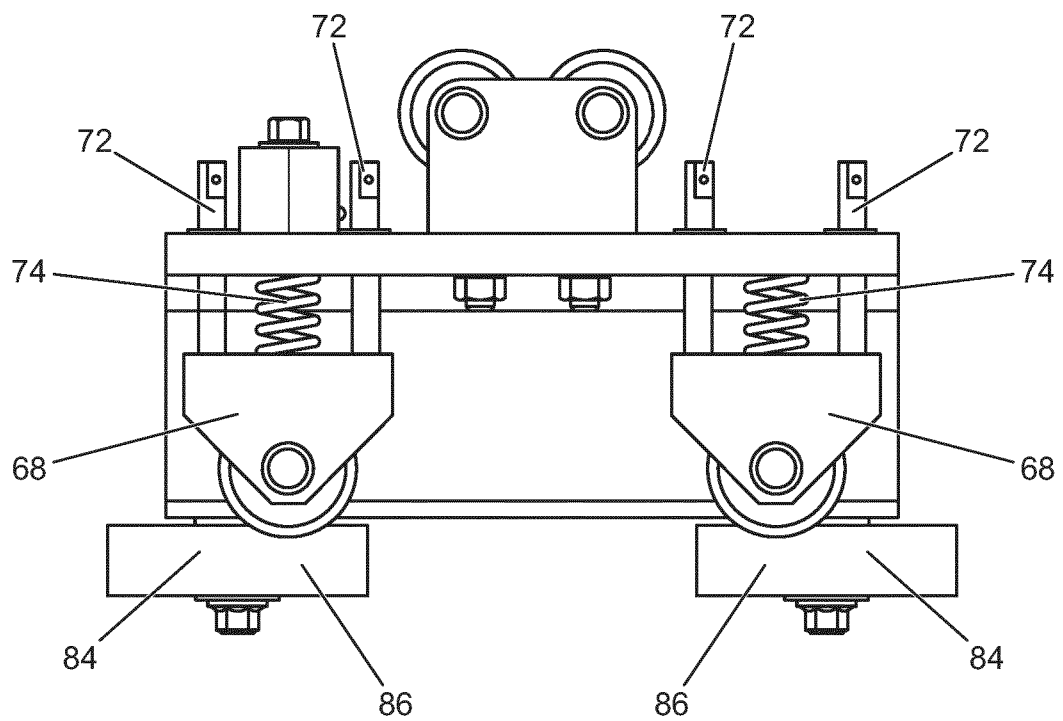


Fig. 3b

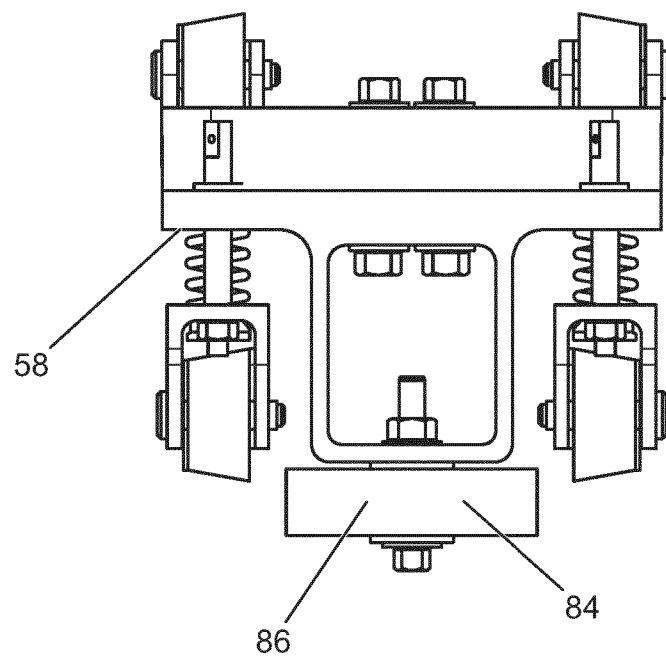


Fig. 3c

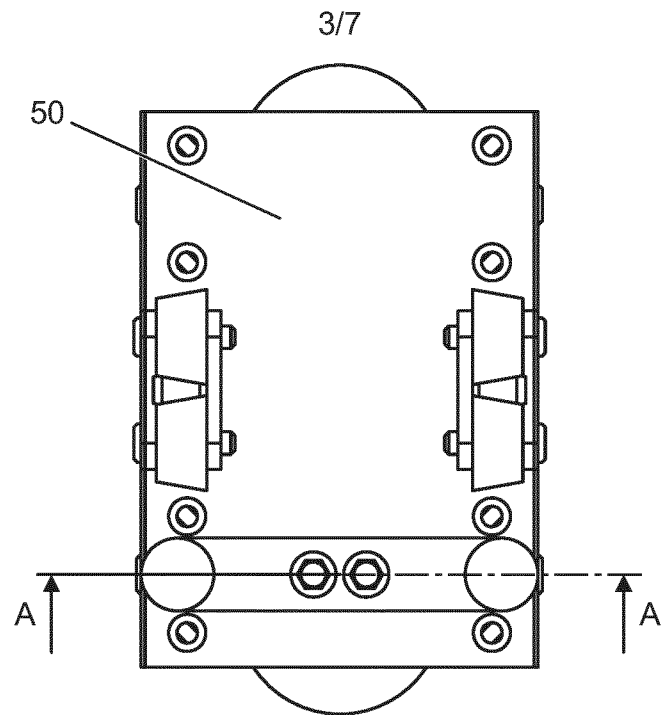


Fig. 3d

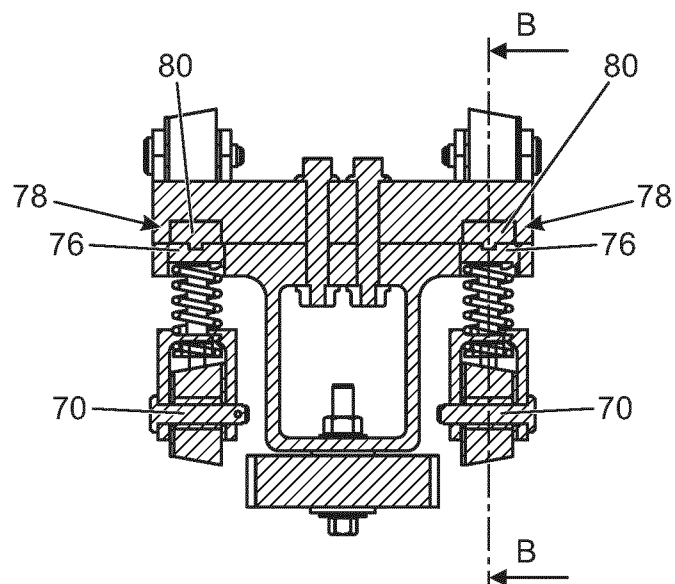


Fig. 3e

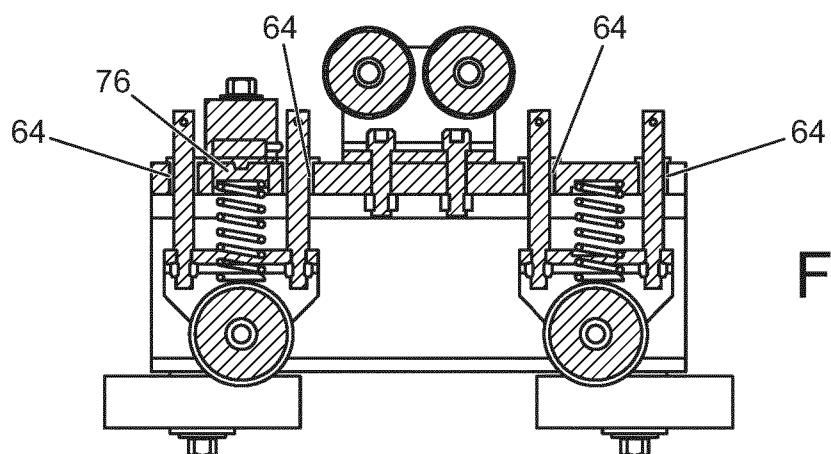


Fig. 3f

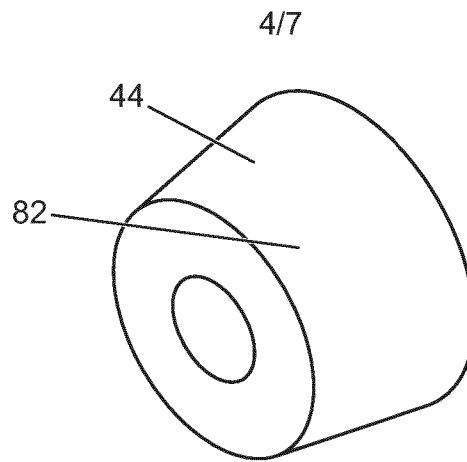


Fig. 3g

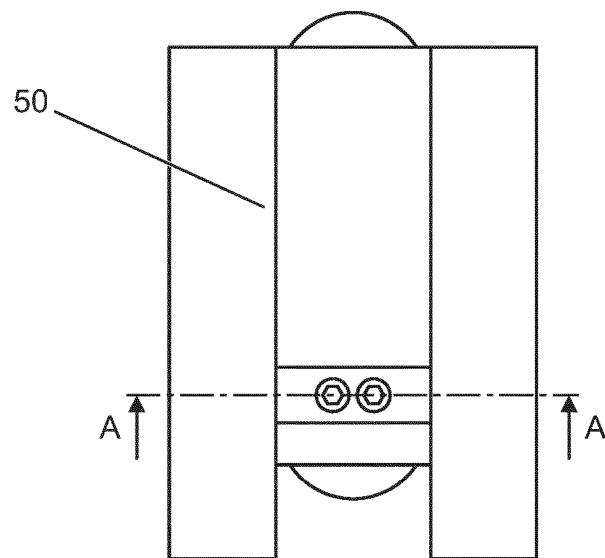


Fig. 4a

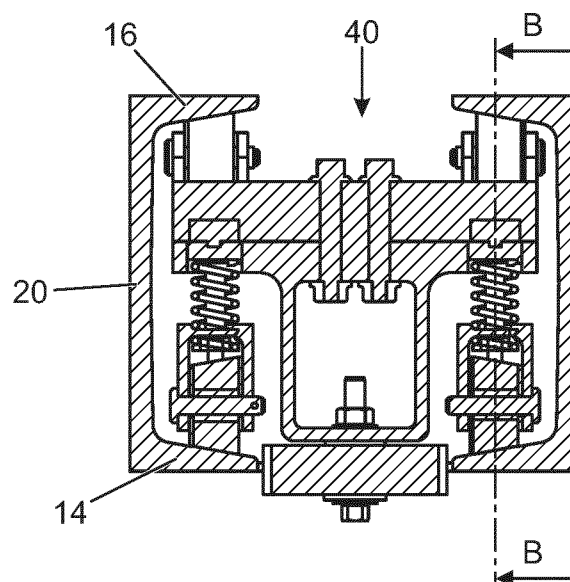


Fig. 4b

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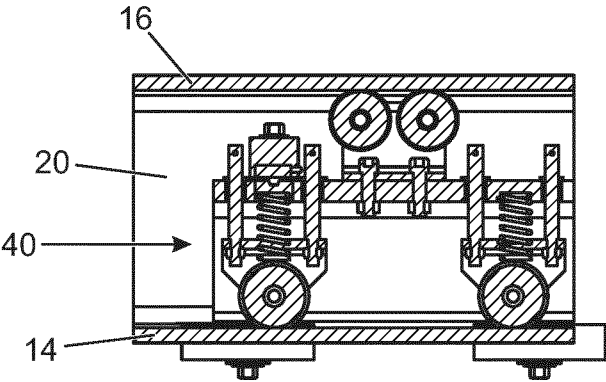


Fig. 4c

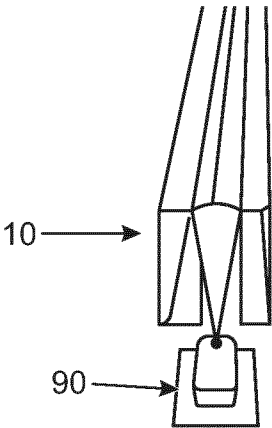


Fig. 5

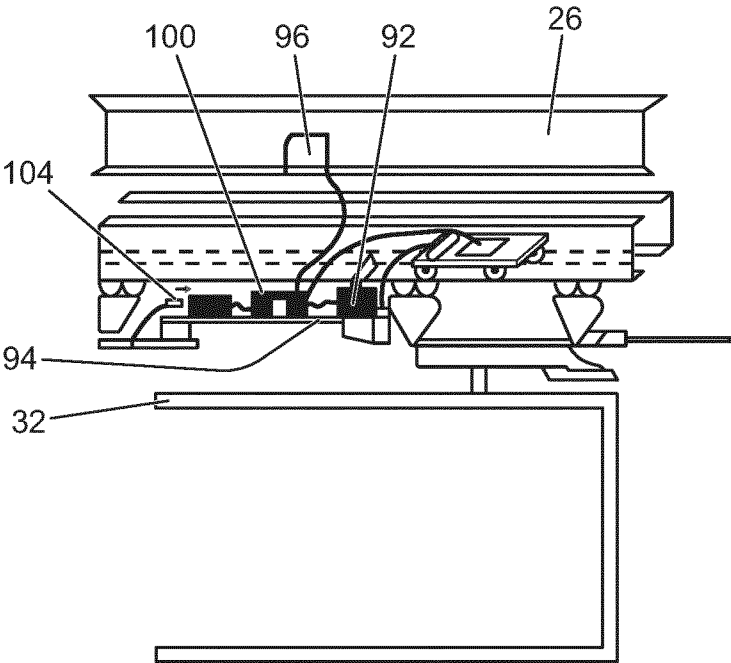
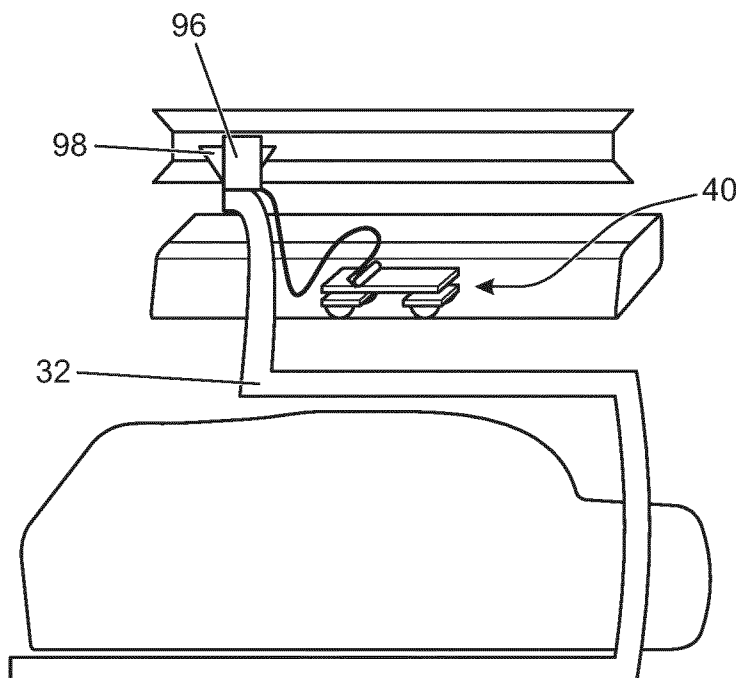
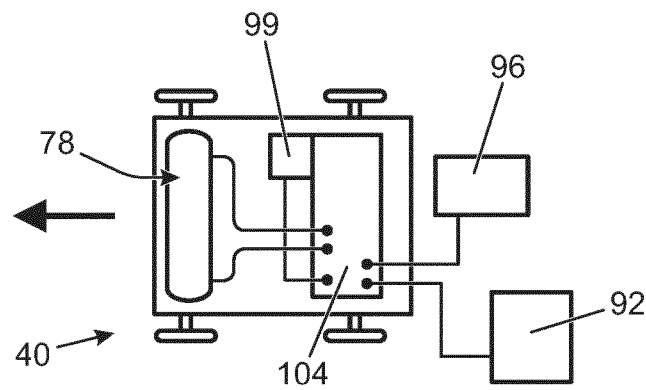
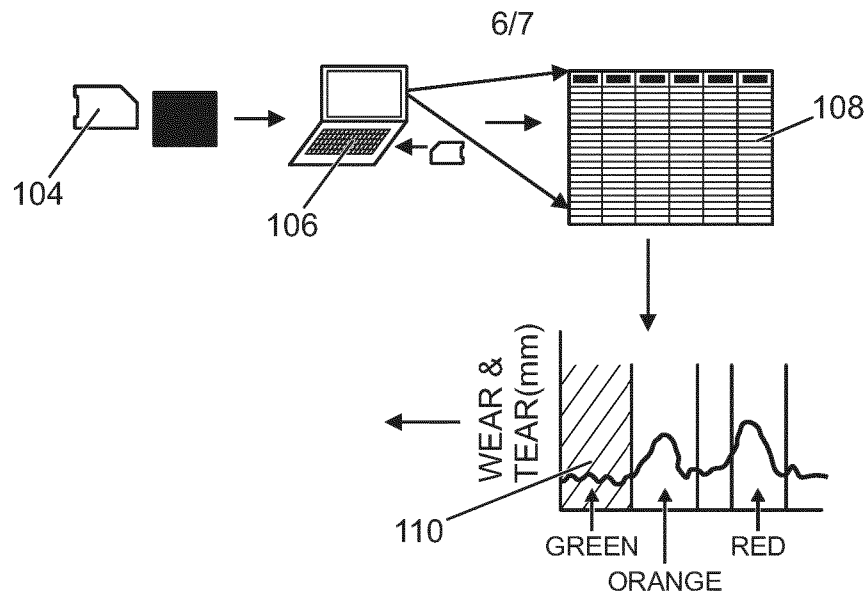


Fig. 6



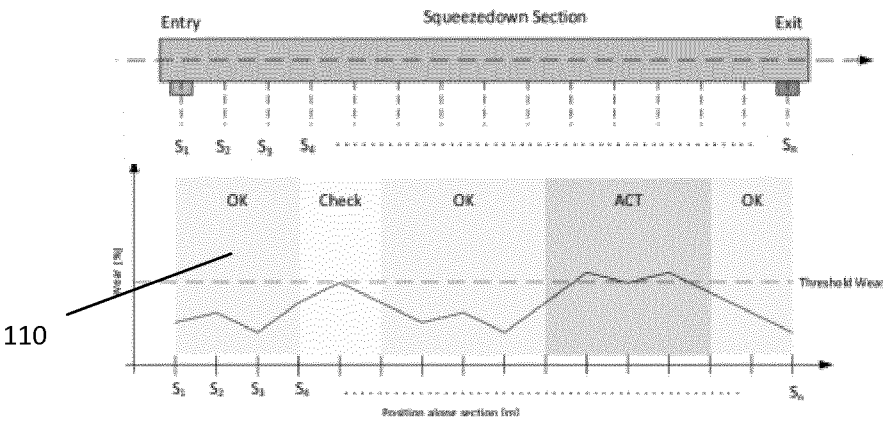


Fig. 10

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2017/081712

A. CLASSIFICATION OF SUBJECT MATTER
INV. G01B7/06 G01B11/14
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
G01B G01M B65G

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	JP 2003 207331 A (NAKANISHI METAL WORKS CO) 25 July 2003 (2003-07-25)	28
Y	paragraphs [0001], [0065], [0066], [0068], [0070]; figures 12,13,14 -----	1-27,29
Y	US 2012/167661 A1 (WELCH EDWARD R [US] ET AL) 5 July 2012 (2012-07-05) paragraphs [0021], [0023], [0025], [0026], [0033], [0036]; figures 1,3 -----	1-27,29
A	US 2015/197399 A1 (MAYER DENNIS L [US] ET AL) 16 July 2015 (2015-07-16) the whole document -----	1-29
A	JP 2008 249508 A (NAKANISHI METAL WORKS CO) 16 October 2008 (2008-10-16) the whole document -----	1-29



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents :

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"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

16 March 2018

Date of mailing of the international search report

06/04/2018

Name and mailing address of the ISA/

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Authorized officer

Biedermann, Benjamin

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/EP2017/081712

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