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(54) **SENSOR FOR HANDLING SYSTEM**

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G06F 7/00 (2006.01)

(52) **U.S. Cl.**
USPC **700/213**

(58) **Field of Classification Search**
USPC 700/213
See application file for complete search history.

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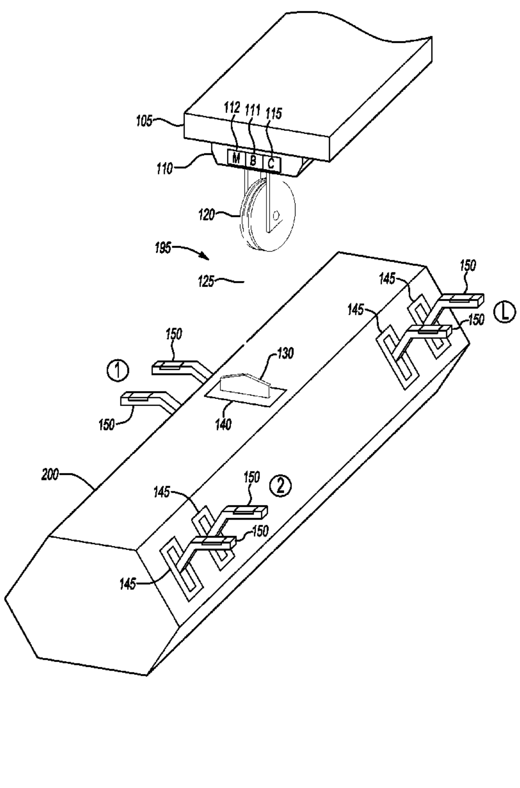
(57) **ABSTRACT**

The cable lift system provides assistance to movement of a flexibly suspended payload actuated by operator input into one or more sensing devices attached to the payload. The sensing device is configured to collect information about the typical push-pull and lift-lower motions of an operator moving the payload horizontally and/or vertically, such that the operator's input to the sensor is intuitive and is provided in a manner which is substantially transparent to the operator. The assist mechanisms included in the system are actuated by a controller processing signals received from the one or more sensing devices on the payload. Movement assistance is provided such that the manual effort required by the operator to overcome the inertia of the payload in a starting or stopping event is substantially relieved, thus minimizing the ergonomic impact of the starting and stopping events on the operator.

12 Claims, 3 Drawing Sheets



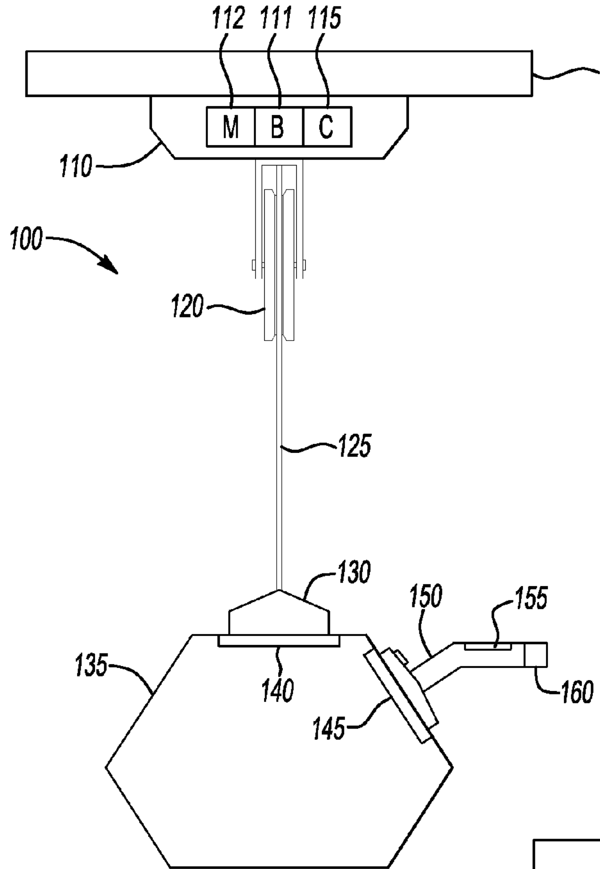

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Fig-1

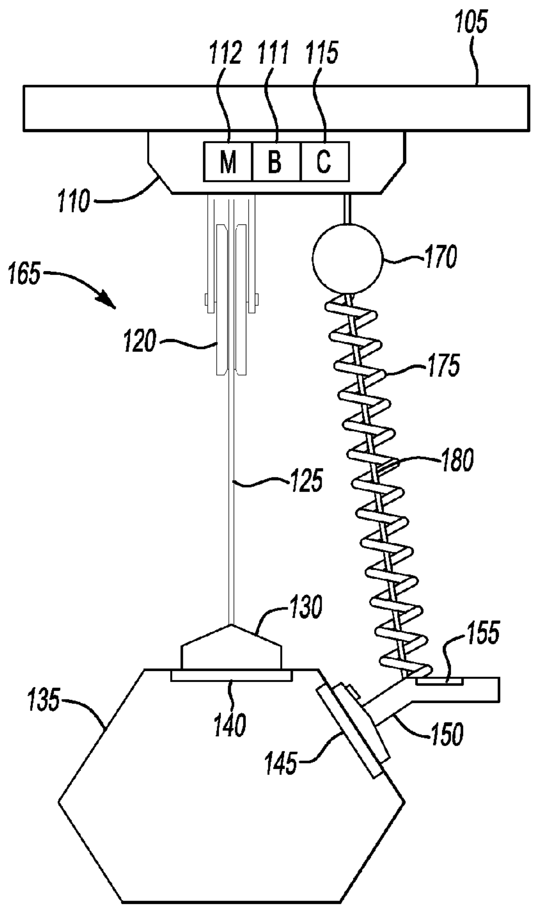
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Fig-2

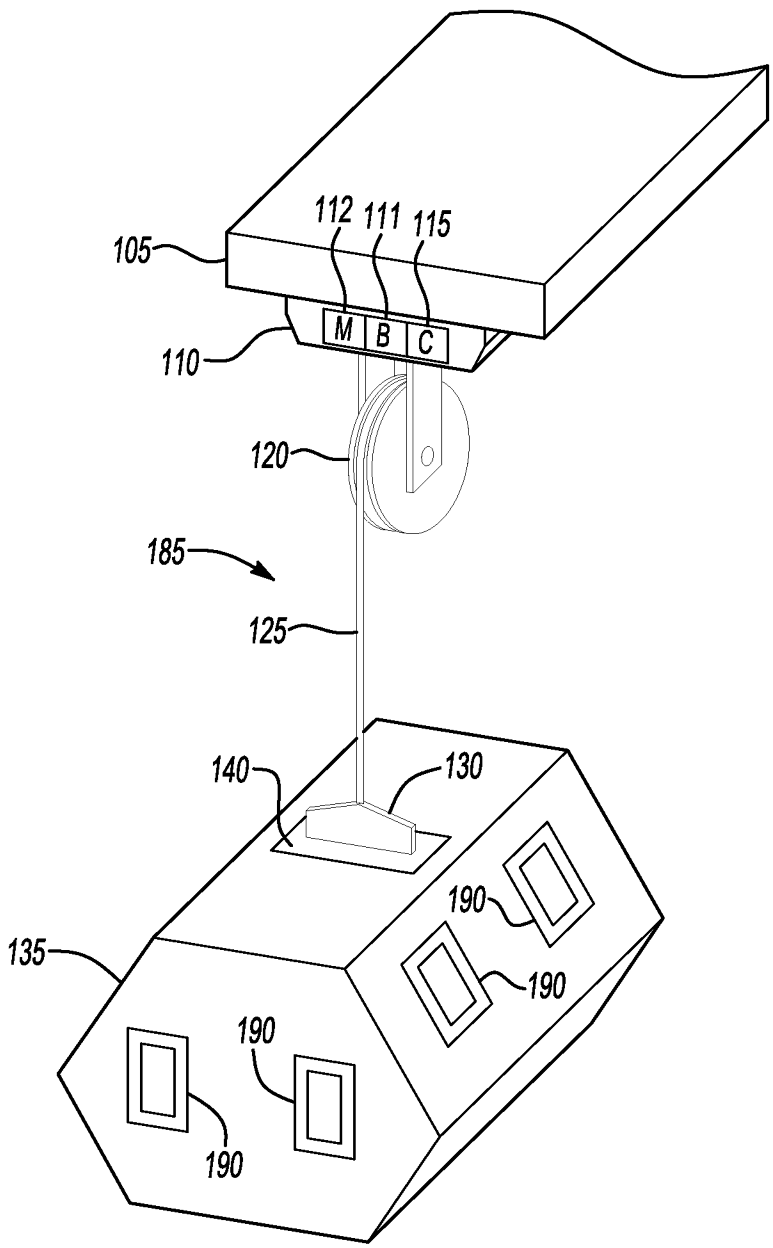
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Fig-3

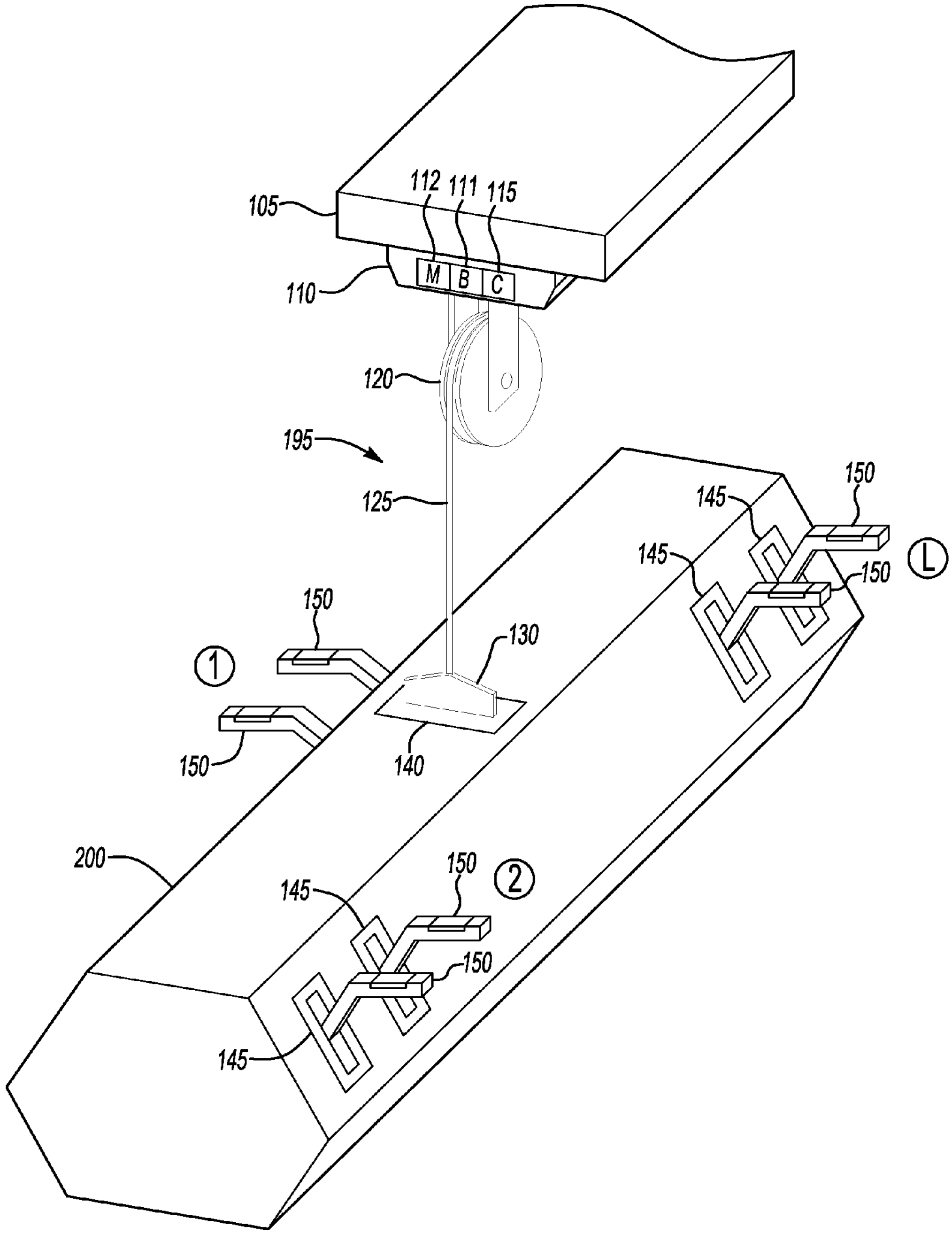
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Fig-4

SENSOR FOR HANDLING SYSTEM

TECHNICAL FIELD

The present invention relates to a method and apparatus for lifting a payload using a flexible suspension system, and in particular to providing assistance in the movement of a payload suspended from a flexible suspension system which is a cable lift system.

BACKGROUND OF THE INVENTION

Cable based lift systems are used in conjunction with track rail or bridge and trolley systems, to move cable suspended payloads. Movement along two horizontal axes can be obtained by moving a bridge on fixed rails along a first axis, then moving a trolley along the bridge along a second horizontal axis, in a direction perpendicular to the direction of the fixed rails. The cable system provides vertical lift assistance, typically through a hoist which may be motorized. The operator physically pushes and pulls the cable suspended payload to start, continue, slow or stop the horizontal movement of the payload. The starting-and-stopping strain on the operator, when the operator must overcome maximum inertia of the payload, is a known ergonomic problem with these types of systems.

A cable lift system with horizontal movement assistance exists which is actuated by an angular deviation of the payload suspending cable from a vertical position. However, horizontal assistance is only actuated after the angle of the cable is deviated from a vertical position, e.g., after the operator has become strained by inputting a manual starting or stopping force against the payload. Because horizontal assistance is not actuated until after the operator has exerted force against the payload to cause the cable to deviate from vertical, this type of device does not address the known ergonomic problem. Another device to provide horizontal assistance includes a vertical column and handle bar arrangement which is disadvantaged by high cost, limited flexibility, increased weight and non-intuitive operator controls.

SUMMARY OF THE INVENTION

The flexible suspension system provided herein provides assistance to horizontal and vertical movement of a flexibly suspended payload actuated by operator input into one or more sensing devices attached to the payload. The flexible suspension system may be, for example, a cable lift system, where the payload is suspended by a flexible suspension device which may be a cable or chain configured with a hoist or similar means to lift and lower the payload in a vertical direction. The sensing device is configured to collect information about the typical push-pull motions of an operator moving the payload in a horizontal plane, such that the operator's input to the sensor is intuitive and is provided through controls which are relatively transparent to the operator. The sensing device may also be configured to collect information about the lift and lower motions of an operator moving the payload in a vertical plane.

The horizontal and vertical assist mechanisms included in the system are actuated by a controller processing signals received from the one or more sensing devices on the payload. Horizontal movement assistance is provided such that the manual effort required by the operator to overcome the inertia of the payload in a starting or stopping event is substantially relieved, thus minimizing the ergonomic impact of the starting and stopping events on the operator. Vertical movement assistance is provided such that the manual effort required by the operator to adjust the load vertically is substantially relieved, minimizing the ergonomic impact of these motions on the operator.

A method for use and a handling system configured to provide horizontal and/or vertical assistance to an operator moving a payload suspended from a cable is provided herein. The assisted flexible suspension system, which includes the category of flexible suspension systems referred to as cable lift systems, includes a cable, which may be of any type of cable, such as a steel cable or a chain, configured to attach to a trolley at a first end and a payload at the second end, where the trolley includes assist mechanisms adapted to assist movement of the payload in a horizontal plane and assist mechanisms adapted to the hoist and/or trolley to assist movement of the payload in a vertical plane. The assist mechanisms may include one or more brakes and/or one or more motors. As would be understood by one skilled in the art, other assist mechanisms, including pulley systems and counterbalances, could be used within the scope of the claimed invention.

A sensing device is provided herein which is adapted to be operatively attached to the payload and is configured to sense the input force and direction of manual movement of the payload and to transmit a signal including force and direction information to a controller. Manual movement, as used herein, includes at least one of starting, accelerating, continuing, rotating, slowing and stopping movement of the payload in a horizontal plane, and/or at least one of lifting, lowering, tilting and angling the payload in a vertical plane.

A controller is provided and configured to receive and process signals from one or more sensing devices attached to the payload. The controller provides input to the trolley assist mechanisms, to assist movement of the payload in response to signals from one or more sensing devices, where the signals correspond to manual input from an operator moving the payload. The controller may also provide input to the trolley to move the trolley to a predetermined location, for example, a payload loading station. The controller may be further configured to receive and process signals from multiple sensing devices simultaneously receiving force and direction input from multiple operators handling a single payload, where one of the operators and the related sensing devices are designated as a lead operator. In this instance, the controller is configured to identify the signals inputted by the lead operator and to use an algorithm to process the incoming signals from the multiple operators, giving priority to the lead signals and excluding or reconciling conflicting signals from non-lead sensing devices. The sensing devices may be configured, in this instance, to be assigned as a lead device, and further to transfer or reassign lead device role to another sensing device through the controller.

The controller may be configured to receive and transmit wireless signals. The sensing devices may be configured to transmit wireless signals. The sensing device provided herein is adapted to be operatively attached to the payload and may be configured to be detached from the payload after movement of the payload by the handling system is completed and reattached to another payload, so as to be reusable. In another embodiment, the sensing device is configured to remain attached to the payload permanently or semi-permanently, so as to be disposable after movement of the payload by the handling system is completed.

The sensing device may be configured as a handle, with sensors that are positioned on the handle such that when an operator grasps the handle in a typical manner, the sensors can detect and collect force, torque and directional information without further input from the operator. The collection of force, torque and directional information may therefore be configured to be substantially transparent with respect to the operator, therefore allowing the operator to guide the payload using the handle in an intuitive manner and without requiring the operator to actively request assistance from the trolley. In another embodiment, the sensing device may be configured as a sensor pad comprised of pressure sensitive conductive materials such as force sensitive resistor tape.

The assistance flexible suspension system, also referred to as a cable lift system, provided herein provides the advantage of a flexible system of sensing devices which can be used with multiple types and configurations of payloads, in a wired or wireless configuration, while substantially eliminating the ergonomic strain associated with the manual pushing, pulling, rotating, lifting and/or lowering of cable suspended loads. The assist mechanisms are provided with minimal additional weight to the cable lift system, with low cost and significant flexibility. The sensing devices provide an intuitive interface to the operator, with the capability to collect force and direction information using controls which may be configured to be substantially transparent to the operator, thus making the system easy to use with minimal training.

The above features and advantages and other features and advantages of the present invention are readily apparent from the following detailed description of the best modes for carrying out the invention when taken in connection with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a schematic plan view of an assisted cable lift system with a detachable wireless sensing device configured as a handle;

FIG. **2** is a schematic plan view of an assisted cable lift system with a detachable wired sensing device configured as a handle;

FIG. **3** is a schematic perspective view of an assisted cable lift system including wireless sensing devices configured as sensor pads; and

FIG. **4** is schematic perspective view of a multi-operator assisted cable lift system with detachable wireless sensing devices.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to the drawings, wherein like reference numbers refer to like components, FIG. **1** presents a schematic plan view of an assisted flexible suspension system, in particular a cable lift system with detachable wireless sensing devices. In a preferred embodiment, generally indicated at **100** is an assisted cable lift system including a trolley **110** moving on a bridge and rail system **105**. Horizontal movement of trolley **110** as shown is assisted by one or more assist mechanisms, which may include one or more motors **112** and one or more brakes **111**, which receive input from a controller **115** in response to input from a sensing device **155** attached to payload **135**. As would be understood by those skilled in the art, horizontal movement of the trolley may be assisted by other means, such as pulleys, cables, servo-actuators and the like, in response to inputs from a controller **115**. The trolley **110** incorporates a cable **125** and hoist mechanism **120**. The hoist mechanism **120** may be a motorized hoist, for example, and is used to lift and lower payload **135** suspended from the cable **125** in a generally vertical direction.

Cable **125** includes a payload attachment **130**, which may be of any type suitable for attaching to payload **135** which is being moved. For example, payload attachment **130** may be a hook, and cable attachment feature **140** may be an eye bolt fixedly attached to payload **135**, which may be, for example, and automotive engine or transmission assembly. Alternatively, the cable attachment feature **140** may be an element of payload **135** without being a separate feature, for example, a rib in a section of aircraft fuselage which may be directly attached to by a hook. Payload attachment **130** may be a clamping mechanism, which may be used, for example, to clamp directly onto a feature of payload **135** provided for that purpose such as a rib or fin, or directly onto the payload **135** itself, for example, where payload **135** is a slab of granite or precast concrete.

Payload **135** may further include a sensor attachment feature **145** for attachment of a sensing device or sensor **155** responsive to operator movement. As shown in FIG. **1**, sensing device **155** may be incorporated into or configured as a handle **150**, which may be attachable to payload **135** by any means known to those skilled in the art. For example, handle **150** may be attached with one or more bolts to payload **135**, wherein the sensor attachment feature **145** may be a pattern of one or more threaded holes to receive the bolts. Alternatively, the handle may be configured to be inserted into an existing hole or orifice in the payload using a threaded, tapered or expanding plug, or may be configured to attach to a protruding feature of the payload using a collet, clamp or similar feature, where the attaching feature may be configured for quick attachment and/or quick release. Sensor attachment feature **145** may be a section of payload **135** which is of appropriate configuration or profile such that it provides an attachment surface without additional preparation. For example, payload **135** may be of a magnetic material and handle **150** may be configured to include one or more magnetic elements which can be actuated as a quick attach/quick release feature to operatively attach directly to payload **135**. As another example, payload **135** may be a construction material, such as glass sheet or granite slab and handle **150** may include one or more suction cups to operatively attach directly to payload **135**.

As shown in FIG. **1**, handle **150** is a standalone unit which may be attached to payload **135** during the process of attaching payload **135** to cable system **100**, or may be attached to the payload **135** at any time earlier and transported with the payload prior to attaching payload **135** to cable system **100**. For example, handle **150** may be attached by an engine supplier before the engine is provided to a vehicle assembly plant where the engine may be moved by a cable lift system using the assistance system of the claimed invention in the vehicle assembly plant during assembly into a vehicle. Handle **150** may then be detached from payload **135** after its movement is completed, and reused on another payload. For example, after assembly of the engine in the vehicle, handle **150** may be detached and returned to the engine supplier to be attached on another engine.

Shown in FIG. **2** is an alternate arrangement of an assisted cable lift system generally indicated at **165**, wherein sensing device or sensor **155** is attached to trolley **110** by a tool holder **170**. Tool holder **170** is shown in FIG. **2** as a retractable tool holder including a retractable cable **175**, although other commonly known means of overhead tool attachment may be used. In this arrangement, handle or handles **150** are attached and detached from payload **135** as part of the process of connecting and disconnecting payload **135** from cable lift system **165**.

Referring again to FIG. **1**, sensing device **155** is shown incorporated into or configured as a handle **150** including one or more sensors **155**. Handle **150** is used by an operator to manually direct or guide movement of payload **135** as payload **135** is moved horizontally and/or vertically in response to operator movement while suspended vertically by cable **125** from trolley **110**. As the operator exerts a force on handle **150** and sensors **155** to move payload **135**, sensors **155** collect force, torque and directional information regarding the intended movement of payload **135** by the operator. One or more sensors **155** may include a generic six degrees of freedom (6 DOF) system used to collect force and torque information. Alternatively, one or more sensors **155** may be a combination of customized sensors to provide a different combination of force sensing capabilities. The sensors **155** may include a gyro sensor, compass or other means to sense the intended direction of movement based on manual input from an operator. Sensors **155** are positioned on handle **150** such that when an operator grasps handle **150** in a typical manner, sensors **155** can detect and collect force, torque and directional information without further input from the operator. The collection of force, torque and directional information may therefore be accomplished in a manner substantially transparent to the operator, allowing the operator to handle and guide payload **135** in an intuitive manner and without requiring the operator to actively request assistance from controller **115**.

The information collected by sensors **155** is transmitted to a controller **115**. As arranged in FIG. **1**, the collected information is transmitted from sensing device **155** as a signal to controller **115** using a wireless transmitter **160**, which may be enabled with Bluetooth, Wi-Fi, RFID or other suitable near field communication technology for wireless transmission of the signal. Controller **115** is configured to receive a wireless signal using Bluetooth, Wi-Fi, RFID or other suitable near field communication technology compatible with the configuration of wireless transmitter **160**.

FIG. **2** shows an alternate arrangement for transmission of signals from sensing device **155**, where sensing device **155** is electrically connected to controller **115** by an electrical wire or cable or wire harness **180**. The information collected by sensor or sensors **155** is transmitted as a signal to controller **115** through wire harness **180**. Wire harness **180** may be part of tool holder **170** or may be separately routed from controller **115** to sensing device **155**. Additionally, wire harness **180** may be permanently connected to sensing device **155** or may be electrically connected to sensing device **155** through one or more connectors (not shown). Not shown, but understood by those skilled in the art, sensing device **155** may be configured to be used for both wireless and wired arrangements, such that the same sensing device could be used in the arrangement shown in FIG. **1** and the arrangement shown in FIG. **2**, where in FIG. **2** the wire harness **180** would be connected to handle **150** through one or more connectors.

Referring again to the systems of FIG. **1** and FIG. **2**, it is also anticipated that more than one sensing device **155** may be attached to a single payload **135**. Using the example where payload **135** is an automotive engine, two sensing devices **155** may be attached at either end of one side of an engine **135**, such that an operator guiding the movement of a cable suspended engine **135** can grasp both handles **150** at the same time, to provide input force to move the engine with better stability and directional control. In this arrangement, the two sensing devices **155** would transmit signals to the controller **115**, which would process the signals and provide input to one or more of the assist mechanisms **111**, **112** and hoist **120** of trolley **110** to assist the operator's horizontal and vertical movement of the engine **135**.

The method of using the cable lift system of FIG. **1** and FIG. **2** is described further herein. A payload **135** is attached to cable **125** using a payload attachment feature **130**. The payload attachment feature **130** may be attached directly to payload **135** or to a cable attachment feature **140**, as described previously. The payload is initially lifted or lowered vertically by cable **125** to the desired height required for horizontal movement by hoist **120** using methods understood by those skilled in the art. Trolley **110**, which is configured to move in a horizontal plane, is further configured with assist mechanisms, which may include one or more motors **112** and/or one or more brakes **111**. One or more of the assist mechanisms **111**, **112** and the hoist **120** may be actuated by a controller **115** to provide assistance moving cable suspended payload **135** in one or both of the horizontal and vertical planes responsive to input from sensing device **155**.

One or more sensing devices **155**, shown configured as handles in FIG. **1** and FIG. **2**, are attached to payload **135** as described previously. In the arrangement shown in FIG. **1**, an additional step may be required to register or synchronize the wireless communication between the sensors **155** and transmitter **160** of each of one or more sensing devices **155** with controller **115**, using methods understood by those skilled in the art. In arrangements where the signal is transmitted through a wired connection as described previously, an additional step may be required to connect wire or wire harness **180** to sensing device **155**, for example, through a pluggable connector or connectors or similar interface.

The operator grasps one or more handles **150** and sensing devices **155** and exerts a force on payload **135** through handles **150** to start movement of payload **135** in a desired direction. As discussed previously, sensors **155** are located on the configured handles **150** of the sensing device such that as the operator grasps the handle or handles **150** and exerts force in the desired direction to start movement of payload **135** from an at rest or static position, the sensors of sensing devices **155** collect force and direction information and send the information as a signal to controller **115**. Controller **115** receives and processes the signal and actuates one or more of the assist mechanisms of trolley **110**, which may include activating a motor or motors **112**, deactivating a brake or brakes **111**, and activating hoist **120** to move the trolley **110** and cable suspended payload **135** in a direction consistent with the input received from the operator through sensors **155**. The movement of the trolley **110** and payload **135** by one or a combination of the assist mechanisms **111**, **112** and hoist **120** substantially relieves the manual effort required from the operator to overcome the resting inertia of payload **135** and to start the movement of payload **135**.

After payload **135** has been started in motion, the operator may continue to grasp handle or handles **150** to push and direct payload **135** toward its destination or final position. Sensors of the sensing device or devices **155** continue to collect force and directional information and send this information as signals to controller **115**. Controller **115** continues to receive and process the signal and to actuate the assist mechanisms of trolley **110** to provide assistance consistent with the input received from the operator through sensors **155**, which may include continuing the movement of the payload at a relatively constant speed or accelerating the movement of the payload. In some cases, the inertia of the moving payload **135** and the configuration of the lift system **100**, **165** may be such that no incremental assistance is required from the assist mechanisms when the moving payload **135** is in continuous motion. In this case, the operator may release handle or handles **150**, which may result in a no signal condition to controller **115**, which would then result in a no assist condition at the trolley **110**.

When payload **135** is approaching its intended destination, the operator may grasp handle or handles **150** to pull on the payload **135** to slow its movement. Sensors **155** will collect the force and directional information corresponding to the operator's pulling efforts, and will send this information as signals to controller **115**. Controller **115** receives and processes the signals and actuates one or more of the assist mechanisms of trolley **110**, which may include activating a brake or brakes **111** and/or hoist **120**, deactivating and/or reversing a motor or motors **112** to slow and position the trolley **110** and cable suspended payload **135** consistent with the input received from the operator through sensors **155**. The slowing of trolley **110** and payload **135** by assist mechanisms **111**, **112** substantially relieves the manual effort required from the operator to overcome the moving inertia of payload **135** to position and slow the movement of payload **135**.

As the operator continues to grasp the handle or handles **150** to stop the payload **135** at its intended destination, the sensors **155** continue to collect force and directional information and send this information as signals to controller **115**. Controller **115** continues to receive and process the signal and to actuate the assist mechanisms of trolley **110** to provide assistance consistent with the input received from the operator through sensors **155**.

The operator may exert one of or a combination of pulling, pushing, rotating, lifting and/or lowering motions on payload **135** as payload **135** approaches its destination, to both slow and guide payload **135** into its stopped position. In this instance, the force and direction information representing the push, pull, rotate, lower and/or lift efforts of the operator will be transmitted from the sensors **155** as a signal to the controller **115**, and the controller **115** may respond by actuating one of or a combination of assist mechanisms which may include actuating at least a motor **112**, a brake **111** and the hoist mechanism **120** in a pattern responsive to signals corresponding to the operator's manual input.

When movement of payload **135** is complete, for example, when payload **135** is at its destination, is in its final assembled position or has been processed such that movement by the cable lift system **100**, **165** is no longer required, handle or handles **150** may be detached from the payload **135**. Handle **150** may also include a "return to home" input, which can be actuated to command the trolley to return, for example, to its originating location to pick up another payload or to park the trolley.

Detached handles **150** can be redeployed for attachment to a new payload. The ability to reuse sensing devices **155** and handles **150** increases the flexibility of cable lift assist systems **100**, **165** and reduces the overall operating cost of the system due to the reusability of the handle sensing devices **155** and handles **150**. Further, sensing devices **155** can be configured for multiple payload configurations, for example, by being fabricated with a pattern of bolt holes or slots that can be used to adjustably fasten a handle **150** to different sensor attachment features **145** on multiple payload types, for example, a variety of engine and transmission assemblies provided to a vehicle assembly plant.

Referring now to FIG. **3**, generally indicated at **185** is a schematic perspective view of an assisted cable lift system including wireless sensing devices or sensors **155** incorporated into or configured as sensor pads **190**. Each sensor pad **190** includes one or more sensors **155**, where the one or more sensors **155** may be fabricated, for example, using pressure sensitive conductive materials such as force sensitive resistor tape. Each sensor pad **190** is configured to transmit a wireless signal to controller **115**, where the signal is derived from force and direction information collected based on operator input into sensor pads **190**. Sensor pad **190** may be attached to payload **135** by any suitable means appropriate to the payload. For example, sensor pad **190** may have an adhesive backing such that sensor pad **190** can be adhesively placed on one or more surfaces of payload **135**. The adhesive may be a non-permanent adhesive; to facilitate removal of sensor pad **190** from payload. Other attachment means known to those skilled in the art may also be employed, for example, the use of hook and barb type fasteners or magnetic fastening elements, which may also allow for removal and reuse of sensor pads **190**.

Sensor pads **190** are optimally placed on surface locations of payload **135** that would typically be contacted by an operator in a non-assisted lift system, so that the operator interface with payload **135** is substantially unchanged with use of an assisted lift system, and operator input can be collected in a manner which is substantially transparent to the operator, e.g., the operator's intuitive pushing, pulling, rotating, lifting and/or lowering locations and points of contact will coincide with the placement of sensor pads **190** on payload **135**.

The method of using the cable lift system of FIG. **3** is similar to the method of use described for the cable lift system of FIGS. **1** and **2**. After positioning one or more sensor pads **190** on payload **135**, sensor pads **190** are synchronized with controller **115** by registering or synchronizing each pad **190** with controller **115** for the payload movement cycle. As described previously for FIG. **1**, sensor pad or pads **190** may be attached to payload **135** as part of the process of attaching payload **135** to cable system **185**, or sensor pad or pads **190** may be attached to payload **135** at an earlier time, for example, by the supplier of payload **135**.

As described previously for FIGS. **1** and **2**, an operator using the horizontally assisted cable lift system **185** of FIG. **3** will exert an effort against payload **135** by pressing against the one or more sensor pads **190** to start movement of payload **135** in a desired direction. As the operator presses against sensor pads **190** and exerts force in the desired direction to start movement of payload **135** from an at rest or static position, the sensor pads **190** collect force and direction information and send the information as a signal to controller **115**. Controller **115** receives and processes the signal and actuates the assist mechanisms of trolley **110**, which may include one of or a combination of activating a hoist **120**, activating motor or motors **112**, and deactivating a brake or brakes **111** to move the trolley **110** and cable suspended payload **135** in a direction consistent with the input received from the operator through sensor pads **190**. The movement of the trolley **110** and payload **135** by assist mechanisms **112** substantially relieves the manual effort required from the operator to overcome the resting inertia of payload **135** and to start the movement of payload **135**.

After payload **135** has been started in motion, the operator may continue to press on sensor pad or pads **190** to push and direct payload **135** toward its destination or final position. Sensor pads **190** continue to collect force and directional information and send this information as signals to controller **115**. Controller **115** continues to receive and process the signals and to actuate the assist mechanisms of trolley **110** to provide assistance consistent with the input received from the operator through sensor pads **190**. In some cases, the inertia of the moving payload **135** and the configuration of the lift system **185** may be such that no incremental assistance is required from the assist mechanisms when the moving payload **135** is in continuous motion. In this case, the operator may cease to press against sensor pads **190**, which may result in a no signal condition to controller **115**, which would then result in a no assist condition at the trolley.

When payload **135** is approaching its intended destination, the operator may push against sensor pads **190** on payload **135** to slow its movement. Sensor pads **190** will collect the force and directional information corresponding to the operator's pushing efforts, and will send this information as signals to controller **115**. Controller **115** receives and processes the signals and actuates one or a combination of the assist mechanisms of trolley **110**, which may include activating a hoist **120**, activating a brake or brakes **111**, and/or deactivating or reversing a motor or motors **112** to slow and position the trolley **110** and to affect the movement of cable suspended payload **135** consistent with the input received from the operator through sensor pads **190**. The slowing and positioning of trolley **110** and payload **135** by assist mechanisms **111**, **112** and hoist **120** substantially relieves the manual effort required from the operator to overcome the moving inertia of payload **135** and slow the movement of payload **135**.

As the operator continues to push against sensor pads **190** to stop the payload **135** at its intended destination, the sensor pads **190** continue to collect force and directional information and send this information as signals to controller **115**. Controller **115** continues to receive and process the signal and to actuate the assist mechanisms of trolley **110** to provide assistance consistent with the input received from the operator through sensors **155**, which may include actuating a combination of assist mechanisms which may include activating and deactivating at least one motor **112** and one brake **111** and hoist mechanism **120** in a pattern responsive to signals received representing the operator's manual input.

When movement of payload **135** is complete, for example, when payload **135** is at its intended destination, or is in its final assembled position or has been processed such that movement by the cable lift system **185** is no longer required, sensor pads **190** may be detached from the payload **135**. The sensor pad **190** may also include a "return to home" input, which can be actuated to command the trolley to return to, for example, its originating location to pick up another payload or to park the trolley.

Removable sensor pads **190** may be redeployed after removal for attachment to a new payload. The ability to reuse the sensor pads **190** increases the flexibility of the cable lift assist system **185** and may reduce the overall operating cost of the system due to the reusability of the sensor pads **190**.

Further, sensing devices such as sensor pads **190** can be configured for multiple payload configurations, for example, by being fabricated in a shape that can be fastened to a variety of engine and transmission assemblies provided to a vehicle assembly plant. Alternatively, one or more of the sensor pads **190** may remain on payload **135** permanently, for example, where installation of payload **135** into an larger assembly precludes access after installation to remove sensor pad **190** or where removal and reuse of the sensor pad **190** is not economically advantageous and the presence of sensor pad **190** is non-detrimental to payload **135**. In this instance, sensor pad **190** can be considered disposable. Further, use of sensor pads **190** may be advantageous with payloads and scenarios which are not compatible with a handled sensing device **155**, for example, the movement and stacking of granite slabs or glass sheets, where handles **150** may interfere with or reduce the efficiency of a stacked storage arrangement.

Referring now to FIG. **4**, generally indicated at **195** is a schematic perspective view of a multi-operator horizontally assisted cable lift system including detachable wireless sensing devices. The payload **200** shown in FIG. **4** is of sufficient size and configuration such that when payload **200** is suspended by cable **125**, it is anticipated that the movement of payload **200** will require the coordinated input of more than one operator, with the number of operators determined as appropriate to move the particular payload size and configuration. For purposes of illustration, the multi-operator cable lift system **195** will be described using an example of three operators. The wireless sensing devices **155** shown in FIG. **4** are of the previously described handle type **150**, however the wireless sensing devices **155** could also be of the previously described sensor pad type **190** within the scope of the claimed invention.

As shown in FIG. **4**, three pairs of sensing handles **150** have been operatively attached to payload **200** at locations identified in circles as L, **1** and **2**. Locations L, **1** and **2** correspond with the location of a lead operator (L), a first operator (**1**) and a second operator (**2**), where each operator will exert force on payload **200** through one or both handles **150** at the operator's location. As described previously, handles **150** are attached to payload **200**, and registered with controller **115**. Controller **115** will recognize signals from handles **150** used by the lead operator (L) as the lead (L) signals; signals from handles **150** used by the first operator (**1**) as signals from location (**1**); and signals from handles used by the second operator (**2**) as signals from location (**2**).

When payload **200** is moved by the multiple operators (L), (**1**) and (**2**), controller **115** receives input from one or more sensing devices **155** incorporated into handles **150**. The controller **115** processes the received signals according to a predetermined program which may be, for example, a control algorithm. Those skilled in the art would recognize the control algorithm would be developed based on the configuration of the sensing devices for a particular application and payload, the number of operators, etc., using known methods for control algorithm development. The control algorithm is designed to prioritize the input signal from the lead operator (L) handle or handles **150** and accept and process input signals from handles **150** used by operators (**1**) and (**2**) only when these input signals are not conflicting with input signals received from the lead operator (L) handles **150**.

The system of FIG. **4** may be further configured to change the lead operator role from the operator (L) to either of the operators at locations (**1**) or (**2**). In this scenario, one of the operators at location (**1**) or (**2**) may request to be the new lead operator. The current lead operator (L) confirms the role change to controller **115**, and controller **115** begins processing signals from the new lead operator location as the lead (L) signals. Concurrently with a change in the lead role or location, the controller **115** may place the trolley **110**, assist mechanisms **111**, **112** and hoist mechanism **120** in a safe state. Additionally, the cable lift system **195** may include a status light system or other indicator system to identify the operator location which is confirmed as the lead role at any point in time, especially in situations where the size or configuration of the payload **200** inhibits the visibility of one or more operators from another operator.

While the best modes for carrying out the invention have been described in detail, those familiar with the art to which this invention relates will recognize various alternative designs and embodiments for practicing the invention within the scope of the appended claims.

The invention claimed is:

1. A handling system configured to provide assistance, including horizontal assistance, to an operator manually moving a payload which is flexibly suspended, comprising:

a trolley adapted to assist manual movement of the payload by the operator in at least one of a horizontal plane and a vertical plane;

a flexible suspension device configured to operatively attach to a trolley at a first end and to the payload at the second end;

a sensing device attachable to the payload and configured to be contacted by the operator during manual movement of the payload by the operator;

wherein the sensing device is configured:

to sense a force input and directional information corresponding to the manual movement of the payload by the operator in contact with the sensing device; and

to transmit a signal responsive to the force input and the direction information;

a controller configured to receive and process the signal from the sensing device and provide input to the trolley; and

wherein the trolley is adapted to assist manual movement of the payload by the operator in response to the input from the controller.

2. The handling system of claim **1**, wherein manual movement of the payload by the operator in at least one of a horizontal plane and a vertical plane includes at least one of a starting, accelerating, continuing, slowing, stopping, lifting, lowering, tilting, angling and rotating movement of the payload.

3. The handling system of claim **1**, wherein the sensing device is further detachable and/or disposable from the payload after movement of the payload by the handling system is completed.

4. The handling system of claim **1**, wherein the sensing device is further configured to remain attached to the payload after movement of the payload by the handling system is completed.

5. The handling system of claim **1**, wherein the signal is configured as a wireless signal.

6. The handling system of claim **1**, further comprising:

a handle;

wherein the sensing device is incorporated into the handle; and

wherein the handle is operatively attachable to the payload, and is configured for operator use to guide the manual movement of the payload by the operator.

7. The handling system of claim **1**, further comprising:

a sensor pad;

wherein the sensing device is incorporated into the sensing pad; and

wherein the sensor pad is attachable to the payload in a configuration such that the sensor pad is contacted by the operator during manual movement of the payload by the operator.

8. The handling system of claim **1**, further comprising at least one brake to assist movement.

9. The handling system of claim **1**, further comprising at least one motor to assist movement.

10. The handling system of claim **1**, wherein the controller is configured to provide input to move the trolley to a predetermined location.

11. The handling system of claim **1**, further comprising:

a plurality of sensing devices, wherein each of the plurality of sensing devices is configured to transmit a respective signal to provide a plurality of signals;

wherein each of the respective signals is assignable to a corresponding respective one of the plurality of sensing devices by the controller; and

wherein the controller is further configured to receive and process the plurality of signals and provide input to the trolley.

12. The handling system of claim **11**, further comprising:

wherein the controller is further configured to process the plurality of signals from the plurality of sensing devices using an algorithm;

wherein the plurality of sensing devices includes a first sensing device configured to transmit a first signal and at least a second sensing device configured to transmit a second signal;

wherein the controller is configured to dynamically and exclusively assign one of the first and at least second signals as the lead signal;

wherein the controller is configured to dynamically and exclusively assign the other of the first and at least second signals as the lead signal; and

wherein the lead signal is identifiable by the controller and prioritized by the algorithm.

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