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(54) APPARATUS AND METHODS FOR PROVIDING A RETRACTABLE MAST

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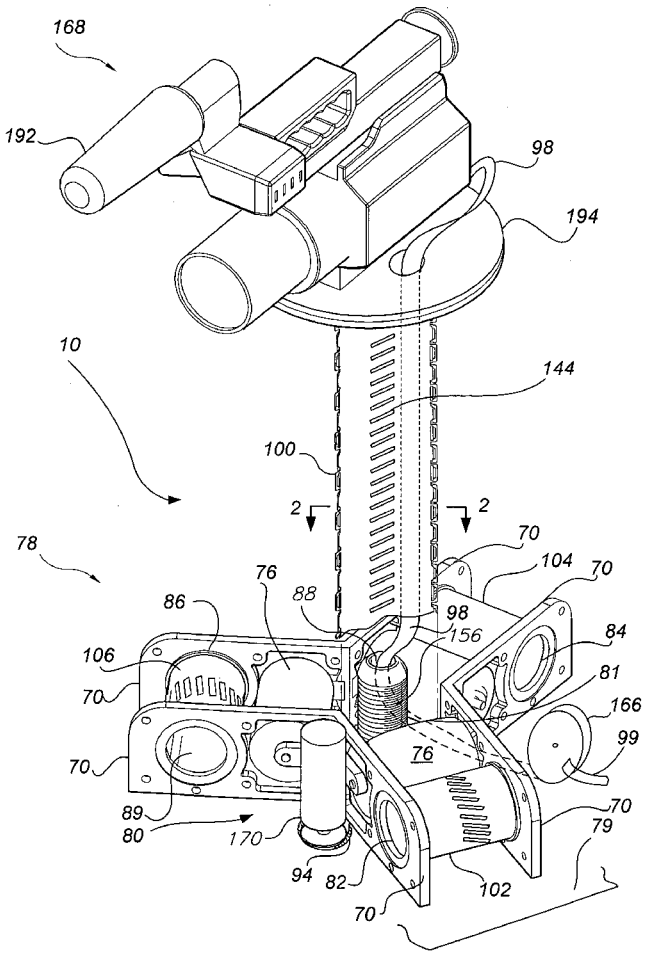
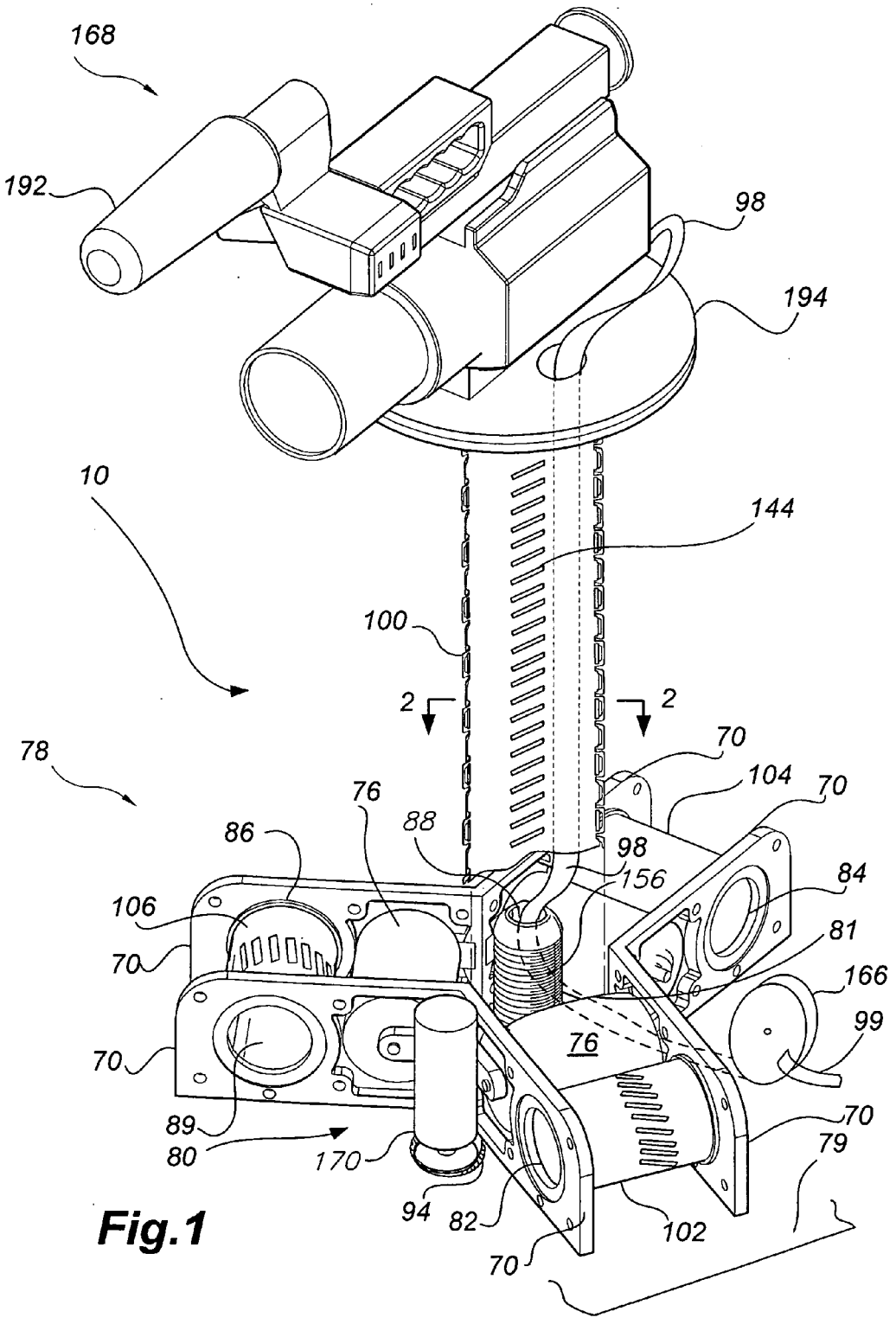
(57) **ABSTRACT**

Apparatus and methods for raising a retractable mast comprise engaging at least three flat flexible strips such that each strip forms a side of a mast. Each strip comprises a set of tabs and slots disposed along opposite edges of the strips. The housing may further comprise a feed mechanism operable to interlock the at least three lengths of flexible strips by drawing the strips together causing each tab of each strip to engage with a slot of an adjacent flexible strip. In addition, the apparatus may comprise a controller module operable to control extending and retracting the mast. The apparatus may be incorporated in a robotic device operable to travel in at least a horizontal plane and extend the retractable mast.




168
192
98
194
10
144
100
2
2
78
70
104
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76
88
86
98
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70
166
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99
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89
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170
94
82
102
79
70

Fig.1

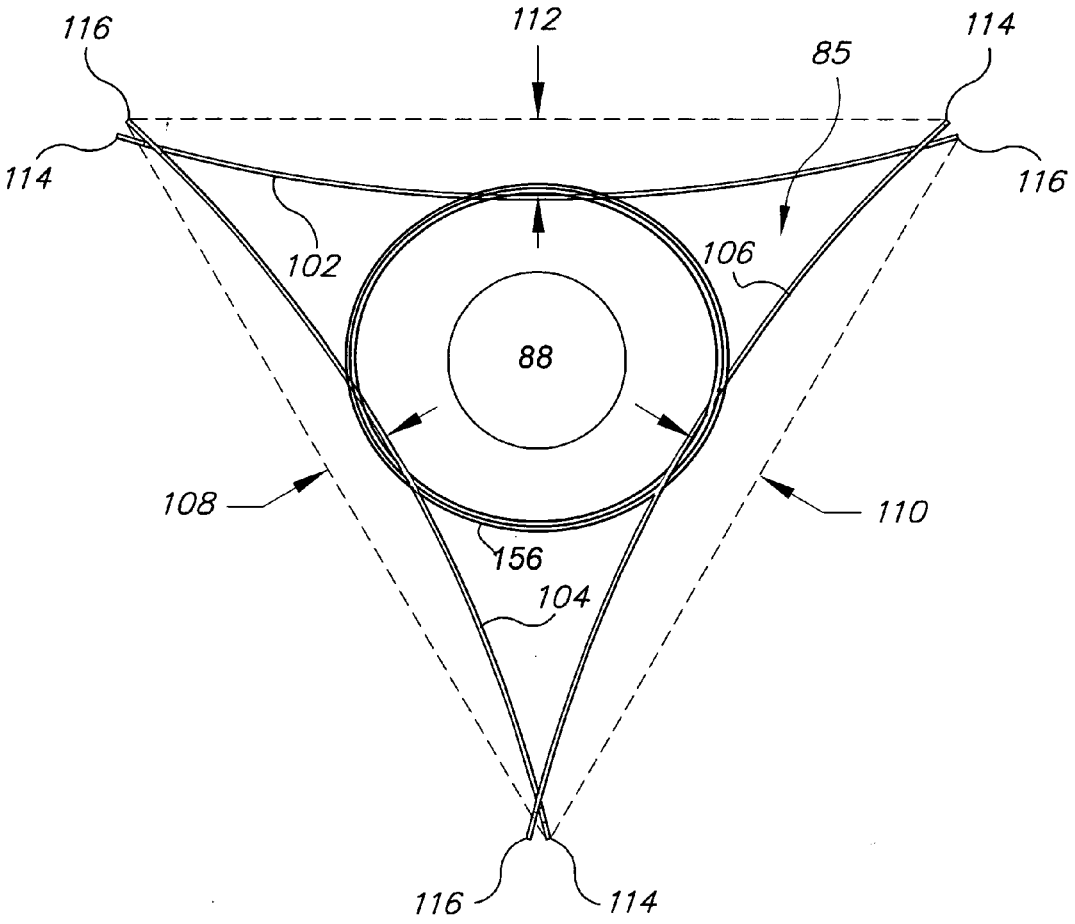

Fig. 2

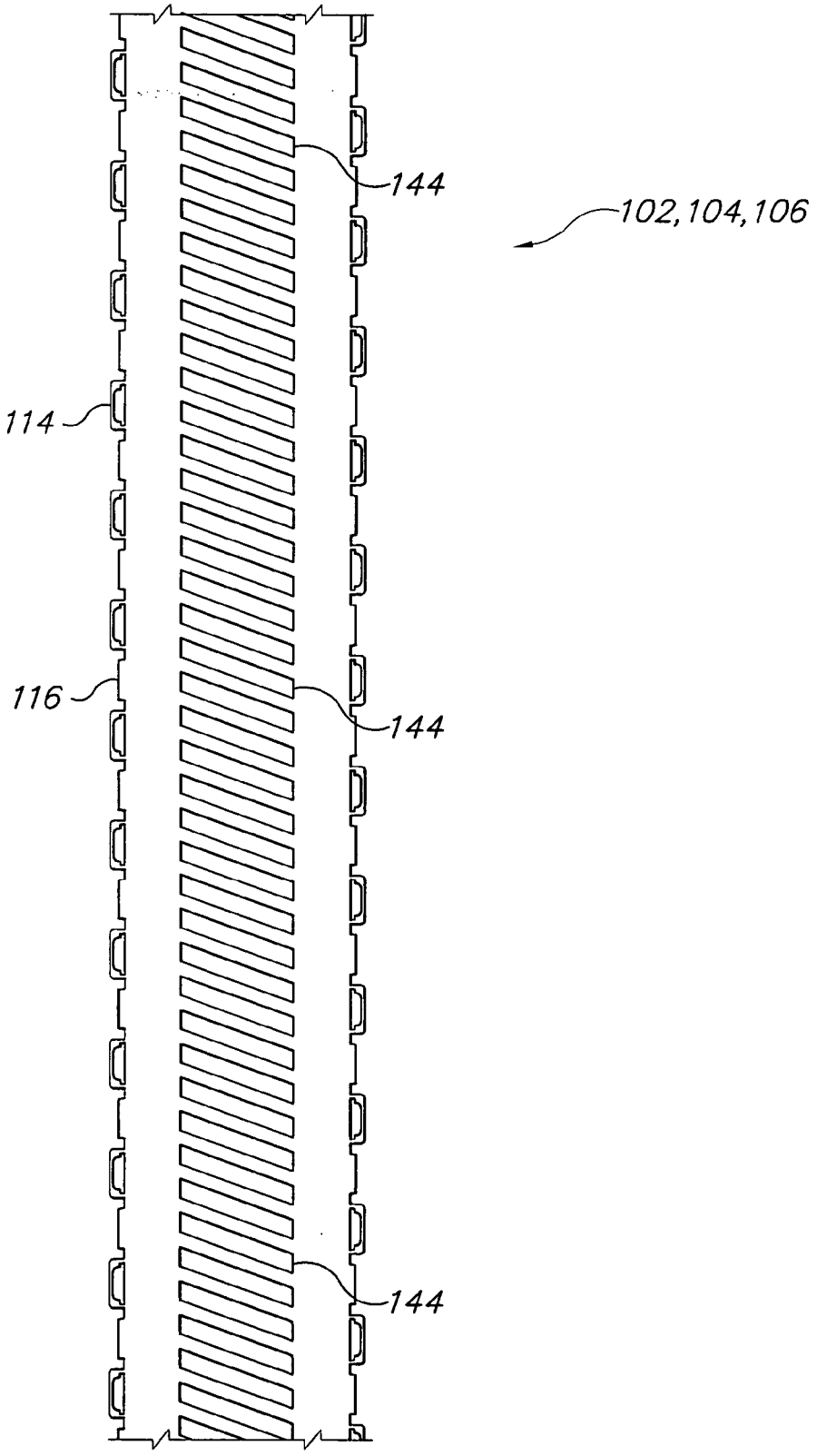

Fig. 3

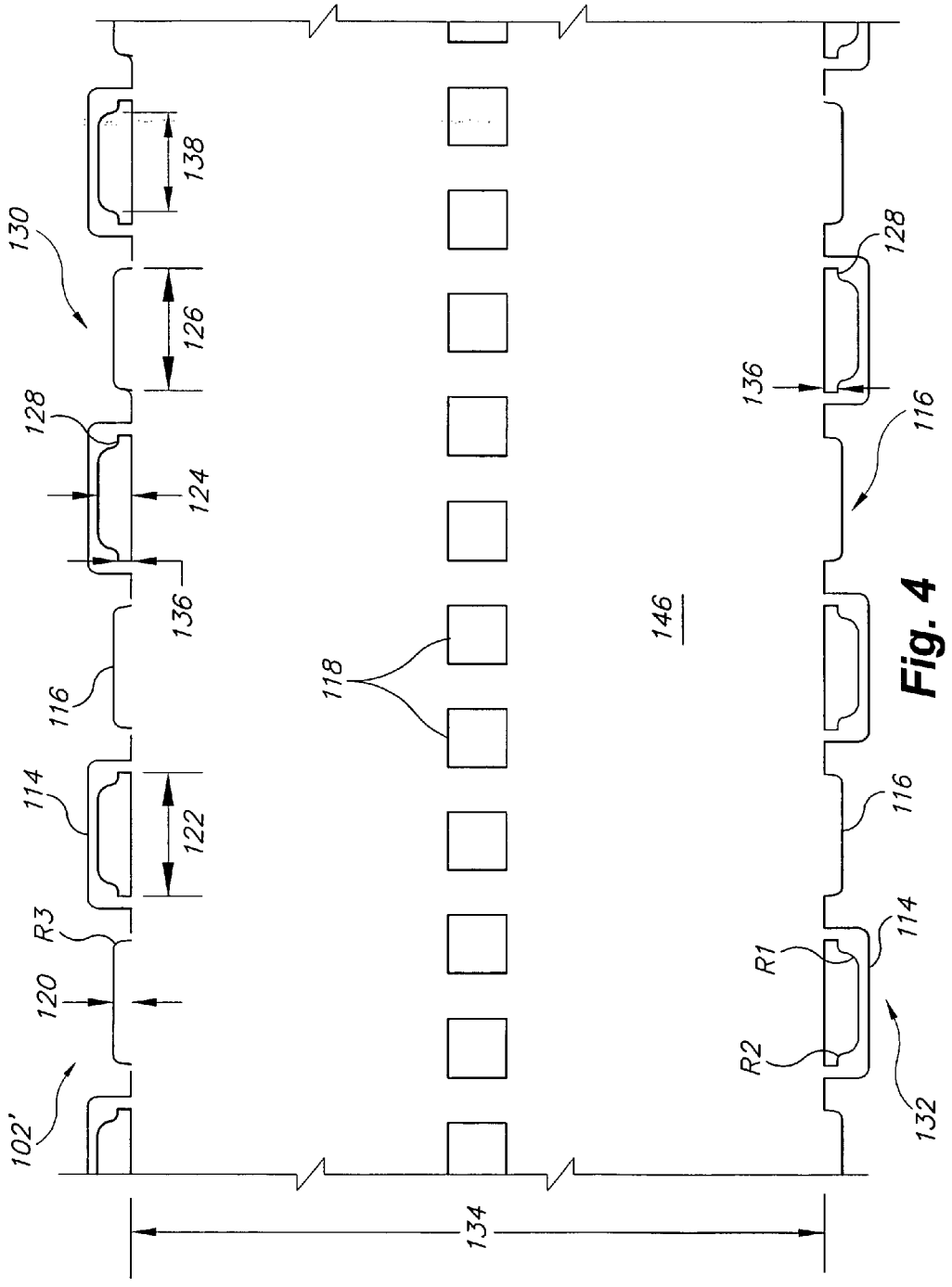
138
130
126
128
124
136
116
118
114
122
R3
120
102'
146
128
136
116
116
114
R1
R2
132
134

Fig. 4

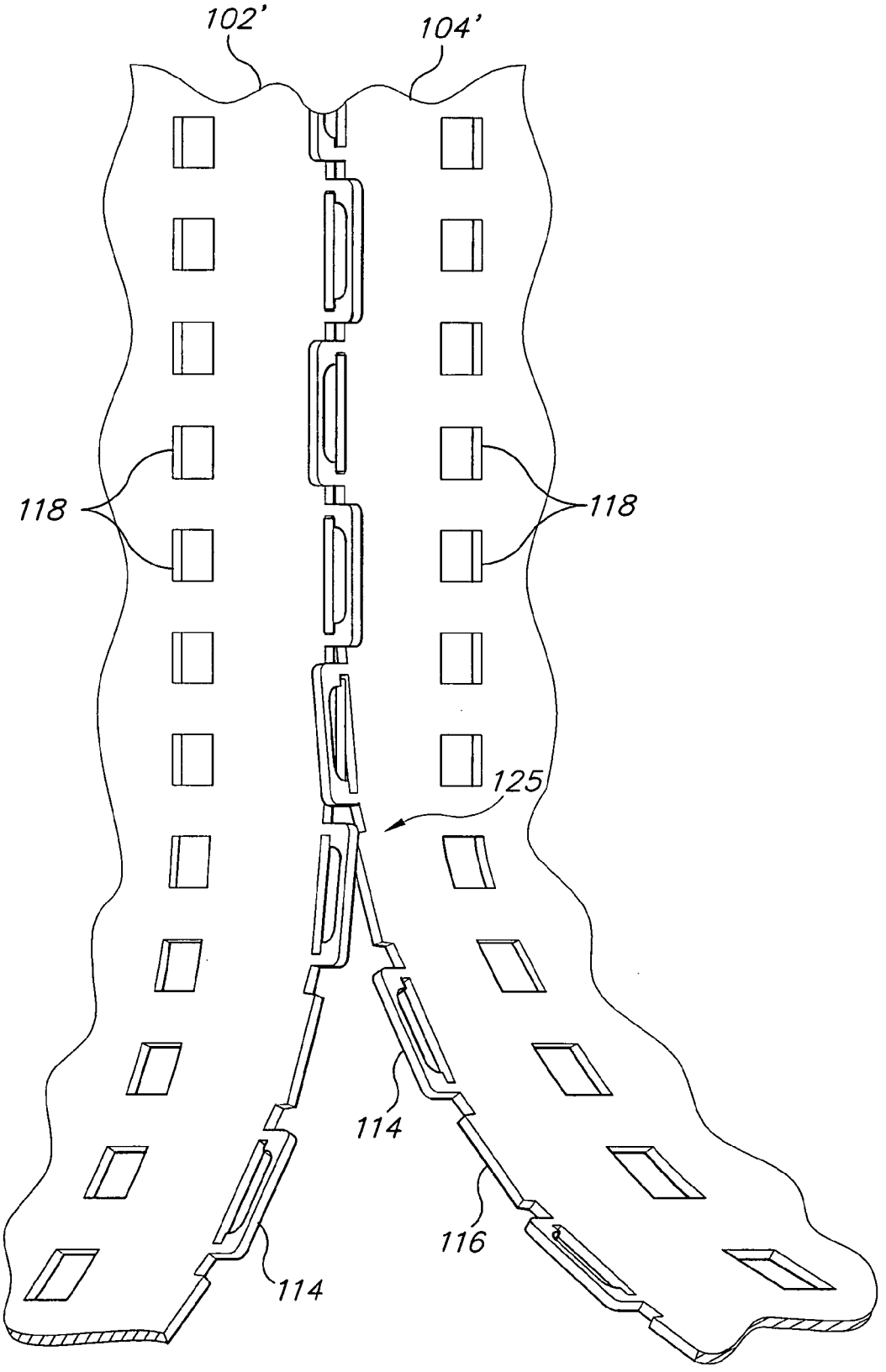

Fig. 5

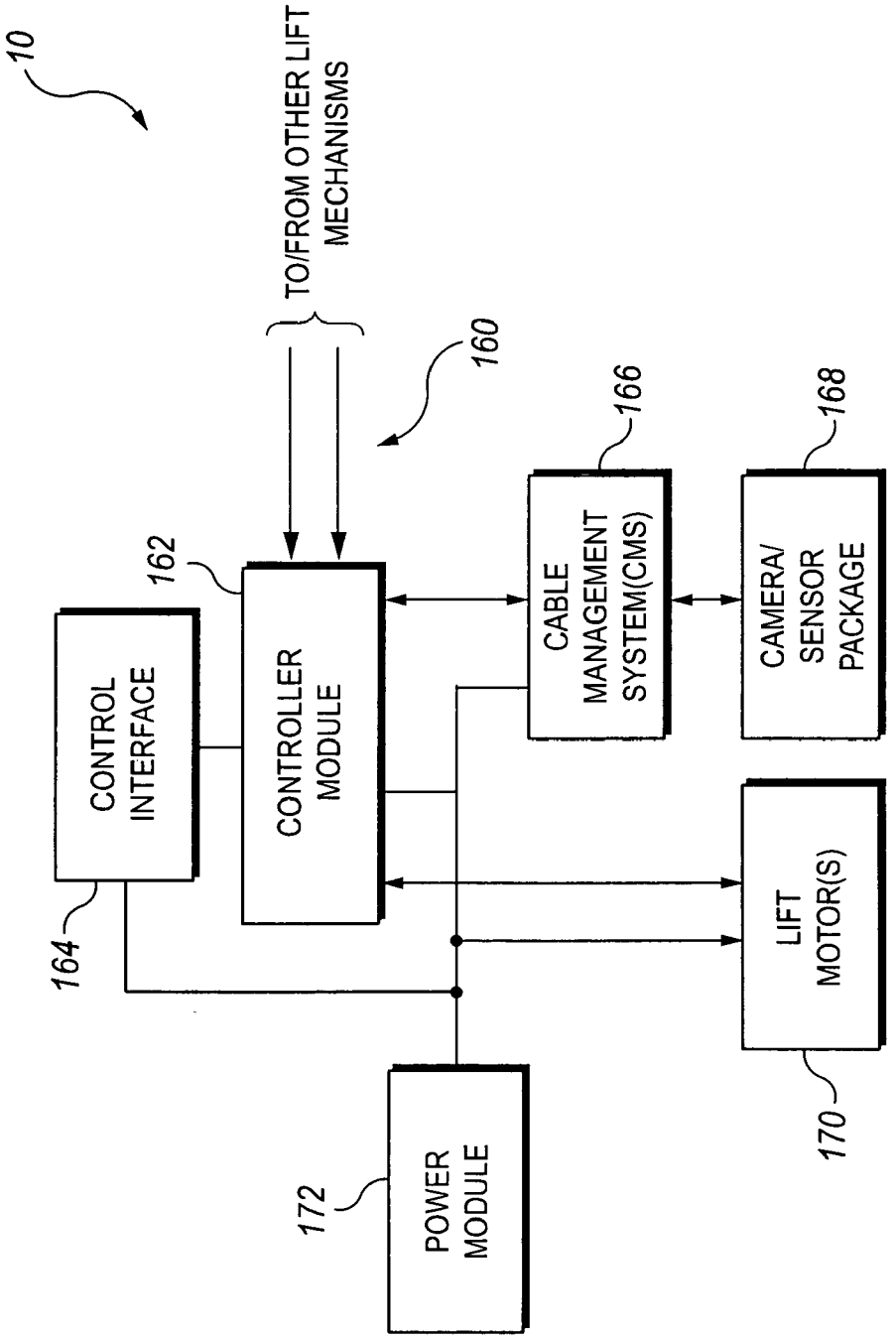
10
TO/FROM OTHER LIFT MECHANISMS
160
162
166
168
CONTROL INTERFACE
CONTROLLER MODULE
CABLE MANAGEMENT SYSTEM(CMS)
CAMERA/ SENSOR PACKAGE
LIFT MOTOR(S)
164
170
172
POWER MODULE

Fig. 6

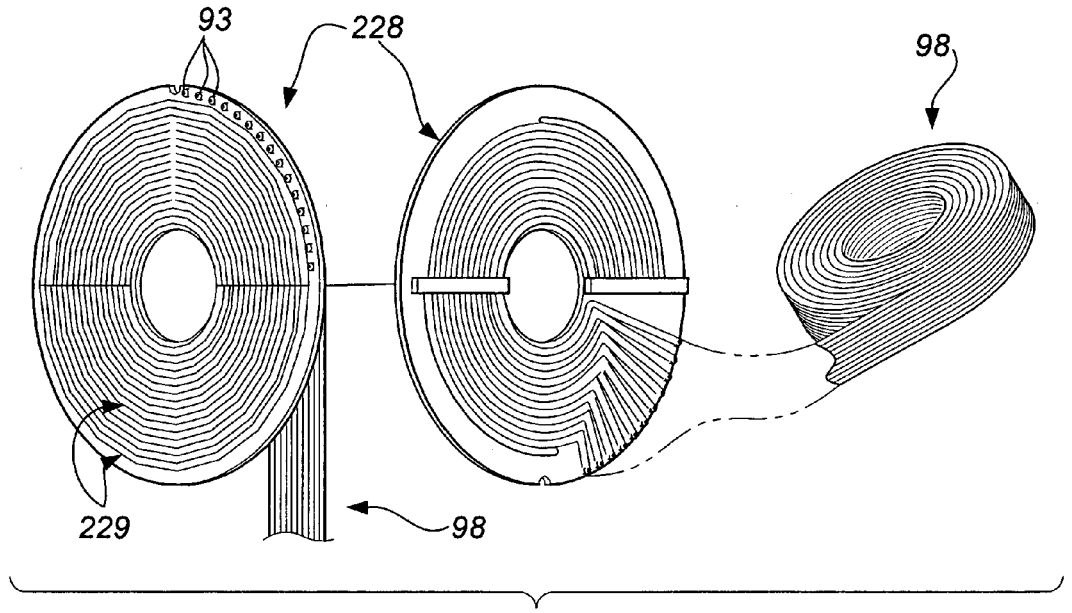

Fig. 7A

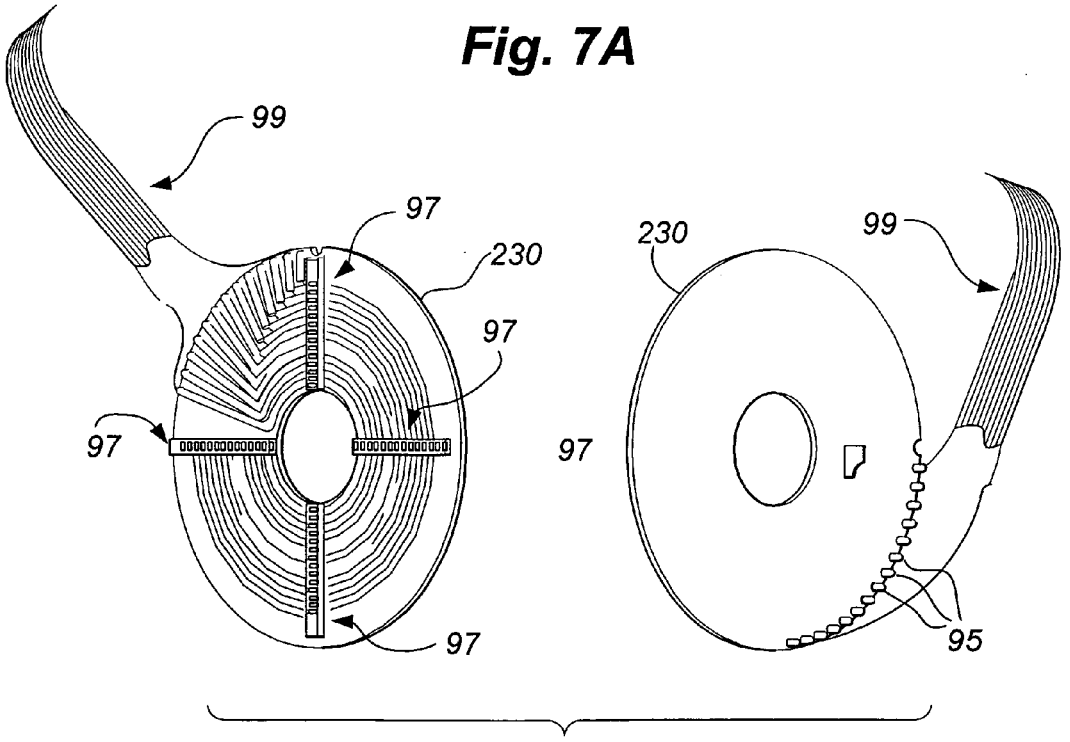

Fig. 7b

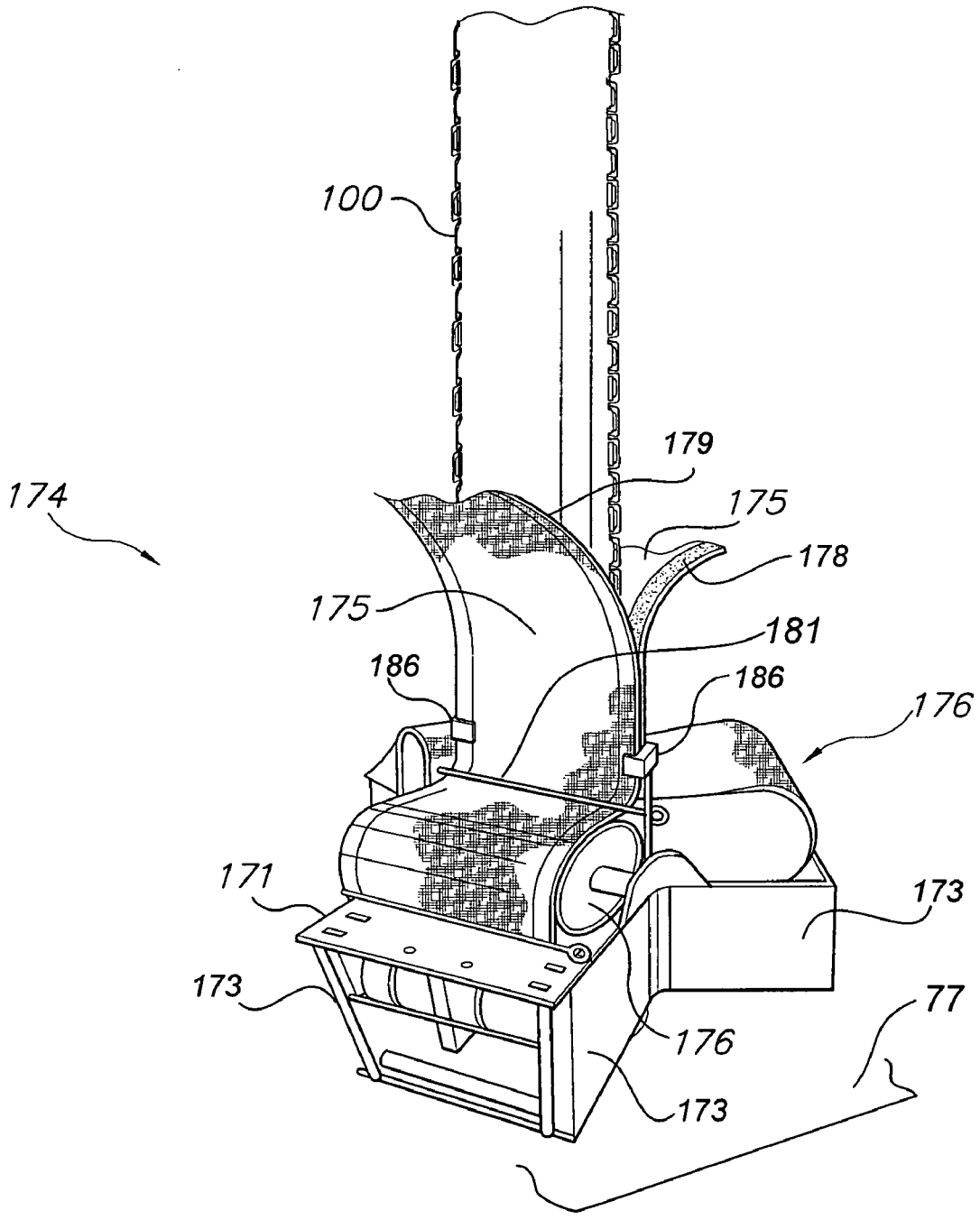

Fig. 8

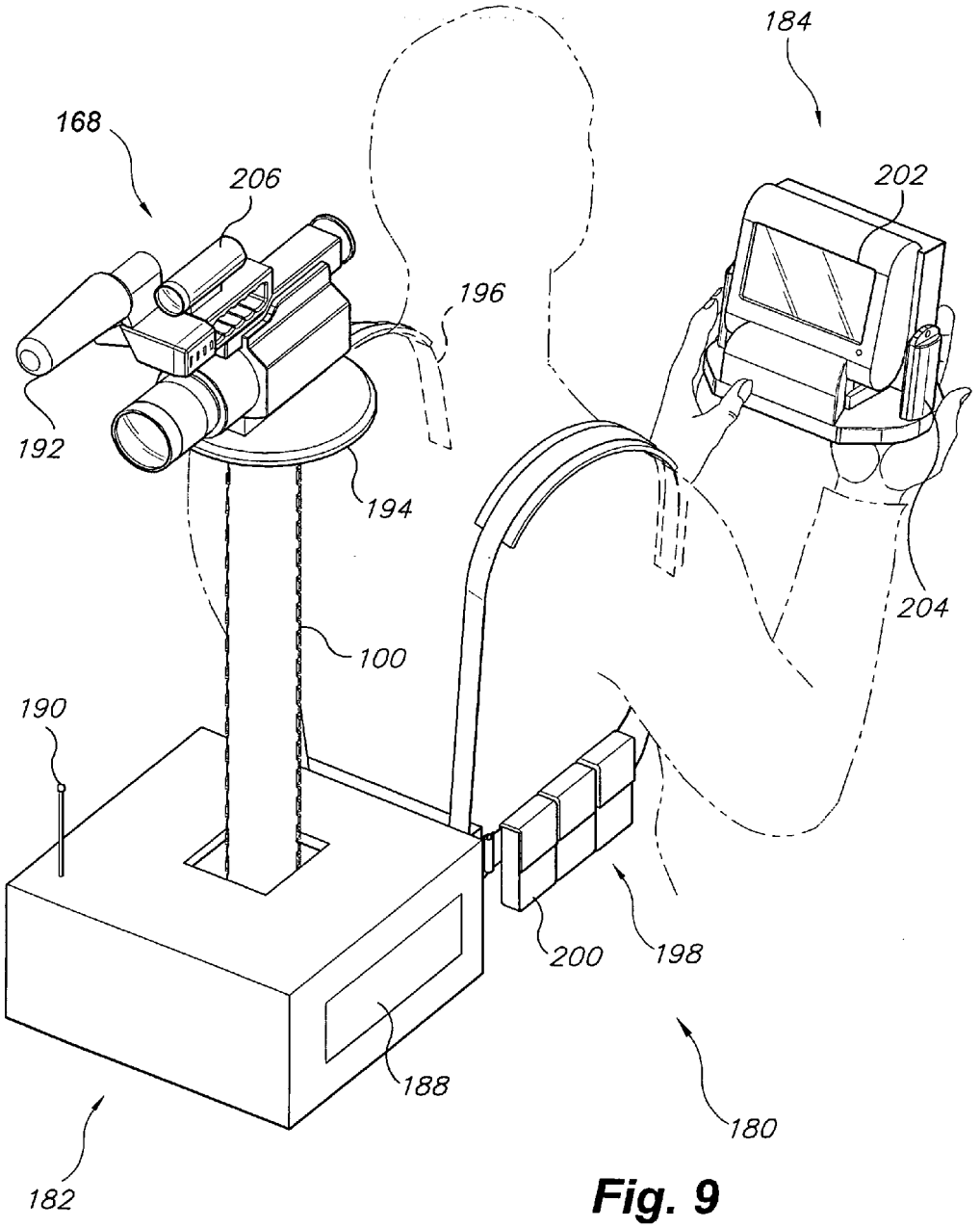

Fig. 9

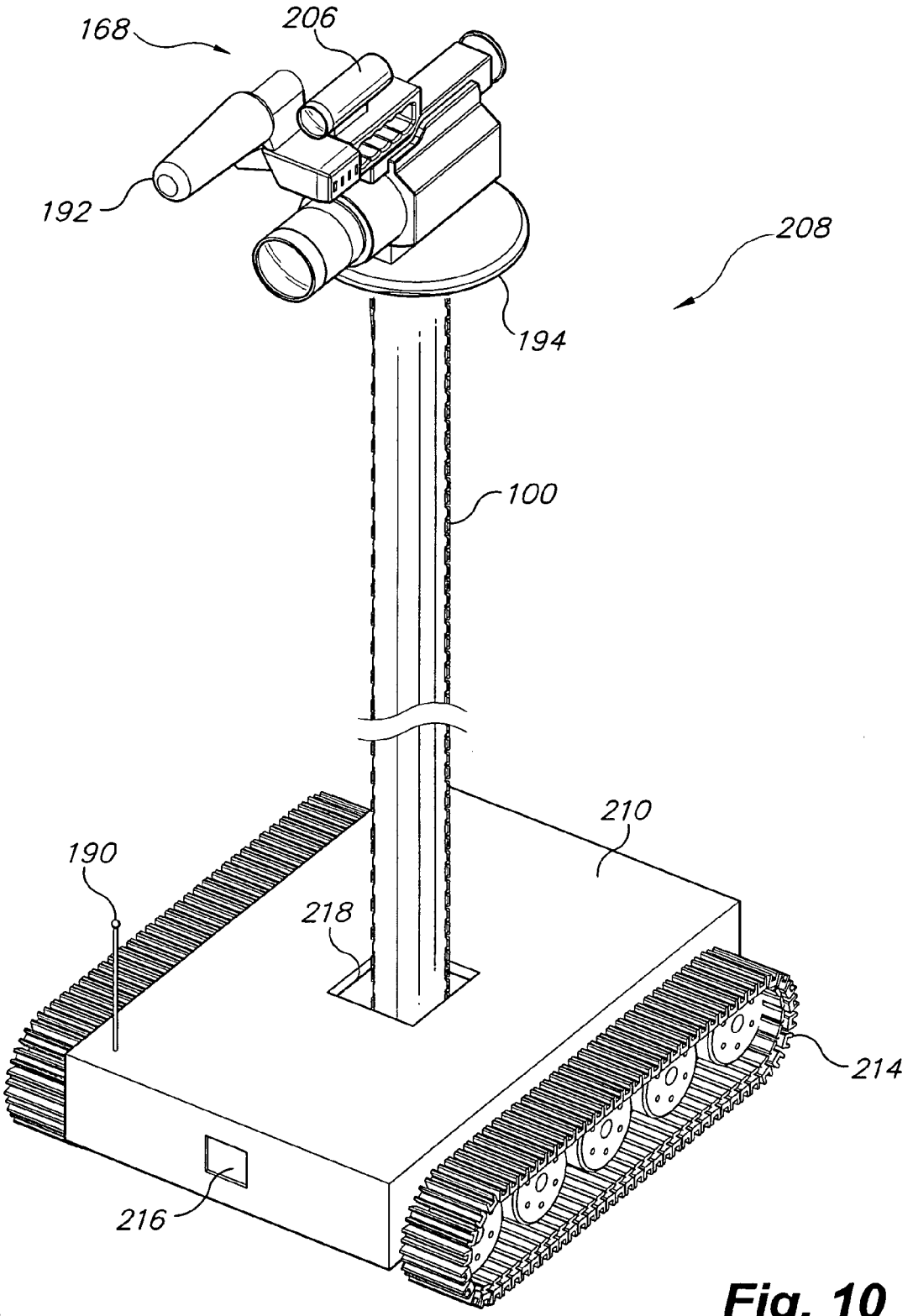

Fig. 10

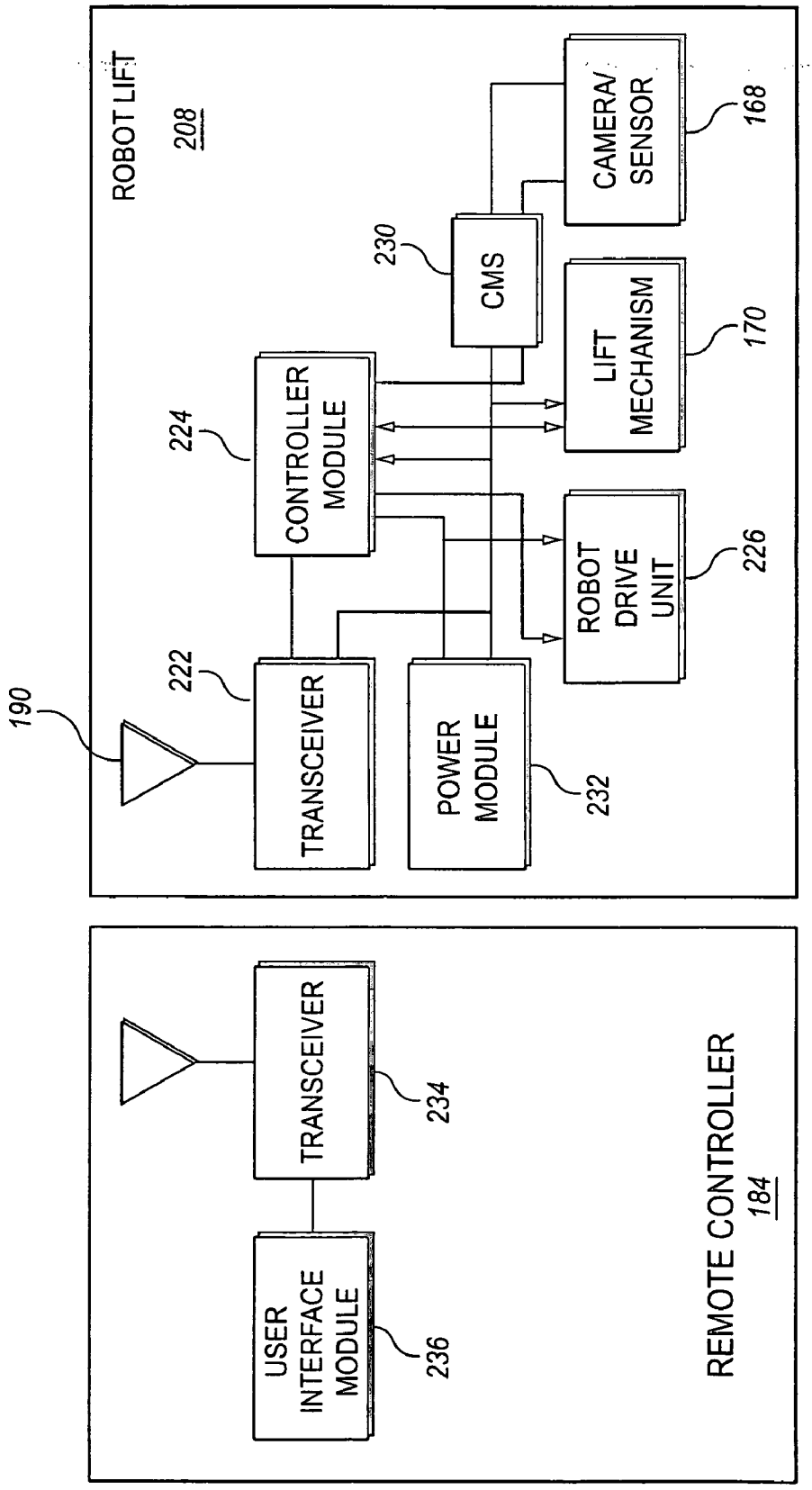
ROBOT LIFT
208
CAMERA/ SENSOR
168
230
CMS
LIFT MECHANISM
170
224
CONTROLLER MODULE
ROBOT DRIVE UNIT
226
190
222
TRANSCEIVER
POWER MODULE
232
TRANSCEIVER
234
USER INTERFACE MODULE
236
REMOTE CONTROLLER
184

Fig. 11

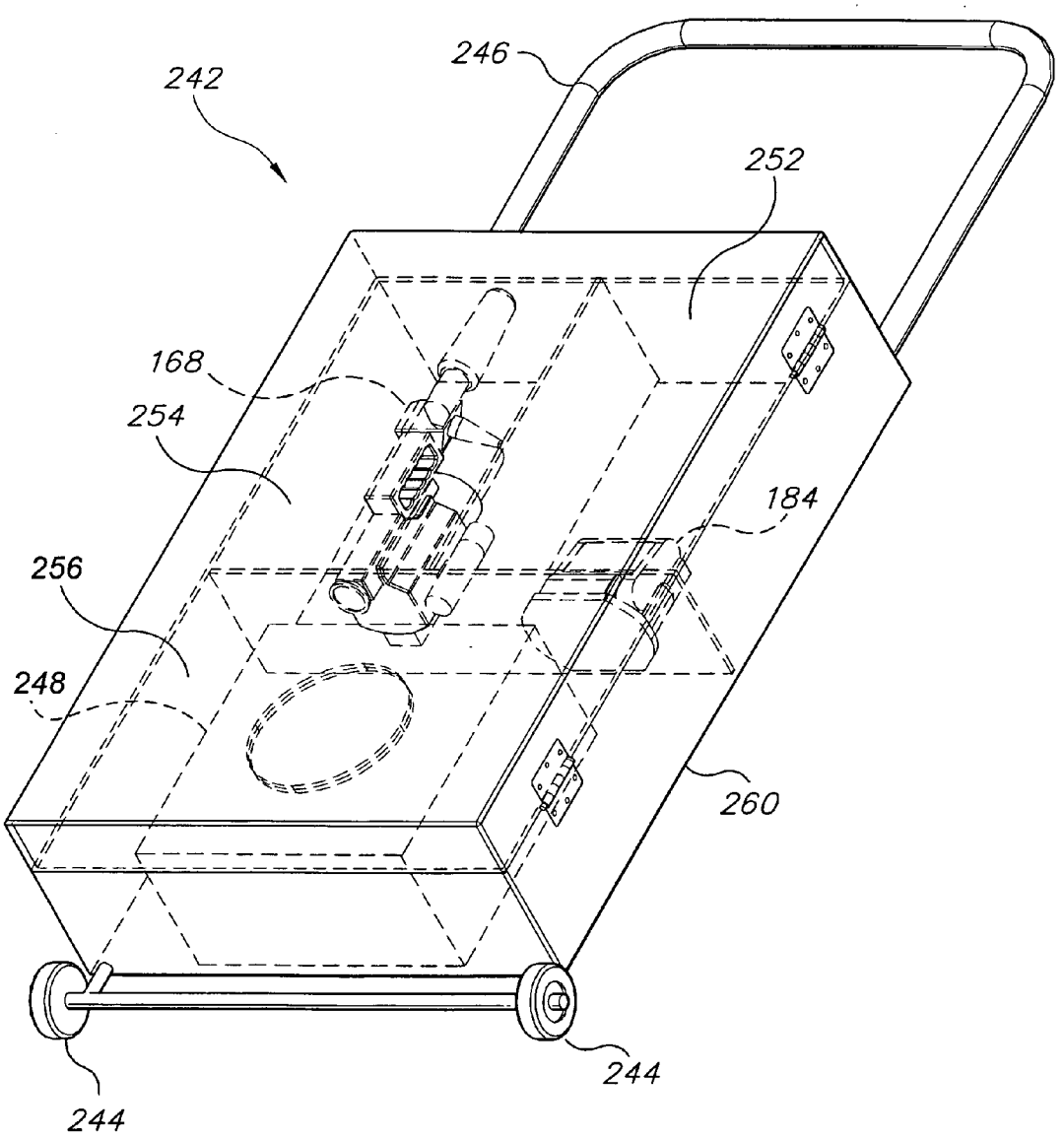

Fig. 12A

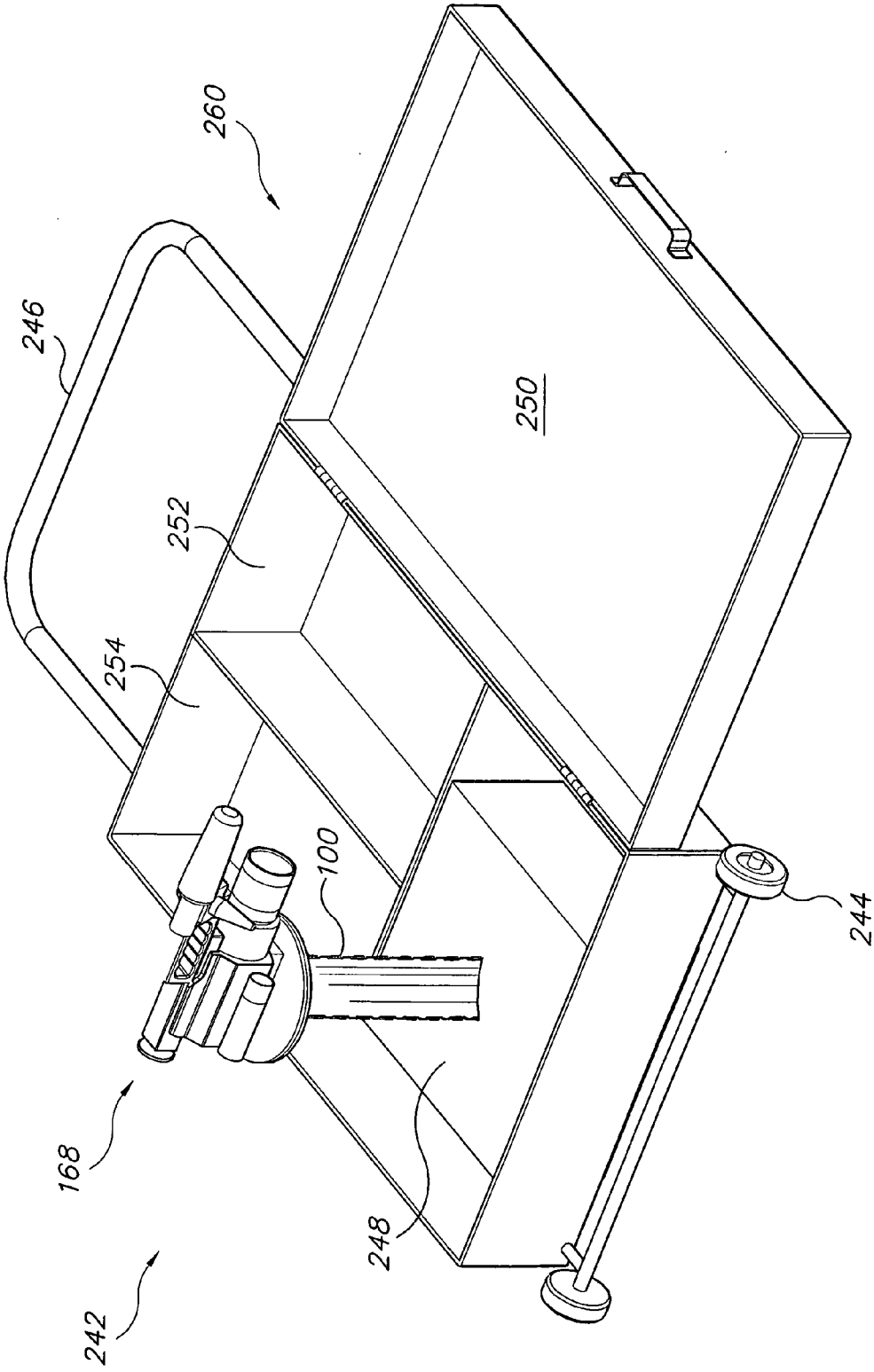

Fig. 12B

APPARATUS AND METHODS FOR PROVIDING A RETRACTABLE MAST

CLAIM OF PRIORITY UNDER 35 U.S.C. §119

[0001] The present Application for Patent claims priority to U.S. Provisional Application No. 60/674,345 entitled "Autonomous or Controlled Robot for Undervehicle Inspection" filed Apr. 19, 2005, U.S. Provisional Application No. 60/674,346 entitled "Sensor/Camera Back Pack Lift" filed Apr. 19, 2005, and U.S. Provisional Application No. 60/755,054 entitled "Zipper Mast Lift" filed Dec. 30, 2005, assigned to the assignee hereof and hereby expressly incorporated by reference herein.

TECHNICAL FIELD

[0002] The disclosed embodiments relate to lift mechanisms, and more particularly, to apparatus and methods for forming a retractable rigid mast.

[0003] Lift mechanism technology includes, but is not limited to, hydraulic, pneumatic, and link type structures that may be combined together to form a rigid structure.

BACKGROUND

[0004] Extendable masts have seen applications in both the commercial and military markets. For example, electronic packages mounted atop retractable masts include communication and sensor devices, i.e., antennas, cameras and microphones, for collecting sensory data and/or transmitting the collected data to a remote location.

[0005] Various mast designs with interlocking webs are known. However the designs of previous interlocking mechanisms have generally required specialized manufacturing processes and manual adjustment by persons of specialized knowledge of the design both during the manufacturing process and during the operation of the lift mechanism, to ensure proper registration of the components forming the mast.

[0006] Because of the nature of the mast, structural integrity of the mast may be critically diminished due to the failure of a relatively small number of interlocking segments. Furthermore, even small registration errors may cause the mast to bind during formation resulting in a failure to raise the mast. Ensuring proper registration without human intervention is critical in remote use application wherein an operator may not be available to ensure that the pieces of the mast interlock correctly.

[0007] Furthermore, previous designs may not have used identical mast components utilizing repeating patterns of interlocking mechanisms to ensure accurate registration of adjacent mast elements. Although slight deviations may not be sufficient to prevent the mast from being formed, even small variations may cause the mast to twist, resulting in instability and an inability to accurately determine a direction in which a device at the top of the mast is pointed.

[0008] As the deployment of mobile surveillance and communication systems increases, a lightweight, portable, mobile, and reliable retractable platform support systems may be desirable.

BRIEF SUMMARY

[0009] In one aspect, a method operable for raising a retractable mast comprises engaging at least three flexible strips such that each strip forms a side of a mast. Each strip further comprises a first edge portion, a second edge portion and a body there between, whereby a set tabs and slots disposed along opposite edges of each of the at least three flexible strips engage opposing slots and tabs disposed on the edge portions of adjacent flexible strips.

[0010] An apparatus for forming a retractable mast may include a support structure for support at least three lengths of flat flexible strips stored on spools. Each flexible strip may include a first planar surface substantially parallel to a second planar surface, a first edge portion, a second edge portion, and a body there between. Disposed along the lengths of opposing first and second edge portions is a plurality of tabs and slots preferably disposed in a repeating pattern.

[0011] In addition, the housing may further comprise a feed mechanism operable to interlock the at least three lengths of flexible strips by drawing the at least three strip together causing each tab of each of the at least three flexible strips to engage with a slot of an adjacent flexible strip.

[0012] Furthermore, the apparatus may comprise a controller module operable to control extending and retracting the mast.

[0013] Another aspect of the apparatus may include a robot device comprising a housing further comprising a transport mechanism operable to propel the housing along a surface and a lift mechanism operable to form a retractable mast.

[0014] The robotic lift mechanism may include at least three lengths of flat flexible strips, a feed mechanism operable to draw the flexible strips together and form the retractable mast. In addition, the housing may include a controller module operable to control an operation of the transport mechanism and the lift mechanism.

[0015] For efficiency in the manufacturing process, the strips forming the mast should be identical and the pattern of slots and tabs disposed on both edges of the strip should be repeating.

[0016] Additional aspects and advantages of the disclosed embodiments are set forth in part in the description which follows, and in part are obvious from the description, or may be learned by practice of the disclosed embodiments. The aspects and advantages of the disclosed embodiments may also be realized and attained by the means of the instrumentalities and combinations particularly pointed out in the appended claims.

BRIEF DESCRIPTION OF THE DRAWINGS

[0017] The disclosed embodiments will hereinafter be described in conjunction with the appended drawings provided to illustrate and not to limit the disclosed embodiments, wherein like designations denote like elements, and in which:

[0018] **FIG. 1** is a perspective drawing of a lift mechanism forming a retractable mast from a set of flexible strips;

[0019] **FIG. 2** is a view taken along lines **2-2** of **FIG. 1**;

[0020] **FIG. 3** is a plan view of a portion of one embodiment of the flexible strip according to **FIG. 1**;

[0021] **FIG. 4** is a plan view of a portion of another embodiment of the flexible strip according to **FIG. 1**;

[0022] **FIG. 5** is partial side view of two adjacent flexible strips interlocking to form the retractable mast of **FIG. 1**;

[0023] **FIG. 6** is a block diagram of the lift mechanism according to **FIG. 1**;

[0024] **FIG. 7A and 7B** are perspective drawings of components of a cable management system according to **FIG. 1**;

[0025] **FIG. 8** is a perspective drawing of one embodiment of a weather shield for protecting the lift mechanism of **FIG. 1**;

[0026] **FIG. 9** is an environmental drawing of one embodiment of a backpack incorporating the lift mechanism of **FIG. 1**.

[0027] **FIG. 10** is an embodiment of a robotic device incorporating the lift mechanism of **FIG. 1**;

[0028] **FIG. 11** is a block diagram of the robotic device according to **FIG. 10**;

[0029] **FIG. 12A** is a perspective drawing of one embodiment of a suitcase incorporating the lift mechanism incorporating the lift mechanism of **FIG. 1**; and

[0030] **FIG. 12B** is a perspective drawing of another embodiment of a suitcase incorporating the lift mechanism incorporating the lift mechanism of **FIG. 1**.

DETAILED DESCRIPTION

[0031] **FIG. 1** illustrates one embodiment of an apparatus **10** for raising a retractable mast **100** formed from at least three flat flexible strips **102**, **104**, **106**, each strip having a set of tabs and slots disposed along opposite edges of the strips so that the tabs of one strip engage the slots of an adjacent strip in an interlocking relationship to hold the strips in a rigid formation. The strips may be identical to reduce manufacturing and production costs.

[0032] Non-limiting, the lift mechanism apparatus **10** of **FIG. 1** illustrates a camera/sensor package **168** and microphone **182** being elevated by a mast **100** rising from a base unit **78** that further comprises three pairs of spaced apart upright support members **70** preferably mounted on a partially shown support surface **79**. Each pair of upright support members **70** respectively supports a spool assembly **82**, **84** and **86** rotatably mounted along a horizontal axis.

[0033] **FIG. 1** further illustrates a feed mechanism **80** mounted to the base **78**. The feed mechanism **80** is operable to draw together strips **102**, **104**, and **106** from spools **82**, **84**, and **86**. The strips may pass around rollers **76** that may include a cambered surface **81** operable to press against the body of each strip thereby inducing the inward camber **108**, **110**, **112** illustrated in the mast section view of **FIG. 2**.

[0034] Locking mechanisms disposed on opposing edges of the strips are brought together by action of the feed mechanism **80** and a mast having a triangular cross section (see **FIG. 2**) is formed, raising platform **194** that supports camera/sensor package **168**.

[0035] Non-limiting, the feed mechanism **80** comprises a threaded shaft **156** rotatably mounted to the base **78** along a substantially vertical axis of rotation, and may be positioned at a center of a triangle formed by the three strips **102**, **104** and **106** as best depicted in **FIG. 2**. Rotated by a motor **170** mounted on the base **78** through a belt drive **94**, chain drive or other appropriate linkage arrangement, the threaded shaft **156** comprises a helical thread **92** operable to extend or lower the mast **100** by engaging at least one row of angled slots **144** disposed along the length of at least one of strips **102**, **104**, and **106**, as depicted in **FIG. 3**. Non-limiting, threaded shaft **156** may operate to engage all strips forming mast **100**, as depicted in **FIG. 2**, or in other embodiments, threaded shaft **156** may be operable to engage only one or some number of strips less than the number of strips forming the mast **100**. For example, in one embodiment, only one strip may comprise angled slots **144** and the threaded shaft is configured to engage only the strip comprising the angled slots **144**.

[0036] Furthermore, **FIG. 1** illustrates threaded shaft **156** having a coaxial bore **88** operable to allow a multiconductor cable **98** to extend from base **78** to the devices mounted on the platform **194** at the top of the mast **100**.

[0037] **FIG. 2** shows a section view of mast **100** illustrating the inward camber **108**, **110**, **112** that may result from the flexing of strips **104**, **106**, **108** respectively, to engage the opposing edges of the strips. Specifically, a tab **116** disposed on an edge of a first strip **102** may engage a slot **114** disposed on the edge of an adjacent strip **104**. The slots **114** and tabs **116** on adjacent strips may be arranged such that at any sectional slice of the mast, a tab **116** disposed on an edge of each strip **102**, **104**, and **106**, engages a slot **114** on an adjacent strip.

[0038] In addition, **FIG. 2** illustrates the threaded shaft **156** that in some embodiments may have a sufficient outside diameter to simultaneously engage angled slots **144** (see **FIG. 3**) spaced along the length of strips **102**, **104**, and **106**. In other embodiments, the threaded shaft **156** may engage a single strip **102**.

[0039] A coaxial bore **88** formed within the threaded shaft **156** may permit at least one signal cable **98** to extend from the base **78** of the apparatus **10**, through a passageway **85** formed by strips **102**, **104**, and **106** along a vertical axis through the length of the mast **100**. The at least one signal cable **98** may interconnect at least one device, i.e., camera/sensor **168**, mounted on top of the rotatable platform **194** at the top of the mast **100** to components located in the base **78** of the apparatus **10**.

[0040] Furthermore, in another embodiment (not shown), the feed mechanism **80** may include a motor mounted within a cavity **89** formed in at least one of spools **82**, **84**, and **86**, operable to drive at least one cambered roller **76** having a gear or sprocket (not shown) having teeth operable to engage the spaced openings **118** (**FIG. 5**) to drive the strips together, or to separate the strips.

[0041] Accordingly, the mast **100** formed is sufficiently rigid for use in environments experiencing external forces such as vibration and wind. Furthermore, in some embodiments, the lift mechanism **10** may be embodied as part of a backpack device **180** carried by an individual, as shown in **FIG. 9**; as part of a robotic terrain traversing device **208**, as shown in **FIG. 11**; and as part of a suitcase **242**, as shown in **FIG. 12**.

[0042] **FIG. 3** illustrates a flat flexible strip **102** incorporated in the lift mechanism **10** shown in **FIG. 1**, wherein the helical thread **92** of threaded shaft **88** engages angled slots **144** spaced along the length of strip **102**. Even though the threaded shaft **88** may engage the angled slots **144** of a single strip **102**, because strips **102**, **104**, and **106** are interlocked above the connection point **125** (see **FIG. 5**), the threaded shaft **88**, when rotated, operates to draw all of strips **102**, **104**, and **106** from their respective spools **82**, **84**, and **86** (see **FIG. 1**).

[0043] FIGS. **4** is a detailed view of a portion of flexible strip **102'** and illustrate one embodiment wherein tabs **116** and slots **114** are alternatingly disposed along opposite edges **130**, **132** of a flat flexible strip **102'** separated by a middle body portion **146**. The tabs and slots shown on strip **102'** are similar to the tabs and slots used in the angled slot embodiment of strip **102**. The specific configuration of the strip **102'** is such that each tab **116** may be disposed opposite a slot **114** on the strip **102'** ensuring when using identical strips, a tab **116** on a first strip aligns with a slot **114** on a last strip when adjacent strips are engaged.

[0044] The configuration of tabs **116** and slots **114** disposed along an edge **130** of a strip is non-limiting, provided that a tab on one strip engages a slot on an adjacent strip. For ease of manufacturing, one tab and slot design is preferred. Accordingly, a tab on one edge **130** is opposite a slot on the opposing edge **132**. For example, a set of alternating tabs **116** and slots **114** may encompass a repeating pattern (not shown) of two tabs followed by two slots along edge **130** for the length of the strip **102**. On the opposing edge **132**, a repeating pattern of two slots followed by two tabs must be formed for the mast to interlock. Accordingly, any known pattern may be used,

[0045] **FIG. 5** illustrates two strips **102'**, **104'**, comprising the slot and tab design illustrated in **FIG. 4**, being drawn together and engaging at the connection point **125**. In some embodiments, when in a retracted state, some number of slots and tabs at the top of the mast, where the platform **194** is mounted, remain fully engaged and may be permanently fixed together so as to register or align the tabs and slots on adjacent strips thereby facilitating proper engagement of the strips when forming the mast **100**. Facilitating the engagement of each tab and slot is especially important in unattended applications, for example in unmanned sites and lift mechanism operating under remote control.

[0046] Each tab **116** is sized to engage a slot **114** of an adjacent strip as the strips are drawn together. Once engaged, the outward force created by the camber **108**, **110**, and **112** operates to maintain the rigidity of the mast **100**.

[0047] The material comprising flexible strips **102**, **104**, and **106**, and the specific dimensions of the strips, tabs **116**, and slots **114** may be predetermined by persons of ordinary skill in the art, upon review of the disclosure and without undue experimentation based upon the operational requirements of the lift mechanism **10**, i.e., the weight of a device mounted on top of the mast **100**, the height of the mast **100**, and the environmental stresses to be experienced by the lift mechanism **10**.

[0048] Furthermore, the lift apparatus **10** has been engineered to facilitate the manufacturing of the apparatus **10**. Specifically, the disclosed slot and tab design may permit the manufacture of identical strips for all strips forming mast **100**, regardless of a specific predetermined height of the extended mast. Furthermore, the strips are substantially flat, allowing them to be stored on spools without undue concern that a tab or slot of one layer may engage a tab or slot of a subsequent layer thereby causing the apparatus to bind.

[0049] Although the exemplary embodiments illustrated and discussed herein may comprise three strips, other embodiments may employ more strips based upon user specific operational requirements.

[0050] In the exemplary embodiments discussed herein, each strip may be composed of 0.25 inch thick Type 301 hardened stainless steel. In other embodiments, the flexible strips may be made of a synthetic material, such as plastic, a flexible ceramic, or a composite material.

[0051] Referring back to **FIG. 4**, in some embodiments, the width **134** of the body **146** of the strip may be 0.820 inches and the tab depth **120** may be 0.040 inches. Furthermore, the length **126** of each tab **116** may be approximately 0.248 inches and the outer corners of each tab **116** may be rounded, having a radius R**3** of approximate 0.030 inches, allowing the tab **116** to easily engage the opposing slot **114**.

[0052] Each slot **114** may be shaped to have a maximum slot length opening **122**, i.e., 0.250 inches, which is slightly larger than the length **126** of a tab **116**. Furthermore, in one embodiment, the width **124** of a slot **114**, i.e., 0.060 inches, may be sufficient large to allow the tab **116** and slot **114** to engage at a point of engagement **125**, where the strips require maneuvering room to properly engage, as shown in **FIG. 5**. The outer corners **127** of the slot **114** may have a radius R**1** of 0.030 inches flowing into a rounded shoulder **128** that has a radius R**2**, i.e., 0.022 inches, in an opposite direction, allowing the tab **116** to easily engage the slot **114** and slide into position. Once engaged, the tab **116** is held securely in the slot by being pressed against shoulders **128** formed on both ends of the slot **114**, the width of the slot **136**, being only 0.100 inch at that point.

[0053] **FIG. 6** is a block diagram illustrating the control logic for the lift mechanism **10** of **FIG. 1** and comprises a controller module **162** electrically connected to at least one lift motor **170**. Electrically connected to the controller module **162** is a control interface **164** operated by a user to raise and lower the mast **100**. The control interface **164** may communicate with the controller module **162** via a wired or wireless data link.

[0054] The controller module **162** may include an application-specific integrated circuit ("ASIC"), or other chipset, processor, logic circuit, or other data processing device. Controller module **162** may also include memory, which may comprise volatile and nonvolatile memory such as read-only and/or random-access memory (RAM and ROM), EPROM, EEPROM, flash, or any memory common to computer devices.

[0055] The controller module **162** may comprise logic that calculates the height of the mast **100** based upon a predetermined formula based upon a run time of the motor **170**. An indication of the mast height provided to the user may allow the user to raise the mast **100** to a user determined height, or may allow the controller **162** to raise the mast **100** to a predetermined height by controlling the activation time of the motor **170**. Furthermore, the controller module **164**

may comprise inputs and outputs **160** that may be connected to other lift mechanisms **10** so as to permit multiple lift mechanism **10** to operate in a master/slave relationship. For example, synchronizing the raising and retracting of a plurality of masts **100** to the same or to different heights based upon predetermined or user selectable inputs may be useful in situations requiring addition support, for example, to form a horizontal surface large enough to support the landing or take-off of an Unmanned Aerial Vehicle (UAV).

[**0056**] Power module **172** may comprise any source of power suitable for use by the lift mechanism **10** and may include AC or DC inputs as well as AC and DC output capability. Non-limiting, the power module **172** may include a power cable to a source of AC power as well as NiMH and Li-ion rechargeable batteries. The power module **172** is operable to deliver required power to the control interface **164**, the controller module **162**, the lift motor(s) **170**, the devices on top of the mast **100**, as well as any other devices requiring electric power.

[**0057**] In addition, the lift mechanism **10** may include a cable management system (CMS) **166** (see **FIG. 1**) that is operable to control the deployment of multi-conductor cable **98**, extending from the base **96** of the lift mechanism **10** through the coaxial bore **88** in the threaded shaft **156** and upwards through the center of the mast to electronic equipment, e.g., camera/sensor **168**, microphone **192**, lights **206**, and/or other devices mounted on rotating platform **194**.

[**0058**] One embodiment of the CMS **166** includes a slip ring mechanism **228**, illustrated in **FIG. 7**. The slip ring **228** is mounted on one side of a rotatably mounted spool (not shown), carrying the multi-conductor cable **98**. Electrical leads on one end of the cable **98** may be permanently connected to a plurality of contacts **231** disposed on one side of the slip ring **228**. A plurality of concentric conductive tracings **229** disposed on a side of the slip ring **228** opposite from the spooled cable **98**, is operable to maintain contact with a plurality of rows **97** of brush contacts disposed on a stationary portion **230** of the CMS **166**, as the slip ring **228** rotates. Although only one row of brush contacts is necessary, multiple rows of contacts **97** may be used to guarantee contact.

[**0059**] Further, one end of a second multi-conductor cable **99** is connected to a plurality of terminals **93** on an outer portion of the stationary portion **230**. The other end of cable **99** may then be connected to controller module **162**, power module **172** and/or other devices supplying signals to or receiving signals from the mast mounted devices.

[**0060**] For example, in other embodiments, the output of the mast supported devices may be fed into recording devices (not shown), the recording devices operable to store the received data for later analysis. Non-limiting, such recording devices may include, analog and digital devices sound and video data received from a mast mounted microphone **192** and camera **168**.

[**0061**] **FIG. 8** illustrates one embodiment of an automatically deployable mast shield apparatus **174**. Under certain environments, the mast **100** may be subject to potentially destructive material which may threaten proper operation of the lift mechanism. For example, rain may pass through openings in the mast **100** and potentially enter the base of the lift mechanism. Furthermore, dust or dirt may clog the slots and freezing rain may lock up the mast **100**. Accordingly, a mast shield apparatus **174** that operates to automatically surround the mast **100** as the mast is raised and automatically retracts when the mast is retracted may be beneficial. Furthermore, a mast shield apparatus may be beneficial in applications, i.e., trade shows, where a retractable mast having an esthetically pleasing covering is appropriate.

[**0062**] The mast shield apparatus **174** may comprise a housing **171** that is mounted over a lift mechanism (not shown). In one embodiment the housing **171** includes three pairs of upright support members **173** preferably mounted on a partially shown support surface **77**. Each pair of support members **173** is operable to support a spring powered roller **176** further comprising a spool of mast protecting material **175**. Non-limiting, the mast protecting material **175** may be comprised of canvas, a synthetic material, or any suitable material and have a width larger than the flexible strips comprising the underlying mast **100**. Furthermore, the top of each strip **175** is securely fastened to the top of the mast **100** or may be fastened to the platform **194** depicted in **FIG. 1**.

[**0063**] As the mast is raised, the spring loaded spools operate to deploy the shield material **175** while at the same time applying tension to a spring (not shown) disposed within each spool **176**. Non-limiting, tensioned rollers are known to those of ordinary skill in the art, and any suitable spooling mechanism may be incorporated.

[**0064**] In one embodiment, a retaining rail **181** is operable to align the shield material **175** in front of the mast **100**, at which point a guide mechanism **186** may operates to force the edges **178**, **179** of the shield **175** together as the strips **175** are drawn off their respective spool **176**. Opposing edges **178**, **179** of adjacent strips **175** may employ an attachment mechanism, e.g., Velcro, a plastic or metal zipper arrangement, or other known mechanism, to removably connect the strips **175** together as the mast is raised. As the mast is retracted, the edges **178**, **179** disengage after passing through the guide mechanism **186**.

[**0065**] **FIG. 9** illustrates a backpack embodiment **180** incorporating the lift mechanism **80** of **FIG. 1**. The lift mechanism may be operated as it is carried by an individual, or may be placed on the ground after being transported to a location. Non-limiting, the exemplary backpack lift **180** may include a lift housing **182**, a harness including shoulder straps **196** and belt **198**, a hand-held controller **184**, and a camera or other sensor device **168** mounted on the rotating platform **194** of the extendable mast **100**.

[**0066**] The backpack lift housing **182** may further include a position locator, such as a global positioning system (GPS); communications equipment, and a control/indicator panel **188**. The control/indicator panel may be wired to modules within the lift housing and may include controls and indicators pertaining to all backpack lift functions, including, but not limited to battery charging connector terminals, manual controls of backpack functions, an indicator of remaining battery power, and geographical position as determined by the GPS.

[**0067**] Furthermore, an antenna **190** mounted on the backpack lift housing **182** may allow a hand held remote control device **184** to communicate with a transceiver mounted inside the housing **182**. The remote control device **184** may comprise a viewing screen **202** and controls **204** operable by

the user to control the raising and lowering of the mast as well as the operation of any apparatus, e.g., camera **186**, microphone **192**, and light **206** mounted on platform **194**. Non-limiting, a communications link between the backpack **182** and the remote control unit **184** may be wired or wireless and may include, but is not limited to: an infrared network such as an Infrared Data Association ("IrDA")-based network; ultrasonic, a short-range wireless network; a Bluetooth® technology network; a ZigBee® protocol network; an ultra wide band ("UWB") protocol network; and a home radio frequency ("HomeRF") network.

[**0068**] Still referring to the backpack lift of **FIG. 9**, harness **196** may slip over the shoulders of an individual and fasten in place by means of a buckle or other attachment mechanism commonly used in backpacks. Rechargeable batteries **200** provide electric power for the lift mechanism and may be mounted in the backpack or on the belt **198**. The batteries **200** may be NiMH and Li-ion rechargeable batteries or other battery material providing high efficiency power output.

[**0069**] **FIG. 10** illustrates a robotic lift apparatus **208** comprising the lift mechanism of **FIG. 1** incorporated within a robotic device **210** and **FIG. 11** illustrates one embodiment of a block diagram according to the robotic lift mechanism of **FIG. 12**. Such a robotic lift apparatus **208** may be beneficial to military and law enforcement agencies in providing surveillance at different elevations.

[**0070**] Mounted in a housing **210** equipped with a transport system, e.g., treads **214**, a mast **100** may be extended through an opening **218** in the housing **210**, raising a camera **168** and/or other devices mounted on a platform **194**. A power module **232** mounted within the housing **210** may comprise rechargeable batteries that may be recharged using an external mounted terminal **216**. Although treads **214** may be incorporated in the robot lift apparatus **208**, robots and robot drive units are known. Accordingly, the actual robot drive unit **226** incorporated may comprise wheels or any other available mechanism.

[**0071**] In some embodiments, the robot **208** may comprise a controller module **224** operable to control the various operations of the robot, including, but not limited to travel along a surface via a robot drive unit **226**, operating lift mechanism **170**, and operating the camera/sensor **168** or other device mounted on top of the mast **100**. The controller module may further include an application-specific integrated circuit ("ASIC"), or other chipset, processor, logic circuit, or other data processing device. Controller module **224** may also include memory, which may comprise volatile and nonvolatile memory such as read-only and/or random-access memory (RAM and ROM), EPROM, EEPROM, flash, or any memory common to computer devices.

[**0072**] In addition, the robot may comprise a transceiver **222** allowing the robotic lift mechanism **208** to operate under control of a remote control unit, such as the remote control unit **184**, illustrated in **FIG. 9**. The remote control unit **184** may comprise a transceiver **234** and a user interface module **236**, wherein the user interface module **236** may interface with the viewer **202** and controls **204**, as shown in **FIG. 9**. In other embodiments, the user interface module **236** may be a desktop device or may incorporate a personal computer (PC) operating software code specifically written to control the robotic lift mechanism **208**.

[**0073**] Furthermore, in other embodiments, the robotic lift mechanism **208** may, under control of a program stored within the controller module, be configured to operate autonomously without user intervention. Such autonomous operations may include traveling to a desired location, extending the retractable mast, activating the camera or other sensor, and transmitting data to a receiving station.

[**0074**] **FIGS. 12A and 12B** illustrate a portable lift mechanism **242** comprising a lift mechanism **248** incorporated within a suitcase **260** configured to be easily transported by an individual. The suitcase **260** may be made of aluminum, titanium, plastic or other material commonly used to transport electronic apparatus and may include wheels **244** and an extendable handle **246**. The suitcase **260** may include several compartments **256**, **252**, and **254** for storing lift mechanism **248**, a remote control unit **184**, a camera **168** or other sensor, cables, batteries, and etc. The wheeled suitcase may lay flat on a surface, such that the lift mechanism **248** may operate without being removed from the suitcase, once lid **250** is removed or raised. In some embodiments, the lift mechanism housing **248** may be removeably mounted, enabling the lift mechanism **248** to be removed from the suitcase prior to use.

[**0075**] While the foregoing disclosure shows illustrative embodiments, it should be noted that various changes and modifications could be made herein without departing from the scope of the described embodiments as defined by the appended claims. However, for efficiency in the manufacturing process, the strips forming the mast should be identical and the pattern of slots and tabs disposed on both edges of the strip should be repeating. Furthermore, in order to maximize the length of strip on a spool as well as to minimize binding of the strips as the strips are drawn or deposited on their respective spool, the strips should be substantially flat.

[**0076**] Furthermore, although elements of the described embodiments may be described or claimed in the singular, the plural is contemplated unless limitation to the singular is explicitly stated.

What is claimed is:

1. A method for raising a retractable mast, comprising:

engaging at least three flexible strips such that each strip forms a side of a mast, each strip comprising a first edge portion, a second edge portion and a body there between, whereby a set of tabs and slots disposed along opposite edges of each of the at least three flexible strips engage opposing slots and tabs disposed on the edge portions of adjacent flexible strips.

2. The method of claim 1, wherein engaging further comprises engaging at least three identical flat flexible strips.

3. The method of claim 1, wherein engaging further comprises engaging alternating sets of tabs and slots disposed along opposite edges of each of at least three flat flexible strips.

4. The method of claim 1, wherein engaging further comprises drawing the at least three flexible strips together from a point within the mast, by operation of a drive mechanism within the mast.

5. The method of claim 1, further comprising automatically extending at least one electronic signal carrying cable

from a base of the mast to a top of the mast, the cable maintaining continuous continuously as the mast is raised and retracted.

6. The method of claim 1, further comprising shielding the mast with a protective cover as the mast is raised and retracted.

7. The method of claim 1, further comprising determining a height to which the mast is raised.

8. The method of claim 1, further comprising synchronizing raising and retracting a plurality of masts.

9. The method of claim 1, further comprising rotating a threaded shaft in an essentially vertical axis, the shaft thread engaging slots disposed on at least one side of the mast.

10. An apparatus for forming a retractable mast, comprising:

a support structure;

at least three lengths of flexible strips, the strips stored within the support structure, each strip including:

a first planar surface substantially parallel to a second planar surface;

a first edge portion, a second edge portion, and a body there between;

a plurality of tabs and slots disposed along the lengths of opposing first and second edge portions;

a feed mechanism mounted to the support member, the feed mechanism operable to interlock the at least three lengths of flexible strips by engaging each tab of each of the at least three flexible strips with a slot of an adjacent flexible strip; and

a controller module operable to control extending and retracting the mast.

11. The apparatus of claim 10, comprising three flat flexible strips.

12. The apparatus of claim 10, wherein alternating sets of slots and tabs are formed on each edge of the at least three lengths of flexible strips.

13. The apparatus of claim 10, wherein each tab disposed along one edge portion of each strip is substantially opposite a slot disposed along the other edge portion of the strip.

14. The apparatus of claim 10, wherein at least one flexible strip comprises a plurality of angled slots spaced along the length of the flexible strip, wherein the feed mechanism comprises a threaded shaft extending in a substantially vertical axis from a base of the mast, and wherein the threaded shaft further comprises a helical thread disposed on an exterior surface of the threaded shaft, the helical thread operable to engage a portion of the plurality of angled slots.

15. The apparatus of claim 14, wherein the threaded shaft comprises a coaxial bore.

16. The apparatus of claim 10, further comprising a retractable shield operable to surround the mast as the mast is extended.

17. The apparatus of claim 10 further comprising a cable management system operable to maintain a continuous electrical connection between at least one electrical device disposed within the housing and at least one other electrical device mounted on a top of the mast while the mast is extended and retracted.

18. The apparatus of claim 17, wherein the cable management system comprises a slip ring operable to maintain at least 15 continuous electrical connections.

19. The apparatus of claim 10 further comprises a control unit in electrical communication with the controller module, the control unit operable by a user to control the extending and retracting of the mast.

20. The apparatus of claim 19, wherein the control unit is in wireless communication with the controller module.

21. The apparatus of claim 10, further comprising a transport mechanism whereby the apparatus is operable to travel along a surface under control of the controller module.

22. The apparatus according to claim 10, further comprising a harness operable to allow an individual to operate the apparatus while harnessed to the individual.

23. The apparatus according to claim 10, further comprising a suitcase wherein the housing is removeably mounted within the suitcase.

24. A robot, comprising a housing, the housing further comprising:

a transport mechanism operable to propel the housing along a surface;

a lift mechanism operable to form a retractable mast, the lift mechanism including:

at least three lengths of flexible strips;

a feed mechanism operable to draw the at least three lengths of flexible strips together and form the retractable mast; and

a controller module operable to control an operation of the transport mechanism and the lift mechanism.

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