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Gonzalez et al.

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(54) **SURFACE DRILL MODULAR MAST**

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E04H 12/00 (2006.01)
E21B 15/00 (2006.01)

(52) **U.S. Cl.**
CPC ***E21B 15/003*** (2013.01); ***E21B 7/023*** (2013.01)

(58) **Field of Classification Search**
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USPC 414/22.51, 22.56
See application file for complete search history.

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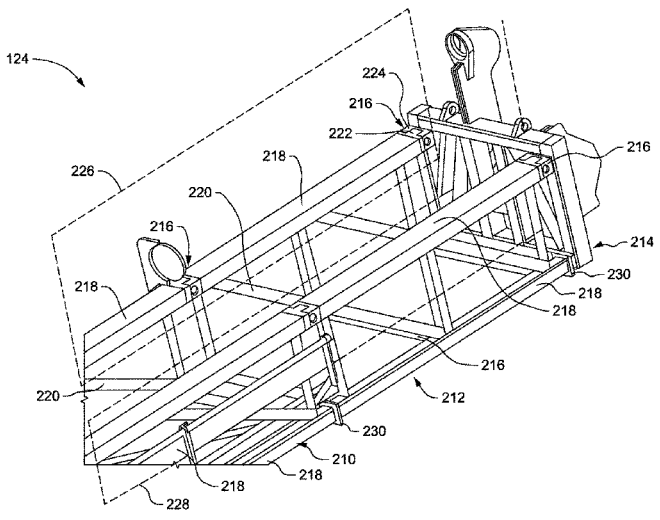
(57) **ABSTRACT**

A modular mast for an earth-drilling machine includes a base module, a crown module, and a fastener. The crown module is coupled with the base module via the fastener. The base module and the crown module each have a surface lying in a common plane. The fastener does not extend beyond the common plane.

7 Claims, 9 Drawing Sheets



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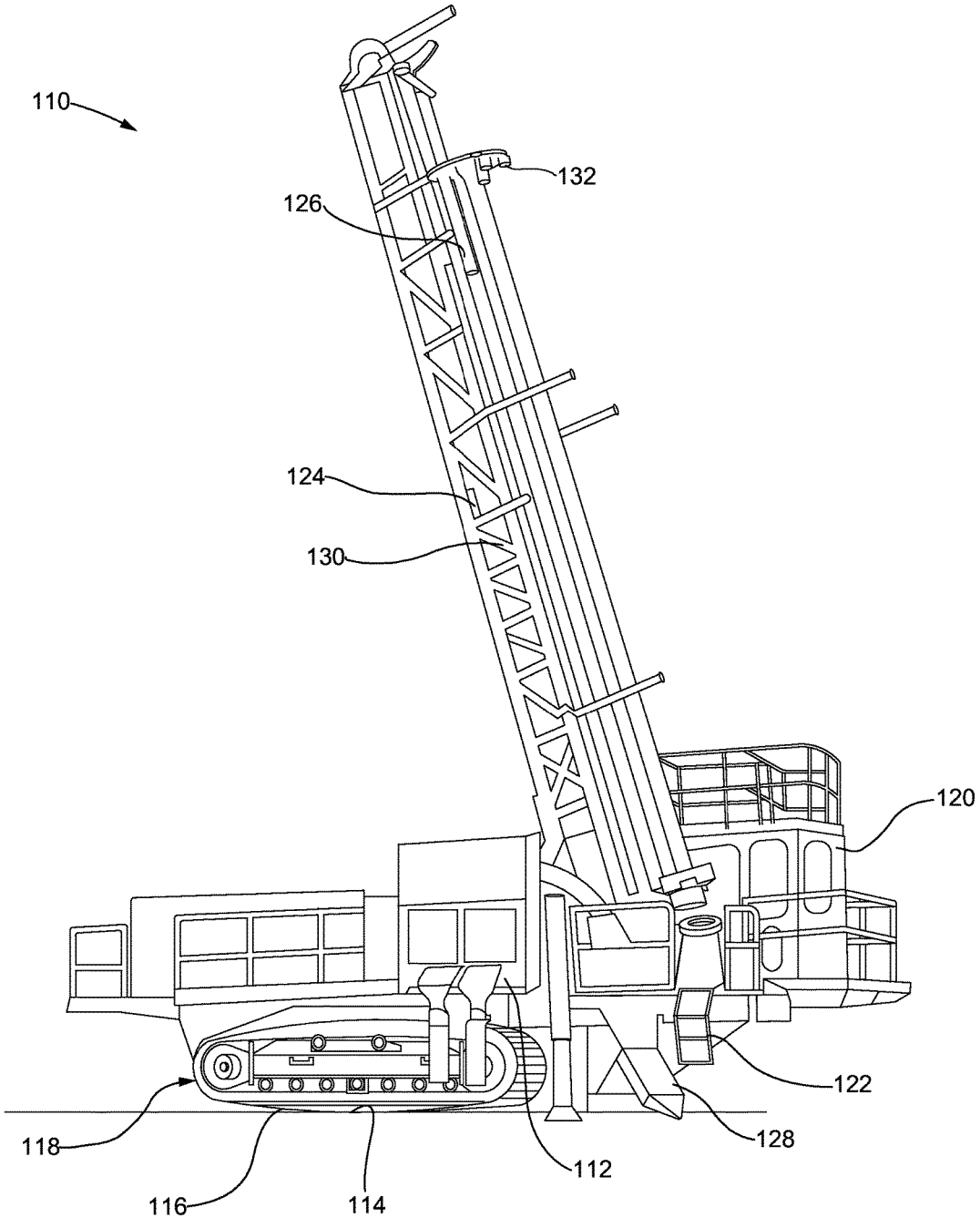
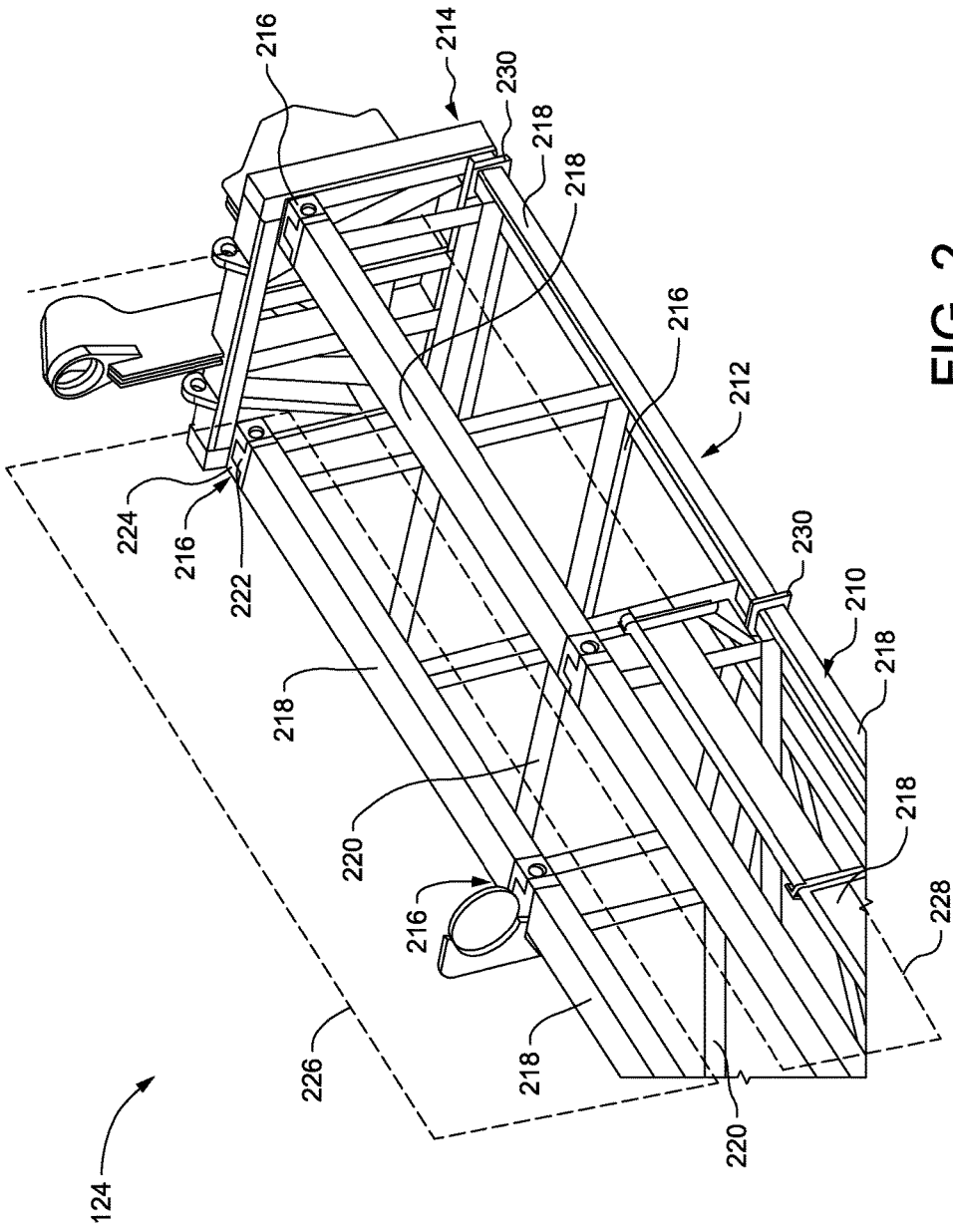


FIG. 1


216
214
230
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210
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228
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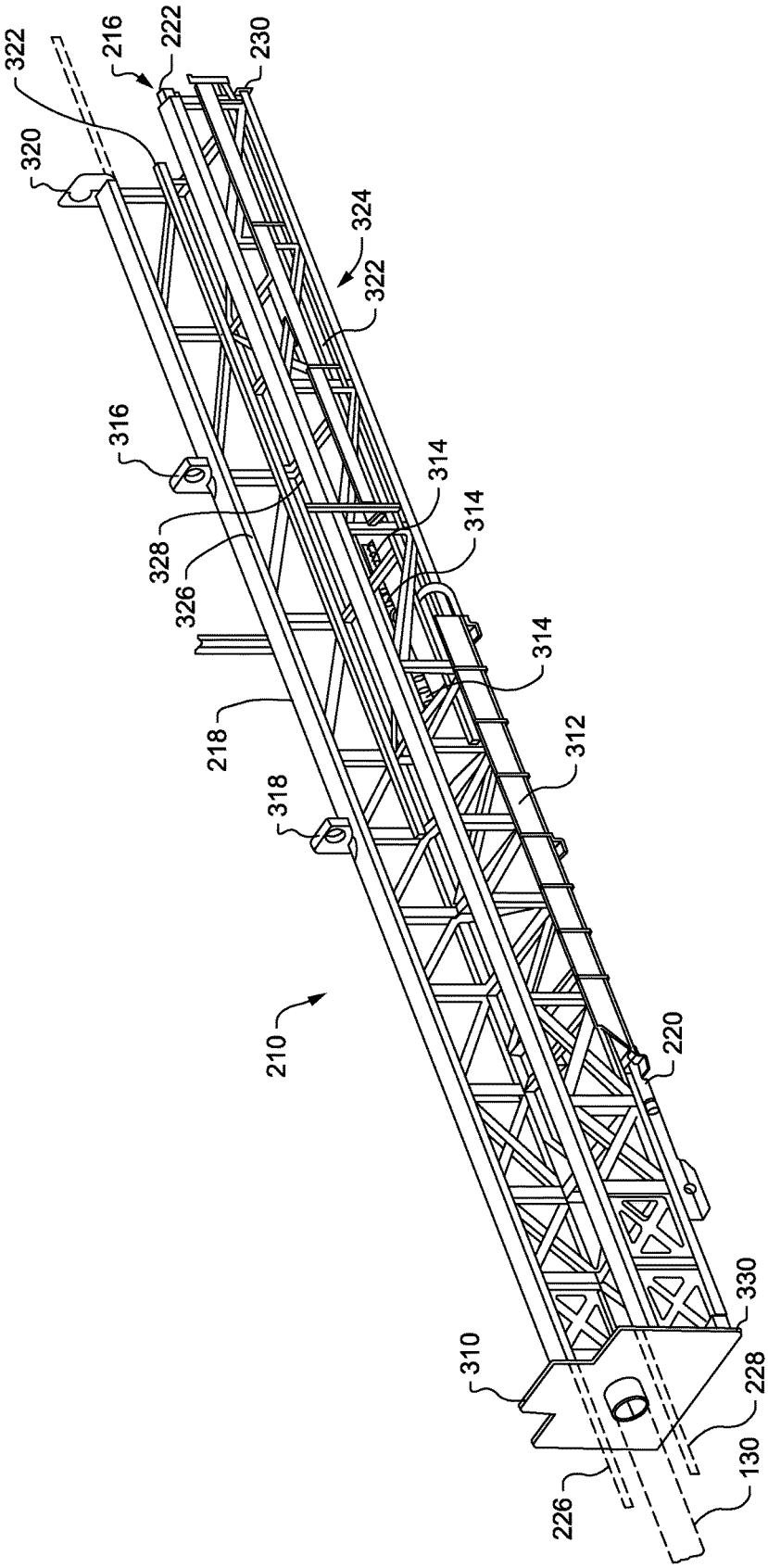
226
220
124

FIG. 2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222
230
320
324
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328
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326
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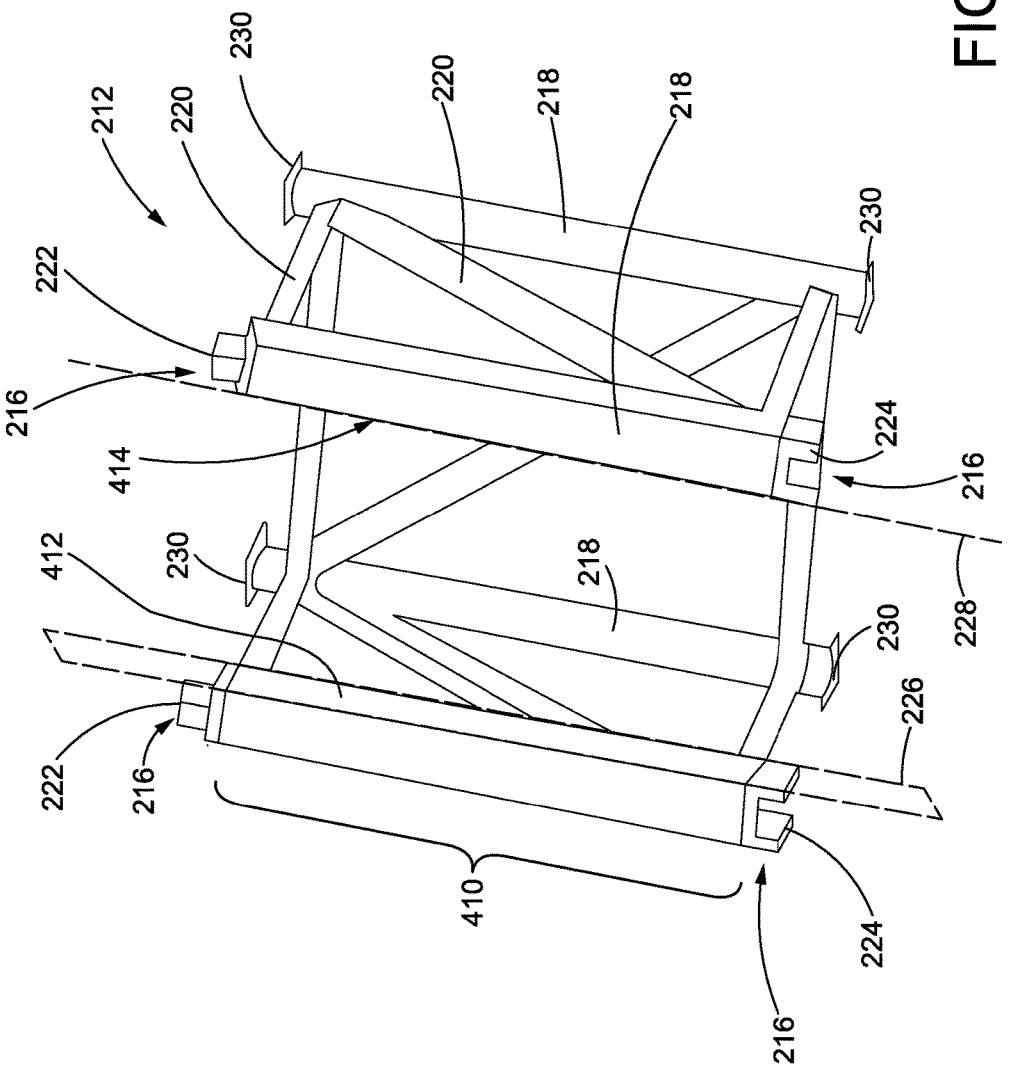
220
330
310
228
130
226

FIG. 3


212
220
230
220
218
218
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414
224
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412
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226
222
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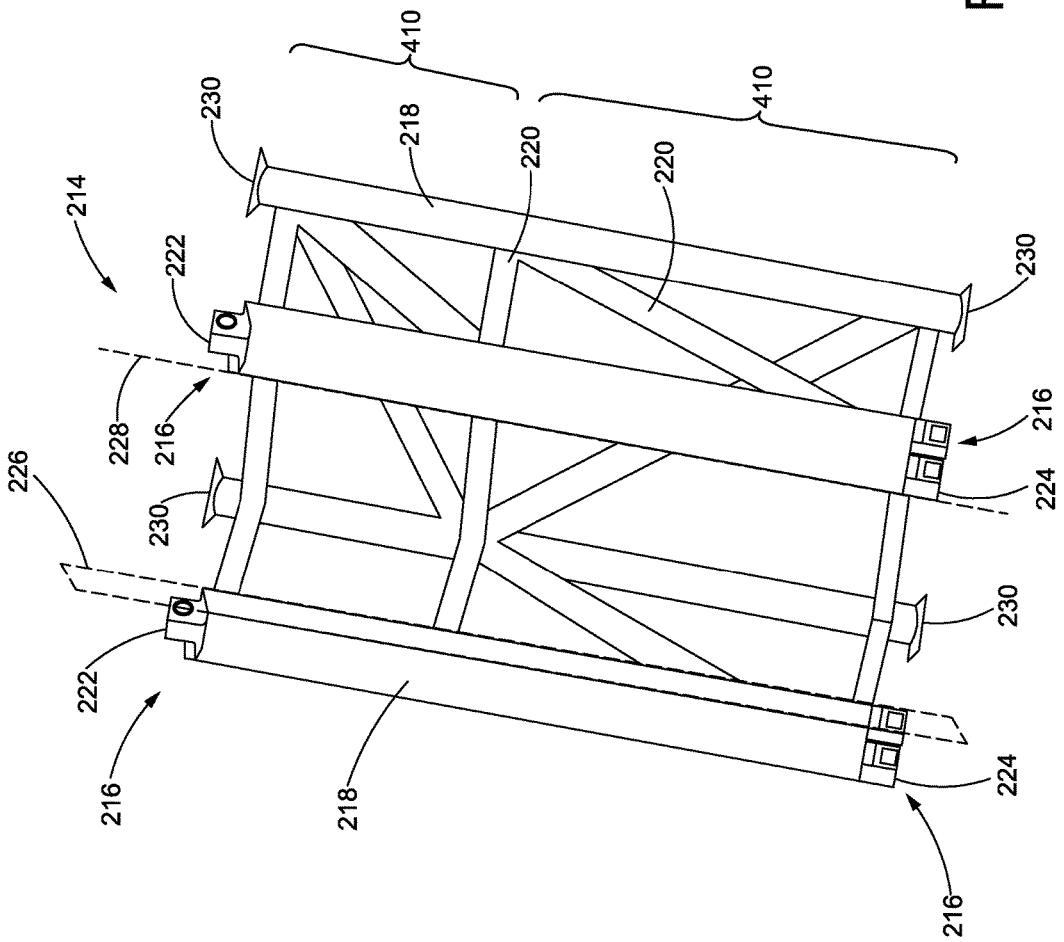
410
224
216

FIG. 4


410
410
230
218
220
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224
216

FIG. 5

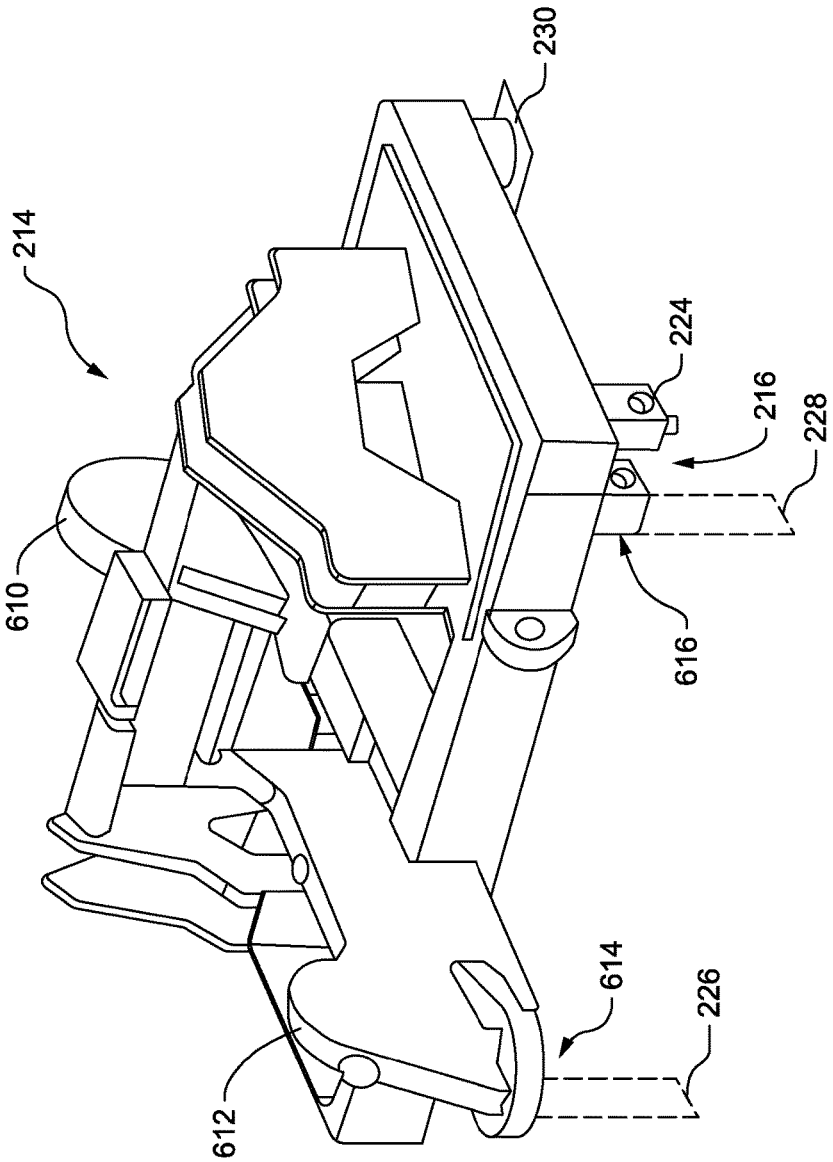
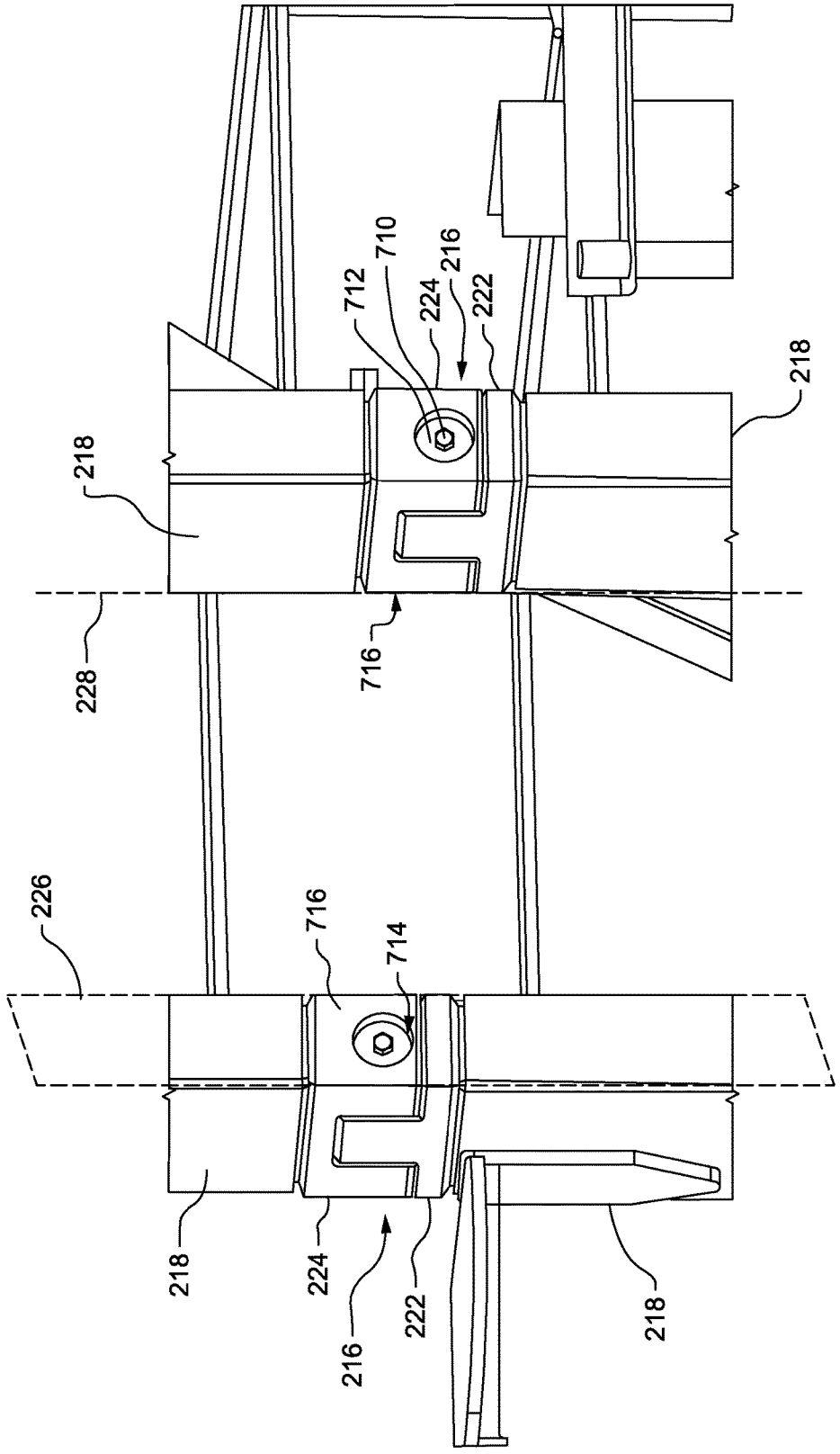


FIG. 6


712
710
224
216
222
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228
716
226
716
714
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224
216
222
218

FIG. 7

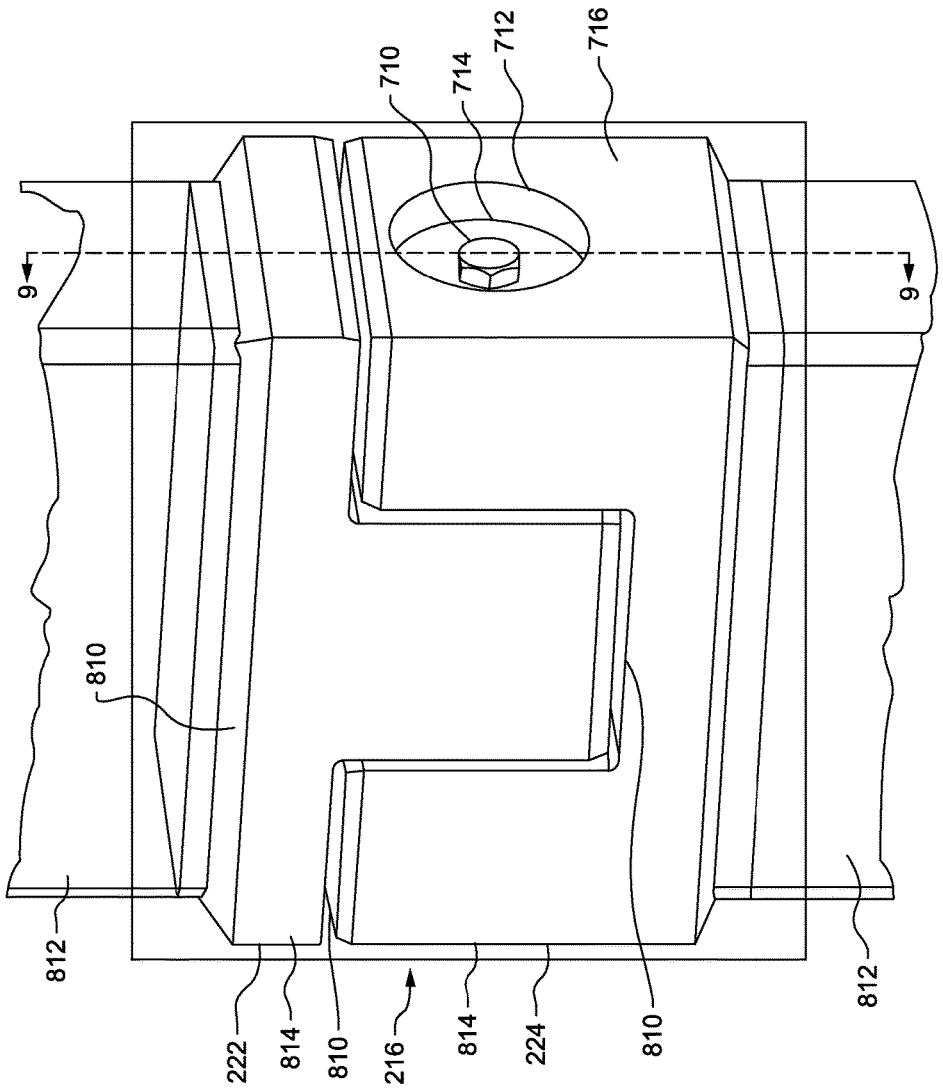

FIG. 8

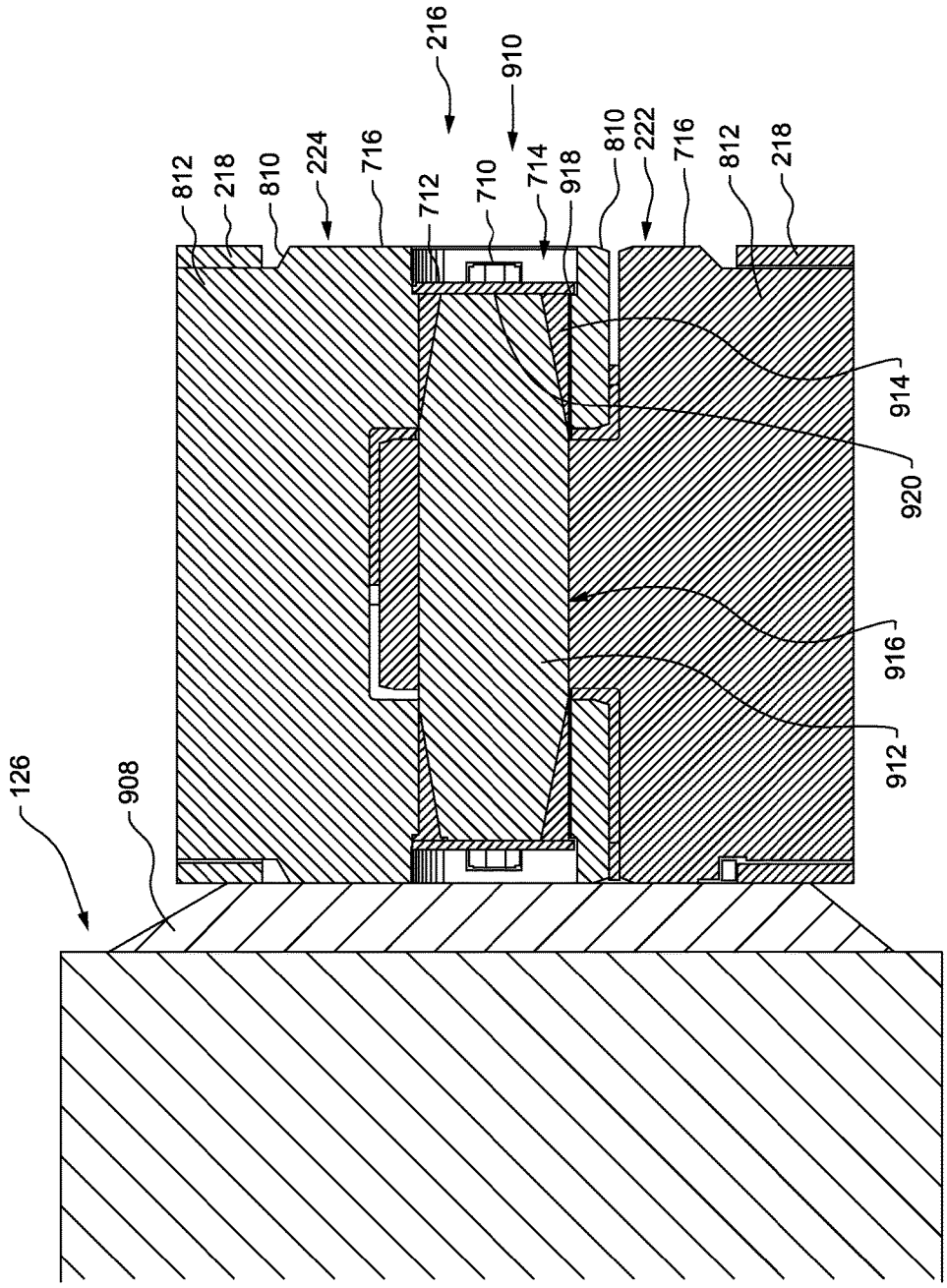
216
910
812
218
810
224
716
712
710
714
918
810
222
716
812
218
914
920
916
912
126
908

FIG. 9

SURFACE DRILL MODULAR MAST

FIELD OF THE DISCLOSURE

The present disclosure relates generally to mining machines and, more particularly, to masts of surface drill mining machines.

BACKGROUND OF THE DISCLOSURE

Surface drill mining machines are often equipped with masts. Such machines may be used to drill into the ground during the construction or maintenance of roads, railways, building sites, landscapes, wells, mines, or other areas. For example, a surface drill mining machine may be used to drill holes to access subterranean minerals, liquids, or gases or to place explosives in preparation for blasting. Typically, such machines include a chassis which supports an engine, an operator cab, and a mast. The mast may support and include a drill head, a carousel, and pipe segments which transmit torque from the drill head to a drill bit. The mast may guide the drill head. The carousel may carry a supply of the pipe segments. As the hole is drilled and pipe segments descend below ground, the carousel may successively load additional pipe segments into the drill head to extend the reach of the drill bit. Pipe segments and masts may be available in different fixed lengths.

Depending on the drilling application, one particular pipe segment length may be preferable over another depending on the drilling application, the substrate being drilled, regional standard pipe segment lengths, or other economic or availability factors. As the mast supports and includes the pipe segments and the carousel, it must in turn have a length that accommodates the particular pipe segment used in the drilling application. While a long mast may accommodate shorter pipe segment lengths, the extra length of the mast is unnecessarily costly and adds unnecessary weight to the surface drilling machine. Therefore, shorter and therefore lighter and less costly masts are often used in drilling applications which call for shorter pipe segment lengths. Such tailoring of the mast to the drilling application may, however, make the surface drill machine unsuited to a subsequent drilling application once the initial drilling application is complete. Therefore, depending on the subsequent drilling application, a surface drill machine may need to be retrofit with a new appropriate length mast, which may be a costly and time-consuming process. Furthermore, if roadways and/or railways between the surface drilling machine supplier and the worksite have overpasses, tunnels, or other obstructions, a surface drilling machine with a long mast installed may not be able to travel to the worksite. Thus, long masts may need to be installed onto the surface drilling machine chassis at the worksite as opposed to the controlled environment of the supplier, which may also be a time-consuming and costly process. Additionally, the tailoring of mast length to drilling applications increases surface drilling machine manufacturing complexity, dealer inventory, and ordering lead time.

Surface drilling machines with some degree of mast length flexibility are available. Such flexible masts are often arranged with mast sections stacked on top of a foundational mast and fastened together. More specifically, mast sections may have protruding interlocking upper and lower members through which the fasteners are placed and additional rails to guide the drill head. However, these efforts to provide mast length flexibility have been found largely lacking as the additional rails hinder the use of a pipe-loading carousel.

One example of an existing strategy for attempting to provide a surface drilling machine with a flexible length mast is shown by Chang in Chinese Patent No. CN202249794U.

It can therefore be seen that improvements in the arrangement of the surface drilling machine mast and associated structures are desired to increase surface drilling machine drilling application flexibility. Furthermore, improvements to the arrangement of the surface drilling machine mast may increase work efficiency and also reduce cost, manufacturing complexity, and manufacturing time.

SUMMARY OF THE DISCLOSURE

In accordance with one embodiment, a modular mast for an earth-drilling machine is disclosed. The modular mast may include a base module, a crown module, and a fastener. The crown module may be coupled with the base module via the fastener. The base module and crown module may each have a surface lying in a common plane. The fastener may not extend beyond the common plane.

In accordance with another embodiment, an earth-drilling machine is disclosed. The earth-drilling machine may include a chassis, a prime mover, a modular mast, and a drill head. The prime mover may be supported by the chassis. The modular mast may extend from the chassis and may include a crown module, an extension module, and a base module. The extension module may be joined to the crown module by a first fastener. The base module may be joined to the extension module by a second fastener. The base module, extension module, and crown module may each have a surface lying in a common plane. The first and second fasteners may not extend beyond the common plane. The drill head may be slidable along the modular mast and the fasteners.

In accordance with yet another embodiment, a modular mast kit for an earth-drilling machine is disclosed. The kit may include a base module, a plurality of extension modules, a crown module, and a plurality of fasteners. The base module, the plurality of extension modules, and the crown module may have surfaces in a common plane. The fasteners may be adapted to join the base module, the plurality of extension modules, and the crown module together such that the surfaces are in a common plane and none of the fasteners extend beyond the common plane.

These and other aspects and features will become more readily apparent upon reading the following detailed description when taken in conjunction with the accompanying drawings. In addition, although various features are disclosed in relation to specific exemplary embodiments, it is understood that the various features may be combined with each other, or used alone, with any of the various exemplary embodiments without departing from the scope of the disclosure.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a side view of a machine, in accordance with an embodiment of the present disclosure.

FIG. **2** is a perspective view of a modular mast of the machine, in accordance with an embodiment of the present disclosure.

FIG. **3**. is a perspective view of a base module of the modular mast of FIG. **2**, in accordance with an embodiment of the present disclosure.

FIG. **4** is a perspective view of an extension module of the modular mast of FIG. **2**, in accordance with an embodiment of the present disclosure.

FIG. **5**. is a perspective view of an extension module of the modular mast of FIG. **2**, in accordance with another embodiment of the present disclosure.

FIG. **6** is a perspective view of a crown module of the modular mast of FIG. **2**, in accordance with an embodiment of the present disclosure.

FIG. **7** is an enlarged perspective view of a removable fastener of the modular mast of FIG. **2**, in accordance with an embodiment of the present disclosure.

FIG. **8** is a further enlarged perspective view of the removable fastener of the modular mast of FIG. **2**, in accordance with an embodiment of the present disclosure.

FIG. **9** is a cross-sectional view of the removable fastener of the modular mast of FIG. **2** taken along line **9-9** of FIG. **8**, in accordance with an embodiment of the present disclosure.

While the present disclosure is susceptible to various modifications and alternative constructions, certain illustrative embodiments thereof will be shown and described below in detail. The disclosure is not limited to the specific embodiments disclosed, but instead includes all modifications, alternative constructions, and equivalents thereof.

DETAILED DESCRIPTION

Referring now to the drawings and with specific reference to FIG. **1**, a machine consistent with certain embodiments of the present disclosure is generally referred to by reference numeral **110**. It is to be understood that although the machine is depicted in FIG. **1** as a surface mining drill, the teachings of the present disclosure can be employed with equal efficacy in connection with many other types of machines and structures used in construction and earth moving applications including but not limited to cranes, scaffolding, worksite elevators, and the like.

The machine **110** may include a chassis **112** supported by continuous tracks **114**. Typically, first and second tracks **116**, **118** laterally flank the chassis **112** but other numbers of tracks are possible. The chassis **112** may support an operator cab **120**, a prime mover **122**, and a modular mast **124**. In the depicted embodiment, an engine is provided as prime mover **122**, but it is to be understood that other power sources such as, but not limited to an electric motor and the like are possible. The modular mast **124** may support a drill head **126** which may be operatively associated with a drill bit **128** via a pipe segment **130** and a carousel **132**. The carousel **132** may carry a plurality of pipe segments **130**. Through the operator cab **120**, a user may control the modular mast **124**, the drill head **126**, and the carousel **132**. It should be understood that the drill head **126** may rotate and may travel along the modular mast **124**, thus turning the drill bit **128** and driving the drill bit **128** into the ground. It should also be understood that as the drill bit **128** is drilled deeper into the ground and the pipe segments **130** attached to the drill bit **128** descend, the carousel **132** may successively load additional pipe segments **130** into the drill head **126** and the modular mast **124** and that the additional pipe segment **130** may be attached to the underground pipe segments **130**, thus extending the reach of the drill bit **128**. The modular and supporting structures of the modular mast **124** are described more fully below in conjunction with FIGS. **2-9** below.

Looking at FIG. **2**, in the depicted embodiment, the modular mast **124** may include a base module **210**, an extension module **212**, and a crown module **214**. In other embodiments, the modular mast **124** may only include the base module **210** and the crown module **214**. In further embodiments, the modular mast may include the base module **210**, a plurality of extension modules **212**, and the crown module **214**. The modular mast **124** may further include a plurality of removable fasteners **216** which may operatively associate the base, extension, and crown modules **210**, **212**, **214** with one another. The base and extension modules **210**, **212** may both be formed of a plurality of mast tubes **218** and a plurality of truss members **220**. As shown in FIG. **2**, the truss members **220** may be substantially perpendicular or diagonal to the mast tubes **218**. In some embodiments the mast tubes **218** and truss members **220** may have rectilinear cross-sections, as shown in FIG. **2**, but it should be understood that the mast tubes **218** and the truss members **220** may be of any convenient cross-sectional shape such as, but not limited to round, circular, oval, triangular, or polygonal. In one embodiment, each removable fastener **216** may include a stud **222** and a yoke **224** which may matingly associate with one another; although, in other embodiments, other forms of removable fasteners including, but not limited to, nuts and bolts are possible. Together, the mast tubes **218** of the base and extension modules **210**, **212**, and removable fasteners **216** may form first and second common planes **226**, **228** (shown in phantom) along which the drill head **126** may travel, as will be explained by FIG. **9** below. Similarly, in some examples the mast tubes **218** may have a non-rectilinear, cross-sectional shape (e.g, a cross-sectional shape such as, but not limited to round, circular, oval, triangular, or polygonal) and such non-rectilinear, cross-sectional shaped mast tubes may also form common planes. Besides the removable fasteners **216**, the base, extension, and crown modules **210**, **212**, **214** may, in some embodiments, additionally be joined with one another by a plurality of flanges **230**. Additional features and structures of the base, extension, and crown modules **210**, **212**, **214** are further explained by FIGS. **3-6** below. Further structures of the removable fasteners will be more fully described by FIGS. **7-9** below.

Turning to FIG. **3**, the base module **210** may include a bottom plate **310**, a pull down cylinder mount **312**, a plurality of pull down cylinder sensor mounts **314**, upper and lower carousel pivot shaft brackets **316**, **318**, a carousel mount **320**, a plurality of sheave guide tubes **322**, and a winch mount **324**. Moreover, the base module **210** may have first and second outer surfaces **326**, **328** that are coplanar with and form part of first and second common planes **226**, **228**, respectively. It should be understood that in addition to travelling along the first and second common planes **226**, **228** shown in FIG. **2**, the drill head **126** (not shown in FIG. **3**) may, in some embodiments, also travel along and be guided by the sheave guide tubes **322**. Further, the bottom plate **310** may include a pipe segment sleeve **330** which may guide pipe segments **130** (shown partially and in phantom). In the depicted embodiment, the base module **210** may further include the stud **226** of the removable fastener **216**. In other embodiments, the base module **210** may include the yoke **224** of the removable fastener **216**. In further embodiments, the base module **210** may also include flanges **230**. These mating structures may work to operatively associate the base module **210** with the extension module **212**, as more fully described in FIGS. **4-5**. In other embodiments, these mating structures may work to operatively associate the base module **210** with the crown module **214**, as better explained by FIG. **6** below.

Looking now at FIGS. **4-5**, in some embodiments, as in FIG. **4**, the extension module **212** may be formed of a pattern

unit **410** of truss members **220**. In other embodiments, as shown in FIG. **5**, the extension module **212** may be formed of a plurality of pattern units **410**. Additionally, the extension module **212** may have third and fourth outer surfaces **412**, **414** that are respectively coplanar with and form part of first and second common planes **226**, **228**. Further, the extension module **212** may include studs **222** and yokes **224** of removable fasteners **216** and flanges **230**. In some embodiments, these mating structures may work to operatively associate the extension module **212** with the crown module **214** as more fully described by FIG. **6** below. In other embodiments, these mating structures may work to operatively associate multiple extension modules **212** together.

Regarding FIG. **6**, the crown module **214** may include first and second guide pulleys **610**, **612** and may have fifth and sixth outer surfaces **614**, **616**. These fifth and sixth outer surfaces **614**, **616** may be coplanar with and form part of first and second common planes **226**, **228**, respectively. In the depicted embodiment, the crown module **214** may also include the yoke **224** of the removable fastener **216**. In other embodiments, the crown module **214** may include the stud **222** of the removable fastener **216**. In additional embodiments, the crown module **214** may also include flanges **230**. In some embodiments, these mating structures may work to operatively associate the crown module **214** with the base module **210**. In further embodiments, these mating structures may work to operatively associate the crown module **214** with the extension module **212**. The choice of one embodiment over another may depend on the drilling application at hand. Additional structures and features of the removable fastener **216** are further explained in FIGS. **7-9** below.

Referring to FIG. **7**, the removable fastener **216** may include a secondary fastener **710** and, in some embodiments, a washer **712**. In some embodiments, the secondary fastener **710** and the washer **712** may be integral. In other embodiments, the washer **712** may be captured on the secondary fastener **710**. Further, the yoke **224** of the removable fastener **216** may have a recess **714** in an outer face **716**. In some installations of the removable fastener **216**, the outer face **716** may be coplanar with and form part of the first common plane **226**. In other installations of the removable fastener **216**, the outer face **716** may be coplanar with and form part of the second common plane **228**. It should be understood and appreciated that when the removable fastener **216** is assembled, the secondary fastener **710** may be disposed wholly in the recess **714** and below the respective first and second common planes **226**, **228**. Put another way, once the removable fastener **216** is assembled, the secondary fastener **710** may be sunk or countersunk into the recess **714** and the first and second common planes **226**, **228** may be unbroken. In the embodiments using the washer **712**, the washer **712** may be operatively associated with the secondary fastener **710** and likewise wholly sunk into the recess **714** to leave the first and second common planes **226**, **228** unbroken. Rephrased again, the assembled removable fasteners **216** may leave the first and second common planes **226**, **228** free of obstructions. Said yet differently again, the assembled removable fasteners **216** may not extend beyond the first and second common planes **226**, **228**. Thus, the drill head **126** (not shown in FIG. **7**) may smoothly and slidably travel along the first and second common planes **226**, **228** formed by the mast tubes **218** and the removable fasteners **216**. Further structures of the removable fastener **216** that may aid in this sliding are more fully shown in FIG. **8**, described below.

Turning to FIG. **8**, the removable fastener **216** may have a plurality of bevels **810** which may help the drill head **126** (not shown in FIG. **8**) to slide smoothly over the removable fastener **216** and may aid insertion of the stud **222** into the yoke **224**. Further, both the stud **222** and the yoke **224** may have a stem **812** that may transition into a joining portion **814** via the bevels **810**. In some embodiments, the stems **812** may be inserted into one of the mast tubes **218**, as best shown in FIG. **9**.

Referring now to FIG. **9**, in some embodiments, the removable fastener **216** may be operatively associated with the base and extension modules **210**, **212** by inserting the stems **812** into the mast tubes **218**. In other embodiments, the removable fastener **216** may be operatively associated with the crown module **214** by inserting the stem **812** into the crown module **214**. Put another way, in some embodiments, the stems **812** may be receivable by the base, extension, and crown modules **210**, **212**, **214**. Rephrased again, in some embodiments, removable fasteners **216** may be recessed into the base, extension, and crown modules **210**, **212**, **214** via the stems **812**. In further embodiments, the studs **222** and yokes **224** of the removable fastener **216** may be integrally formed in the mast tubes **218** of the base and extension modules **210**, **212** and in the crown module **214**. Further, the mast tubes **218** and the removable fastener **216** may be slidably associated with the drill head **126** via a tube engagement structure **908**, allowing for the drill head **126** to slide freely over the associated mast tubes **218**. In some embodiments, the tube engagement structure **908** may be beveled so as to ease sliding along the mast tubes **218** and the removable fasteners **216**. In other embodiments, as shown in FIG. **9**, the removable fastener **216** may be a collet pin fitting **910**. In further embodiments the removable fastener **216** may use linking strategies such as, but not limited to, a bolt with a nut, a bolt with an internally threaded yoke **224**, a cotter pin, and the like.

More specifically with respect to the embodiment of FIG. **9** in which the removable fastener **216** may be a collet pin fitting **910**, the removable fastener **216** may further include a barrel **912** and a wedge sleeve **914** and the secondary fastener **710** may be a bolt. Additionally, the yoke **224** and the stud **222** of the removable fastener **216** may have a collinear hole **916** and a chamfer **918** may be formed between the hole **916** and the recess **714**. The barrel **912** may extend through the yoke **224** and the stud **222** by way of the hole **916**. Further, the barrel **912** may have a tapered end **920** about which the wedge sleeve **914** may be disposed. From there, the washer **712** may be operatively associated with the wedge sleeve **914** and may contact the chamfer **918**. The secondary fastener **710** may then be threadably engaged with the barrel **912** and may thus hold the washer **712** against the wedge sleeve **914** and the wedge sleeve **914** against the tapered end **920**. It should be understood and appreciated that as the secondary fastener **710** is tightened, the washer **712** may push on the wedge sleeve **914** and the wedge sleeve **914** may be driven against the tapered end **920**. This driving of the wedge sleeve **914** against the tapered end **920** may cause the wedge sleeve **914** to expand slightly in the hole **916**, thus causing the yoke **224**, the wedge sleeve **914**, and the barrel **912** to fit tightly together. By the point in tightening that the secondary fastener **710** that the washer **712** contacts the chamfer **918**, the yoke **224**, the wedge sleeve **914**, and the barrel **912** may be effectively rigidly bonded together. While the example removable fastener **216** of FIG. **9** includes the collet pin fitting **910** and a wedge sleeve **914**, certainly other collet fittings may be alternatively used for the removable fastener **216**, such as,

but not limited to, a collet with a sleeve split into multiple segments, a collet having a taper or wedge applied to a planar or spiraled surface, a press-fit solid or hollow pin, and the like. Thus, the removable fastener **216** may be firmly fastened and the modules being attached, i.e., the base and crown modules **210**, **214** with any number (including zero) of extension modules **212**, may be surely secured together.

INDUSTRIAL APPLICABILITY

In operation, the foregoing disclosure finds utility in various industrial applications, such as, but not limited to, construction, road building, agriculture, mining, demolition, excavation, and transportation. In particular, the disclosed modular mast and removable fastener may be applied to construction equipment and any other machine equipped with structures formed at least partially of tubes. By using the disclosed modular mast and removable fastener, surface mining drills may be more quickly and easily tailored to drilling applications. Instead of retrofitting an entire mast to a surface drilling machine, users may simply add or subtract extension modules to make the modular mast an appropriate height for the drilling application at hand. Further, manufacturers may more quickly and efficiently mass produce the three types of modules as opposed to custom manufacturing a new fixed length mast for each individual new surface drilling machine. Along the same lines, dealers may simply keep a supply of extension modules available to retrofit used surface drilling machines for subsequent drilling applications as opposed to warehousing or custom ordering entire fixed length masts. Additionally, besides surface drilling machine masts and other construction equipment, the removable fastener attachment technique may also be applied to any structure formed of tubes, such as, but not limited to towers, beams, braces, and the like. Use of the removable fasteners in other applications with tubes may lend a smooth, obstruction-free surface to the assembled tubes which, as with the modular mast and the drill head, may be used to slidably, rollably, or otherwise freely guide other machinery components such as, but not limited to, wheeled carts, elevators, conveyors, escalators, rollercoaster cars, and the like. The disclosed modular mast and removable fastener may thus increase worksite efficiency and provide cost saving measures.

While the foregoing detailed description has been given and provided with respect to certain specific embodiments, it is to be understood that the scope of the disclosure should not be limited to such embodiments, but that the same are provided simply for enablement and best mode purposes. The breadth and spirit of the present disclosure is broader than the embodiments specifically disclosed and encompassed within the claims appended hereto. Moreover, while some features are described in conjunction with certain specific embodiments, these features are not limited to use with only the embodiment with which they are described, but instead may be used together with or separate from, other features disclosed in conjunction with alternate embodiments.

What is claimed is:

1. A modular mast for an earth-drilling machine comprising:

a base module, and

a crown module coupled with the base module via a collet pin fitting recessed into the modular mast,

the base module and the crown module each having a surface lying in a common plane, the collet pin fitting not extending beyond the common plane,

wherein each surface lying in the common plane is an outer surface and wherein the collet pin fitting includes

a yoke having an outer face, the outer face lying in the common plane,

a stud matingly associated with the yoke,

a barrel extending through the yoke and the stud, the barrel having a tapered end disposed below the outer face,

a wedge sleeve about the tapered end and below the outer face,

a washer operatively associated with the wedge sleeve and below the outer face, and

a bolt threadably engaged with the barrel, operatively associated with the washer, and disposed below the outer face.

2. The modular mast of claim **1**, wherein the yoke and the stud each have a stem and a joining portion, the stem being receivable by the base module and the crown module and transitioning to the joining portion via at least one bevel.

3. A modular mast for an earth-drilling machine comprising:

a base module,

a crown module,

a first extension module positioned between the base module and the crown module, and

a second extension module positioned between the base module and the first extension module,

the crown module being coupled with the first extension module via a first fastener, the first extension module being coupled with the second extension module via a second fastener, and the second extension module being coupled with the base module via a third fastener,

the base module and the crown module each having a surface lying in a common plane, the first fastener not extending beyond the common plane.

4. The modular mast of claim **3**, wherein the first extension module and the second extension module are different lengths.

5. A modular mast kit for an earth-drilling machine, the kit comprising:

a base module;

a plurality of extension modules;

a crown module; and

a plurality of fasteners adapted to join the base module, the plurality of extension modules, and the crown module together such that a surface of each of the base module, of the plurality extension modules, and of the crown module are in a common plane and none of the fasteners extend beyond the common plane,

wherein the plurality of extension modules is a first extension module and a second extension module and the first extension module and the second extension module are provided in different lengths.

6. The modular mast kit for an earth-drilling machine of claim **5**, wherein the fasteners are collet pin fittings adapted to be recessed into the base module, the extension module, and the crown module.

7. The modular mast kit for an earth-drilling machine of claim **5**, wherein each collet pin fitting of the plurality of collet pin fittings includes

a yoke having an outer face, the outer face having a recess and configured to be in the common plane,

a stud configured to matingly associate with the yoke,

a barrel configured to extend through the yoke and the stud, the barrel having a tapered end configured to be disposed below the outer face,

a wedge sleeve configured to circumscribe the tapered end and to be disposed below the outer face,

a washer configured to operatively associate with the wedge sleeve and to be disposed in the recess below the outer face, and

a secondary fastener configured to threadably engage with the barrel, to operatively associate with the washer, and to be disposed in the recess below the outer face.

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