US 20250263280A1

(19) **United States**
(12) **Patent Application Publication**
Foster et al.
(10) **Pub. No.: US 2025/0263280 A1**
(43) **Pub. Date: Aug. 21, 2025**

(54) **SCISSOR LIFT**

(71) Applicant: **Custom Equipment, LLC**, Richfield, WI (US)

(72) Inventors: **Brendan J. Foster**, West Allis, WI (US); **Sean M. McGlone**, West Bend, WI (US); **Mac S. Abfall**, Kewaskum, WI (US)

(21) Appl. No.: **19/054,128**

(22) Filed: **Feb. 14, 2025**

Related U.S. Application Data

(60) Provisional application No. 63/554,106, filed on Feb. 15, 2024.

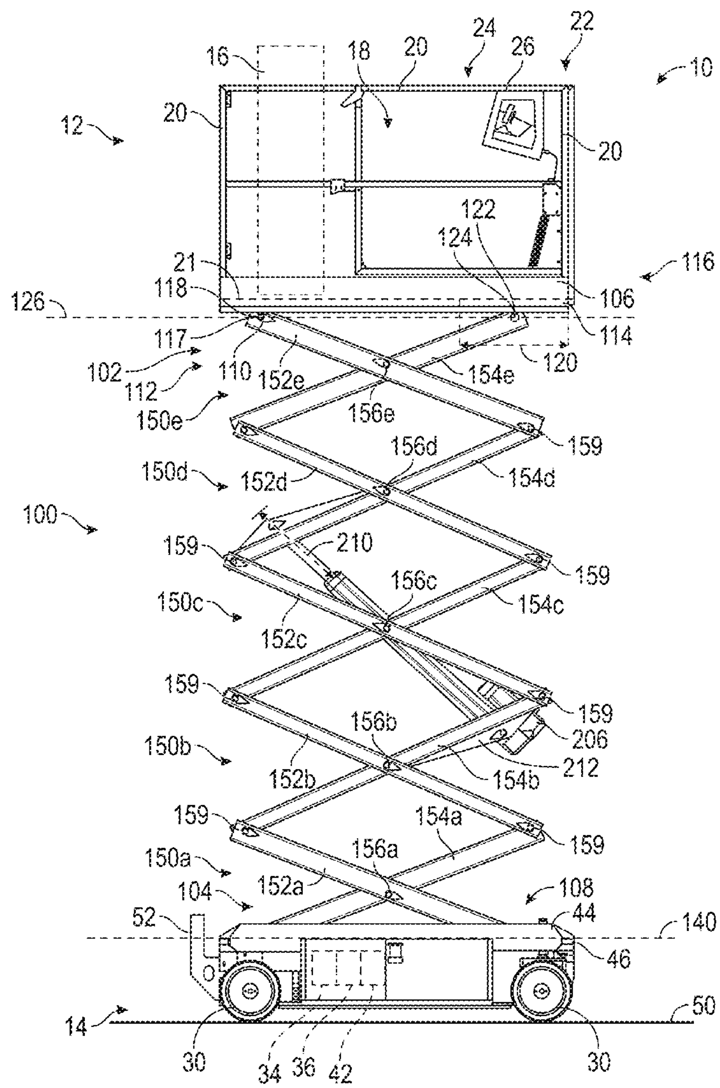
Publication Classification

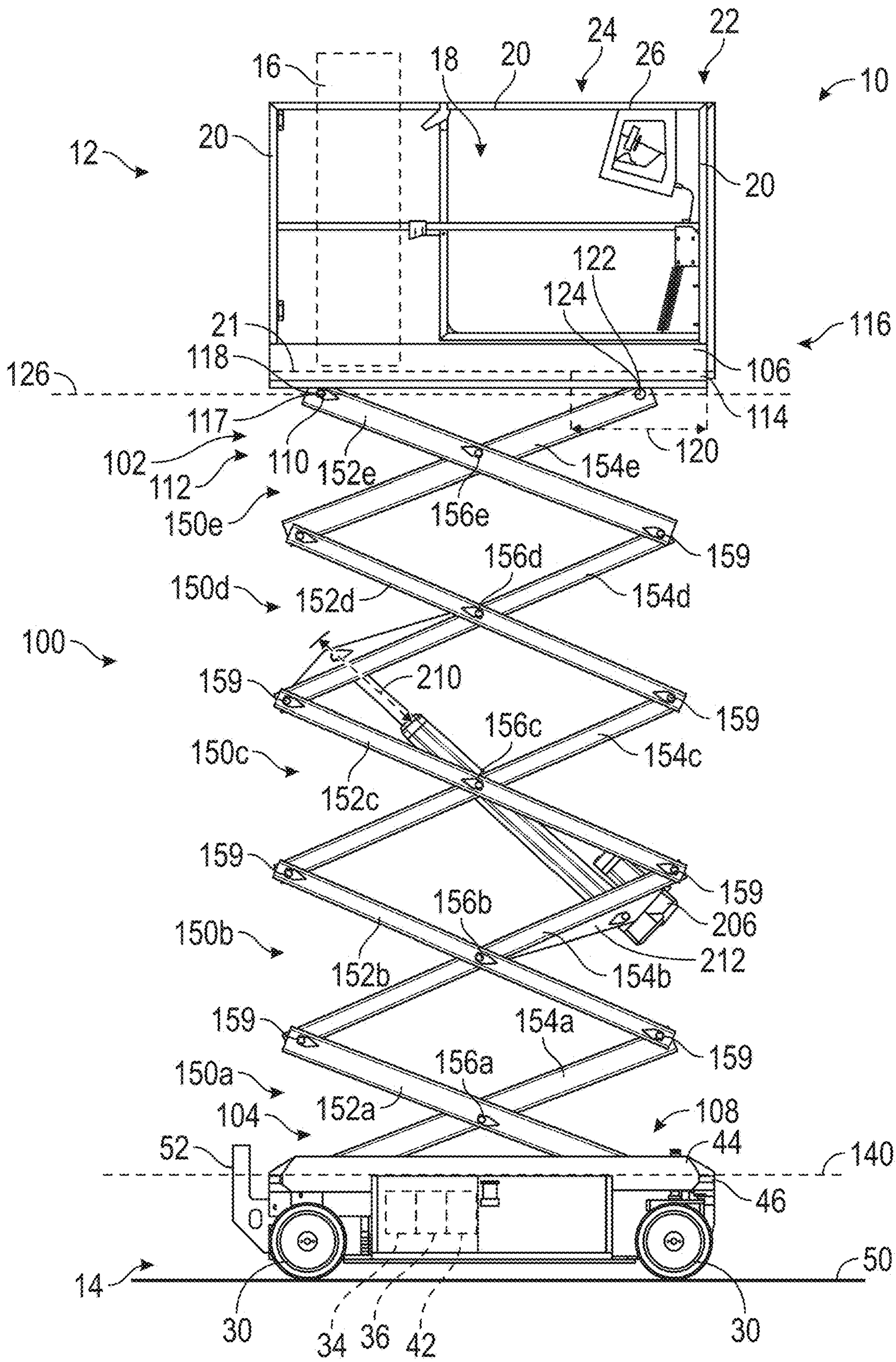
(51) **Int. Cl.**
B66F 11/04 (2006.01)

(52) **U.S. Cl.**
CPC ***B66F 11/042*** (2013.01)

(57) **ABSTRACT**

Lift equipment includes a chassis, a prime mover, multiple wheels, a lift platform, and a scissor stack assembly. The scissor stack assembly includes a first scissor cross, a second scissor cross, a third scissor cross, and an actuator. The first scissor cross is coupled to the chassis and has first links of a first link length. The second scissor cross is coupled to the lift platform and has second links of a second link length. The third scissor cross is coupled between the first scissor cross and the second scissor cross and has third links of a third link length. The actuator is coupled to the prime mover and is configured to transition the scissor stack assembly between a retracted position and an extended position. The first link length is different than at least one of: (i) the second link length or (ii) the third link length.





10
12
14
16
18
20
20
20
20
21
22
24
26
30
30
34
36
42
44
46
50
52
100
102
104
106
108
110
112
114
116
117
118
120
122
124
126
140
150a
150b
150c
150d
150e
152a
152b
152c
152d
152e
154a
154b
154c
154d
154e
156a
156b
156c
156d
156e
159
206
210
212

FIG. 1

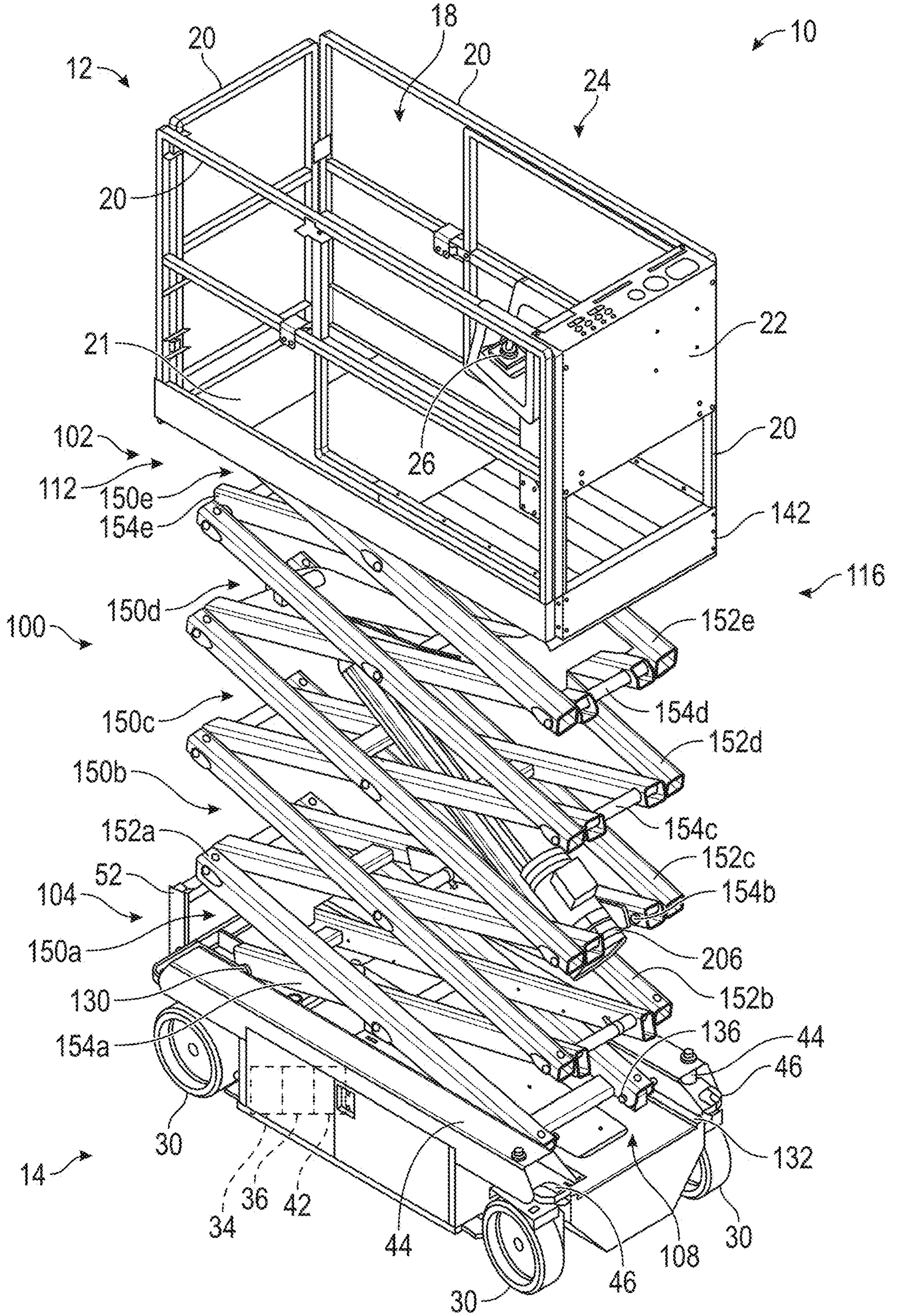

10
12
18
20
20
24
20
22
21
26
102
112
150e
154e
20
142
116
150d
100
152e
154d
150c
152d
150b
154c
152a
152c
52
154b
104
150a
206
130
152b
154a
136
44
46
30
132
14
34
36
42
44
108
30
46
30

FIG. 2

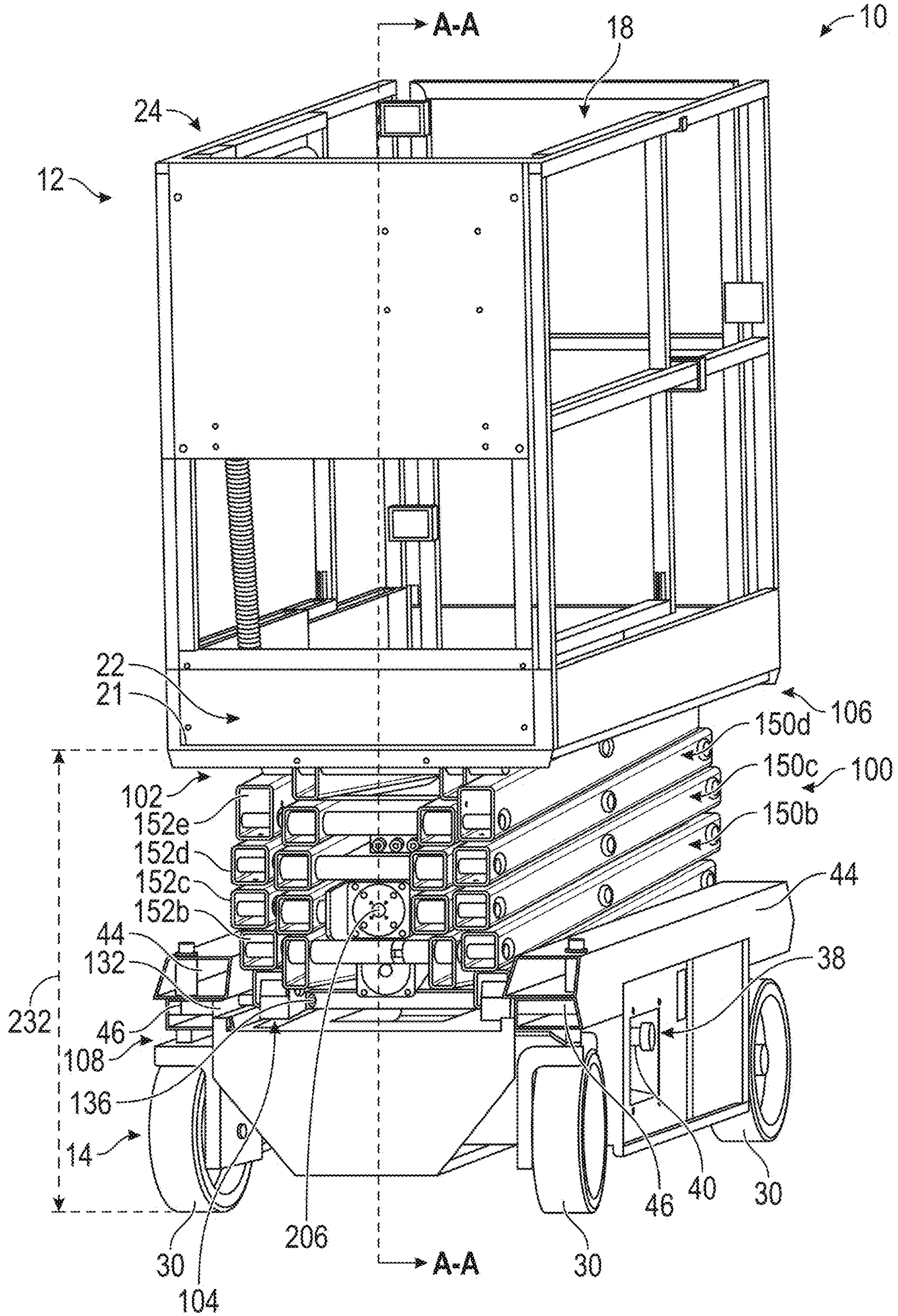

A-A
10
18
24
12
22
21
106
150d
150c
100
102
152e
150b
152d
152c
152b
44
44
132
38
232
46
108
136
14
206
46
40
30
30
30
104
A-A

FIG. 3

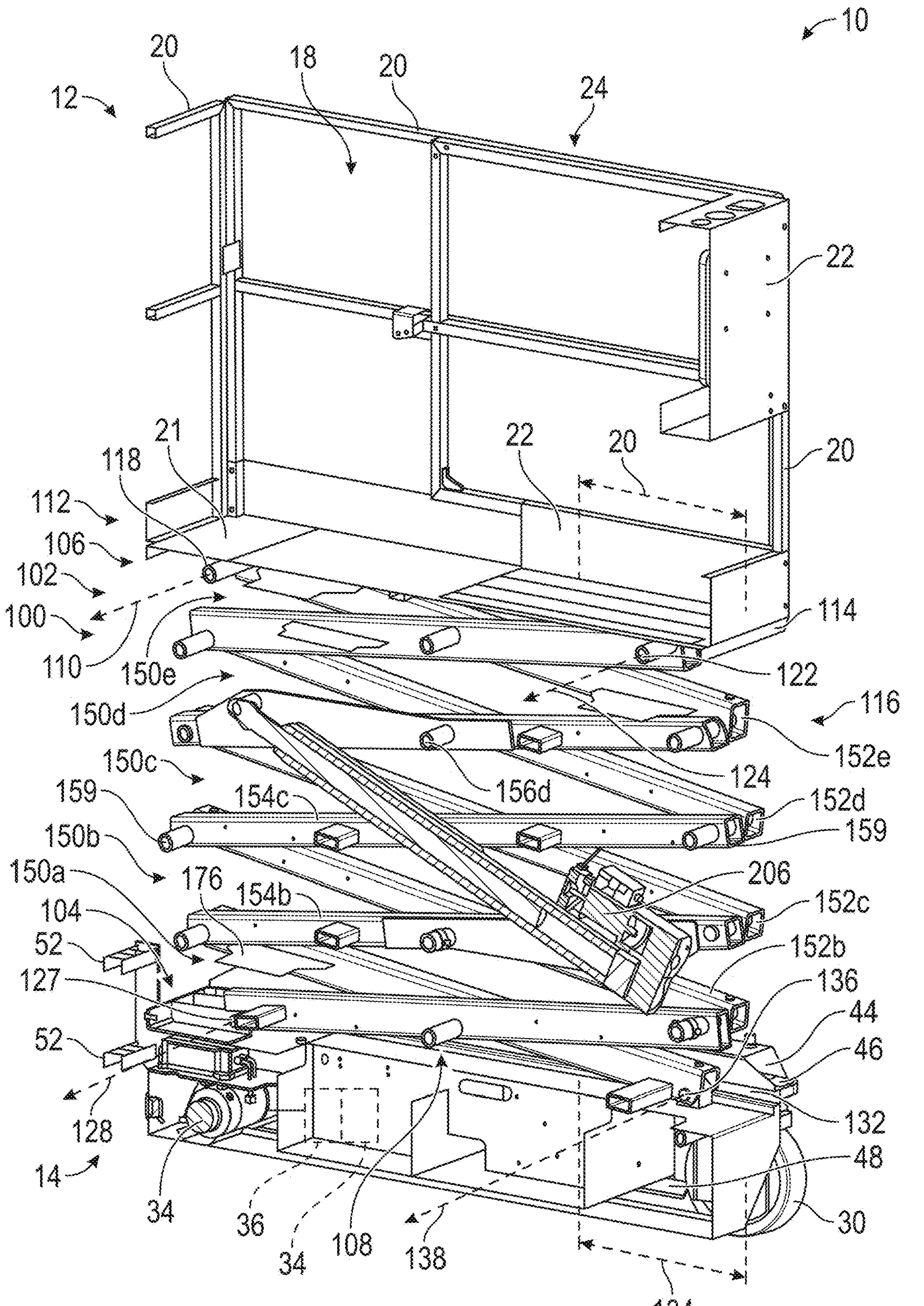

10
20
18
20
24
12
22
21
22
20
20
118
112
106
102
100
110
150e
114
122
116
150d
152e
124
150c
156d
159
154c
152d
159
150b
150a
176
154b
206
152c
104
52
152b
127
136
44
46
52
132
128
48
14
34
36
34
108
138
30
134

FIG. 4

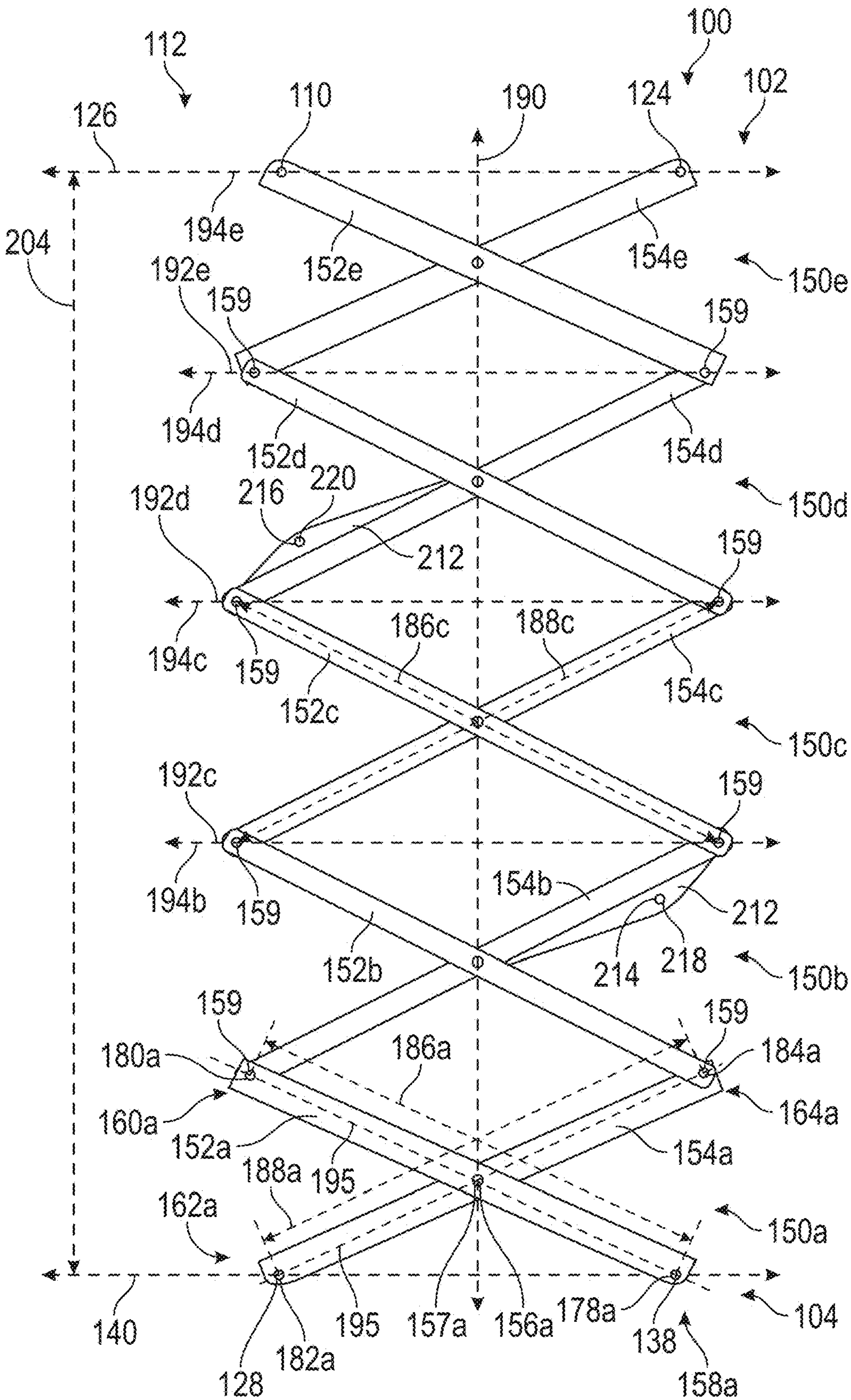

100
112
102
116
126
110
190
124
204
194e
152e
154e
150e
192e
159
159
194d
152d
154d
150d
192d
216
220
212
159
194c
159
186c
188c
152c
154c
150c
192c
159
194b
159
154b
212
214
218
152b
150b
159
159
180a
186a
184a
160a
164a
152a
195
154a
188a
162a
150a
140
195
157a
156a
178a
138
104
128
182a
158a

FIG. 5

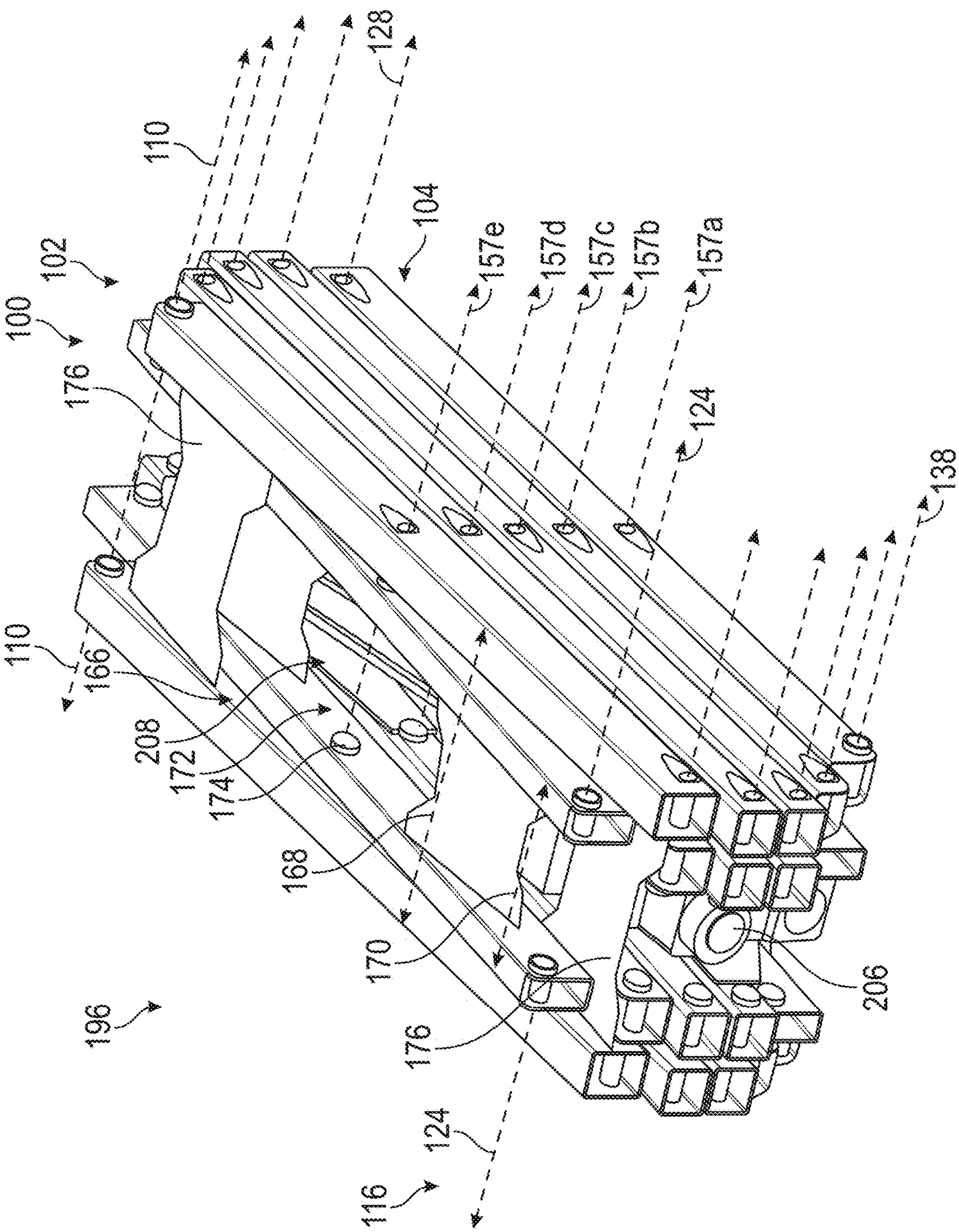

100
102
104
110
128
157e
157d
157c
157b
157a
176
124
138
110
166
208
172
174
168
170
176
206
196
124
116

FIG. 6

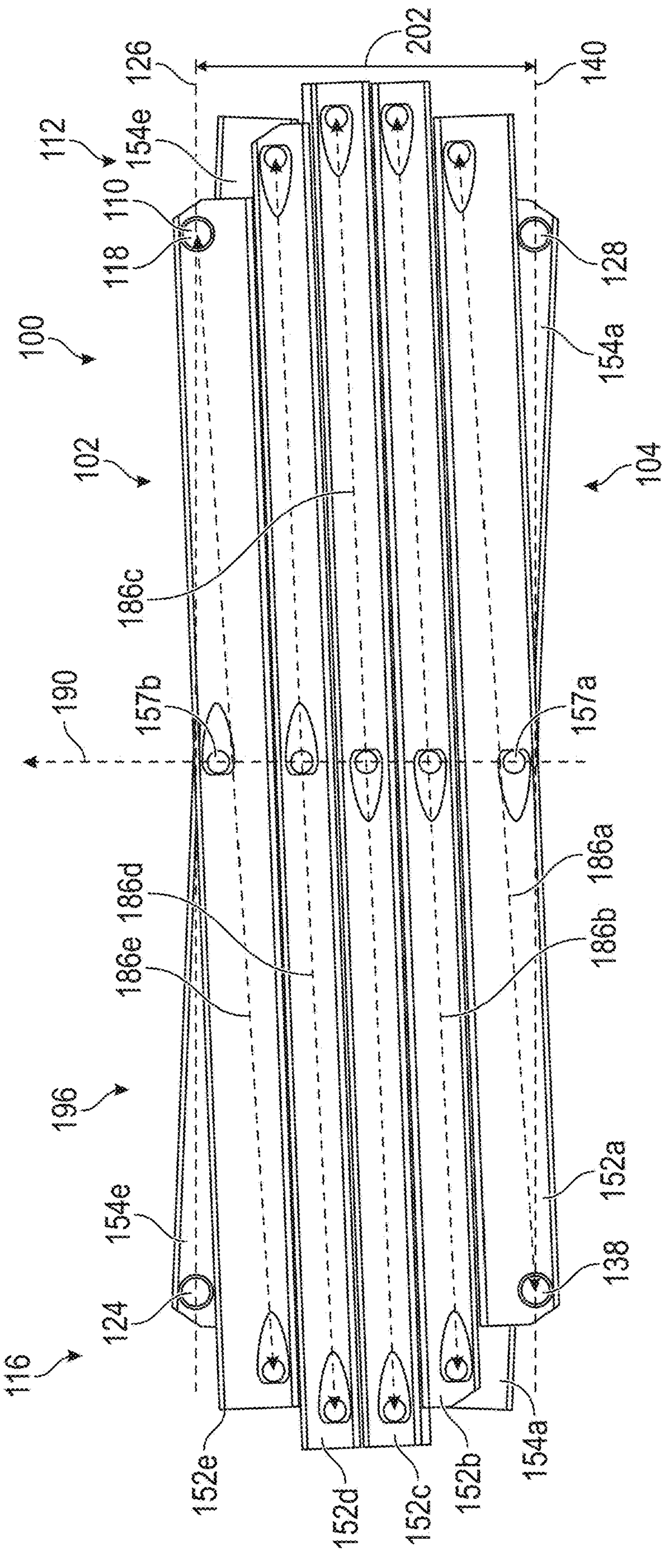
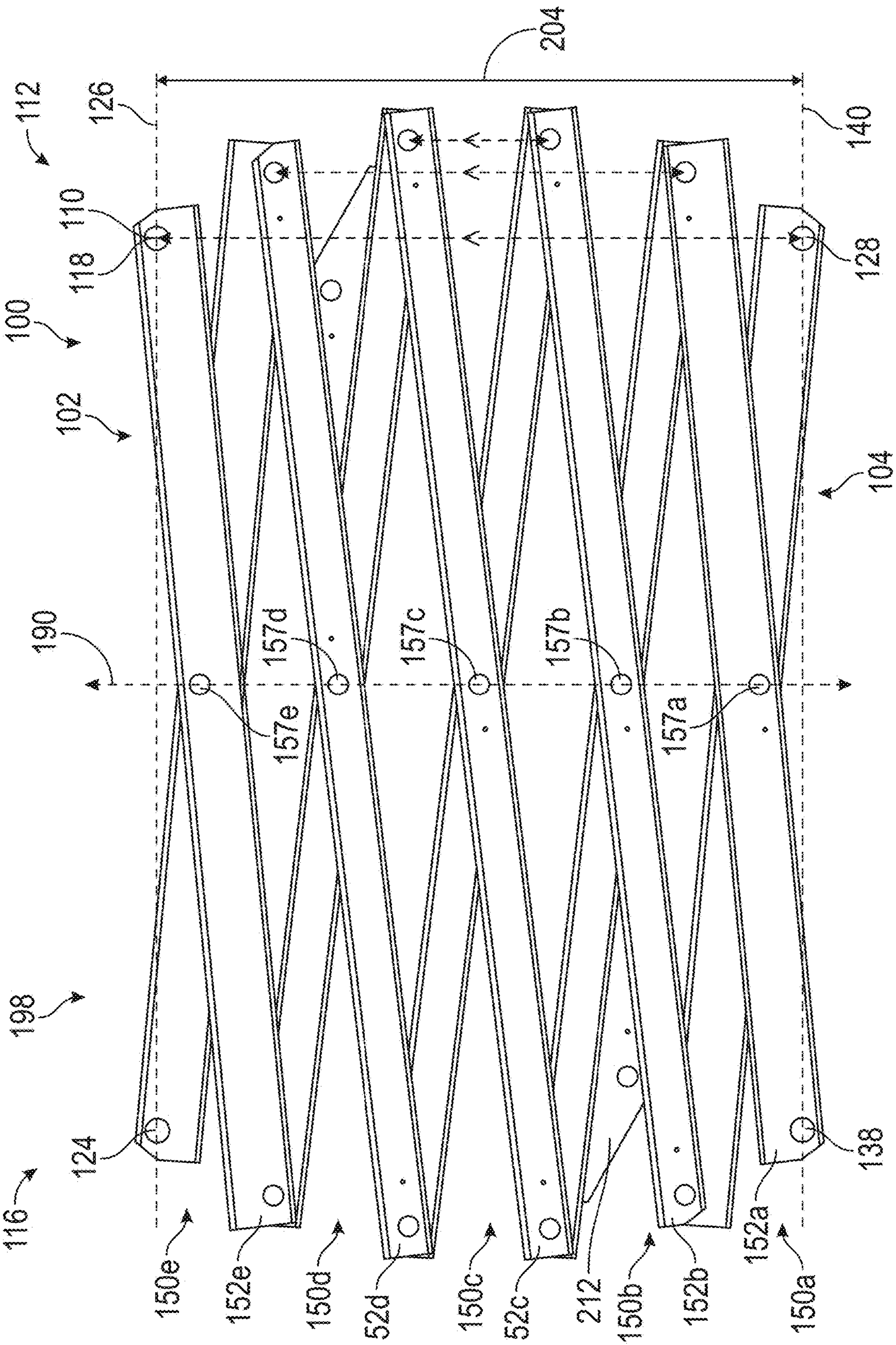

202
126
140
112
154e
110
118
128
100
154a
102
104
186c
190
157b
157a
186a
186d
186e
186b
196
152a
154e
138
124
116
152e
152d
152c
152b
154a

FIG. 7



204
112
126
140
110
118
128
100
102
104
190
157d
157c
157b
157e
157a
198
124
138
116
150e
152e
150d
152d
150c
152c
212
150b
152b
152a
150a

FIG. 8

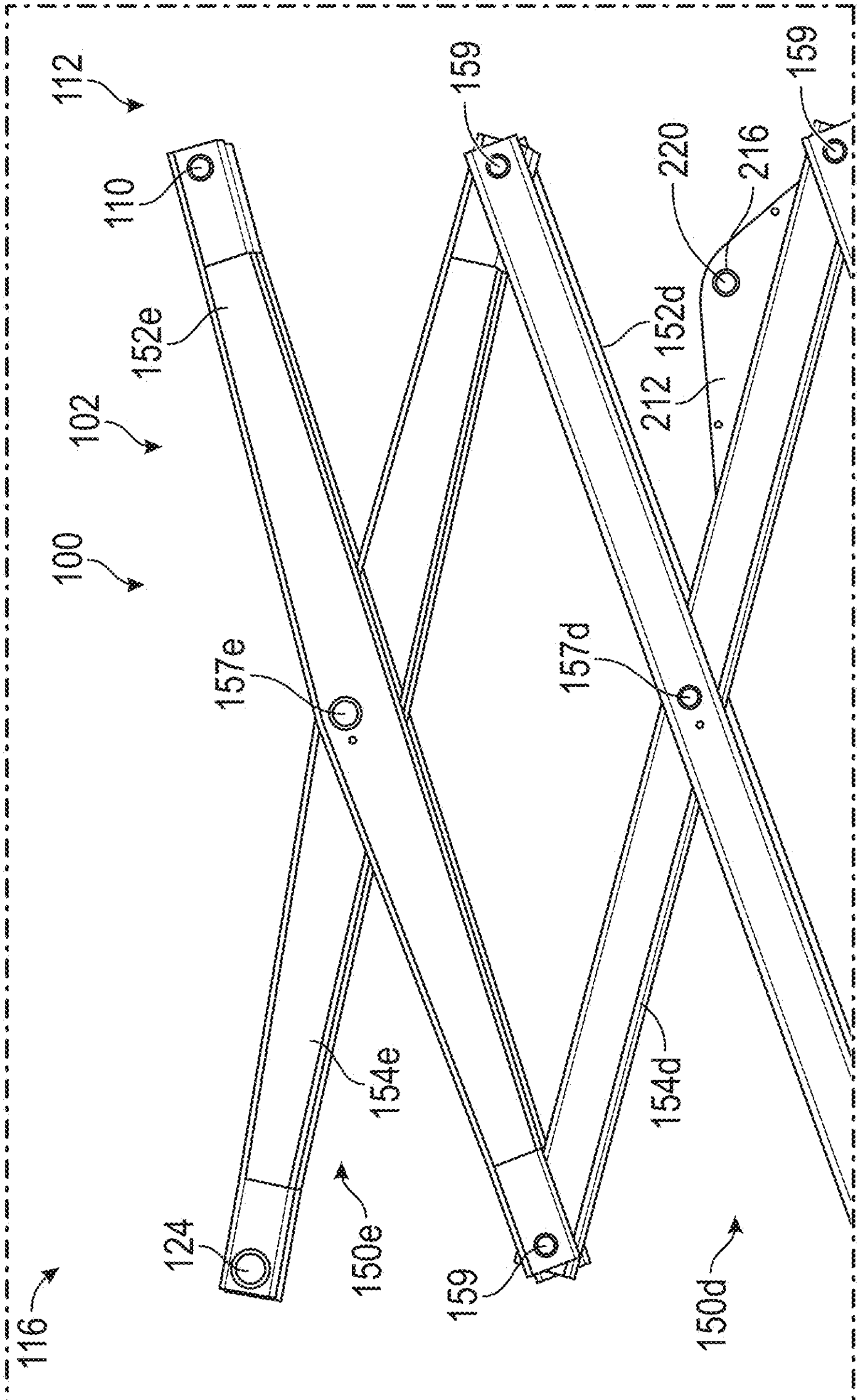

112
110
159
159
220
216
152e
152d
212
102
100
157e
157d
154e
154d
124
150e
159
150d
116

FIG. 9

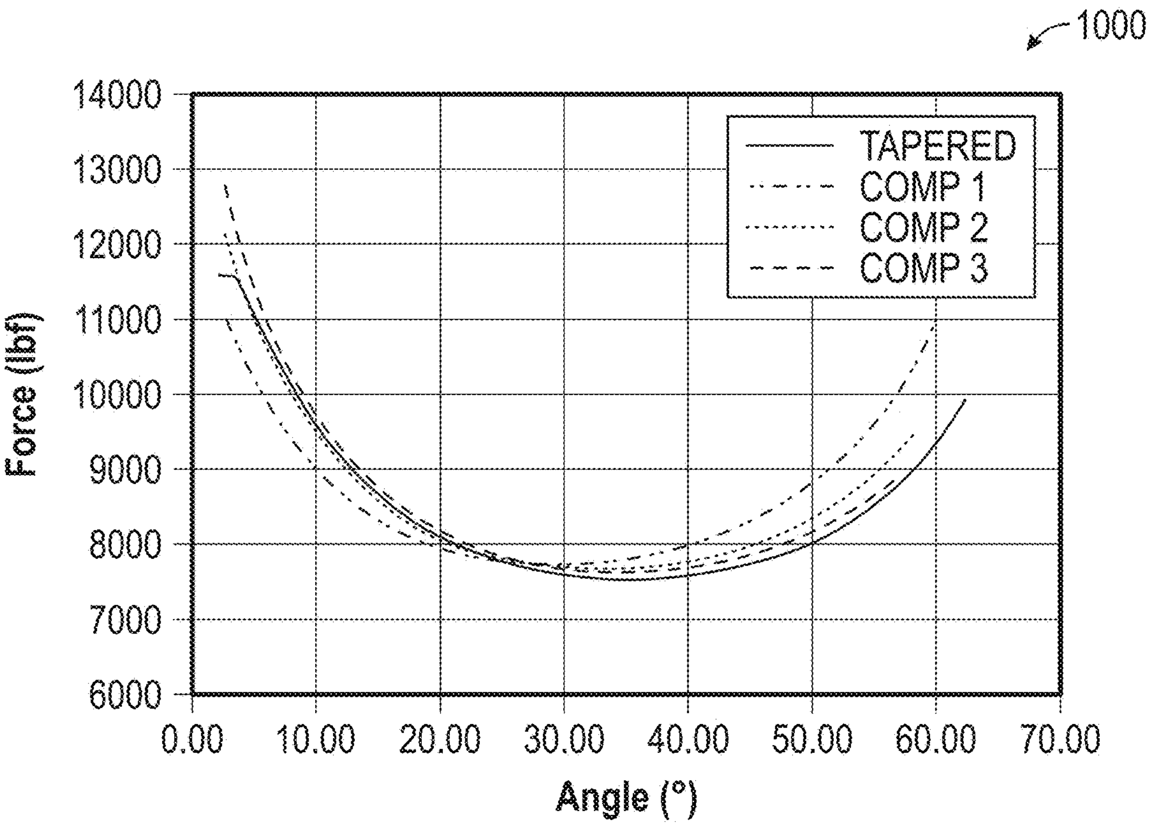

1000
14000
13000
12000
11000
10000
9000
8000
7000
6000
Force (lbf)
TAPERED
COMP 1
COMP 2
COMP 3
0.00
10.00
20.00
30.00
40.00
50.00
60.00
70.00
Angle (°)

FIG. 10

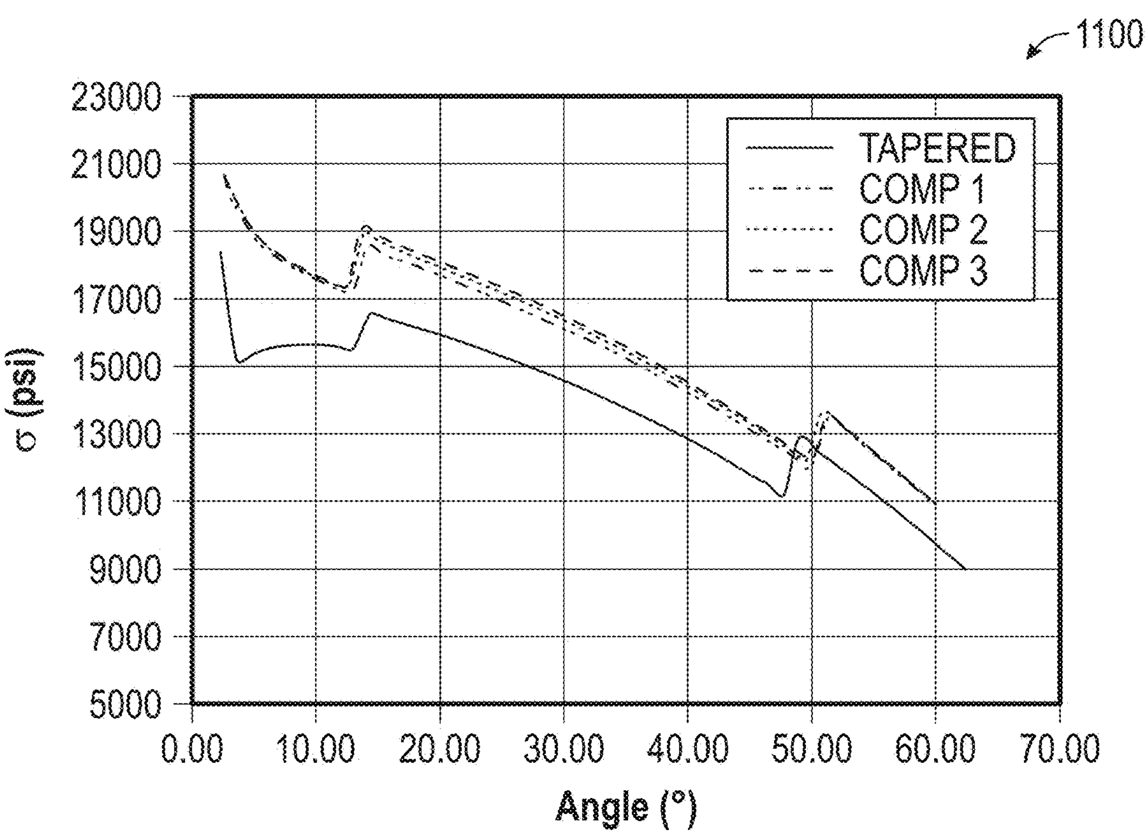

1100
23000
21000
19000
17000
15000
13000
11000
9000
7000
5000
σ (psi)
TAPERED
COMP 1
COMP 2
COMP 3
0.00
10.00
20.00
30.00
40.00
50.00
60.00
70.00
Angle (°)

FIG. 11

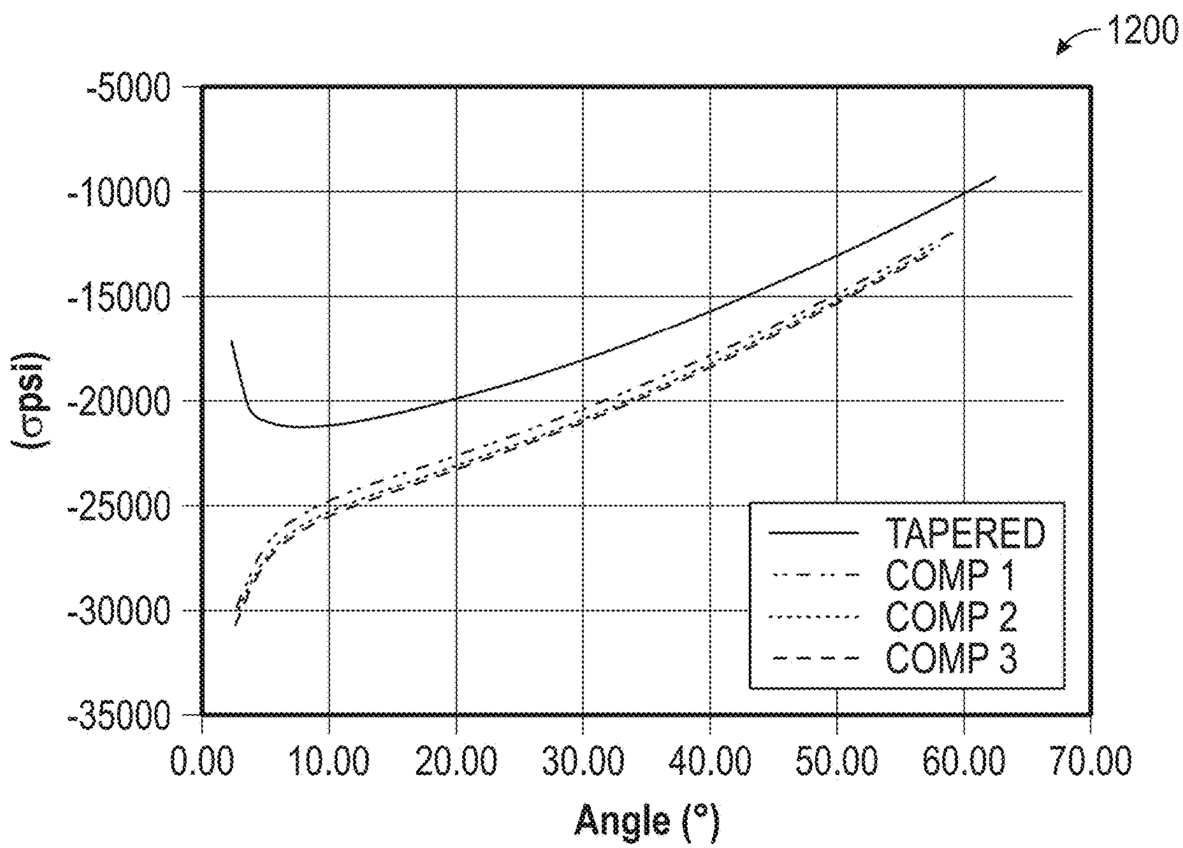

1200
-5000
-10000
-15000
-20000
-25000
-30000
-35000
(σpsi)
0.00
10.00
20.00
30.00
40.00
50.00
60.00
70.00
Angle (°)
TAPERED
COMP 1
COMP 2
COMP 3

FIG. 12

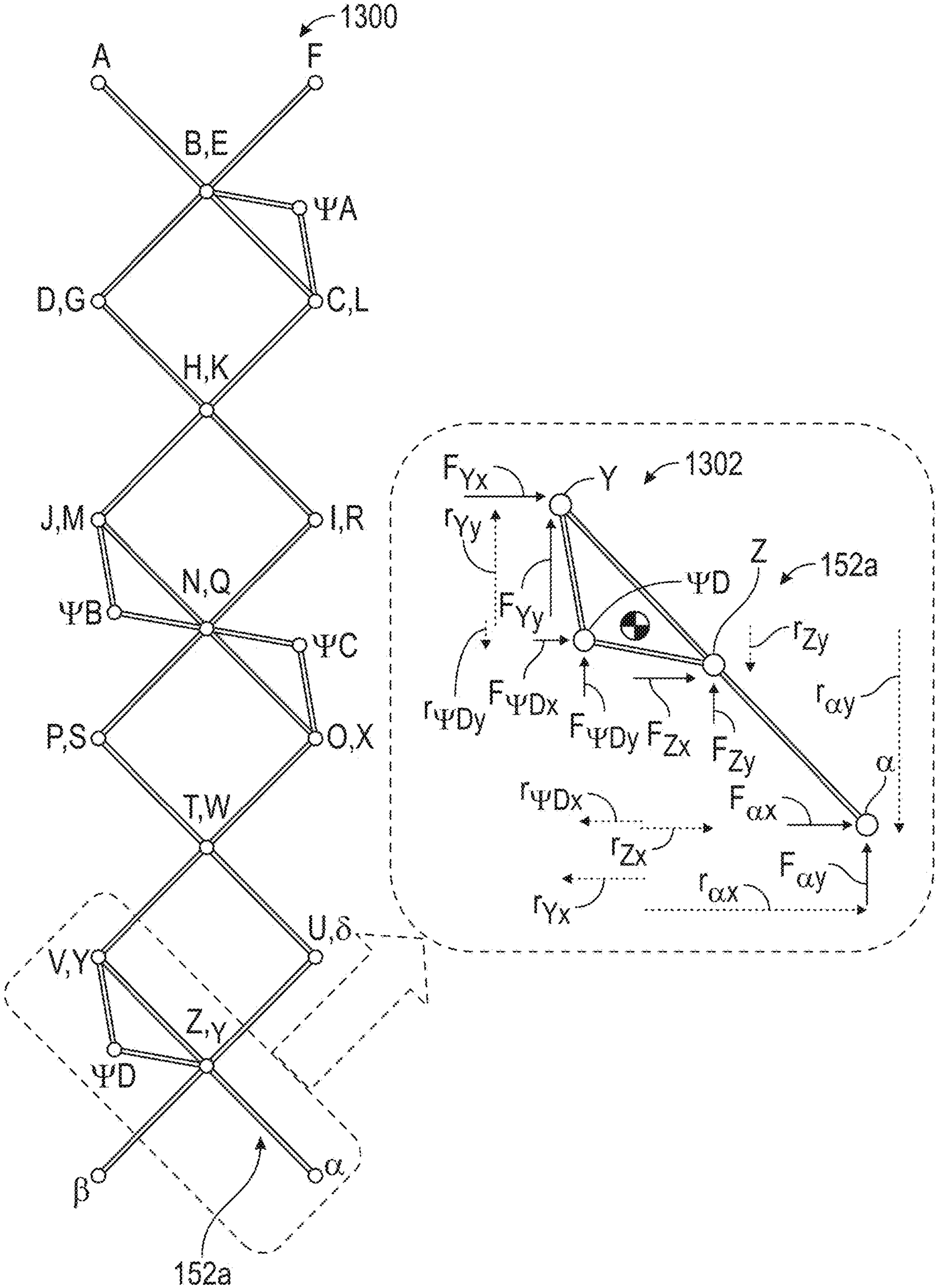

1300
A
F
B,E
ΨA
D,G
C,L
H,K
J,M
I,R
N,Q
ΨB
ΨC
P,S
O,X
T,W
U,δ
V,Y
Z,Y
ΨD
β
α
152a
1302
F_{Yx}
Y
r_{Yy}
F_{Yy}
Z
ΨD
152a
r_{Zy}
$r_{\Psi Dy}$
$F_{\Psi Dx}$
$F_{\Psi Dy}$
F_{Zx}
F_{Zy}
$r_{\alpha y}$
α
$r_{\Psi Dx}$
$F_{\alpha x}$
r_{Zx}
$F_{\alpha y}$
r_{Yx}
$r_{\alpha x}$

FIG. 13

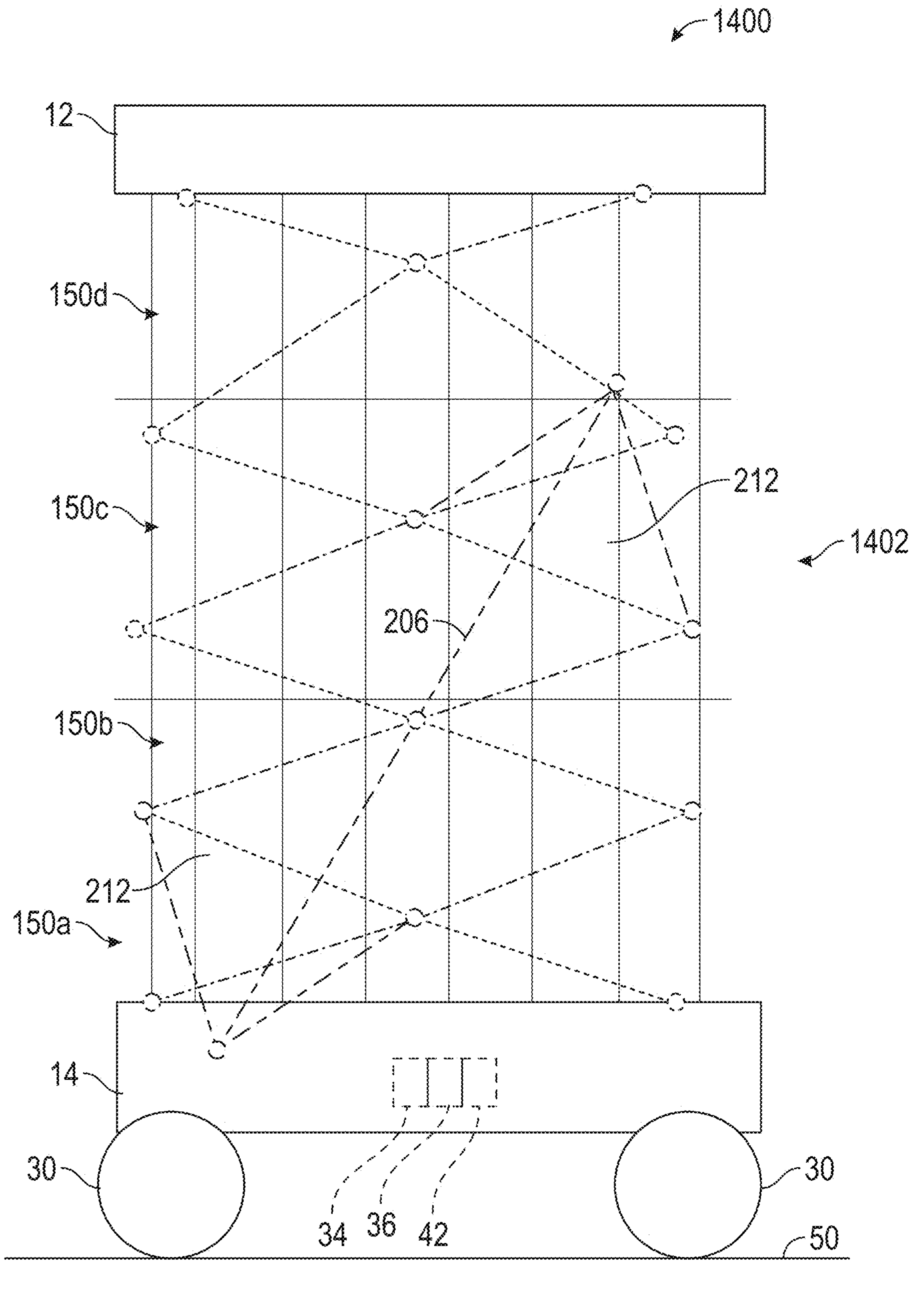


FIG. 14

SCISSOR LIFT

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This application claims the benefit of and priority to U.S. Provisional Patent Application No. 63/554,106 filed on Feb. 15, 2024, the entirety of which is hereby incorporated by reference herein.

BACKGROUND

[0002] The present disclosure relates generally to lift equipment and more particularly the present disclosure relates to scissor lifts and scissor stacks.

[0003] Lift equipment is often utilized to elevate a load (e.g., personnel, equipment, and/or materials) to an elevated work location. For example, lift equipment can be utilized to situate building materials on a ceiling or wall of a jobsite. Lift equipment may be transported to and from a jobsite, and often is maneuvered and operated within a jobsite.

SUMMARY

[0004] At least one implementation relates to lift equipment including a chassis, a prime mover, multiple wheels, a lift platform, and a scissor stack assembly. The prime mover is coupled to the chassis. The multiple wheels are rotatably coupled to the chassis. The scissor stack assembly includes a first scissor cross, a second scissor cross, a third scissor cross, and an actuator. The first scissor cross is coupled to the chassis and has first links of a first link length. The second scissor cross is coupled to the lift platform and has second links of a second link length. The third scissor cross is coupled between the first scissor cross and the second scissor cross and has third links of a third link length. The actuator is operatively coupled to the prime mover and is configured to transition the scissor stack assembly between the retracted position and the extended position. The first link length is different than at least one of: (i) the second link length or (ii) the third link length.

[0005] At least one implementation relates to a scissor stack assembly for lift equipment. The scissor stack assembly includes a first scissor cross, a second scissor cross, a third scissor cross, and an actuator. The first scissor cross has a pair of first links configured to couple a base dock at a first end. The pair of first links has a first link length. The second scissor cross has a pair of second links configured to couple an platform dock at a second end. The pair of second links has a second link length. The third scissor cross has a pair of third links pivotally coupled between the first scissor cross and the second scissor cross. The pair of third links have a third link length and a link aperture. The actuator is disposed within the link aperture and is configured to selectively transition between a retracted position and an extended position to thereby influence an extension distance between the first end and the second end. The first link length is different than at least one of: (i) the second link length or (ii) the third link length.

[0006] At least one implementation relates to a scissor lift, including a chassis, multiple wheels, a lift platform, a first scissor cross, a second scissor cross, and a third scissor cross. The multiple wheels are rotatably coupled to the chassis. The first scissor cross is coupled to the chassis and has first links of a first link length. The second scissor cross is coupled to the lift platform and has second links of a second link length. The third scissor cross is coupled between the first scissor cross and the second scissor cross and has third links of a third link length. The first link length is different than at least one of: (i) the second link length or (ii) the third link length.

[0007] In some implementations, the first link length is less than the third link length. In some implementations, the second link length is less than the third link length. In some implementations, the third link length is less than the second link length. In some implementations, the first link length and the second link length are less than the third link length. In some implementations, the third link length is less than the first link length. In some implementations, the scissor stack assembly includes a fourth scissor cross having links of a fourth link length. In some implementations, the fourth scissor cross is coupled between the second scissor cross and the third scissor cross. In some implementations, the scissor stack assembly includes a fifth scissor cross having links of a fifth link length. In some implementations, the fifth scissor cross is coupled between the third scissor cross and the first scissor cross. In some implementations, the first link length and the second link length are less than the fourth link length and the fifth link length, and the fourth link length and the fifth link length are less than the third link length. In some implementations, the first links are arcuate or the second links are arcuate. In some implementations, the scissor stack defines an internal volume and the actuator is disposed within the internal volume. In some implementations, the scissor stack has an extension distance of at least 10 feet but not more than 30 feet. In some implementations, the extension distance is at least 10 feet. In some implementations, the collapsed distance of the scissor stack assembly is at most 18 inches.

[0008] This summary is illustrative only and is not intended to be in any way limiting. Other aspects, inventive features, and advantages of the devices or processes described herein will become apparent in the detailed description set forth herein, taken in conjunction with the accompanying figures, wherein like reference numerals refer to like elements.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] FIG. **1** is a right perspective view of a scissor lift, according to an exemplary implementation;

[0010] FIG. **2** is a front right perspective view of the scissor lift of FIG. **1**;

[0011] FIG. **3** is a front left perspective view of the scissor lift of FIG. **1**;

[0012] FIG. **4** is a cross sectional view of the scissor lift of FIG. **1** taken along line A-A;

[0013] FIG. **5** is a right side view of a scissor stack, according to an exemplary implementation;

[0014] FIG. **6** is a top right rear perspective view of the scissor stack of FIG. **4**;

[0015] FIG. **7** is a right side view of the scissor stack of FIG. **4**;

[0016] FIG. **8** is a right side view of the scissor stack of FIG. **4**;

[0017] FIG. **9** is a detail view of a scissor cross of the scissor stack of FIG. **4**;

[0018] FIG. **10** is a plot of an actuation force, according to some implementations;

[0019] FIG. **11** is a plot of a maximum stress in a scissor stack, according to some implementations;

[0020] FIG. **12** is a plot of a minimum stress in a scissor stack, according to some implementations;

[0021] FIG. **13** is a linkage diagram of a scissor stack, according to some implementations; and

[0022] FIG. **14** is a schematic diagram of a side view of a scissor lift, according to some implementations.

DETAILED DESCRIPTION

[0023] Before turning to the figures, which illustrate the exemplary implementations in detail, it should be understood that the present application is not limited to the details or methodology set forth in the description or illustrated in the figures. It should also be understood that the terminology is for the purpose of description only. Like reference numerals in the figures may represent and refer to the same or similar element, feature, or function.

[0024] Described in detail herein are systems and methods for improved lift equipment to better meet the needs of users. Lift equipment (e.g., areal lift equipment, low-access lift equipment, access lift equipment, etc.) is often utilized at a jobsite to provide access to one or more elevated portions of a jobsite. Operating lift equipment poses many technical challenges and can be difficult and burdensome. For example, uneven floors, low ceilings, constricted access points (e.g., doorways, elevator thresholds, etc.), and delicate floors (e.g., tiled floors, carpeted floors, marble floors, etc.) can burden or inhibit operation of lift equipment at a jobsite.

[0025] The lift equipment described herein provides solutions to these and other technical problems through a scissor stack assembly having scissor crosses of differing dimensions that facilitate improved mechanical performance, such as lower internal stresses, improved lift height, improved lift capacity, improved structural soundness, a compact footprint, and a low weight. The lift equipment described herein provides the user the flexibility to utilize lift equipment in environments that would otherwise be burdensome to lift equipment operations, and gives a user the flexibility to transport, store, and operate additional equipment in a space.

Overall Machine

[0026] Referring now to FIGS. **1-4**, lift equipment (e.g., areal lift equipment, low-access lift equipment, access lift equipment, etc.), shown as a scissor lift **10**, includes a lift platform **12**, a chassis **14**, and a scissor stack assembly **100**, according to some implementations. The lift platform **12** is configured to support and at least partially contain an operator **16** within a platform volume **18** defined within one or more rails **20** or walls and a platform floor **21**, according to some implementations. The rails **20** may be configured to fold or detach to reduce the distance between the top of the rails **20** and the platform floor **21**. The platform volume **18** may at least partially contain equipment (e.g., welding machines, tools, etc.), building materials (e.g., fasteners, sheet metal, drywall, piping, electrical conduit, etc.), and personnel (e.g., operator **16**). In some implementations, the lift platform **12** is configured to accommodate more than one operator **16** (e.g., two operators, three operators, four operators, etc.) within the platform volume **18**. In some implementations, the lift platform **12** includes a slideout portion **22** that is configured to nest within a slideout housing portion **24** of the lift platform **12** in a retracted position, and slidably extend outwardly and away from the slideout housing portion **24** of the lift platform **12** in an extended position. In this way, the slideout **22** can increase or decrease the size of the platform volume **18**, according to some implementations. In some implementations, the slideout portion **22** is configured to travel approximately thirty inches between the extended position and the retracted position.

[0027] In some implementations, the lift platform **12** includes a user interface **26** configured to receive one or more user inputs regarding control of one or more operations of the scissor lift **10** (e.g., a direction of travel, an application of brakes, a platform height, etc.).

[0028] In some implementations, the chassis **14** is configured to support the scissor stack assembly **100** and the lift platform **12**. The chassis **14** may include one or more wheels **30**. In some implementations, one or more of the wheels **30** may be tractive wheels. In some implementations, one or more of the wheels **30** are caster wheels. In some implementations, the wheels **30** facilitate a zero-turn radius of the scissor lift **10**. In some implementations, one or more wheels **30** are configured to steer the scissor lift **10** (e.g., spin, turn, pivot, etc.).

[0029] In some implementations, the chassis **14** includes a prime mover **34**. In some implementations, the prime mover **34** is or includes an electric motor (e.g., an AC motor, a DC motor, etc.) and/or an internal combustion motor (e.g., diesel engine, petrol engine, natural gas engine, propane engine, etc.). In some implementations, the chassis **14** is self-propelled. For example, rotation of one or more wheels **30** may be driven by power from the prime mover **34**. For example, one or more of the wheels **30** may be coupled to the prime mover **34** directly (e.g., hub motor) and/or via a drivetrain.

[0030] In some implementations, the chassis **14** includes an energy storage device **36** (e.g., fuel tank, battery, battery array, capacitor bank, etc.) configured to supply energy to the prime mover **34**. In some implementations, the energy storage device **36** is or includes one or more lithium-ion batteries (e.g., a lithium cobalt oxide battery, a lithium iron phosphate battery, a lithium magnesium oxide battery, etc.) and/or a valve regulated lead-acid battery (e.g., a sealed lead-acid battery, an absorbent glass mat battery, etc.).

[0031] In some implementations, the chassis **14** includes a user interface **38**. The user interface **38** is configured to receive one or more inputs via input device **40**. For example, input device **40** may include one or more button, toggle switches, valve, touch sensitive surface, and/or joystick. In some implementations, the user interface **38** is configured to send messages to a controller **42** (e.g., microprocessor, a system on a chip, computing device, etc.) based on an input received by the input device **40**. In some implementations, the controller **42** is configured to control one or more operations of the scissor lift **10**. For example, the controller **42** may be configured to control one or more actuators (e.g., a hydraulic cylinder, an electric motor, a linear drive device, the actuator **206**, etc.) and receive sensor values from one or more sensors (e.g., contact sensors, position sensors, proximity sensors, temperature sensors, speed sensors, timers, etc.).

[0032] In some implementations, the chassis **14** includes fork pockets **44** and anchors **46** that are configured to facilitate lifting (e.g., by crane, by hoist, etc.) or transporting the scissor lift **10**. In some implementations, the chassis **14** includes deployable supports **48**. The deployable supports **48** are configured to provide additional contact between the chassis **14** and the ground surface **50** when the scissor lift **10** is stationary (e.g., parked), according to some implementations. In some implementations, the chassis **14** includes a step **52** configured to aid in ergonomic access to the platform volume **18** of the lift platform **12**.

Scissor Stack Assembly

[0033] Referring to FIGS. **1-9**, the scissor stack assembly **100** is coupled to the lift platform **12** at an implement end **102** and the chassis **14** at a base end **104**. The scissor stack assembly **100** is configured to support the lift platform **12** and regulate the distance (e.g., height) between the lift platform **12** and the chassis **14**.

[0034] In some implementations, the scissor stack assembly **100** includes a platform dock **106**. The platform dock **106** may couple the lift platform **12** to the scissor stack assembly **100**. The platform dock **106** includes a mount **117** (e.g., a dowel pin receptacle, a bearing, pin hole, a bushing, etc.) that extends along a platform pin axis **110** at a rear end **112**. The platform pin axis **110** extends along the longitudinal axis (e.g., pivot axis) of a platform pin **118** (e.g., a dowel pin, etc.). In some implementations, the platform pin **118** is configured to engage the mount **117** and pivotally couple the platform dock **106** to the scissor stack assembly **100**.

[0035] In some implementations, the platform dock **106** includes a platform pin slider track **114** at a front end **116**. In some implementations, the front end **116** is the end that leads in the direction of travel of the chassis **14**. The platform pin slider track **114** extends along an implement slider length **120** in a direction perpendicular to the platform pin axis **110**, according to some implementations. The platform pin slider track **114** is configured to enforce substantially linear motion of an implement slider pin **122** along the implement slider length **120**. The implement slider pin **122** extends along an implement slider pin axis **124**. In some implementations, the implement slider pin axis **124** is parallel to the platform pin axis **110**. In some implementations, the implement slider pin axis **124** and the implement slider length **120** define an implement slider plane **126**. In some implementations, the platform pin axis **110** is in plane with the implement slider plane **126**.

[0036] In some implementations, the scissor stack assembly **100** includes a base dock **108**. In some implementations, the base dock **108** couples the chassis **14** to the scissor stack assembly **100**. The base dock **108** includes a mount **127** (e.g., a dowel pin receptacle, a bearing, pin hole, a bushing, etc.) that extends along a base pin axis **128** at the rear end **112**. The base pin axis **128** extends along the longitudinal axis (e.g., pivot axis) of a base pin **130**. In some implementations the base pin **130** is configured to engage the mount **127** and pivotally couple the base dock **108** to the scissor stack assembly **100**.

[0037] In some implementations, base dock **108** includes a base pin slider track **132** at the front end **116**. The base pin slider track **132** extends along a base pin slider length **134** in a direction perpendicular to the base pin axis **128**, according to some implementations. The base pin slider track **132** is configured to enforce substantially linear motion of a base slider pin **136** along the base pin slider length **134**. The base slider pin **136** extends along a base slider pin axis **138**. The base slider pin axis **138** is parallel to the base pin axis **128**. In some implementations, the base pin axis **128** and the base pin slider length **134** define a base slider plane **140**. In some implementations, the base pin axis **128** is in plane with the base slider plane **140**. In some implementations, the base pin axis **128** and the platform pin axis **110** are parallel, and the base slider plane **140** and the implement slider plane **126** are parallel.

[0038] In some implementations, the platform dock **106** is configured to receive a portion of the lift platform **12** and releasably couple the lift platform **12** by one or more removable fasteners **142** (e.g., bolts, screws, pins, ball and detent, etc.). In some implementations, the lift platform **12** may be separated or dismounted from the platform dock **106** (e.g., by loosening or removing the removable fasteners **142**) and then a different implement (e.g., a lift platform with shorter rails, a flat platform, a renewed lift platform **12**, etc.) may be coupled to the platform dock **106**. In some implementations, the platform dock **106** is built into the lift platform **12** (e.g., formed into, welded, etc.). In some implementations, the base dock **108** is built into the chassis **14**.

[0039] Referring to FIGS. **1-9**, the scissor stack assembly **100** includes multiple scissor crosses **150**, according to some implementations. In some implementations, the scissor stack assembly **100** includes five scissor crosses **150**. For ease of reference, each instance of a scissor cross **150** is assigned an alphabetic suffix (e.g., scissor cross **150***a*, scissor cross **150***b*, scissor cross **150***c*, scissor cross **150***d*, scissor cross **150***e*, etc.).

[0040] In some implementations, the scissor cross **150** includes a first link **152** and a second link **154**. The first link **152** and the second link **154** are pivotally coupled (e.g., pinned) by a center pin **156**. The center pin **156** extends along a center pin axis **157**. The first link **152** has a proximal end **158** and a distal end **160**. The link **154** has a proximal end **162** and a distal end **164**. The proximal end **158** and the proximal end **162** are proximate to the base dock **108**. The distal end **160** and the distal end **164** are distal to the base dock **108**. In some implementations, the first link **152** defines a link aperture **166**. In some implementations, a portion of the second link **154** passes through the link aperture **166**. In some implementations, the second link **154** extends through the link aperture **166** and is pinned by the center pin **156** within the link aperture **166**. In some implementations, the center pin **156** extends along the center pin axis **157** through a portion of the first link **152**, then through a portion of the second link **154**, and then through another portion of the first link **152**. The first link **152** spans a link width **168** and the second link **154** spans a link width **170**. In some implementations, the second link **154** defines a link aperture **172**. In some implementations, the center pin **156** does not traverse the link aperture **172**. For example, the center pin **156** may pass through a portion of the first link **152** and then a portion of the second link **154**, and then a second center pin **174** may pass through a portion of the second link **154** and then a portion of the first link **152**. The center pin **156** and the second center pin **174** extend along the center pin axis **157**.

[0041] In some implementations, the scissor crosses **150** are linked by end pins **159**. The end pins **159** pivotally couple the proximal end **162** and the proximal end **158** of a scissor cross **150** to the distal end **160** and distal end **164** of an adjacent scissor cross **150**.

[0042] In some implementations, the first link **152** includes a link plate **176** at the distal end **160** and/or the proximal end **158**. In some implementations, the first link

152 and the second link **154** include interlocking knuckles that are each configured to receive a pin and pivotally couple (e.g., hinge) the first link **152** and the second link **154** about the pin.

[0043] In some implementations, the first link **152** includes a mount (e.g., bearing, through hole, pin pocket, bushing, etc.) that extends along an end pin axis **178** at the distal end **160**, and a mount that extends along an end pin axis **180** at the proximal end **158**. The end pin axis **178** and the end pin axis **180** are parallel. The second link **154** includes an end pin axis **182** at the distal end **164** and an end pin axis **184** at the proximal end **162**. The end pin axis **182** and the end pin axis **184** are parallel. In some implementations, the end pin axis **178**, end pin axis **180**, end pin axis **182**, end pin axis **184**, and center pin axis **157** are parallel. The end pins **159** extend along the end pin axes **178**, **180**, **182**, **184**.

[0044] In some implementations, the link **152** and/or the link **154** includes an elongated member (e.g., rectangular tube, pipe, rod, beam, etc.) that spans the length of the link. The link length **186** is the perpendicular distance between the end pin axis **178** and the end pin axis **180**. The link length **188** is the perpendicular distance between the end pin axis **182** and the end pin axis **184**. In some implementations, the link length **186** is at least 58 inches and not more than 66 inches. In some implementations, the link length **186** and the link length **188** are the same quantity. For example, the link length **186** and the link length **188** may both be thirty units of length (e.g., inches, centimeters, hands, etc.).

[0045] In some implementations, the end pin axis **178** and end pin axis **182** of a scissor cross are colinear with the end pin axis **184** and the end pin axis **180** of the adjacent scissor cross. For example, the scissor cross **150***b* is coupled to scissor cross **150***c* by end pins **159**, and the end pin axis **178***c* is collinear with the end pin axis **184***b*, and the end pin axis **182***c* is collinear with the end pin axis **180***b*. The scissor cross **150***a* is coupled between the base dock **108** and the scissor cross **150***b*. The end pin axis **184***a* is colinear with the base pin axis **128**, and the end pin axis **180***a* is colinear with the base slider pin axis **138**. The proximal end **162***a* is pivotally coupled to the chassis **14** by the base pin **130** and the proximal end **162***a* is coupled to the base dock **108** by the base slider pin **136**.

[0046] In some implementations, the scissor cross **150***e* is coupled between the platform dock **106** and the scissor cross **150***d*. In some implementations, the distal end **160***e* is pivotally coupled to the platform dock **106** by the platform pin **118**. In some implementations, the distal end **164***e* is pivotally coupled to the platform dock **106** by the implement slider pin **122**. In some implementations, the end pin axis **180***e* is colinear with the platform pin axis **110**. In some implementations, the end pin axis **184***e* is colinear with the implement slider pin axis **124**. In some implementations, the end pin axis **182***e* is colinear with the end pin axis **180***d*. In some implementations, the end pin axis **178***e* is colinear with the end pin axis **184***d*.

[0047] In some implementations, the center pins **156***a*, **156***b*, **156***c*, **156***d*, **156***e* are coplanar and define a center pin plane **190**. The center pin plane **190** is perpendicular to the implement slider plane **126** and the base slider plane **140**. The end pin axis **178** and the end pin axis **182** are coplanar and define a proximate end pin plane **192**. The end pin axis **184** and the end pin axis **180** are coplanar and define a distal end pin plane **194**. The proximate end pin plane **192** and the distal end pin plane **194** are parallel. The proximate end pin plane **192** and the distal end pin plane **194** are perpendicular to the center pin plane **190**.

[0048] In some implementations, the scissor cross **150***a* and the scissor cross **150***e* have the same link length (e.g., 58 inches), and one or more of the interstitial scissor crosses (e.g., scissor cross **150***b*, scissor cross **150***c*, and/or scissor cross **150***d*) have a second length that is different than the first length (e.g., 64 inches). In some implementations, the link lengths **186***a*, **188***a* are less than the link lengths **186***b*, **188***b*. In some implementations, the link lengths **186***a*, **188***a* are greater than the link lengths **186***b*, **188***b*. In some implementations, the link lengths **186***a*, **188***a* are different than at least one of: (i) the link lengths **186***c*, **188***c* or (ii) the link lengths **186***e*, **188***e*. In some implementations, one or more of the link length **186***a*, the link length **186***b*, the link length **186***c*, the link length **186***d*, the link length **186***e* are different lengths. In some implementations, the link length **186***a* is less than the link length **186***c*. In some implementations, the link lengths **186***e*, **188***e* are less than the link lengths **186***c*, **188***c*. In some implementations, the link lengths **186***c*, **188***c* are less than the link lengths **186***e*, **188***e*. In some implementations, the link lengths **186***a*, **188***a* and the link lengths **186***e*, **188***e* are less than the link lengths **186***c*, **188***c*. In some implementations, the link lengths **186***c*, **188***c* are less than the link lengths **186***a*, **188***a*.

[0049] In some implementations, one or more of the links **152**, **154** of the scissor stack assembly **100** are arcuate links, according to some implementations. For example, the center pin axis **157***a* may be offset from a link length plane **195***a* that contains the end pin axis **178***a* and the end pin axis **180***a* of the link **152***a*. In some implementations, the link **152***a*, the link **154***a*, the link **152***e*, and the link **154***e* are arcuate links. In some implementations, the link **152***a* and the link **154***a* are arced away from the base dock **108**, and the link **152***e* and the link **154***e* are arced toward the base dock **108**. For example, the center point of an arc perpendicular and tangent to the end pin axis **178***a*, the center pin axis **157***a*, and the end pin axis **180***a* is located to the side of the link length plane **195***a* that faces toward the base dock **108**, according to some implementations. In some implementations, one or more scissor crosses **150** have arcuate links. In some implementations, the links **152***a* and the link **154***a* arc away from the base dock **108**. In some implementations, the links **152***e* and the link **154***e* arc away from the base dock **108**.

[0050] In some implementations, the scissor cross **150***d* is coupled between the scissor cross **150***e* and the scissor cross **150***c*. In some implementations, the scissor cross **150***b* is coupled between the scissor cross **150***c* and the scissor cross **150***a*. In some implementations, the link lengths **186***a*, **188***a* and the link lengths **186***e*, **188***e* are less than the link lengths **186***d*, **188***d* and the link lengths **186***b*, **188***b*; and the link lengths **186***d*, **188***d* and the link lengths **186***b*, **188***b* are less than the link lengths **186***c*, **188***c*. Advantageously, shorter link lengths **186**, **188** at the base end **104** and/or implement end **102** can facilitate a smaller base dock **108** (and thereby a smaller chassis **14**) and/or a smaller platform dock **106**, which can reduce the overall footprint and weight of the scissor lift **10**, according to some implementations.

[0051] In some implementations, the link length **174***a*, **176***a*, and the link length **174***e*, **176***e* are approximately 91% of the link length of an interstitial scissor cross (e.g., the link lengths **174***b*, **176***b* of scissor cross **150***b*, the link lengths

174*b*, 176*b*, the link lengths 174*c*, 176*c* of scissor cross 150*c*, the link lengths 174*d*, 176*d* of scissor cross 150*d*). In some implementations, the link length 174*a*, 176*a*, and the link length 174*e*, 176*e* are at most 91% of the link length of an interstitial scissor cross (e.g., the link lengths 174*b*, 176*b* of scissor cross 150*b*, the link lengths 174*b*, 176*b*, the link lengths 174*c*, 176*c* of scissor cross 150*c*, the link lengths 174*d*, 176*d* of scissor cross 150*d*). In some implementations, the link length 174*b*, 176*b*, and the link length 174*d*, 176*d* are approximately 97% of the link length of the link lengths 174*c*, 176*c* of scissor cross 150*c*. Unexpectedly, varied link lengths 186, 188 of scissor crosses 150 in the scissor stack assembly 100 reduces peak stresses and actuator loads in the scissor stack assembly 100.

[0052] Referring to FIGS. 1-7, in operation, the scissor stack assembly 100 is configured to transition between a retracted position 196 (i.e., a stowed position, a collapsed position, a folded position) (see, e.g. FIGS. 3, 6, 7), and an extended position 198 (see, e.g., FIGS. 1, 2, 4, 5, 8). In the retracted position 196 the platform dock 106 is spaced from the base dock 108 by a collapsed distance 202 (e.g., collapsed height). In the extended position 198 the platform dock 106 is spaced from the base dock 108 by an extension distance 204. The collapsed distance 202 is the distance between the base slider plane 140 and the implement slider plane 126 when the scissor stack assembly 100 is in the retracted position 196. The extension distance 204 is the distance between the base slider plane 140 and the implement slider plane 126 when the scissor stack assembly 100 is in the extended position 196. The extension distance 204 is greater than the collapsed distance 202.

[0053] In some implementations, the scissor stack assembly 100 includes an actuator 206. In some implementations, the actuator 206 is a linear actuator (e.g., a hydraulic cylinder, a pneumatic cylinder, an electromechanical linear actuator, etc.). In some implementations, the actuator 206 is coupled between a pair of parallel or substantially parallel links of the scissor stack assembly 100. For example, the actuator 206 may be coupled between the link 154*a* and the link 154*c*. In some implementations, the actuator 206 is coupled between links of the same link length. In some implementations, the actuator 206 is coupled to a first scissor cross at a first end and is coupled to a second scissor cross at a second end. In some implementations, the scissor stack assembly 100 defines an internal volume 208 between the platform dock 106, the base dock 108, and the link aperture 172. In some implementations, the actuator 206 is contained within the internal volume 208.

[0054] In some implementations, in operation, the actuator 206 is configured to extend and retract along a stroke length 210, which influences the scissor crosses 150 to open or close, and thereby influences the scissor stack assembly 100 to extend or retract, according to some implementations. For example, when the actuator 206 extends, the distance between the end pin axis 178 and the end pin axis 182 decreases, and simultaneously the distance between: (i) the end pin axis 178 and the end pin axis 184; and (ii) the end pin axis 182 and the end pin axis 180; increases, and thus the extension distance 204 increases, according to some implementations. In some implementations, the scissor stack assembly 100 extends or retracts based on actuation of the actuator 206 over the stroke length 210.

[0055] In some implementations, the actuator 206 is coupled to actuator mounting plates 212. The actuator mounting plates 212 may be coupled to the scissor stack assembly 100 via one or more fasteners, welds, adhesives, or combinations thereof. In some implementations, the actuator mounting plates 212 are formed with one or more links 152, 154 (e.g., cast, additively manufactured, milled, etc.) and/or define a unitary body with the links 152, 154. The actuator 206 may be pivotally coupled to the actuator mounting plates 212 by actuator pin 214 and actuator pin 216. The actuator pin 214 extends along an actuator pin axis 218. The actuator pin 216 extends along an actuator pin axis 220. The actuator pin axis 218 and the actuator pin axis 220 are parallel. In some implementations, actuator pin axis 218 and the actuator pin axis 220 are spaced by approximately 48 inches when the scissor stack assembly 100 is in the retracted position 196. In some implementations, the actuator pin axis 218 and the actuator pin axis 220 are spaced by approximately 84 inches when the scissor stack assembly 100 is in the extended position 198. In some implementations, the actuator pin axis 218, the actuator pin axis 220, the center pin axes 157, the end pin axes 178, 180, 182, 184, the base pin axis 128, the platform pin axis 110, the base slider pin axis 138, and the implement slider pin axis 124 are parallel.

[0056] In some implementations, the scissor stack assembly 100 has a collapsed distance 202 that is at least 16 inches and not more than 18 inches. In some implementations, the scissor stack assembly 100 has an extension distance of approximately 25 feet. In some implementations, the scissor stack assembly 100 has an extension distance of at least 10 feet and not more than 40 feet. In some implementations, the scissor stack assembly 100 has a maximum footprint of approximately 70 inches by approximately 20 inches.

[0057] Referring to FIGS. 10-12, the actuation force and peak stresses of the scissor stack assembly 100 are shown, according to some implementations. The TAPERED plot line corresponds to a dataset of the scissor stack assembly 100, according to some implementations. For the datasets shown in FIGS. 10-12: the link lengths 186*a*, 188*a*, and the link lengths 186*e*, 188*e* are 58 inches; the link lengths 186*b*, 188*b*, and the link lengths 186*d*, 188*d* are 64 inches; the link lengths 186*c*, 188*c* are 66 inches; the links 152*a*, 154*a* are arcuate and arc away from the base end 104; the center pin axis 157*a* is offset from the link length plane 195*a* by 1.55 inches; the links 152*e*, 154*e* are arcuate and arc toward the base end 104; and the center pin axis 157*e* is offset from the link length plane 195*e* by 1.55 inches. The COMP 1 plot line corresponds to a dataset of a scissor stack where all links are linear, and all link lengths are 64.6 inches. The COMP 2 plot line corresponds to a dataset of a scissor stack where all links are linear, and all link lengths are 65.8 inches. The COMP 3 plot line corresponds to a dataset of a conventional scissor stack where all links are linear, and all link lengths are 66.4 inches. The left-hand ends of the plot lines correspond to the retracted position 196. The right-hand ends of the plot lines correspond to the extended position 198. For each of the plot lines, the right-most end of the plot line corresponds to an equivalent extension distance 204. For example, each stack was tested over the same vertical distance using the same actuator.

[0058] FIG. 10 is an illustration of a plot 1000 of the force supplied by the actuator while the scissor stack travels from the retracted position 196 to the extended position 198, according to some implementations.

[0059] FIG. **11** is an illustration of a plot **1100** of the maximum stress experienced by at least one link of the scissor stack assembly **100** while the scissor stack travels from the retracted position **196** to the extended position **198**, according to some implementations. The maximum stress accounts for axial stresses, bending stresses, shear stresses, and torsional stresses.

[0060] FIG. **12** is an illustration of a plot **1200** of the minimum stress experienced by a link of the scissor stack assembly **100** while the scissor stack travels from the retracted position **196** to the extended position **198**, according to some implementations. The minimum stress accounts for axial stresses, bending stresses, shear stresses, and torsional stresses.

[0061] Unexpectedly, the scissor stack assembly **100** experiences a lower maximum stress (e.g., 42.6% less than COMP **1**, 43.7% less than COMP **2**, 44.3% less than COMP **3**) and a lower average actuator force (e.g., 1.7% less than COMP **1**, 0.5% less than COMP **2**, 0.4% less than COMP **3**), among other technical benefits.

[0062] FIG. **13** is an illustration of a linkage diagram **1300** of the scissor stack assembly **100**, including a free body diagram **1302** of link **152***a*, according to some implementations. In the free body diagram **1302**, each "F" represents a force, and each "r" is a moment arm relative to the center of mass, according to some implementations. In FIG. **13**, the arrows shown with arrow heads in the general vicinity of a point correspond to a force applied to the point. For example, in free body diagram **1302**, point a of the member YZα is the point at which the forces r_{ay}, F_{ax}, F_{ay}, and r_{ax} are applied to the member YZα. As another example, in free body diagram **1302**, point Z of the member YZα is the point at which the forces r_{zy}, F_{Zx}, F_{Zy}, and r_{Zx} are applied to the member YZα. In linkage diagram **1300** and free body diagram **1302**, pin point ΨA and pin point ΨB are a pair associated with mounting points of a first actuator (e.g., actuator **206**), and pin point ΨC and pin point ΨD are a pair associated with mounting points of a second actuator.

[0063] Referring again to FIG. **3**, the access height **232** of the scissor lift **10** is the distance between the platform floor **21** and the ground surface **50**. In some implementations, the access height **232** is at most 34 inches. In some implementations, the base slider plane **140** is at least 26 inches and not more than 34 inches above the ground surface **50**. In some implementations, the rails **20** are approximately 78 inches above the ground surface **50** when the scissor stack assembly **100** is in the retracted position **196**. In some implementations, the rails **20** are not higher than 78 inches above the ground surface **50** when the scissor stack assembly **100** is in the extended position **198**. In some implementations, the footprint of the scissor lift **10** is at least 30 inches by 64 inches but not more than 32 inches by 80 inches.

[0064] Referring to FIG. **14**, a scissor lift **1400** includes the chassis **14**, the lift platform **12**, and a scissor stack **1402**, according to some implementations. The scissor stack **1402** includes four scissor crosses **150**. The scissor cross **150***a* is coupled to the chassis **14** and the scissor cross **150***b*. The scissor cross **150***b* is coupled to the scissor cross **150***a* and the scissor cross **150***c*. The scissor cross **150***c* is coupled to the scissor cross **150***b* and the scissor cross **150***d*. The scissor cross **150***d* is coupled to the lift platform **12** and the scissor cross **150***c*.

[0065] Although the scissor stack assembly **100** is illustrated as having five scissor crosses **150** and the scissor stack **1402** is illustrated as having four scissor crosses **150**, in some implementations the scissor stack assembly **100** has more or fewer scissor crosses **150** (e.g., two scissor crosses, three scissor crosses, six scissor crosses, seven scissor crosses, eight scissor crosses, nine scissor crosses, etc.). In such implementations, the terminal scissor cross of the scissor stack (i.e., the scissor cross furthest from the base dock **108**) is coupled to the platform dock **106**.

[0066] In some implementations, the scissor stack assembly **100** includes multiple actuators **206** (e.g., two actuators, three actuators, etc.). In such implementations, the actuators **206** may work in tandem or in a sequence at the same or different locations of the scissor stack assembly **100**. For example, a first actuator **206** may be coupled between the link **154***a* and the link **154***c*, and a second actuator **206** may be coupled between the link **154***c* and the link **154***e*. In some implementations, an actuator **206** is configured to extend in the direction of the implement slider length **120**. For example, an actuator **206** may be directly coupled to the implement slider pin **122** and be configured to slide the implement slider pin **122** in the implement slider plane **126**. In some implementations, an actuator **206** is configured to extend in the direction of the base pin slider length **134**. For example, an actuator **206** may be coupled to the base slider pin **136** and be configured to slide the base slider pin **136** in the base pin slider plane **140**.

[0067] As utilized herein with respect to numerical ranges, the terms "approximately," "about," "substantially," and similar terms generally mean +/−10% of the disclosed values. When the terms "approximately," "about," "substantially," and similar terms are applied to a structural feature (e.g., to describe its shape, size, orientation, direction, etc.), these terms are meant to cover minor variations in structure that may result from, for example, the manufacturing or assembly process and are intended to have a broad meaning in harmony with the common and accepted usage by those of ordinary skill in the art to which the subject matter of this disclosure pertains. Accordingly, these terms should be interpreted as indicating that insubstantial or inconsequential modifications or alterations of the subject matter described and claimed are considered to be within the scope of the disclosure as recited in the appended claims.

[0068] It should be noted that the term "exemplary" and variations thereof, as utilized herein to describe various implementations, are intended to indicate that such implementations are possible examples, representations, or illustrations of possible implementations (and such terms are not intended to connote that such implementations are necessarily extraordinary or superlative examples).

[0069] The term "coupled" and variations thereof, as used herein, means the joining of two members directly or indirectly to one another. Such joining may be stationary (e.g., permanent or fixed) or moveable (e.g., removable or releasable). Such joining may be achieved with the two members coupled directly to each other, with the two members coupled to each other using a separate intervening member and any additional intermediate members. If "coupled" or variations thereof are modified by an additional term (e.g., directly coupled), the generic definition of "coupled" provided above is modified by the plain language meaning of the additional term (e.g., "directly coupled" means the joining of two members without any separate intervening member), resulting in a narrower definition than the generic definition of "coupled" provided above. Such coupling may be mechanical, electrical, or fluidic.

[0070] References herein to the positions of elements (e.g., "top," "bottom," "above," "below") are merely used to describe the orientation of various elements in the FIGURES. It should be noted that the orientation of various elements may differ according to other exemplary implementations, and that such variations are intended to be encompassed by the present disclosure.

[0071] It is important to note that the construction and arrangement of the scissor lift **10** as shown in the various exemplary implementations is illustrative only. Additionally, any element disclosed in one implementation may be incorporated or utilized with any other implementation disclosed herein. Although only one example of an element from one implementation that can be incorporated or utilized in another implementation has been described above, it should be appreciated that other elements of the various implementations may be incorporated or utilized with any of the other implementations disclosed herein.

What is claimed is:

1. Lift equipment, comprising:

a chassis;

a prime mover coupled to the chassis;

a plurality of wheels rotatably coupled to the chassis;

a lift platform; and

a scissor stack assembly configured to transition between a retracted position and an extended position, the scissor stack assembly comprising:

a first scissor cross coupled to the chassis and having first links of a first link length;

a second scissor cross coupled to the lift platform and having second links of a second link length;

a third scissor cross coupled between the first scissor cross and the second scissor cross and having third links of a third link length; and

an actuator operatively coupled to the prime mover and configured to transition the scissor stack assembly between the retracted position and the extended position;

wherein the first link length is different than at least one of: (i) the second link length or (ii) the third link length.

2. The lift equipment of claim **1**, wherein the first link length is less than the third link length.

3. The lift equipment of claim **1**, wherein the second link length is less than the third link length.

4. The lift equipment of claim **1**, wherein the third link length is less than the second link length.

5. The lift equipment of claim **1**, wherein the first link length and the second link length are less than the third link length.

6. The lift equipment of claim **1**, wherein the third link length is less than the first link length.

7. The lift equipment of claim **1**, wherein the scissor stack assembly further comprises:

a fourth scissor cross having links of a fourth link length;

wherein the fourth scissor cross is coupled between the second scissor cross and the third scissor cross.

8. The lift equipment of claim **7**, wherein the scissor stack assembly further comprises:

a fifth scissor cross having links of a fifth link length;

wherein the fifth scissor cross is coupled between the third scissor cross and the first scissor cross.

9. The lift equipment of claim **8**, wherein the first link length and the second link length are less than the fourth link length and the fifth link length, and wherein the fourth link length and the fifth link length are less than the third link length.

10. The lift equipment of claim **1**, wherein the first links are arcuate or the second links are arcuate.

11. The lift equipment of claim **1**, wherein the scissor stack assembly defines an internal volume and wherein the actuator is disposed within the internal volume.

12. The lift equipment of claim **1**, wherein the scissor stack assembly has an extension distance of at least 10 feet.

13. The lift equipment of claim **1**, wherein the scissor stack assembly has a collapsed distance of at most 18 inches.

14. A scissor stack assembly for lift equipment, comprising:

a first scissor cross having a pair of first links configured to couple a base dock at a first end, wherein the first links having a first link length;

a second scissor cross having a pair of second links configured to couple an platform dock at a second end, wherein the second links have a second link length;

a third scissor cross having a pair of third links pivotally coupled between the first scissor cross and the second scissor cross, wherein the third links have a third link length and a link aperture; and

an actuator disposed within the link aperture and configured to selectively transition between a retracted position and an extended position to thereby influence an extension distance between the first end and the second end;

wherein the first link length is different than at least one of: (i) the second link length or (ii) the third link length.

15. The scissor stack assembly of claim **14**, wherein the first link length and the second link length are less than the third link length.

16. The scissor stack assembly of claim **14**, further comprising:

a fourth scissor cross having a pair of fourth links having a fourth link length; and

a fifth scissor cross having a pair of fifth links having a fifth link length;

wherein the fourth scissor cross is coupled between the second scissor cross and the third scissor cross, and the fifth scissor cross is coupled between the third scissor cross and the first scissor cross; and

wherein the first link length is less than the fifth link length, and the fifth link length is less than the third link length.

17. The scissor stack assembly of claim **14**, wherein the pair of first links are arcuate and the pair of second links are arcuate.

18. The scissor stack assembly of claim **14**, wherein the extension distance is 10 feet to 30 feet.

19. A scissor lift, comprising:

a chassis;

a plurality of wheels rotatably coupled to the chassis;

a lift platform;

a first scissor cross coupled to the chassis and having first links of a first link length;

a second scissor cross coupled to the lift platform and having second links of a second link length; and a third scissor cross coupled between the first scissor cross and the second scissor cross and having third links of a third link length;

wherein the first link length is different than at least one of: (i) the second link length or (ii) the third link length.

20. The scissor lift of claim **19**, wherein the first link length and the second link length are less than the third link length.

* * * * *