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(54) **PIVOTING HOPPER FOR PARTICLE BLAST APPARATUS**

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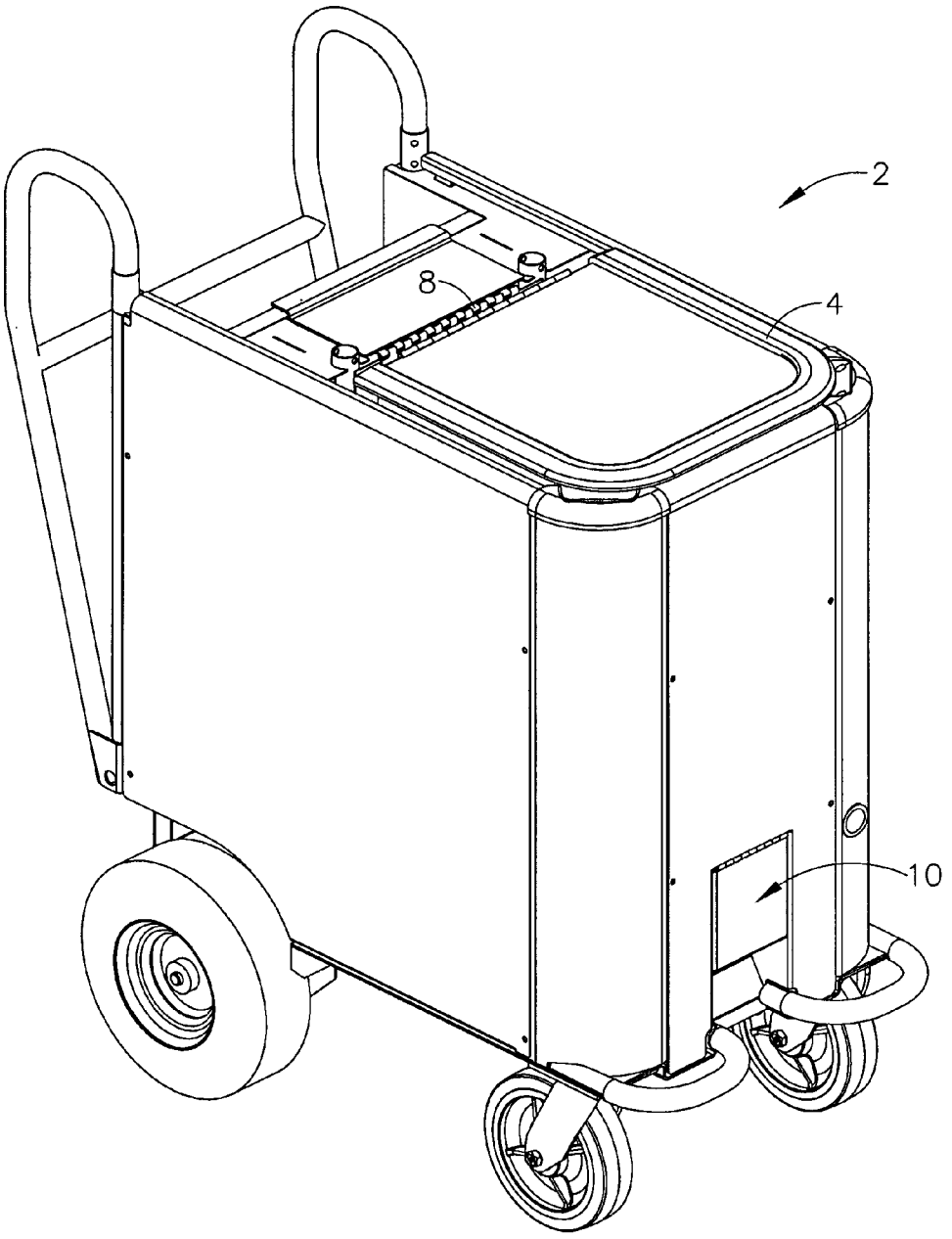
(57) **ABSTRACT**

A particle blast apparatus has a pivoting hopper, allowing the hopper exit to move from or between a first position at which the exit is aligned with the feeder entrance to a second position where the hopper exit is not aligned as such. The hopper may emptied or cleared in this manner. The hopper may be provided with a device configured to impart energy to the hopper while the hopper exit is located at the second position.



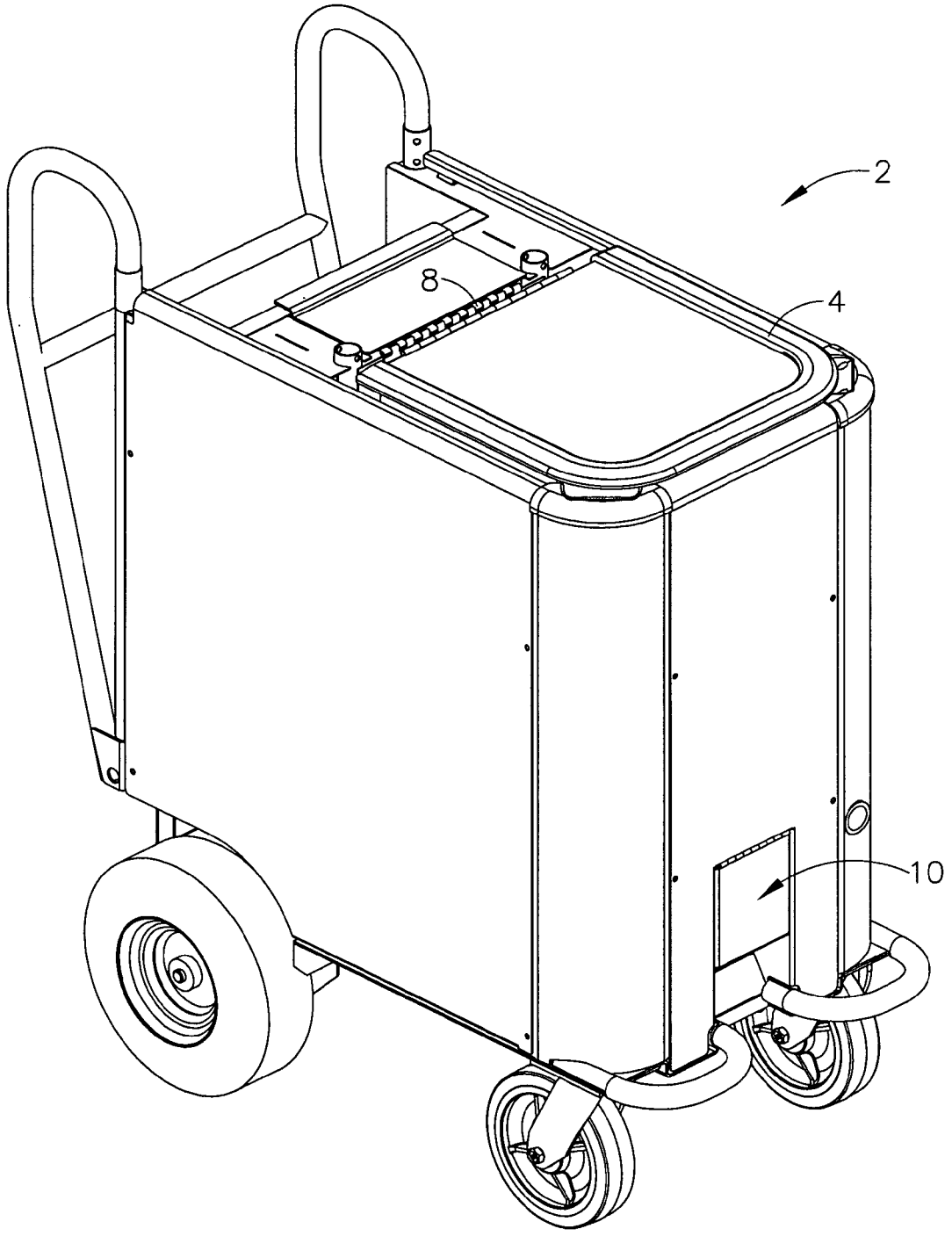


FIG. 1

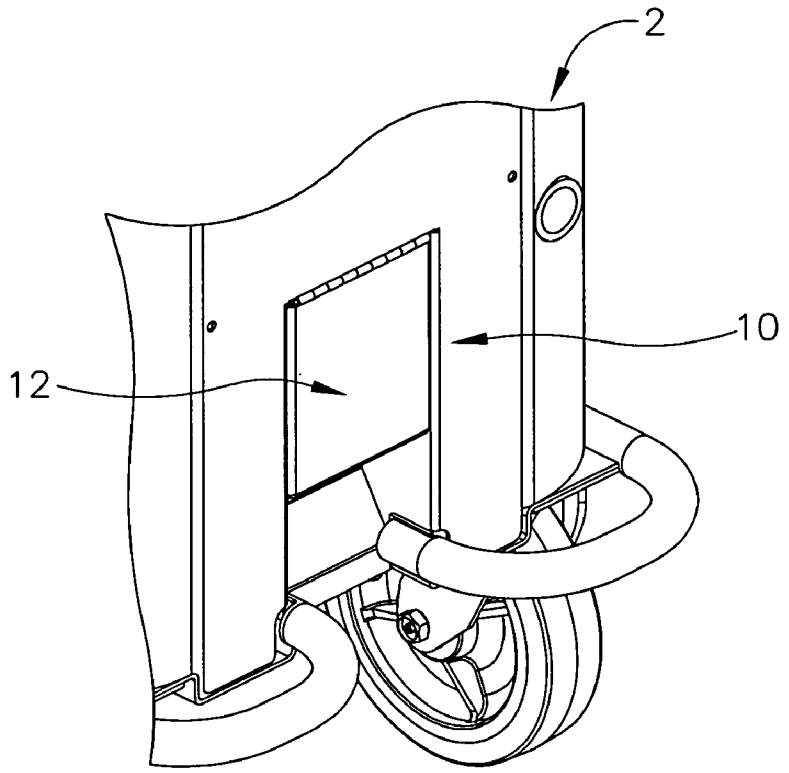


FIG. 2

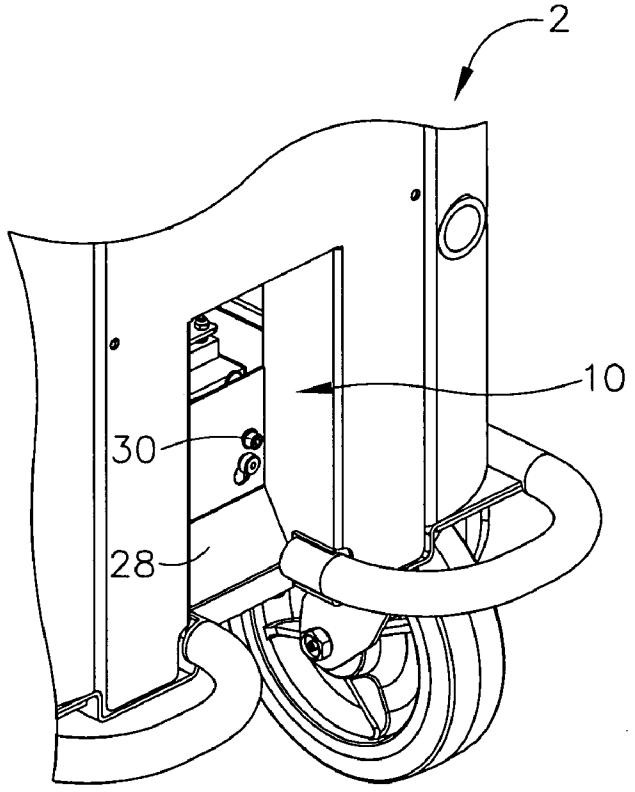


FIG. 3

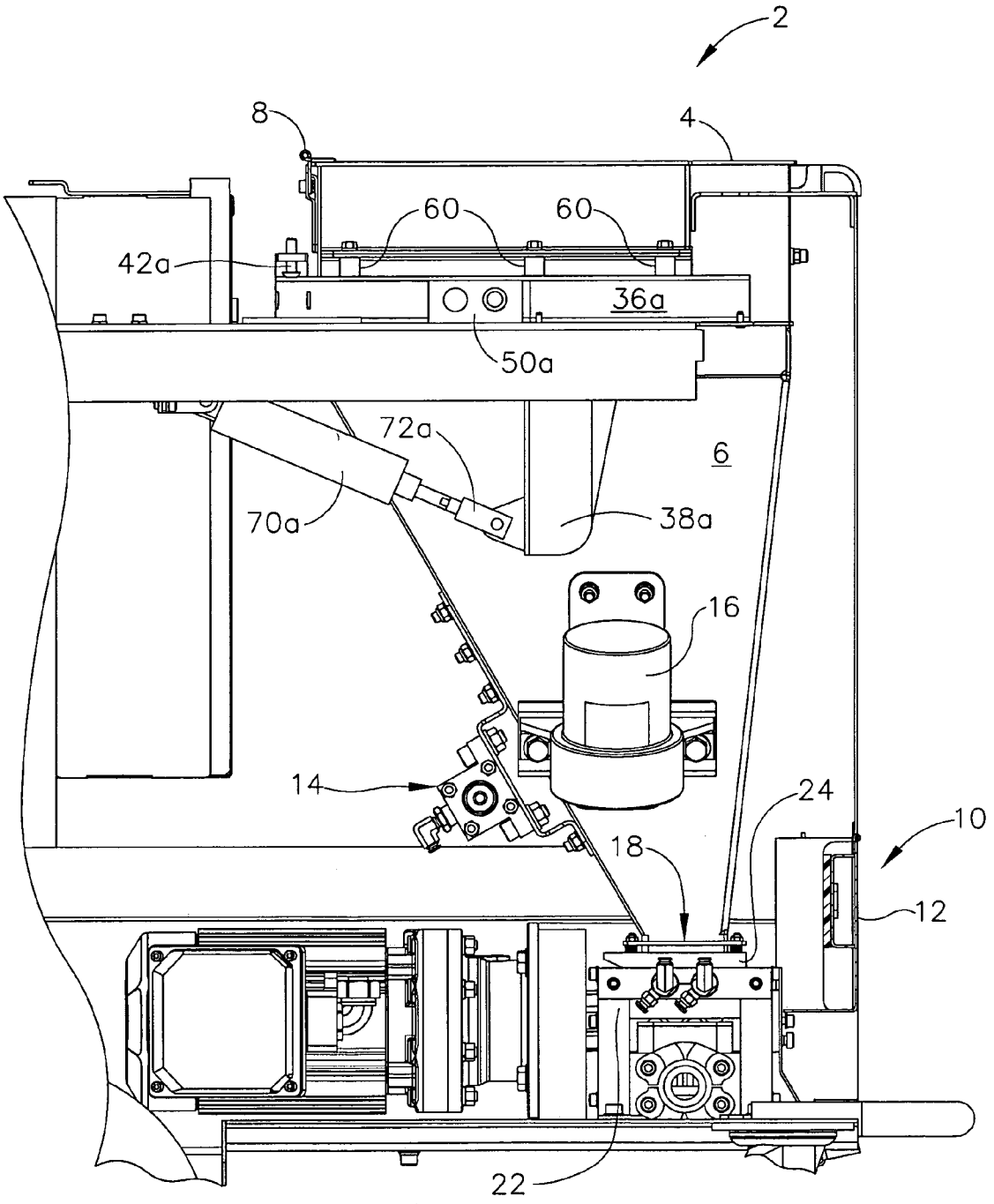


FIG. 4

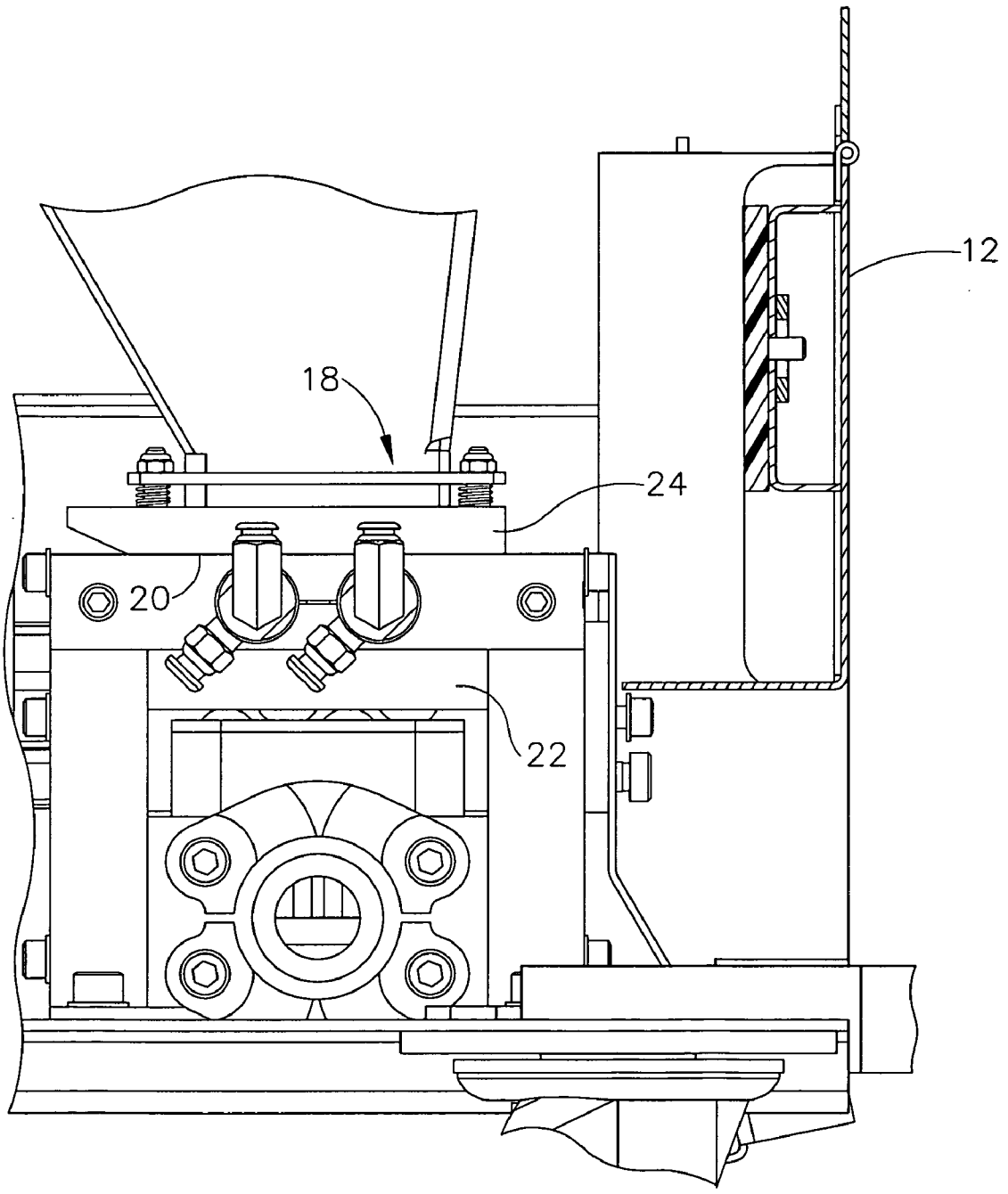


FIG. 5

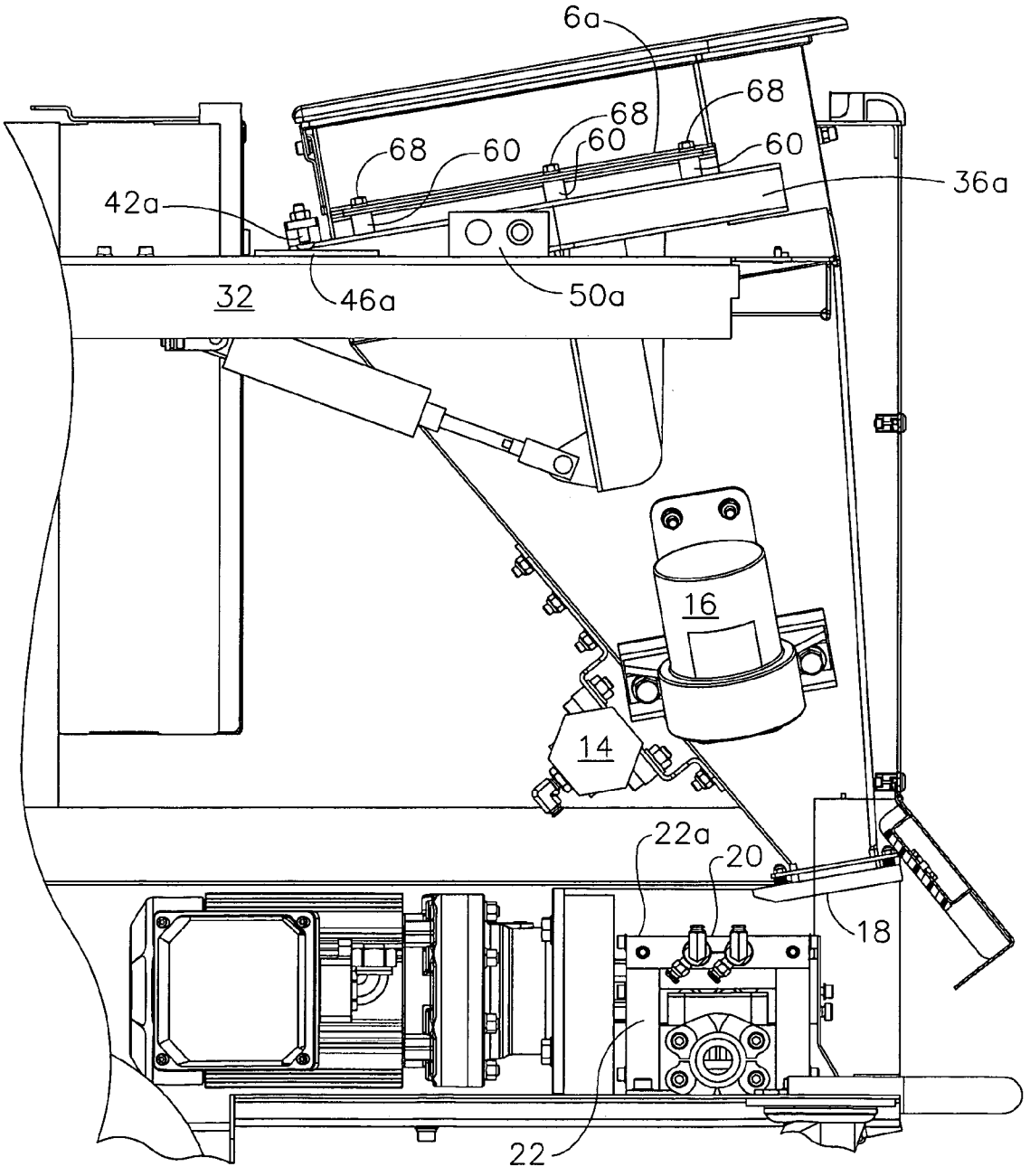


FIG. 6

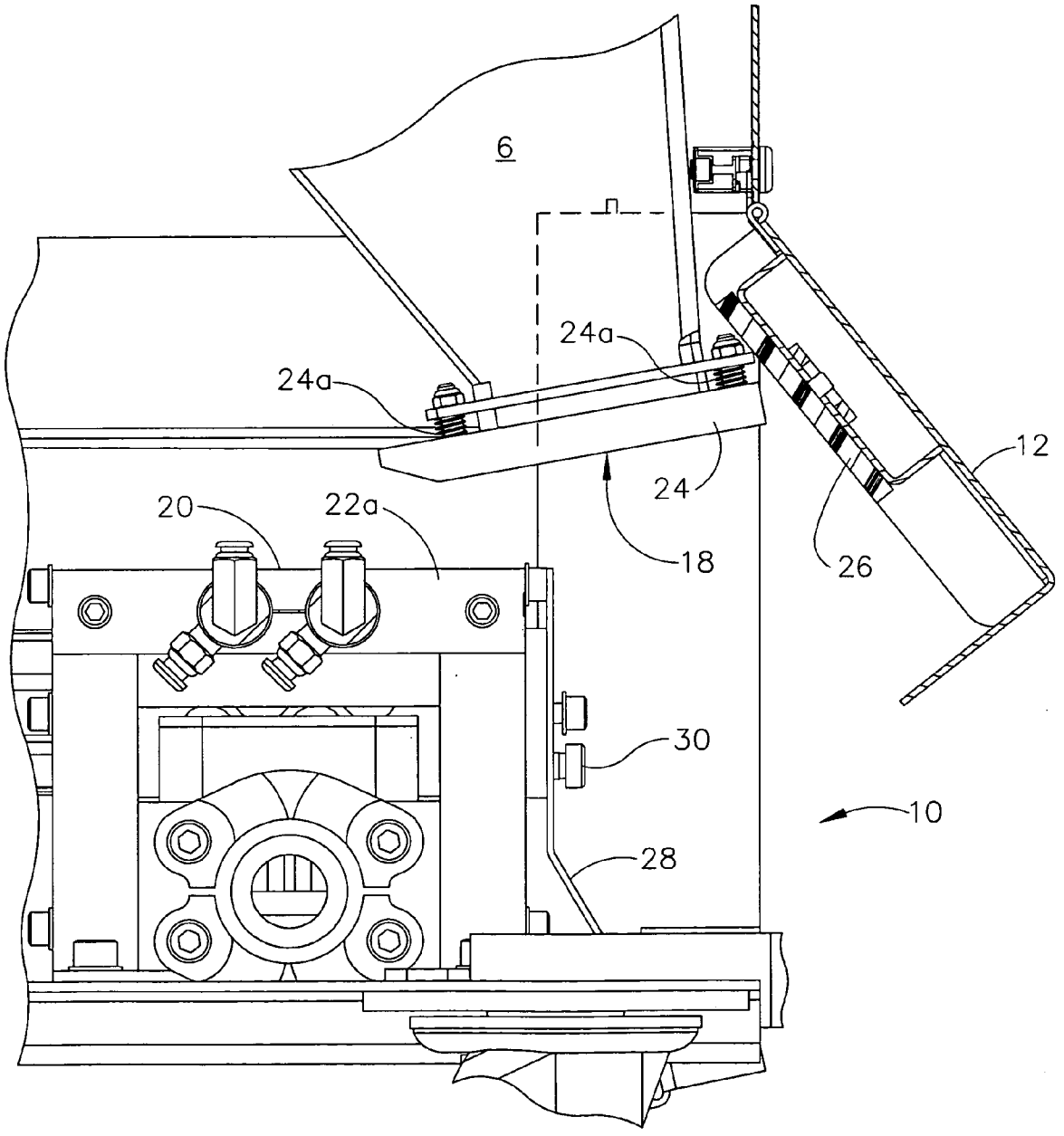


FIG. 7

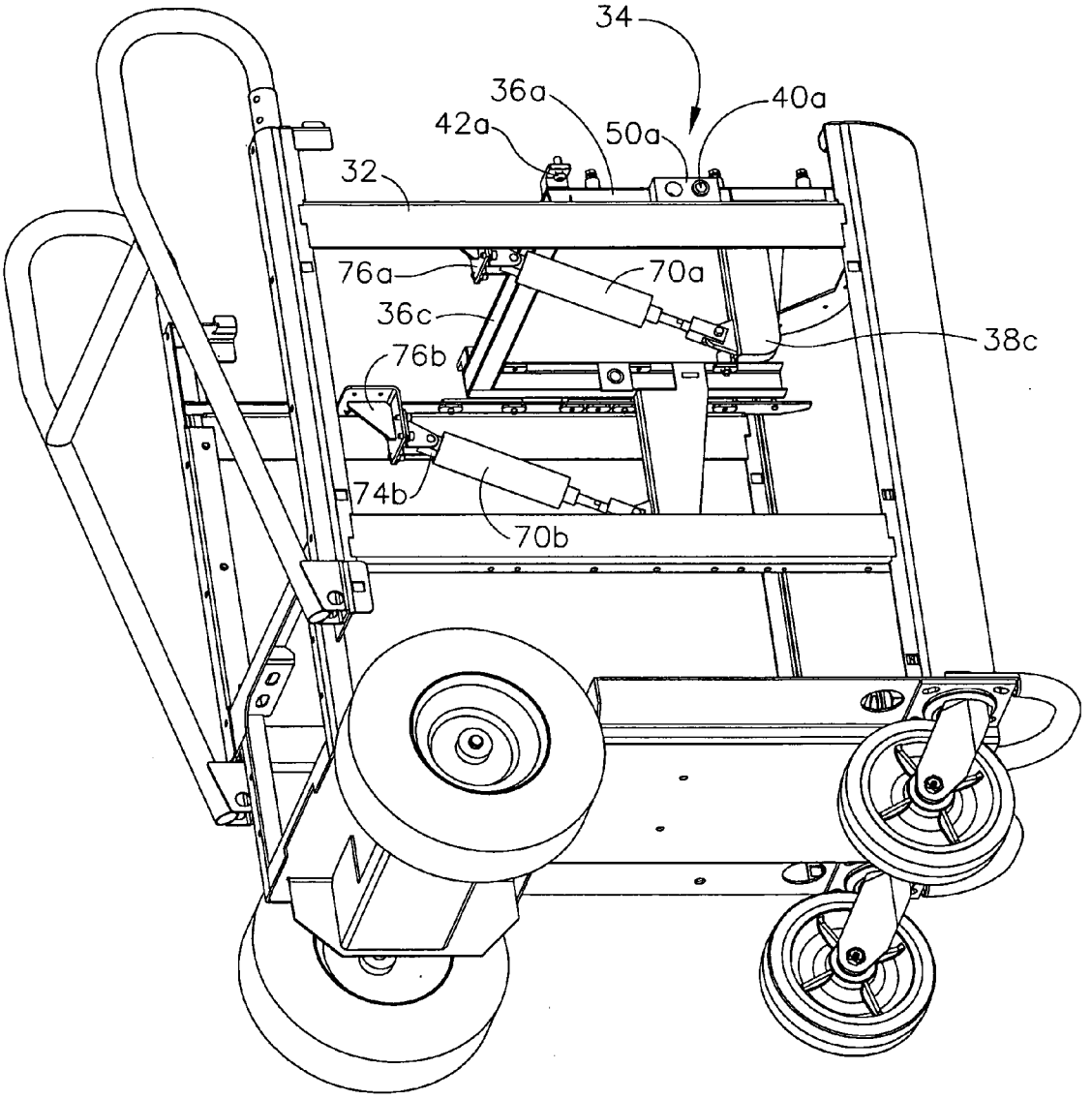


FIG. 8

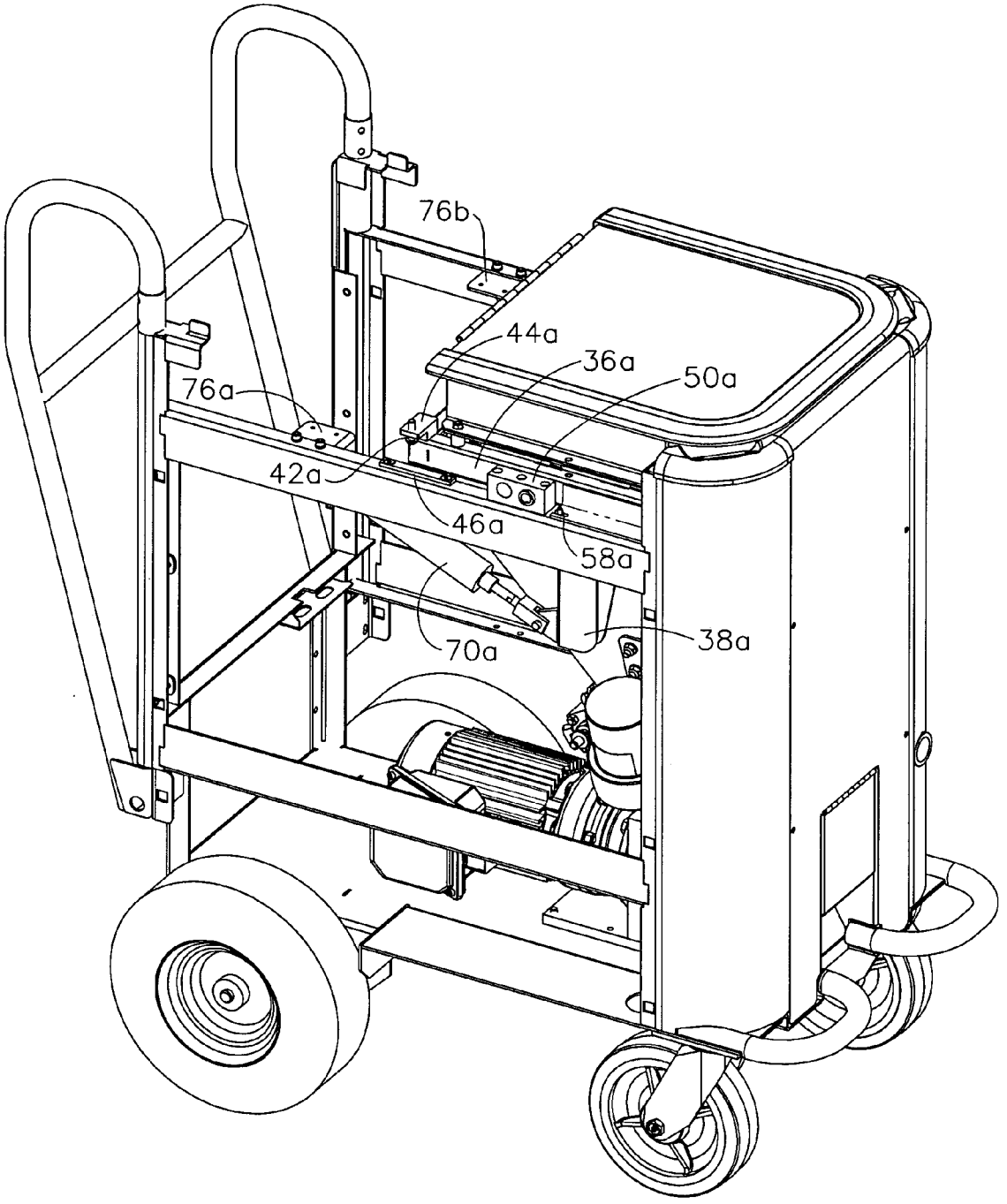


FIG. 9

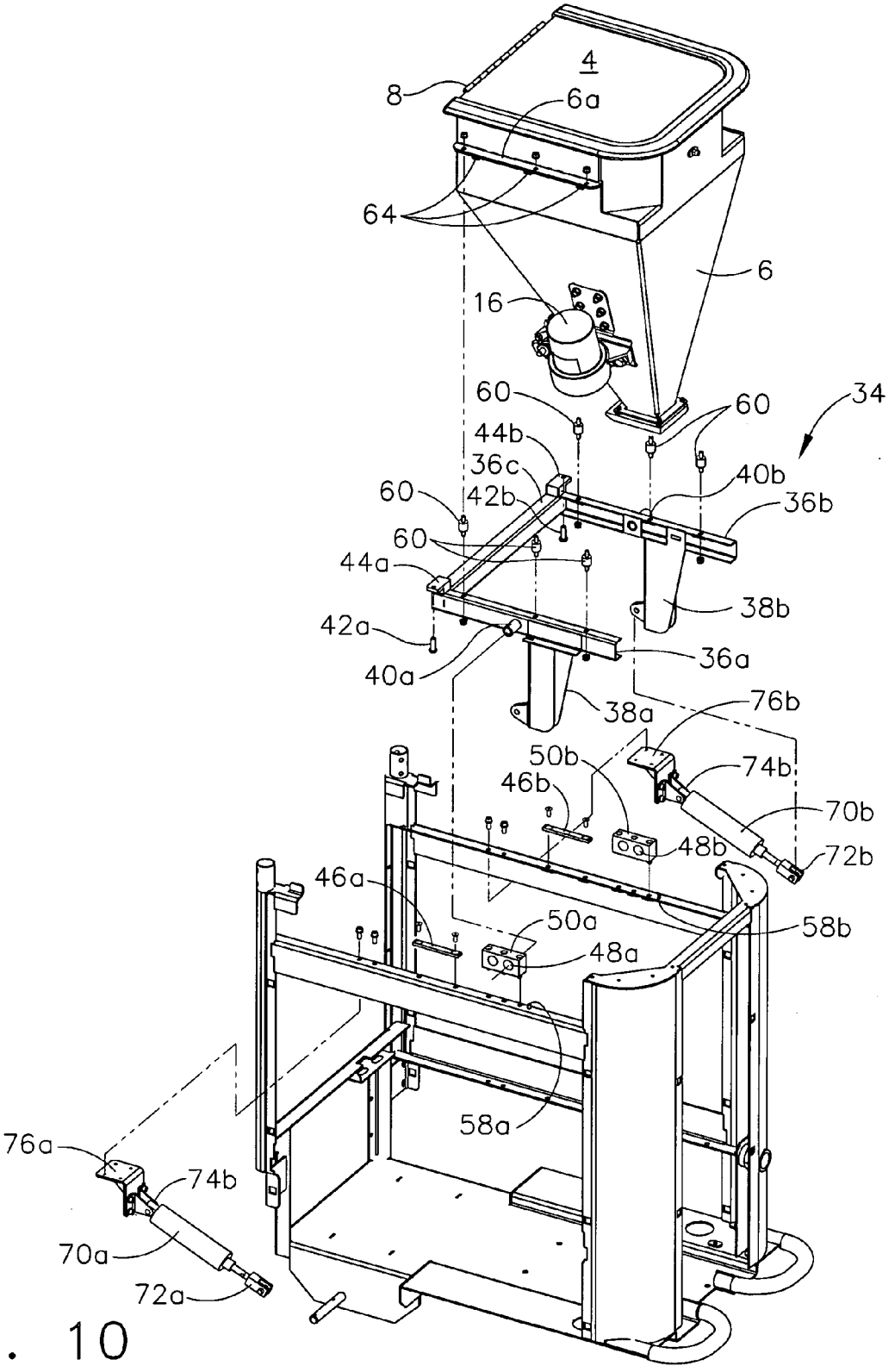
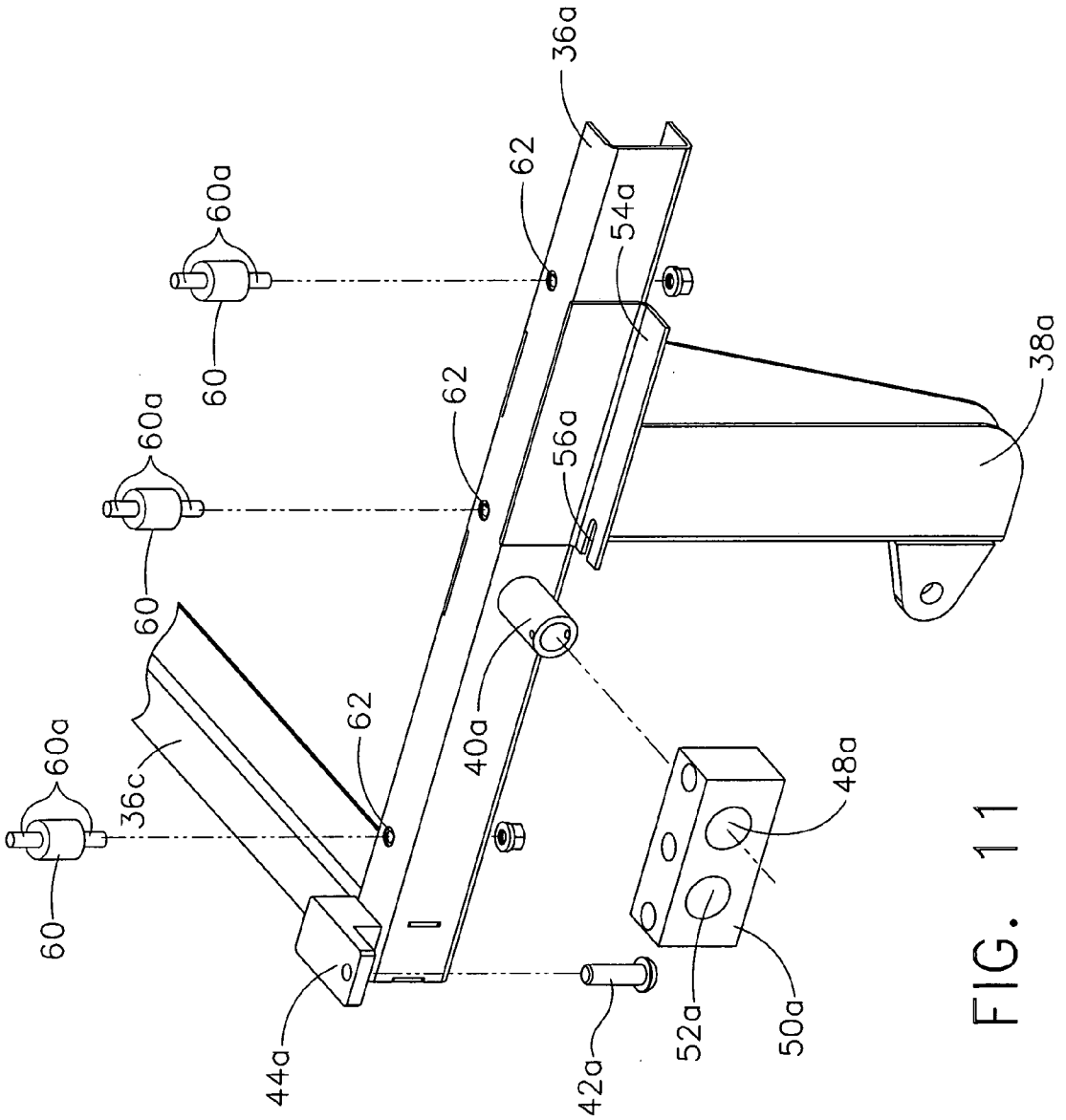

4
8
6a
64
6
16
60
60
34
44b
36c
40b
60
42b
36b
60
44a
38b
42a
36a
40a
38a
76b
50b
74b
46b
70b
48b
72b
46a
50a
58b
48a
58a
76a
74b
70a
72a

FIG. 10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60a
54a
60
62
38a
60a
56a
60
62
40a
60a
36c
62
48a
60
44a
42a
52a
50a

FIG. 11

PIVOTING HOPPER FOR PARTICLE BLAST APPARATUS

TECHNICAL FIELD

[0001] The present invention relates generally to particle blast system, and is particularly directed to a particle blast apparatus comprising a pivoting hopper and to a method of operating a particle blast apparatus which comprises a hopper wherein the hopper exit is moveable between two positions.

BACKGROUND

[0002] Particle blasting systems have been around for several decades. Typically, particles, also known as blast media, are fed into a transport gas flow and transported as entrained particles to a blast nozzle, from which the particles exit, being directed toward a workpiece or other target. It is not unknown for the particles to clump or stick together, impeding the delivery of particles into the transport gas flow.

[0003] Such compaction and agglomeration of particles is particularly a problem when the blast media is cryogenic particles, such as in carbon dioxide blasting. Although still a relatively young industry, carbon dioxide blasting systems are well known in the industry, and along with various associated component parts, are shown in U.S. Pat. Nos. 4,744,181, 4,843,770, 4,947,592, 5,050,805, 5,018,667, 5,109,636, 5,188,151, 5,301,509, 5,571,335, 5,301,509, 5,473,903, 5,660,580, 5,795,214, 6,524,172 and 6,726,549 all of which are incorporated herein by reference. Although the present invention will be described herein in connection with a particle feeder for use with carbon dioxide blasting, it will be understood that the present invention is not limited in use or application to carbon dioxide blasting. The teachings of the present invention may be used in application in which there can be compaction or agglomeration of any type of particle blast media.

[0004] Generally, the blast media particles, such as carbon dioxide particles, are transported from a hopper, which holds the supply of particles, into a transport gas. The particles may be introduced into the transport gas by venturi or other vacuum effect, or by a feeder. Various feeder designs exist, functioning to transport the particles from the hopper exit into the transport gas, such as by the radial transport feeder shown in U.S. Pat. No. 4,947,592. Hoppers may receive particles from any source, such as a pelletizer that is part of the blast system, or a source separate from the blast system and loaded into the hopper. Practice of the present inventions is not limited to a particular type of feeder.

[0005] For a variety of reasons, particles may need to be cleared from the hopper from time to time, such as to clear clogs in the hopper or to dispose of unused or unwanted particles without directing them through feeder and ultimately the blast hose. USP '172 discloses and claims a hopper that is moveable from a first position at which the hopper exit is generally aligned with the inlet of a feeder to a second position at which the hopper exit is not aligned with the feeder inlet. The '172 patent discloses that the hopper may be pivoted or moved by translational motion, such as by a parallel rotating framework.

[0006] The present invention provides a particle blast apparatus with a unique structure for a pivoting hopper, and a method of operating the apparatus.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007] The accompanying drawings, which are incorporated in and constitute a part of this specification, illustrate embodiments of the invention, and, together with the general description of the invention given above, and the detailed description of the embodiments given below, serve to explain the principles of the present invention.

[0008] FIG. **1** is a perspective view of a perspective view of a particle blast apparatus embodying the teachings of the present invention.

[0009] FIG. **2** is an enlarged, fragmentary perspective view of the discharge area of the apparatus of FIG. **1**.

[0010] FIG. **3** is an enlarged, fragmentary perspective view of the discharge area of the apparatus of FIG. **1** with the door omitted.

[0011] FIG. **4** is fragmentary side view of the apparatus of FIG. **1**, with the outer skin omitted.

[0012] FIG. **5** is an enlarged, fragmentary side view of the apparatus of FIG. **1**, showing the hopper exit and the feeder inlet, and the discharge area in partial cross section.

[0013] FIG. **6** is a fragmentary side view of the apparatus of FIG. **1**, illustrating the hopper pivoted to a hopper discharge position.

[0014] FIG. **7** is an enlarged, fragmentary side view of the apparatus of FIG. **1**, illustrating the hopper pivoted to the hopper discharge position, showing the hopper exit and feeder inlet, and the discharge area.

[0015] FIG. **8** is a bottom perspective view of the apparatus of FIG. **1**, with the hopper and most of the skin omitted.

[0016] FIG. **9** is a side perspective view of the apparatus of FIG. **1**.

[0017] FIG. **10** is an exploded perspective view of the apparatus of FIG. **1**.

[0018] FIG. **11** is an enlarged, fragmentary perspective view of a portion of the support members of the apparatus of FIG. **1**.

[0019] Reference will now be made in detail to the present preferred embodiment of the invention, an example of which is illustrated in the accompanying drawings.

DETAILED DESCRIPTION

[0020] In the following description, like reference characters designate like or corresponding parts throughout the several views. Also, in the following description, it is to be understood that terms such as front, back, inside, outside, and the like are words of convenience and are not to be construed as limiting terms. Terminology used in this patent is not meant to be limiting insofar as devices described herein, or portions thereof, may be attached or utilized in other orientations. Referring in more detail to the drawings, an embodiment of the invention will now be described.

[0021] Referring to FIGS. **1**, particle blasting apparatus is generally indicated at **2**. Apparatus **2** includes pivoting cover **4** which overlies the charging area of hopper **6** (see FIG. **4**), which in the embodiment depicted is attached to hopper **6** by hinge **8**. Apparatus **2** includes discharge area generally indicated at **10**, through which particles being cleared from hopper **6** may be discharged. Referring also to FIGS. **2** and **3**, in the embodiment depicted, discharge area **10** may include door **12** (omitted from FIG. **3** for clarity), which may, as shown, be hinged at the top and may be biased toward the closed or vertical position.

[0022] Apparatus **2** may include devices to impart mechanical energy to hopper **6** to cause vibrations in hopper **6**, although the pivoting hopper configuration of the present invention is not limited to use with any such energy imparting devices. FIG. **4** depicts two energy imparting devices carried

by hopper **6**. Impulse assembly **14**, such as described in U.S. Pat. No. 6,726,549, shown carried by hopper **6**, is, in the embodiment depicted, configured to selectively impart impulse energy to hopper **6** at intervals, during blasting operations or during clearing discharges (as will be described below). While actuated, assembly **14** provides impulse energy to hopper **6**. The intervals may be of any length, whether identical, varying or even random. The amount of energy delivered by assembly **14** may be constant or varied. Continuous energy assembly **16**, such as described in U.S. Pat. No. 6,726,549, shown carried by hopper **6**, is, in the embodiment depicted, configured to selectively impart continuous energy to hopper **6** during blasting operations or during clearing discharges (as will be described below). While actuated, assembly **16** provides continuous energy to hopper **6** at energy at energy levels, frequencies (continuous or variable) and duty cycles as may be suitable. Although it is desirable for hopper **6** to carry assemblies **14** and **16** directly, assemblies **14** and **16** may be mounted elsewhere while still configured to deliver energy to hopper **6**.

[0023] Referring to FIGS. **4** and **5**, hopper **6** includes at its lower hopper exit **18**, from which particles are discharged. Exit **18** is shown aligned with entrance **20** of feeder assembly **22**, with seal **24** disposed therebetween, seating against feeder assembly **22** adjacent entrance **20**. Seal **24** may be of any suitable configuration, such as is in U.S. Pat. No. 6,726,549. **0**During blasting operations, exit **18** is disposed at a first position, such as illustrated in FIGS. **4** and **5**, at which hopper exit **18** is generally aligned with entrance **20** so as to deliver particles directly to feeder assembly **22**, or indirectly in the event of additional structure between hopper exit **18** and entrance **20**, for entrainment in the transport gas flow.

[0024] Referring to FIGS. **6** and **7**, hopper **6** is moveable from its supply operation position shown in FIGS. **4** and **5** to a second position at which hopper exit **18** is not aligned with feeder entrance **20**. At the second position, hopper **6** may be emptied or cleared. As seen in FIGS. **6** and **7**, door **12** has been pivoted outwardly by the lower end of hopper **6**, in particular in the embodiment depicted, by part of the assembly of seal **24**. Wear pad **26** may be disposed inside of door **12** in a position to be engaged by the seal assembly, or alternatively by any suitable structure configured to engage and rotate door **12** outwardly. At the position illustrated in FIGS. **6** and **7**, exit **18** is disposed such that particles within hopper **6** may be discharged outside of apparatus **2**. Discharge area **10** may be, as seen in the embodiment depicted, configured as a chute such that particles are guided outside of apparatus **2**. Chute may be formed by suitably shaped panels **28**, secured in any suitable manner, such as by fasteners **30**. Fasteners **30** could also be configured to be flush or nearly flush to panel **28** to present a flat profile.

[0025] As hopper **6** is pivoted from the first position to the second position, seal **24** disengages feeder **22**. As will be described below, the pivot axis of hopper **6** is preferably located relative to exit **18** and feeder **22** such that the movement of exit **18** is away from feeder **22**. Such an orientation results in lateral translation of seal **24** as it slides along upper surface **22***a*, and a reduction in the force biasing seal **24** against upper surface **22***a* as springs **24***a* extend, until such time as the rotation of hopper **6** produces complete disengagement of seal **24** from upper surface **22***a*. This configuration avoids increasing the force between seal **24** and upper surface **22***a* during rotation. It should be noted that although believed to be undesirable, the pivot axis of hopper **6** could be disposed such that such force between seal **24** and upper surface **22***a* does increase if the force preferably does not reach a level that results in premature failure of any components.

[0026] FIG. **8** illustrates the pivotable mechanism configured to allow hopper **6** to be selectively pivoted. Particle blast apparatus **2** includes main frame **32** which supports pivotable subframe **34**. Referring also to FIGS. **9** and **10**, subframe **34** comprises spaced apart support members **36***a* and **36***b*, disposed on opposite sides of hopper **6**, with member **36***c* extending between proximal ends of support members **36***a* and **36***b*. Subframe **34** includes arms **38***a* and **38***b* depending downwardly from support members **36***a* and **36***b*, respectively. Pivots **40***a* and **40***b* extend outwardly from support members **36***a* and **36***b*, respectively. Stops **42***a* and **42***b* extend downwardly from respective brackets **44***a* and **44***b* mounted to subframe **34** as shown. As shown in the embodiment depicted, stops **42***a* and **42***b* may be configured to be adjustable, such as by external threads on stops **42***a* and **42***b* engaging internal threads formed in brackets **44***a* and **44***b*. The distal ends of stops **42***a* and **42***b* may comprise a wear resistant and/or resilient material. As shown in the embodiment depicted, plates **46***a* and **46***b* may be secured to main frame **32** in any suitable manner, aligned with stops **42***a* and **42***b* such that main frame **32** is not worn by pivoting hopper **6**.

[0027] In the depicted embodiment, pivots are depicted as pins **40***a* and **40***b* which are respectively rotatably received by complementarily shaped openings **48***a* and **48***b* of bearing blocks **50***a* and **50***b*, respectively. Bearing blocks **50***a* and **50***b* may be made of any suitable material, such as HDPE and secured to main frame **32** in any suitable manner, such as by threaded fastener. Each bearing block **50***a*, **50***b* may include one or more additional openings shaped complementary to pivot pins **40***a* and **40***b* so that in the event openings **48***a* and/or **48***b* become excessively worn, either bearing block **50***a* or **50***b* may be reoriented such that openings **52***a* and/or **52***b* receive pivot pin pivot pin **40***a* and/or **40***b*. This avoids having to order and replace bearing block **50***a* or **50***b* once the first used pivot pin opening wears out.

[0028] Each support member **36***a* and **36***b* and main frame **32** may respectively be configured to locate subframe **34** laterally relative to main frame **32**. Any suitable configuration may be used. Referring to FIG. **11**, support member **36***a* in the embodiment depicted comprises laterally extending bracket **54***a* with a longitudinally extending opening or slot **56***a*. (Although support member **36***b* is not seen in FIG. **11**, its configuration is a mirror image of support member **36***a* and bracket **54***a*.) Referring also to FIG. **10**, main frame **32** includes upwardly extending members **58***a* and **58***b*. Slot **56***a* receives pin **58***a* so as to limit lateral movement and locate hopper laterally.

[0029] Referring to FIGS. **10** and **11**, hopper **6** is carried by but isolated from subframe **34** in a manner that minimizes transfer of mechanical energy from hopper **6**. As seen in FIGS. **10** and **11**, a plurality of isolators **60** are interposed between subframe **34** and hopper **6**. In the embodiment depicted, isolators **60** are spaced apart disposed at non-contiguous locations such that the center of gravity of hopper, empty or full, falls within the footprint or plan area of isolators **60**. During blast operations, isolators **60** are in compression with the loading being essentially vertical.

[0030] Isolators **60** may be secured to subframe **34** and hopper **6** in any suitable manner. In the embodiment depicted, isolators **60** include threaded shafts **60***a* which extend in opposite direction from the middle portions of isolators **60**.

The downwardly depending threaded shafts **60***a* are disposed through openings **62** formed in subframe **34** and secured thereto by nuts **64**. Similarly, the upwardly extending threaded shafts **60***a* are received by openings **66** formed in flanges **6***a* and **6***b* (on side opposite flange **6***a*, not illustrated) of hopper **6**. Nuts **68** secure flanges **6***a* and **6***b* to isolators **60**.

[0031] Alternatively to, or in addition to, the use of isolators **60**, isolation of hopper **6** to minimize from the rest of apparatus **2** may occur between pivot pins **40***a* and **40***b* and main frame **32**. For example, isolation may be provided between bearings **50***a* and **50***b* and main frame **32**.

[0032] Referring to FIG. **10**, actuators **70***a* and **70***b* are used to effect pivoting of subframe **34** and concomitantly hopper **6**. In the embodiment depicted, actuators **70***a* and **70***b* are double acting pneumatic cylinders, although any suitable actuator and any suitable configuration may be used. In the embodiment depicted, ends **72***a* and **72***b* of actuators **70***a* and **70***b*, respectively, are pivotably connected to the distal ends of arms **38***a* and **38***b*, respectively. Ends **74***a* and **74***b* of actuators **70***a* and **70***b*, respectively, are pivotably connected to brackets **76***a* and **76***b* which are secured to main frame **32**.

[0033] In the embodiment depicted, during blast operations, actuators **70***a* and **70***b* bias hopper **6** in the first position whereat hopper exit **18** is aligned with feeder entrance **20** with a force of about 80 lbf (axially relative to actuators **70***a* and **70***b*). In the embodiment depicted, this is accomplished by applying the force to arms **38***a* and **38***b*, and thereby to subframe **36**. To empty or clear hopper **6**, actuators are actuated to cause hopper **6** to pivot to move hopper exit **18** to a second position at which hopper exit **18** is not aligned with feeder entrance **20**. In the embodiment depicted, actuators **70***a* and **70***b* bias hopper exit **18** to discharge area **10**. Rotation of hopper **6** is limited by the engagement of stops **42***a* and **42***b* with plates **46***a* and **46***b* (see FIG. **6**). At this second position, hopper **6** may be emptied or cleared.

[0034] A method of operating particle blast apparatus **2** includes the steps of applying energy to hopper **6** while hopper exit **18** is located at discharge area **10** to assist in dislodging particles from hopper **6** for discharge. This may be accomplished by activating energy assemblies **14** and **16**, either simultaneously, separately or sequentially, while hopper exit **18** is disposed at the discharge area **10**.

[0035] The foregoing description of a preferred embodiment of the invention has been presented for purposes of illustration and description. It is not intended to be exhaustive or to limit the invention to the precise form disclosed. Obvious modifications or variations are possible in light of the above teachings. The embodiment was chosen and described in order to best illustrate the principles of the invention and its practical application to thereby enable one of ordinary skill in the art to best utilize the invention in various embodiments and with various modifications as are suited to the particular use contemplated. It is intended that the scope of the invention be defined by the claims submitted herewith.

1. A method of operating a particle blast apparatus, said particle blast apparatus having a hopper, the hopper having an exit, and having a particle feeder having an inlet for receiving particles, the exit being disposable at a first position at which the exit is not aligned with said inlet, comprising the step of applying energy to said hopper while said exit is disposed at side first position.

2. The method of claim **1**, wherein said step of applying energy comprises the step of applying mechanical energy.

3. The method of claim **1**, wherein the energy applied during said step of applying energy is applied as impulses.

4. The method of claim **1**, wherein the energy applied during said step of applying energy is applied continuously.

5. The method of claim **1**, wherein the energy applied during said step of applying energy is applied as impulses and as continuous energy.

6. A particle blast apparatus, comprising:

a. a particle feeder having an inlet for receiving particles;

b. a hopper having an exit, said hopper being pivotable about a pivot axis between a first hopper position at which said exit is at a first exit position at which said exit is aligned with said inlet, and a second hopper position at which said exit is disposed at a second exit position at which said exit is not aligned with said inlet; and

c. said pivot axis being disposed relative to said exit such that said exit does not move toward said inlet as said hopper moves from said first hopper position toward said second hopper position.

7. The particle blast apparatus of claim **6**, further comprising a seal carried by said hopper adjacent said exit and disposed to sealingly engage said inlet when said exit is disposed at said first exit position, said pivot axis being disposed relative to said exit such that force between said seal and said inlet does not substantially increase as said hopper moves from said first hopper position toward said second hopper position.

8. The particle blast apparatus of claim **7**, wherein said force does not increase as said hopper moves from said first hopper position toward said second hopper position.

9. The particle blast apparatus of claim **6**, further comprising:

a. a first frame, said first frame carrying said particle feeder; and

b. a second frame, said second frame carrying said hopper, said second frame being pivotably carried by said first frame.

10. The particle blast apparatus of claim **9**, wherein said second frame comprises:

a. first and second spaced apart support members disposed on either side of said hopper;

b. first and second pivots carried respectively extending from said first and second members;

c. said first and second pivots rotatably supported by said first frame.

11. The particle blast apparatus of claim **10**, comprising first and second bearings carried by said first frame, and wherein said first and second pivots respectively comprise first and second pins, said first and second pins being rotatably carried by said first and second bearings respectively.

12. A particle blast apparatus, comprising:

a. a particle feeder having an inlet for receiving particles;

b. a hopper having an exit, said hopper being pivotable about a pivot axis between a first hopper position at which said exit is at a first exit position at which said exit is aligned with said inlet, and a second hopper position at which said exit is disposed at a second exit position at which said exit is not aligned with said inlet; and

c. a pivotable door disposed adjacent said second hopper position, said door being moveable between a first and second position, said door disposed such that as said hopper is moved toward said second hopper position said hopper moves said door toward said second position.

13. The particle blast apparatus of claim **12**, wherein said door is biased toward said first position.

14. The particle blast apparatus of claim **12**, comprising a wear pad carried by said door, said wear pad disposed to be engaged by said hopper when said hopper moves said door toward said second position.

* * * * *