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Mueller et al.

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(54) **ZERO HORIZONTAL REACTION FORCE EXCAVATOR**

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E02F 3/32 (2006.01)
E02F 5/00 (2006.01)
E02F 3/18 (2006.01)

(52) **U.S. Cl.**
CPC .. ***E02F 5/00*** (2013.01); ***E02F 3/188*** (2013.01)

(58) **Field of Classification Search**
USPC 37/443, 353, 91, 95, 189, 190, 329, 92, 37/93, 462; 405/164, 179; 299/7, 17, 67; 198/304, 316.1, 508, 585, 506, 509; 414/133
See application file for complete search history.

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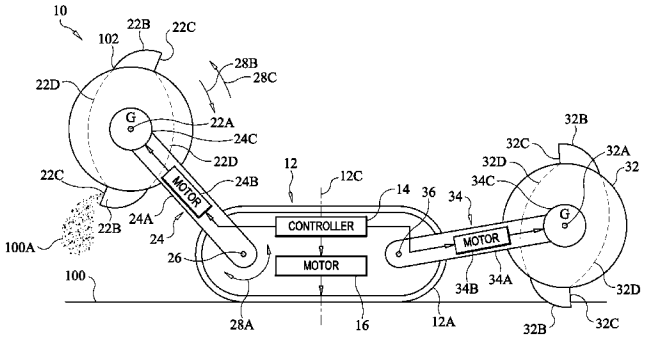
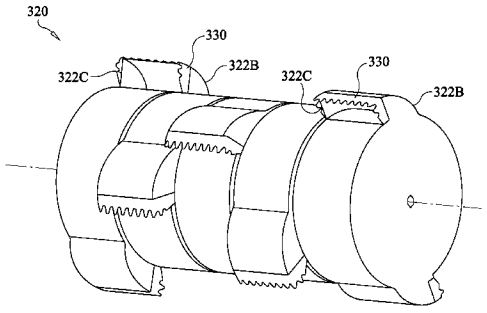
(57) **ABSTRACT**

An excavator includes a mobile chassis with a first bucket drum and a second bucket drum coupled thereto. The first bucket drum and second bucket drum are coupled to the chassis for positioning thereof on the surface at opposing ends of the chassis. Each first scoop on the first bucket drum is a mirror image of one second scoop on the second bucket drum when (i) the first bucket drum and second bucket drum are on the surface adjacent opposing ends of the chassis, and (ii) the first bucket drum is rotated in one direction and the second bucket drum is simultaneously rotated in an opposing direction.

29 Claims, 7 Drawing Sheets





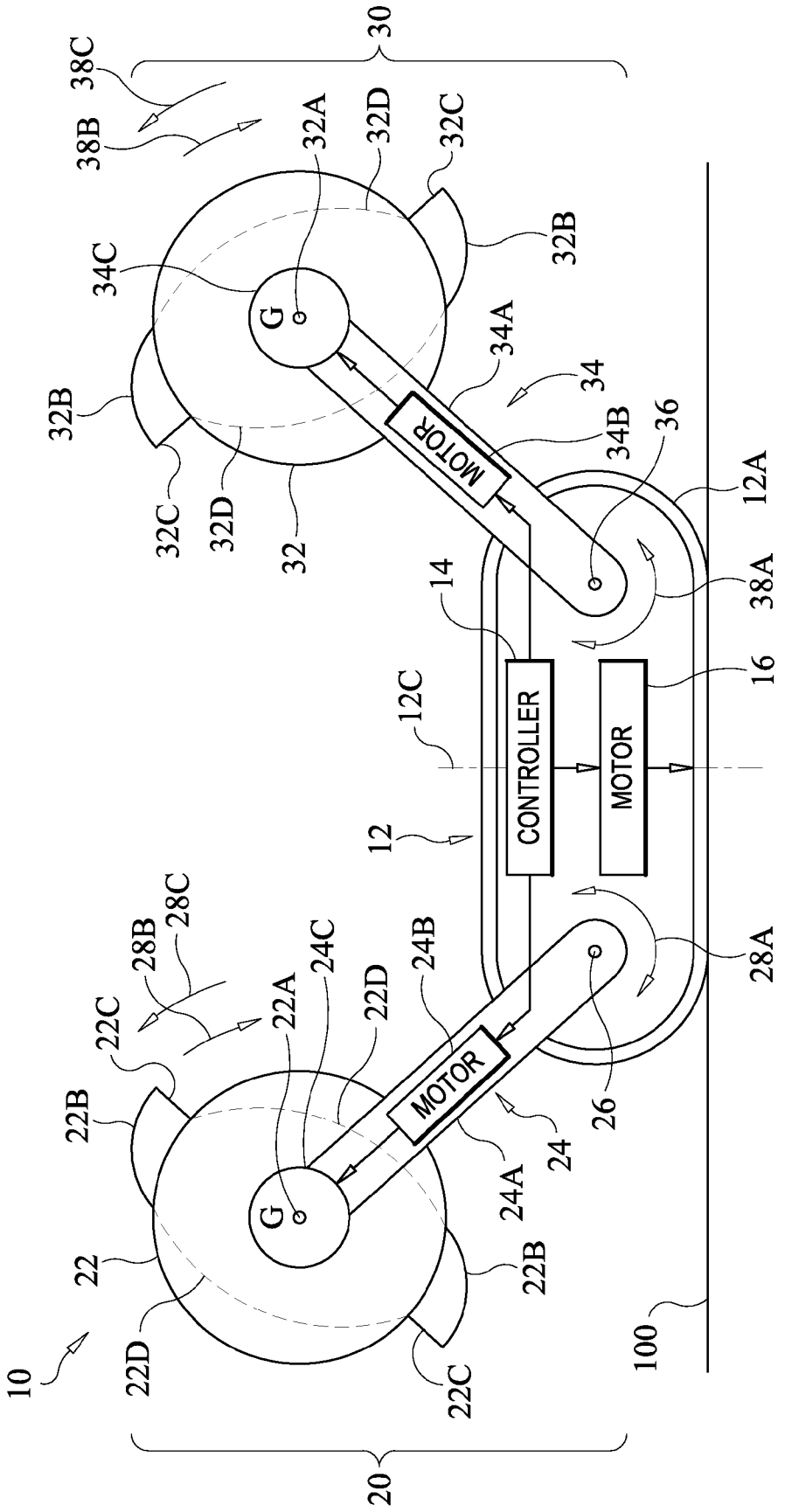

10
20
22
22A
22B
22C
22D
24
24A
24B
24C
26
28A
28B
28C
30
32
32A
32B
32C
32D
34
34A
34B
34C
36
38A
38B
38C
12
12A
12C
14
16
100
G
MOTOR
CONTROLLER
MOTOR

FIG. 1

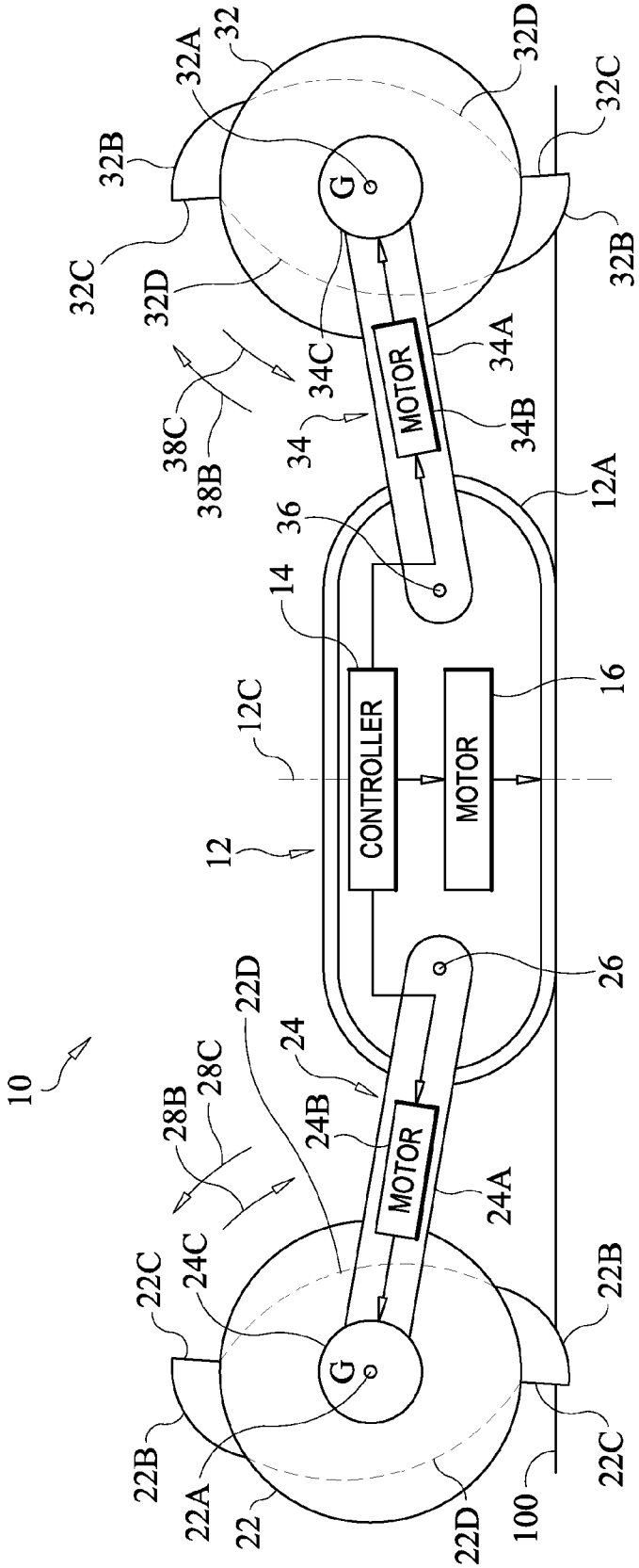

10
12
12A
12C
14
16
22
22A
22B
22C
22D
24
24A
24B
24C
26
28B
28C
32
32A
32B
32C
32D
34
34A
34B
34C
36
38B
38C
100
CONTROLLER
MOTOR
MOTOR
MOTOR
G
G

FIG. 2

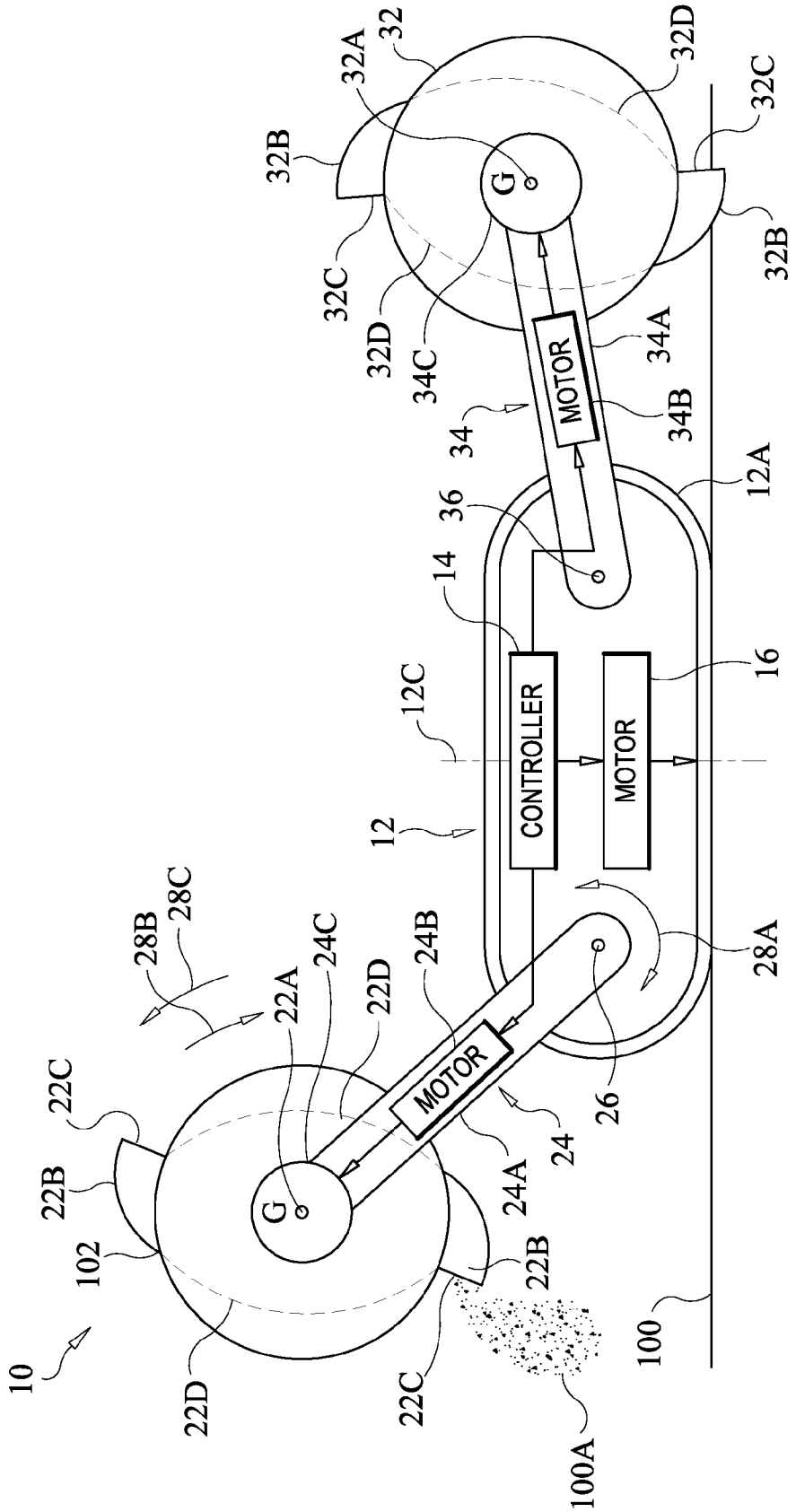

10
102
22B
22C
22D
22A
24C
24B
28B
28C
G
MOTOR
24
24A
26
28A
12
12C
CONTROLLER
MOTOR
16
14
36
34
34B
34A
MOTOR
34C
32D
32C
32B
32A
32
G
12A
100
100A

FIG. 3

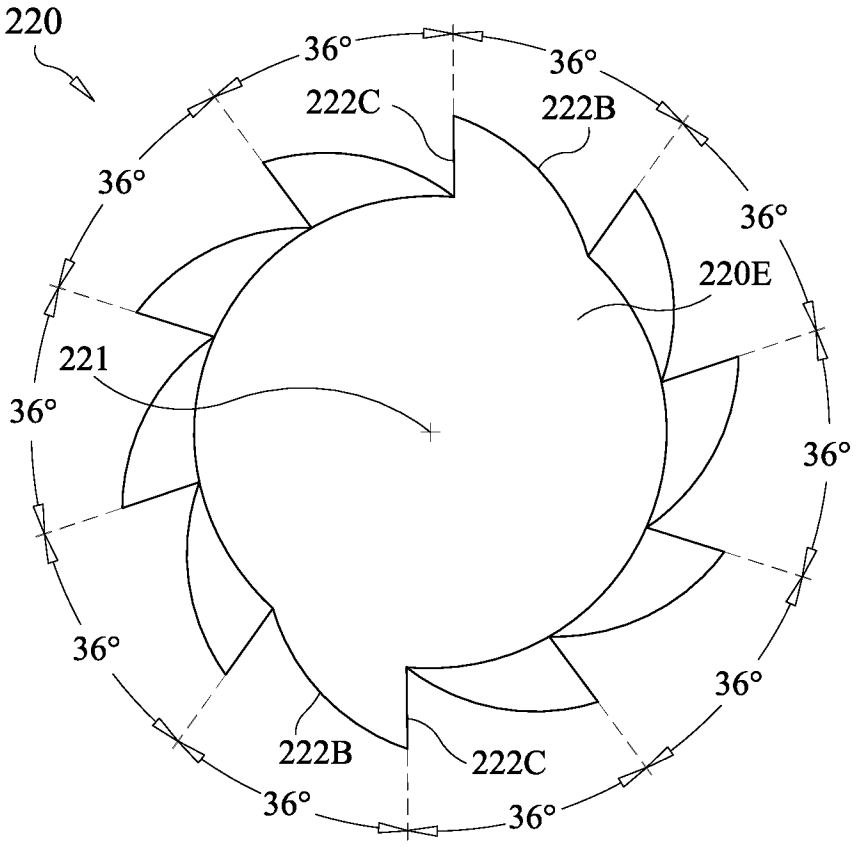


FIG. 4

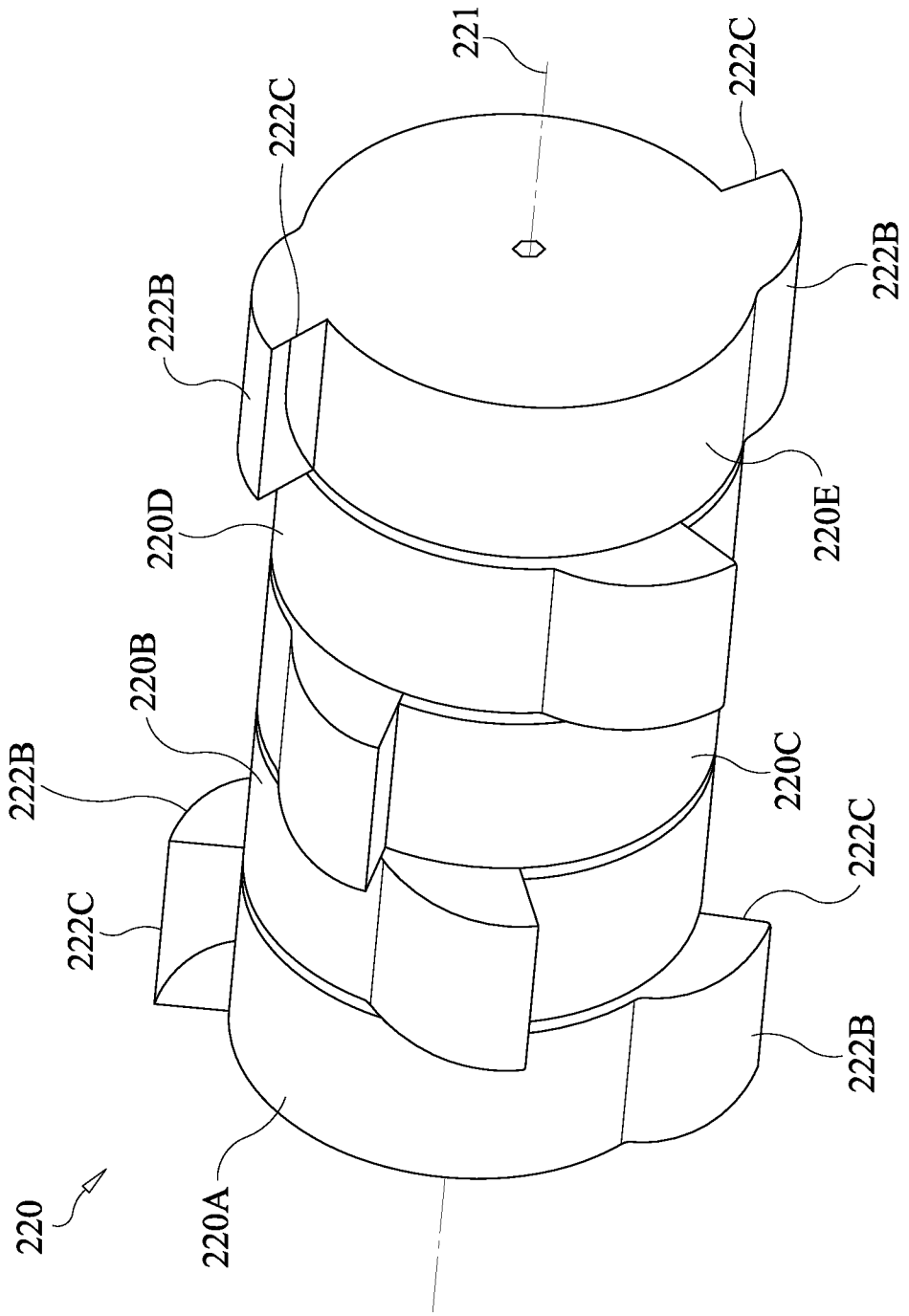

221
222C
222C
222B
222B
220D
220E
220B
222B
220C
222C
222C
222B
220
220A

FIG. 5

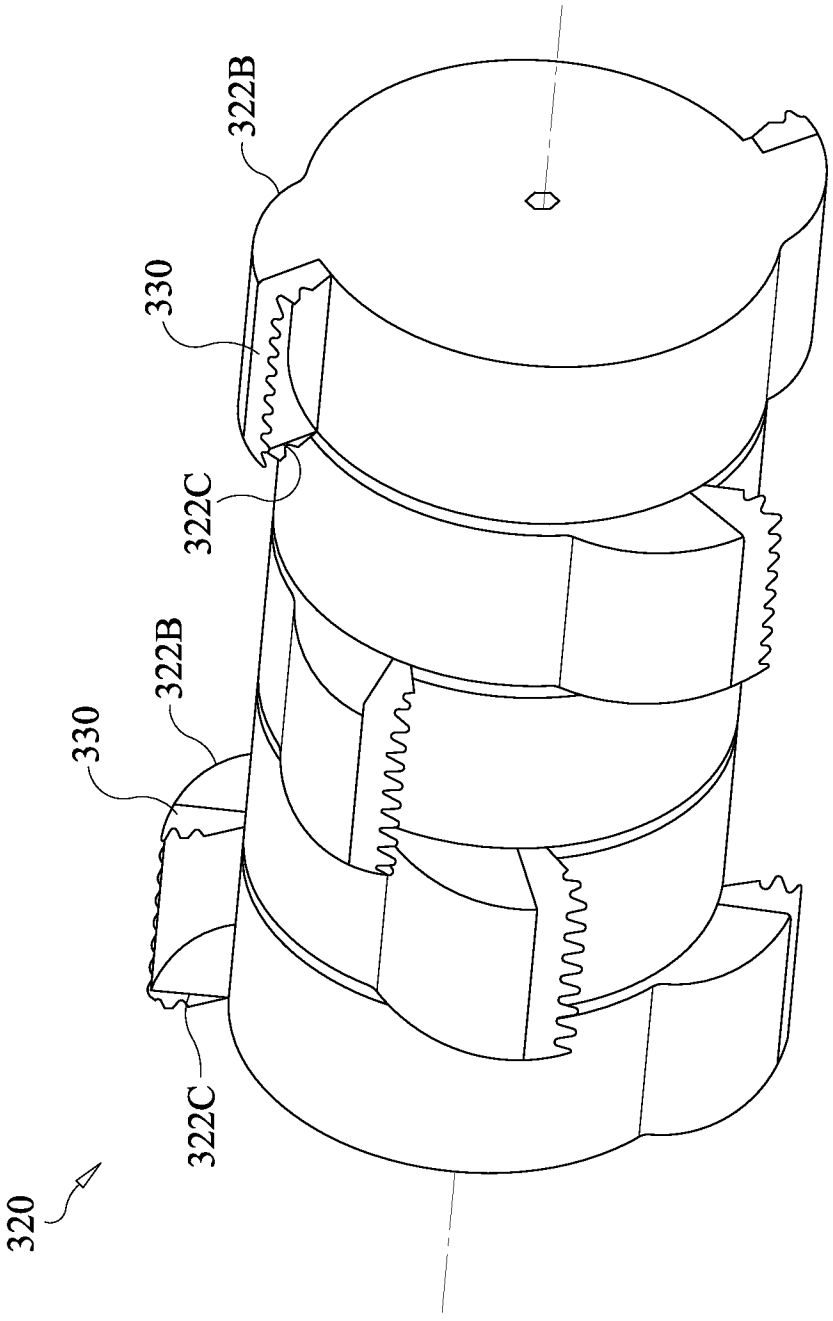


FIG. 6

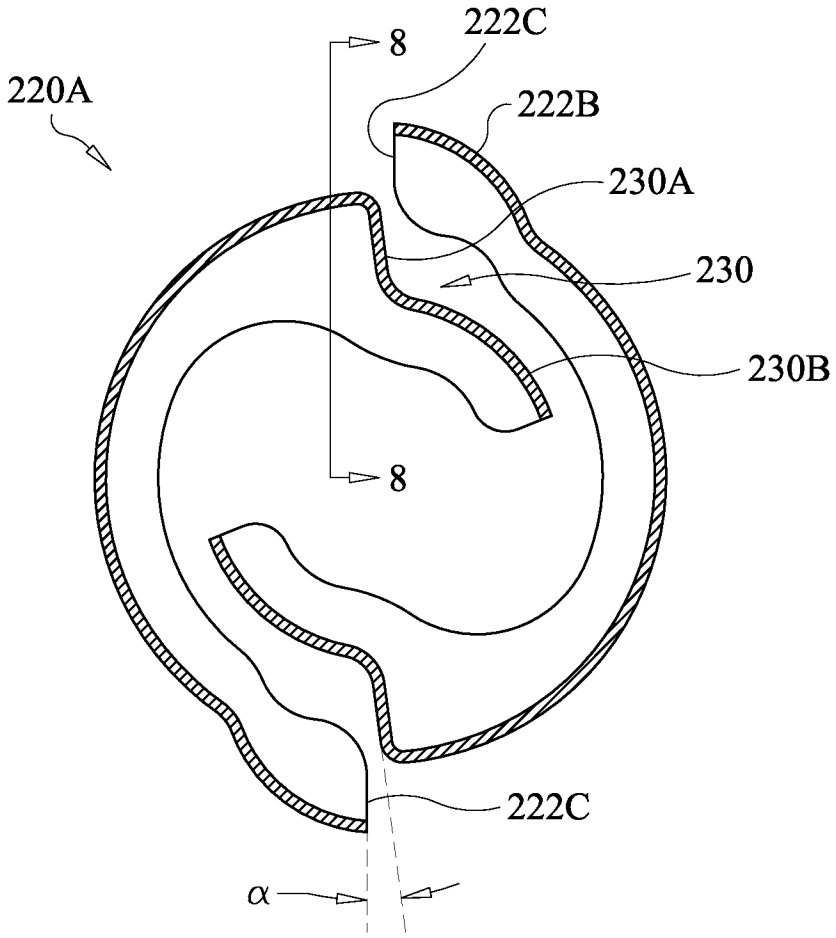

220A
8
222C
222B
230A
230
230B
8
222C
α

FIG. 7

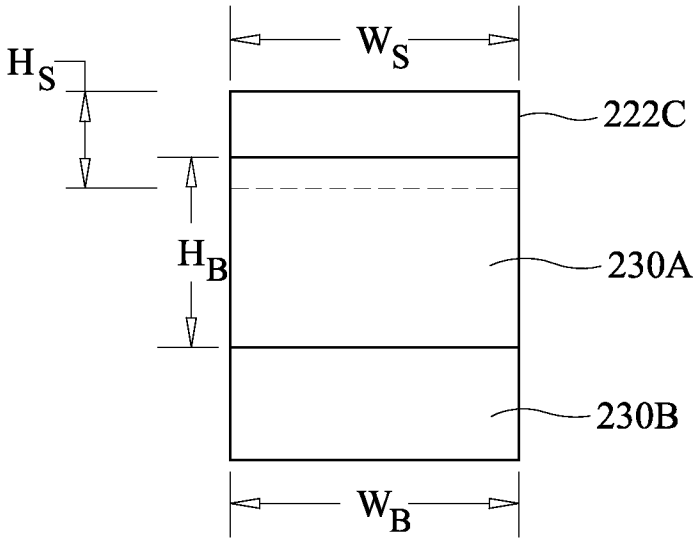

H_S
W_S
222C
H_B
230A
230B
W_B

FIG. 8

ZERO HORIZONTAL REACTION FORCE EXCAVATOR

CROSS-REFERENCE TO RELATED APPLICATIONS

This application claims the benefit under 35 U.S.C. §119 (e) of U.S. Provisional Patent Application Ser. No. 61/649,008 filed May 18, 2012, the contents of which are incorporated herein by reference.

ORIGIN OF THE INVENTION

The invention described herein was made in the performance of work under a NASA contract and by an employee of the United States Government and is subject to the provisions of Public Law 96-517 (35 U.S.C. §202) and may be manufactured and used by or for the Government for governmental purposes without the payment of any royalties thereon or therefore. In accordance with 35 U.S.C. §202, the contractor elected not to retain title.

BACKGROUND OF THE INVENTION

This invention relates to excavators. More specifically, the invention is an excavator that generates zero horizontal reaction force when excavating a surface region.

Lunar soil/regolith excavation is considered a vital requirement for future space missions to the Moon and other extra-terrestrial bodies such as Mars, asteroids, or even comets. The regolith is necessary for purposes of In-Situ Resource Utilization (ISRU) in order to create needed commodities such as propellants, breathable air, buffer gases, water for plant growth, portable drinking water for life support, manufacturing, and science as well as to pursue civil engineering construction such as landing pads, berms, roads, surface stabilization for dust control and thermal heat sinks, foundations, structures, habitats, and micro-meteorite/radiation shielding. The excavation of regolith is extremely difficult because deeper regolith (i.e., at depths of 30 cm and more) has bulk densities as high as 1.8 grams/cm^3. Specifically, the very small regolith grain particles (e.g., 0-100 microns) exhibit strong cohesion due to electrostatic forces, van der Waals forces, and interlocking morphology.

In addition to the problems associated with regolith density, the low weight in space surface environments (e.g., the Moon's gravity is $\frac{1}{6}^{th}$ that of the Earth) means that the mass of the excavator vehicle is of little or no value in terms of generating a reaction force for the excavator blade and scoop. That is, the excavator's blade and scoop cannot penetrate the regolith using conventional excavation techniques. In comparison, Earth-based excavators can utilize a brute force solution simply by making the excavator heavy to thereby create the desired reaction force. Due to the current high costs of lifting goods into space (i.e., approximately $4,000/kilogram), as well as packaging and launch vehicle shroud volume constraints, regolith excavation machines designed for use on extra-terrestrial bodies must necessarily be both small and lightweight. Accordingly, conventionally-designed excavation machines are not suitable options for in-space applications.

SUMMARY OF THE INVENTION

Accordingly, it is an object of the present invention to provide an excavator for use in low-gravity environments.

Another object of the present invention is to provide an excavator that is small and lightweight.

Still another object of the present invention is to provide an excavator for regolith excavation on extra-terrestrial bodies.

Other objects and advantages of the present invention will become more obvious hereinafter in the specification and drawings.

In accordance with the present invention, an excavator includes a mobile chassis, a first bucket drum, and a second bucket drum. The first bucket drum has a first axis of rotation and is coupled to the chassis. The first bucket drum has at least one first scoop formed thereon that is adapted to dig into a surface when the first bucket drum is placed on the surface and is rotated about its first axis of rotation in a first direction. The second bucket drum has a second axis of rotation and is coupled to the chassis. The second bucket drum has at least one second scoop formed thereon that is adapted to dig into the surface when the second bucket drum is placed on the surface and is rotated about its second axis of rotation in a second direction that is opposite to the first direction. The first bucket drum and second bucket drum are coupled to the chassis for positioning thereof on the surface at opposing ends of the chassis. Each first scoop on the first bucket drum is a mirror image of one second scoop on the second bucket drum when (i) the first bucket drum and second bucket drum are on the surface adjacent opposing ends of the chassis, and (ii) the first bucket drum is rotated in the first direction and the second bucket drum is simultaneously rotated in the second direction.

BRIEF DESCRIPTION OF THE DRAWINGS

Other objects, features, and advantages of the present invention will become apparent upon reference to the following description of the preferred embodiments and to the drawings, wherein corresponding reference characters indicate corresponding parts throughout the several views of the drawings and wherein:

FIG. **1** is a side schematic view of a zero reaction force excavator in a transport position in accordance with an embodiment of the present invention;

FIG. **2** is a side schematic view of the zero reaction force excavator in its excavation position;

FIG. **3** is a side schematic view of the zero reaction force excavator with one of its bucket drums in a dumping position;

FIG. **4** is an isolated side view of a bucket drum showing the relative scoop positions in accordance with an embodiment of the present invention;

FIG. **5** is an isolated perspective view of the bucket drum shown in FIG. **4**;

FIG. **6** is an isolated perspective view of a bucket drum with each scoop having a serrated blade attached thereto in accordance with another embodiment of the present invention;

FIG. **7** is a cross-sectional view of a bucket drum shown in FIG. **5** illustrating a baffle adjacent to each scoop in accordance with an embodiment of the present invention; and

FIG. **8** is a plan view of a scoop's open end and adjacent baffle that is taken along line **8-8** in FIG. **7**.

DETAILED DESCRIPTION OF THE INVENTION

Referring now to the drawings, simultaneous reference will be made to FIGS. **1-3** where a zero horizontal reaction force excavator **10** in accordance with an embodiment of the present invention is shown in three of its many possible positions. Briefly, FIG. **1** illustrates excavator **10** in a travel or transport position; FIG. **2** illustrates excavator **10** in its dig-

ging or excavation position; and FIG. **3** illustrates excavator **10** with one of its bucket drums raised to a dumping position. As will be explained further below, excavator **10** generates no horizontal reaction force when it excavates (i.e., the FIG. **2** position) thereby allowing excavator **10** to be small and lightweight as is required for space transport to low-gravity environments. However, excavator **10** could also be used on Earth where its small and lightweight attributes make it an ideal candidate for use in excavating soft surfaces (e.g., sand) in which conventional heavy excavators would sink.

Excavator **10** includes a mobile chassis or vehicle **12** that could be manned or unmanned without departing from the scope of the present invention. Since excavator **10** produces zero reaction forces during excavation operations, it is well suited for space applications that will generally make use of an unmanned form of vehicle **12**. For such unmanned applications, a controller **14** will generally be mounted on vehicle **12**. Controller **14** could include stored programs for pre-planned operations of excavator **10**, could be responsive to control signals received from a remote source for "on the fly" operations of excavator **10**, or could control excavator **10** using a combination of stored programs and remotely-received instructions. The choice of controller **14** and how it achieves its control functions are not limitations of the present invention.

Vehicle **12** can be any suitable structure that can navigate over a surface **100** to include a variety of surface types (e.g., smooth, rocky, hilly, hard, soft, etc.). By way of example vehicle **12** could be outfitted with one or more endless treads or tracks **12**A capable of moving and navigating vehicle **12** over a surface as track **12**A is driven by a motor **16** (e.g., an electric motor) controlled by controller **14**. Such single or multi-track type vehicles and their navigation are well understood in the art. It is further to be understood that wheels could be used in combination with track **12**A or in place thereof without departing from the scope of the present invention.

Disposed on opposing ends of vehicle **12**, at mirror image locations on vehicle **12** relative to its center **12**C, are bucket drum assemblies **20** and **30**. Since assemblies **20** and **30** are identical in construction, a description of just assembly **20** (using reference numerals in the 20's) will be provided herein with the corresponding elements of assembly **30** being referenced by numerals in the 30's.

Bucket drum assembly **20** includes a rotatable bucket drum **22** coupled to vehicle **12** by a cantilevered assembly **24** that is pivotally coupled to vehicle **12** at pivot coupling **26**. There could be another cantilevered assembly on the other side of vehicle **12** for support of bucket drum **22** without departing from the scope of the present invention. Briefly, cantilevered assembly **24** is controlled by controller **14** to pivot about coupling **26** (as indicated by two-headed direction arrow **28**A) to thereby position bucket drum **22** on surface **100** (FIG. **2**) at a location that is adjacent or offset from one end of vehicle **12**, or off surface **100** (FIGS. **1** and **3**). In general, the rotational positions of cantilevered assemblies **24** and **34** can be used to lift one or both ends of vehicle **12** off surface **100** thereby allowing excavator **10** to achieve a wide variety of robotic poses that can be demanded by terrain, application, or desired excavator function.

Cantilevered assembly **24** includes a rigid support arm **24**A and mechanisms to rotate bucket drum **22** clockwise about a longitudinal axis **22**A thereof as indicated by direction arrow **28**B or counterclockwise as indicated by direction arrow **28**C. Briefly, the mechanisms to rotate bucket drum **22** can include a motor **24**B provided (or incorporated) in cantilevered assembly **24** coupled to a gear assembly ("G") **24**C provided on bucket drum **22**. Motor **24**B could be controlled via instructions received from controller **14**. Cantilevered assemblies **24** and **34** keep the respective bucket drums' longitudinal axes **22**A and **32**A parallel to one another throughout operation of excavator **10**.

As is generally known in the art, the term "bucket drum" refers to a drum-like device/assembly having open-ended scoops formed thereon that communicate with interior region(s) within the drum. When the drum is rotated at a surface region such that each scoop scrapes/digs into the surface, scraped/dug material is deposited into the interior region(s). Accordingly, in the present invention, each bucket drum **22** includes/defines an interior volume (or volumes) accessible only via one or more open scoops **22**B (two are illustrated) formed on bucket drum **22**. In the illustrated embodiment, the interior region of bucket drum **22** is indicated in a general fashion by the region between dashed lines **22**D. The number of scoops **22**B is not a limitation of the present invention. For clarity of illustration in FIGS. **1-3**, only two scoops **22**B are shown. More typically, a number of such scoops will be formed on the bucket drum and distributed about the drum's rotating periphery as will be explained further below. The number, size and position of scoops **22**B is duplicated for scoops **32**B on bucket drum **32**.

Each of scoops **22**B is open at one end **22**C with open end **22**C designed to cut into a surface during excavation. As will be explained further below, open end **22**C can be sharp, serrated, etc., to more readily dig into a surface during excavation. A sacrificial edge (not shown in FIGS. **1-3**) could be attached to some or all of each open end **22**C thereby allowing each scoop **22**B to be repaired without replacing bucket drum **22**.

When bucket drum **22** is rotated in clockwise direction **28**B about its longitudinal axis **22**A, each open end **22**C of a scoop **22**B forms the leading edge thereof. Conversely, when bucket drum **32** is rotated in counterclockwise direction **38**C about its longitudinal axis **32**A, each open end **32**C of a scoop **32**B forms the leading edge thereof. The significance of this will be explained in an operational description of excavator **10**.

With continued reference to FIGS. **1-3**, three basic operations of excavator **10** will be explained. In FIG. **1**, both bucket drum **22** and **32** are raised off surface **100** by their respective cantilevered assemblies **24** and **34**. Such positioning of bucket drums **22** and **32** allows vehicle **12** to move/navigate over surface **100**. The particular distance between surface **100** and bucket drums **22** and **32** is not a limitation of the present invention. Further, cantilevered assemblies **24** and **34** could be individually controlled such that the position of bucket drum **22** above surface **100** can be different than the position of bucket drum **32** above surface **100**.

FIG. **2** illustrates excavator **10** in its excavating position where bucket drums **22** and **32** are positioned on surface **100** (by their respective cantilevered assembly) and where bucket drum **22** is rotated in clockwise direction **28**B while bucket drum **32** is simultaneously rotated in counterclockwise direction **38**C. It is to be understood that the present invention could also be practiced by reversing the drums such that counterclockwise rotation of drum **22** and simultaneous clockwise rotation of drum **32** resulted in surface excavation. In either case, prior to such opposing directional rotation of bucket drums **22** and **32**, bucket drums **22** and **32** are synchronized with respect to each other such that each scoop **22**B has a mirror image scoop **32**B during the opposite-direction rotation of the bucket drums. The respective longitudinal axes **22**A and **32**A are maintained parallel to one another throughout such opposite-direction rotation of bucket drums **22** and **32**.

The above-described configuration, positioning, scoop synchronization, and counter-rotation of bucket drums **22** and **32** result in a zero horizontal reaction force (i.e., parallel to surface **100**) on excavator **10**. More specifically, symmetric and "equal-but-opposing" digging forces are generated as each mirror-image scoop pair **22**B/**32**B is in engagement with surface **100**. The opposing horizontal forces cancel one another out thereby resulting in a net horizontal reaction force of zero. In addition, rotation of bucket drums **22** and **32** in this fashion places respective cantilevered assembles **24** and **34** in compression (i.e., a condition that support arms **24**A and **34**A can better tolerate) as compared to being placed in tension.

Surface material cut/dug and scooped by each scoop **22**B/**32**B falls into the interior volume region **22**D (or regions) within the respective bucket drum **22**/**32**. To retain material in each bucket drum during its excavation rotation, baffles (See FIG. **7**) are provided in each bucket drum. In general, such baffles help retain material during excavation rotation of a bucket drum but allow the material to exit a scoop when a bucket drum is rotated in a direction opposite that of its excavation rotation. An improved baffle design for use in the present invention will be disclosed later herein.

FIG. **3** illustrates the dumping operation of excavator **10** with respect to bucket drum **22**. Specifically, bucket drum **22** is raised off surface **100** by cantilevered assembly **24**. Bucket drum **22** is then rotated in counterclockwise direction **28**C such that each open end **22**C of a scoop **22**B trails the scoop during such rotation. Surface material **100**A collected in the interior volume(s) **22**D of bucket drum **22** exits each open end **22**C as shown. Note that the position of bucket drum **32** can be on or off surface **100** during dumping of bucket drum **22**.

As mentioned above, a number of scoops can be provided on each bucket drum. For example, the number of scoops and distribution thereof about the rotating periphery of a bucket drum can be designed such that there is always at least one scoop in engagement with a surface during excavation rotation of the bucket drum. By doing this on both bucket drums, the zero horizontal reaction force will be continuous during excavation. An embodiment for achieving this is illustrated in FIGS. **4** and **5** where a bucket drum **220** having a longitudinal axis **221** is constructed from five identical and individual drums **220**A-**220**E, each of which has two scoops **222**B open at end **222**C thereof. More or fewer bucket drums and/or scoops could be used without departing from the scope of the present invention. The five bucket drums are rigidly coupled to one another such that the scoops' open ends are evenly distributed about the bucket drum's rotating periphery. For the illustrated 5-drum and 10-scoop design, there is an open end **222**C every 36° about the rotational periphery of bucket drum **220**. Other angular spacing could be used without departing from the scope of the present invention.

Referring now to FIG. **6**, another embodiment of a bucket drum is shown in isolation and referenced generally by numeral **320**. Bucket drum **320** is similar to bucket drum **220**. Additionally, each open end **322**C of a scoop **322**B has a serrated blade **330** attached thereto. In this way, a strong and generally expensive cutting material can be used sparingly for blades **330**. Further, when a blade **330** wears out, it can simply be replaced without removing bucket drum **320** from service. Although blade **330** is shown with a fully serrated edge, it would be obvious to one skilled in the art that additional configurations (e.g., flat, partially serrated, etc.) could be attached to the scoops without departing from the scope of the present invention.

Referring now to FIG. **7**, a cross-sectional view of one of the individual drums in FIG. **5** (e.g., drum **220**A) is shown in order to illustrate an improved baffle design that can be incorporated into a bucket drum of the present invention. The baffle portion of drum **220**A is a shaped region referenced generally by numeral **230**. More specifically, baffle **230** includes a flat baffle wall **230**A substantially aligned with open end **222**C and a curved baffle wall **230**B coupled to and extending from flat baffle wall **230**A into the interior region of drum **220**A. Referring additionally to FIG. **8**, the width "W_B" of flat baffle wall **230**A is the same as the width "W_S" of open end **222**C. However, the height "H_B" of flat baffle wall **230**A is greater than the height "H_S" of open end **222**C. As a result, the area of flat baffle wall **230**A is greater than the area defined by open end **222**C. Thus, material scooped by open end **222**C during excavation enters an expanded area (defined by flat baffle wall **230**A) to thereby minimize the chance that drum **220**A will clog during excavation. This feature is especially useful in low or zero gravity environments where clogging is more likely to occur since gravity is not available to pull material into the bucket drum as it rotates. Additionally, flat baffle wall **230**A and open end **222**C can have a slight angle α defined there between (e.g., on the order of a few degrees) to further improve material flow. Still further, all edges at open end **222**C and baffle region **230** can be rounded for improved material flow. The length of curved baffle wall **230**B can be adjusted for optimum material retention based on the needs of an application.

The advantages of the present invention are numerous. The present invention is directed to a completely new type of excavator capable of overcoming all of the problems associated in space environments on planetary bodies with conventional excavation apparatus. In particular, the present invention is a compact, lightweight, scalable regolith excavator that uses counter-rotating bucket drums mounted on each end of the excavator. During excavation, the excavator generates a zero horizontal reaction force due to the effective self-cancellation of the symmetrical and equal-but-opposing digging forces created by the counter-rotating bucket drums. In addition, the bucket drum design can incorporate multiple small scoops that reduce the digging forces at any given moment in the excavation operation, while being capable of hauling and dumping the regolith load without a separate storage container or dump bin. An improved baffle design reduces clogging and improves material retention.

In addition to the above-described excavation features and advantages, the opposing-end bucket drum placement can be used to manipulate the excavator in a variety of ways. For example, bucket drum positioning and selective rotation thereof can be used to help the excavator perform maneuvers such as climbing stepped surfaces, extracting itself from soft terrain, righting itself if tipped over, raising up the chassis for maintenance purposes, and achieve a wide variety of robotic poses.

Although the invention has been described relative to a specific embodiment thereof, there are numerous variations and modifications that will be readily apparent to those skilled in the art in light of the above teachings. It is therefore to be understood that, within the scope of the appended claims, the invention may be practiced other than as specifically described.

What is claimed as new and desired to be secured by Letters Patent of the United States is:

1. An excavator, comprising:

a mobile chassis;

a first bucket drum having a first axis of rotation, said first bucket drum coupled to said chassis, said first bucket drum having at least one open-ended first scoop formed thereon that provides access to an interior region of said first bucket drum and that is adapted to dig into a surface

when said first bucket drum is placed on the surface and is rotated about said first axis of rotation in a first direction;

a second bucket drum having a second axis of rotation, said second bucket drum coupled to said chassis, said second bucket drum having at least one open-ended second scoop formed thereon that provides access to an interior region of said second bucket drum and that is adapted to dig into the surface when said second bucket drum is placed on the surface and is rotated about said second axis of rotation in a second direction that is opposite to said first direction;

said first bucket drum and said second bucket drum coupled to said chassis for positioning thereof on the surface at opposing ends of said chassis;

each said first scoop on said first bucket drum being a mirror image of one said second scoop on said second bucket drum when (i) said first bucket drum and said second bucket drum are on the surface adjacent opposing ends of said chassis, and (ii) said first bucket drum is rotated in said first direction and said second bucket drum is simultaneously rotated in said second direction.

2. An excavator, comprising:

a mobile chassis;

a first bucket drum having a first axis of rotation, said first bucket drum coupled to said chassis, said first bucket drum having at least one first scoop formed thereon that is adapted to dig into a surface when said first bucket drum is placed on the surface and is rotated about said first axis of rotation in a first direction;

a second bucket drum having a second axis of rotation, said second bucket drum coupled to said chassis, said second bucket drum having at least one second scoop formed thereon that is adapted to dig into the surface when said second bucket drum is placed on the surface and is rotated about said second axis of rotation in a second direction that is opposite to said first direction;

said first bucket drum and said second bucket drum coupled to said chassis for positioning thereof on the surface at opposing ends of said chassis;

each said first scoop on said first bucket drum being a mirror image of one said second scoop on said second bucket drum when (i) said first bucket drum and said second bucket drum are on the surface adjacent opposing ends of said chassis, and (ii) said first bucket drum is rotated in said first direction and said second bucket drum is simultaneously rotated in said second direction, wherein each said first scoop and each said second scoop has an open end, and wherein said first bucket drum and said second bucket drum include a baffle adjacent each said open end, each said baffle including a flat baffle wall substantially aligned with said open end, said flat baffle wall having an area greater than that of said open end.

3. An excavator as in claim **2** further comprising a blade attachable to an outboard edge of each said first scoop and each said second scoop.

4. An excavator as in claim **2**, wherein said first bucket drum is coupled to said chassis using at least one rigid support arm pivotally coupled to said chassis for positioning said first bucket drum on the surface, said rigid support arm supporting rotation of said first bucket drum in at least said first direction.

5. An excavator as in claim **2**, wherein said second bucket drum is coupled to said chassis using at least one rigid support arm pivotally coupled to said chassis for positioning said second bucket drum on the surface, said rigid support arm supporting rotation of said second bucket drum in at least said second direction.

6. An excavator as in claim **2**, further comprising:

a first mechanism coupled to said first bucket drum for moving said first bucket drum in at least said first direction; and

a second mechanism coupled to said second bucket drum for moving said second bucket drum in at least said second direction.

7. An excavator as in claim **2**, wherein said first axis of rotation is parallel to said second axis of rotation.

8. An excavator as in claim **2**, wherein said first bucket drum has a plurality of first scoops formed thereon and said second bucket drum has a plurality of second scoops formed thereon, and wherein at least one of said first scoops is in engagement with the surface throughout rotation of said first bucket drum in said first direction and at least one of said second scoops is in engagement with the surface throughout rotation of said second bucket drum in said second direction.

9. An excavator as in claim **2**, wherein each said first scoop and each said second scoop terminates in a serrated edge.

10. An excavator as in claim **2**, wherein an angular relationship of greater than zero degrees is defined between said flat baffle wall and said open end.

11. An excavator as in claim **2**, wherein said baffle further includes a curved baffle wall coupled to said flat baffle wall.

12. An excavator, comprising:

a vehicle adapted for movement over a surface;

a first cantilevered assembly pivotally coupled on one end to said vehicle and having an outboard end rotatable to a position offset from a first end of said vehicle;

a first bucket drum having a first axis of rotation, said first bucket drum coupled to said outboard end of said first cantilevered assembly in support of said first axis of rotation, said first bucket drum having at least one open-ended first scoop formed thereon and providing access to an interior region of said first bucket drum, each said first scoop adapted to dig into a surface when said first bucket drum is placed on the surface by said first cantilevered assembly and is rotated about said first axis of rotation in a first direction wherein said first cantilevered assembly is placed in compression;

a second cantilevered assembly pivotally coupled on one end to said vehicle and having an outboard end rotatable to a position offset from a second end of said vehicle that is opposite said first end of said vehicle;

a second bucket drum having a second axis of rotation, said second bucket drum coupled to said outboard end of said second cantilevered assembly in support of said second axis of rotation, said second bucket drum having at least one open-ended second scoop formed thereon and providing access to an interior region of said second bucket drum, each said second scoop adapted to dig into the surface when said second bucket drum is placed on the surface by said second cantilevered assembly and is rotated about said second axis of rotation in a second direction that is opposite to said first direction wherein said second cantilevered assembly is placed in compression; and

each said first scoop on said first bucket drum being a mirror image of one said second scoop on said second bucket drum when (i) said first bucket drum and said second bucket drum are on the surface and offset from said first end of said vehicle and said second end of said vehicle, respectively, and (ii) said first bucket drum is rotated in said first direction and said second bucket drum is simultaneously rotated in said second direction.

13. An excavator, comprising:

a vehicle adapted for movement over a surface;

a first cantilevered assembly pivotally coupled on one end to said vehicle and having an outboard end rotatable to a position offset from a first end of said vehicle;

a first bucket drum having a first axis of rotation, said first bucket drum coupled to said outboard end of said first cantilevered assembly in support of said first axis of rotation, said first bucket drum having at least one first scoop formed thereon and adapted to dig into a surface when said first bucket drum is placed on the surface by said first cantilevered assembly and is rotated about said first axis of rotation in a first direction wherein said first cantilevered assembly is placed in compression;

a second cantilevered assembly pivotally coupled on one end to said vehicle and having an outboard end rotatable to a position offset from a second end of said vehicle that is opposite said first end of said vehicle;

a second bucket drum having a second axis of rotation, said second bucket drum coupled to said outboard end of said second cantilevered assembly in support of said second axis of rotation, said second bucket drum having at least one second scoop formed thereon and adapted to dig into the surface when said second bucket drum is placed on the surface by said second cantilevered assembly and is rotated about said second axis of rotation in a second direction that is opposite to said first direction wherein said second cantilevered assembly is placed in compression; and

each said first scoop on said first bucket drum being a mirror image of one said second scoop on said second bucket drum when (i) said first bucket drum and said second bucket drum are on the surface and offset from said first end of said vehicle and said second end of said vehicle, respectively, and (ii) said first bucket drum is rotated in said first direction and said second bucket drum is simultaneously rotated in said second direction, wherein each said first scoop and each said second scoop has an open end, and wherein said first bucket drum and said second bucket drum include a baffle adjacent each said open end, each said baffle including a flat baffle wall substantially aligned with said open end, said flat baffle wall having an area greater than that of said open end.

14. An excavator as in claim **13**, further comprising a blade attachable to an outboard edge of each said first scoop and each said second scoop.

15. An excavator as in claim **13**, further comprising:

a first mechanism coupled to said first bucket drum for moving said first bucket drum in one of said first direction and said second direction; and

a second mechanism coupled to said second bucket drum for moving said second bucket drum in one of said first direction and said second direction.

16. An excavator as in claim **13**, wherein said first axis of rotation is parallel to said second axis of rotation.

17. An excavator as in claim **13**, wherein said first bucket drum has a plurality of first scoops formed thereon and said second bucket drum has an identical plurality of second scoops formed thereon, and wherein at least one of said first scoops is in engagement with the surface throughout rotation of said first bucket drum in said first direction and at least one of said second scoops is in engagement with the surface throughout rotation of said second bucket drum in said second direction.

18. An excavator as in claim **13**, wherein each said first scoop and each said second scoop terminates in a serrated edge.

19. An excavator as in claim **13**, wherein an angular relationship of greater than zero degrees is defined between said flat baffle wall and said open end.

20. An excavator as in claim **13**, wherein said baffle further includes a curved baffle wall coupled to said flat baffle wall.

21. An excavator, comprising:

a vehicle adapted for movement over a surface;

a first cantilevered assembly pivotally coupled on one end to said vehicle and having an outboard end rotatable to a position offset from a first end of said vehicle;

a first bucket drum having a first axis of rotation, said first bucket drum coupled to said outboard end of said first cantilevered assembly in support of said first axis of rotation, said first bucket drum having at least one open-ended first scoop formed thereon and providing access to an interior region of said first bucket drum, each said first scoop adapted to dig into a surface when said first bucket drum is placed on the surface by said first cantilevered assembly and is rotated about said first axis of rotation in a first direction wherein said first cantilevered assembly is placed in compression;

a second cantilevered assembly pivotally coupled on one end to said vehicle and having an outboard end rotatable to a position offset from a second end of said vehicle that is opposite said first end of said vehicle;

a second bucket drum having a second axis of rotation, said second bucket drum coupled to said outboard end of said second cantilevered assembly in support of said second axis of rotation, said second bucket drum having at least one open-ended second scoop formed thereon and providing access to an interior region of said second bucket drum, each said second scoop adapted to dig into the surface when said second bucket drum is placed on the surface by said second cantilevered assembly and is rotated about said second axis of rotation in a second direction that is opposite to said first direction wherein said second cantilevered assembly is placed in compression;

said first cantilevered assembly and said second cantilevered assembly coupled to said vehicle at mirror image locations thereon relative to a center of said vehicle between said first end and said second end thereof; and

each said first scoop on said first bucket drum being a mirror image of one said second scoop on said second bucket drum when (i) said first bucket drum and said second bucket drum are on the surface and offset from said first end of said vehicle and said second end of said vehicle, respectively, and (ii) said first bucket drum is rotated in said first direction and said second bucket drum is simultaneously rotated in said second direction.

22. An excavator, comprising:

a vehicle adapted for movement over a surface;

a first cantilevered assembly pivotally coupled on one end to said vehicle and having an outboard end rotatable to a position offset from a first end of said vehicle;

a first bucket drum having a first axis of rotation, said first bucket drum coupled to said outboard end of said first cantilevered assembly in support of said first axis of rotation, said first bucket drum having at least one first scoop formed thereon and adapted to dig into a surface when said first bucket drum is placed on the surface by said first cantilevered assembly and is rotated about said first axis of rotation in a first direction wherein said first cantilevered assembly is placed in compression;

a second cantilevered assembly pivotally coupled on one end to said vehicle and having an outboard end rotatable

to a position offset from a second end of said vehicle that is opposite said first end of said vehicle;

a second bucket drum having a second axis of rotation, said second bucket drum coupled to said outboard end of said second cantilevered assembly in support of said second axis of rotation, said second bucket drum having at least one second scoop formed thereon and adapted to dig into the surface when said second bucket drum is placed on the surface by said second cantilevered assembly and is rotated about said second axis of rotation in a second direction that is opposite to said first direction wherein said second cantilevered assembly is placed in compression;

said first cantilevered assembly and said second cantilevered assembly coupled to said vehicle at mirror image locations thereon relative to a center of said vehicle between said first end and said second end thereof; and

each said first scoop on said first bucket drum being a mirror image of one said second scoop on said second bucket drum when (i) said first bucket drum and said second bucket drum are on the surface and offset from said first end of said vehicle and said second end of said vehicle, respectively, and (ii) said first bucket drum is rotated in said first direction and said second bucket drum is simultaneously rotated in said second direction, wherein each said first scoop and each said second scoop has an open end, and wherein said first bucket drum and said second bucket drum include a baffle adjacent each said open end, each said baffle including a flat baffle wall substantially aligned with said open end, said flat baffle wall having an area greater than that of said open end.

23. An excavator as in claim **22**, further comprising a blade attachable to an outboard edge of each said first scoop and each said second scoop.

24. An excavator as in claim **22**, further comprising:

a first mechanism coupled to said first bucket drum for moving said first bucket drum in one of said first direction and said second direction; and

a second mechanism coupled to said second bucket drum for moving said second bucket drum in one of said first direction and said second direction.

25. An excavator as in claim **22**, wherein said first axis of rotation is parallel to said second axis of rotation.

26. An excavator as in claim **22**, wherein said first bucket drum has a plurality of first scoops formed thereon and distributed evenly there about, said second bucket drum having an identical plurality of second scoops formed thereon and distributed evenly there about, and wherein at least one of said first scoops is in engagement with the surface throughout rotation of said first bucket drum in said first direction and at least one of said second scoops is in engagement with the surface throughout rotation of said second bucket drum in said second direction.

27. An excavator as in claim **22**, wherein each said first scoop and each said second scoop terminates in a serrated edge.

28. An excavator as in claim **22**, wherein an angular relationship of greater than zero degrees is defined between said flat baffle wall and said open end.

29. An excavator as in claim **22**, wherein said baffle further includes a curved baffle wall coupled to said flat baffle wall.

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