Abstract: A grinding apparatus for grinding a surface is disclosed which includes a plurality of satellites, a carrier for supporting the plurality of satellites, a plurality of primary gears rotatably mounted within the carrier and disposed about a motor output, a static gear which is fixed with respect to the motor and coaxial with the motor output, and a plurality of secondary gears which each rotate with one of the primary gears. The primary gears rotate the satellites with respect to the carrier and the secondary gears rotate the carrier around the static gear.
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FLOOR GRINDING APPARATUS

Field of the invention:

The present invention relates to an apparatus for processing a surface. More particularly, in its preferred intended use, the present invention relates to a grinding apparatus.

Background of the invention:

Floor grinding apparatuses and the like are very well known in the art.

Conventional floor grinding apparatuses are usually provided, alone or in combination with other similar apparatuses, as part of larger floor grinders, mounted on movable chassis that can travel along a given surface. The chassis of the apparatus can be provided with wheels and a handle so as to be movable by an operator around a work area, or can be mounted onto a motorized chassis, such as a cart, and driven. The grinding apparatus typically comprises a motor which drives one or more grinding disks. Each grinding disk comprises a grinding surface on a bottom side and rotates about its axis, thereby grinding the floor when in contact therewith.

United States Patent No. 3,128,581 to Tesetti discloses a prior art grinding apparatus including a set of three grinding stones which are each operable to rotate about a respective axis. United States Patent No. 4,319,434 to Brejcha discloses a prior art surface processing machine including a set of six processing tools fixed in a spaced apart relationship and operable to rotate about a common central axis.

A major drawback associated with conventional types of grinding apparatus is that they are likely to produce an unequal, wavy surface due to the uneven weight and grinding distribution. Specifically, it is known that the weight on the grinding discs
is higher in the center where the motor is typically placed and that the pressure on the discs therefore diminishes outside that area. Furthermore, it is known that the grinding disks of such apparatuses are often arranged to partially overlap in order to ensure that no area beneath the apparatus is missed. The combination of these two factors results in that, as the apparatus travels over a work surface, more material may be removed along the centre of the apparatus than along its the lateral sides. This effect is especially pronounced on soft or medium-hard surfaces. Because the end result is irregular, these conventional apparatuses are only suitable for surface preparation and coating overlay removal, rather than surface finishing which typically requires a uniform finish.

It is also known to provide a combination of the two patents mentioned herein above wherein a plurality of grinding disks, called "satellites", are operable to rotate not only about their own axis, but also an axis central to the grinding apparatus. Such a motion, that is the individual rotation of the satellite grinding disks and the rotation of these disks about a central axis, is called a "planetary" motion.

United States Patent No. 383,147 to Burgess discloses a floor cleaning machine including a planetary gear system wherein a pair of satellites which are attached to respective gears mounted between a driven spur gear and an outer crown gear. Similarly, United States Patent No. 2,171,060 to De Spirt discloses a floor surfacing machine wherein a set of satellites are mounted to a casing which is fixed to a motor drive shaft. The rotation of the casing pushes satellites around a main gear, causing them to rotate with respect to the casing as well.

United States Patent No. 7,140,957 to Thysell et al. discloses a belt driven planetary grinding apparatus. A belt rotates a set of four satellites with respect to a planet wheel, as well as rotating the planet wheel with respect to the apparatus.

While a planetary grinding apparatus is generally preferable to a non-planetary one, a major drawback associated with this conventional type of belt driven
grinding apparatus, also called a passive planetary apparatus, is that such friction-driven power transmission is prone to slippage, which creates an uneven and non-uniform grinding effect. Moreover, this limits the torque applied to, and by, the device and because of this conventional grinding apparatuses such as this are limited in their speed of operation. It is also known that during extended operation such belt-driven grinders are subject to belt failure, which is time consuming and costly to repair.

Also known to the Applicant are the following US patents and international patent laid-open application which describe other grinding apparatuses and the like: US 593,220, US 1,984,205, US 2,316,886, US 4,342,485, US 5,643,047, and WO 2005/077599.

In all cases, there is a need for an improved grinding apparatus which is active planetary and can operate at higher torque and/or higher speed than conventional apparatuses.

More specifically, in light of the above, there is a need for an improved grinding apparatus, which by virtue of its design and components, would be able to overcome some of the above-discussed prior art problems.

**Summary of the invention:**

In accordance with an aspect of the present invention, there is provided a grinding apparatus for grinding a surface, the grinding apparatus operable to be powered by a motor including a rotatable motor output, the grinding apparatus comprising:

a) a plurality of satellites for engaging the surface;

b) a carrier for supporting the plurality of satellites, each of the plurality of satellites being disposed around the motor output and rotatably mounted to the carrier, the carrier being rotatably mounted to the motor;

c) a plurality of primary gears rotatably mounted within the carrier, the primary gears disposed about the motor output and drivable thereby, the primary
gears engaging the satellites and thereby enabling the rotation of the satellites with respect to the carrier;

d) a static gear which is fixed with respect to the motor, the static gear being co-axial with the motor output; and

e) a plurality of secondary gears, each secondary gear being co-axial with a corresponding one of the primary gears and rotatable therewith with respect to the carrier, the secondary gears engaging the static gear and thereby enabling the rotation of the carrier with respect to the motor.

Preferably, the plurality of primary gears includes a set of inner gears, each inner gear engaging the motor output and operable to be driven thereby; and a set of outer gears, each outer gear engaging a respective one of the inner gears and drivable thereby, each outer gear being co-axial with a corresponding one of the satellites.

Preferably the static gear is a crown gear.

Preferably, each secondary gear is mounted to a respective one of the outer gears by an outer axle, each secondary gear and respective outer gear thereby being operable to rotate together with respect to the carrier. Preferably each satellite is mounted to its respective outer gear by a respective outer axle.

Preferably, the carrier includes a lower plate, an upper plate and an enclosing wall. Preferably, each outer axle extends through the upper plate such that each secondary gear is mounted outside the carrier. Preferably, each outer axle extends through the lower plate such that each satellite is mounted outside the carrier opposite the secondary gears.

Preferably, the grinding apparatus further includes an outer casing, the outer casing being fixed to the motor and operable to enclose the top plate and the enclosing wall.
Preferably, the grinding apparatus further includes an edging attachment which includes an edging disk and a bevel gearing assembly mounted to the carrier and operable to drive the rotation of the edging attachment.

In accordance with another aspect of the present invention, the each secondary gear is preferably mounted to one of the inner gears by an inner axle, each secondary gear and respective inner gear thereby operable to rotate with respect to the carrier.

The invention and its advantages will be better understood by reading the following non-restrictive description of the preferred embodiments thereof, made with reference to the accompanying drawings.

**Brief description of the drawings:**

FIG. 1 illustrates a perspective view of a floor grinder comprising a grinding apparatus in accordance with an embodiment of the present invention;

FIG. 2 illustrates a perspective view of a grinding apparatus in accordance with an embodiment of the present invention;

FIG. 3 illustrates the grinding apparatus of FIG. 2 with the outer casing removed;

FIG. 4 illustrates the grinding apparatus of the previous FIGs. with the motor hub removed;

FIG. 5 is a perspective view of the grinding apparatus of the previous figures in cross-section;

FIG. 6 is an exploded view of the grinding apparatus of previous FIGs.;
FIG. 7 is a perspective view of a grinding apparatus according to another embodiment of the present invention, in cross section; and

FIG. 8 is a perspective view of the grinding apparatus of FIG. 7 including an edger attachment;

**Detailed description of preferred embodiments of the invention:**

In the following description, the same numerical references refer to similar elements. The embodiments shown in the figures are preferred and disclosed for exemplification purposes only.

As will be apparent to one skilled in the art, in the context of the present description the expression "grinding" includes all types of surface processing, such as grinding, finishing, polishing, processing, levelling and screeding, surface-preparation, coating overlay removal, honing, and polishing. For this reason, these expressions should not be taken as to limit the scope of the present invention and includes all other kinds of usages or items with which the present invention may be used and could be useful.

In addition, although the preferred embodiments of the present invention as illustrated in the accompanying drawings comprise various components, and although the preferred embodiments of the floor grinding apparatus and corresponding parts of the present invention as shown, have certain geometrical configurations as explained and illustrated herein, not all of these components and geometries are essential to the invention and thus should not be taken in their restrictive sense, i.e. should not be taken as to limit the scope of the present invention. It is to be understood, as also apparent to one skilled in the art, that other suitable components and cooperations therebetween, as well as other suitable geometrical configurations may be used for the floor grinding apparatus according to the present invention, as will be briefly explained herein and as can
be easily inferred herefrom by one skilled in the art, without departing from the scope of the invention.

In addition, it will be appreciated that certain standard items such as bearings and bearing mounts have been omitted for the sake of clarity. As will be apparent to one skilled in the art, it is preferable that any axle or other rotating member be provided with a bearing and, in some cases a bearing mount, positioned between it and whichever element it is rotating with respect to.

In FIG. 1, a floor grinder 100 is illustrated comprising a grinding apparatus 110 which is supported by a frame 112. A handle 114 and wheels 116 are provided for manual displacement of the apparatus 100, enabling it to be pushed along a surface during operation. A motor 118 is provided for driving the grinding apparatus 110 during use. It will be understood that the grinding apparatus 110 may similarly be used on a motorized vehicle such as a cart, or self-propelled using one of more motors coupled to the wheels 116, rather than pushed manually, and that the motor 118 may be any of a number of types of motor, such as electric, gas powered, hydraulic or pneumatic. The motor 118 comprises a motor output 119 for transferring the generated power to the apparatus 110. The motor output 119 of the motor 118 illustrated in the Figures is a drive shaft 119, although it will be appreciated that alternative embodiments of the apparatus 110 may be used which receive various other types of motor outputs.

With reference now to the preferred embodiment of the invention shown in FIG. 2, the grinding apparatus 110 comprises a motor hub 120 which attaches an outer casing 122 of the apparatus 110 to the motor 118. Preferably, the outer casing 122 includes a housing plate 121 which is fixed to the hub 120 and a flexible skirt 123. A plurality of grinding disks 124 (on of which is shown in FIG. 3), also called satellites, extend from beneath the apparatus 110 for engaging the floor during use. The satellites 124 include a plurality of abrasive inserts 126 which can themselves comprise diamond segments and the like. As will be appreciated, a number of types and varieties of such satellites 124 and segments 126 are
appropriate for use with the grinding apparatus 110. As will be further appreciated, the plurality of satellites 124 comprises four satellites 124 in the illustrated preferred embodiments, although the use of less or more is equally appropriate.

With additional reference to FIGs. 3 to 6, the preferred embodiment of the grinding apparatus 110 of FIG. 2 is illustrated with various elements removed for clarity. The motor's drive shaft 119 is extended into a primary gearing assembly 134, which is housed within a carrier 131 along with much of the gearing. The carrier 131 comprises upper and lower plates 132 and an enclosing wall 133. The enclosing wall preferably isolates much of the gearing in order to prevent dirt, or other contaminants/foreign objects from infiltrating the grinding apparatus 110 or otherwise getting caught therein.

The drive shaft 119 passes through a carrier holder 128 and transfers rotary motion from the motor 118 to the grinding apparatus 110. The carrier holder 128 is bolted to the upper carrier plate 132 along its lower extremity. The upper portion of the carrier holder 128 engages the inner race of a bearing assembly 130 (shown in the exploded view of FIG 6). The outer race of the bearing 130 engages the inside of the motor hub 120 while the inner race engages the carrier holder. In this manner, the carrier 131 and its contents are free to rotate with respect to the motor hub 120, the outer casing 122 and the motor 118 itself.

The primary gearing assembly 134 rotates the satellites 124 about their respective axes with respect to the carrier 131. The motor drive shaft 119 includes a central spur gear 140 engages and transfers power to a plurality of adjacent primary gears 142 and 144 which are rotatably mounted within the carrier 131 and disposed about the drive shaft 119.

In the preferred embodiment illustrated in FIGs. 3 and 4, two sets of primary gears 142 and 144 are provided. The primary gears 142 which engage the spur gear 140 directly are referred to as inner gears 142. The inner gears 142 engage and transfer power to a plurality of outer gears 144, which engage the satellites 124 and thereby enable rotation of the satellites 124 with respect to the carrier 131. It
will be appreciated that the plurality of outer gears 144 may be equal in number to the plurality of inner gears 142, as illustrated, or could indeed be greater in an alternative embodiment wherein more than one outer gear 144 engages each inner gear 142. It will be further illustrated that additional primary gears could be provided between the inner and outer gears 142 and 144 for, *inter alia*, changing the direction of rotation of the satellites 124.

The satellites 124 are mounted on outer axles 136 which extend through the lower of the two carrier plates 132. Each satellite 124 is fixed to one of the outer gears 144 outside the carrier 131 and both rotate together about their respective outer axle 136. In this manner, the power of the motor 118 is used to rotate the satellites 124 about the carrier 131 by transferring the rotational motion of the drive shaft 119 via the central gear 140, to each of the inner gears 142 and then to each satellite 124 via its respective outer gear 144. Preferably, the gears 140, 142, 144 and 154 are helical gears.

In addition, a secondary gearing assembly 150 is provided for rotating the carrier 131 and the satellites 124 about the grinding apparatus 110 itself, *i.e.* for enabling active planetary motion. In the preferred embodiment illustrated in FIGs. 3 and 4, the secondary gearing assembly 150 includes a plurality of secondary gears 152 and a static gear 154. The static gear 154 is preferably a crown gear 154 and is attached to the underside of the housing plate 121 of the outer casing 122 such that it remains fixed with respect to the motor 118. Each secondary gear 152 coaxial and rotates with a respective one of the primary gears 142 and 144. Preferably each secondary gear 152 is fixed to a respective outer gear 144 and the two are operable to rotate together about the carrier 131.

Each outer gear 144 and secondary gear 152 pair are fixed at opposite ends of an outer axle 136 which extends through the upper carrier plate 132 and pivots with respect to the lower carrier plate 132. As such, the secondary gears 152 are mounted outside the carrier 131. Each inner gear 142 is provided with a respective inner axle 156 with which it is able to rotate about the carrier 131.
As the central spur gear 140 drives the primary gears 142 and 144, the corresponding rotation of the secondary gears 152 and their engagement with the crown gear 154 drive the carrier 131 and the elements mounted thereto about the crown gear 154 and with respect to the motor 118. It will be appreciated that the rotation of the satellites 124 about the axes 136 is opposite to the direction of the planetary rotation of those axes about the static gear 154. This opposite rotation advantageously increases stability and eases grinding.

This planetary motion occurs within the outer casing 122 which is fixed to the motor 118 via the motor hub 120. As shown most clearly in FIG. 3, the engagement of the secondary gears 152 and the crown gear 154 preferably occurs above the upper carrier plate 132, although it will be appreciated that other arrangements are within the scope of the present invention.

FIG. 7 illustrates another preferred embodiment of the grinding apparatus 110. Herein, the secondary gears 152 are co-axial with the inner gears 142 and attached to the inner axles 156, and the crown gear has been replaced with a static gear 154 having outward facing teeth.

Due to their large circular shape, conventional grinding apparatuses have difficulty grinding the edges of a surface, such as a junction with a wall, and leave a gap of at least one inch which cannot be processed. With reference to FIG. 8, the grinding apparatus 110 of FIG. 7 is provided with an edging attachment 170. The edging attachment 170 comprises two edging disks 172 which are driven by a bevel gear 174 fixed to the upper carrier plate 132. A bevel gearing assembly 176 transfers the rotation of the upper carrier plate 132 to each edging disk 172 by respective horizontal shafts 178, vertical shafts 180 and bevel gears 182. For clarity, the supports for these elements have not been illustrated.
The pressure exerted by the edging disks 172 is preferably adjustable by hand, or by an electric motor controlled from a control panel. The edging disks 172 are preferably flexible so as to follow the level of an uneven surface.

The grinding apparatus 110 may further be provided with an automatic electronic levelling mechanism and ultrasonic or infrared gloss sensors for automatically adjusting rotation speed and/or apparatus alignment and pressure. Furthermore, the grinding apparatus 110 may be equipped with positional sensors operable to navigate the grinding apparatus 110 along a given surface in response to an initial user input or external sensor stimuli which senses walls, obstacles and the like so as to be run without an operator. The grinding apparatus 110 may also be provided with automatic cooling sensors which detect the satellites’ temperature and distribute a cooling substance, such as a water mist, if their operating temperature reaches a predetermined maximum.

As being now better appreciated, the present invention is an improvement and presents several advantages over other related apparatuses known in the art. Indeed, the present invention is particularly advantageous in that it provides a robust planetary gear assembly, instead of a belt-driven assembly, which will allow the grinding apparatus to operate at high speeds. As will be appreciated by one skilled in the art, higher operating speeds advantageously allow faster grinding, which saves time, but also use of coarser grinding material. It will further be appreciated that the above-described grinding apparatuses are operable to work on all types of floor, for example concrete, terrazzo, or natural stones such as granite and marble. It will also be appreciated that the above-described grinding apparatuses are usable for any type of grinding or other surface processing application, such as finishing, polishing, processing, levelling and screeding, surface-preparation, levelling, coating overlay removal, honing, and polishing.

Of course, numerous modifications could be made to the above-described embodiments without departing from the scope of the invention, as apparent to a person skilled in the art.
Claims:

1. A grinding apparatus for grinding a surface, the grinding apparatus operable to be powered by a motor comprising a rotatable motor output, the grinding apparatus comprising:
   a) a plurality of satellites for engaging the surface;
   b) a carrier for supporting the plurality of satellites, each of the plurality of satellites being disposed around the motor output and rotatably mounted to the carrier, the carrier being rotatably mounted to the motor;
   c) a plurality of primary gears rotatably mounted within the carrier, the primary gears disposed about the motor output and drivable thereby, the primary gears engaging the satellites and thereby enabling the rotation of the satellites with respect to the carrier;
   d) a static gear which is fixed with respect to the motor, the static gear being co-axial with the motor output; and
   e) a plurality of secondary gears, each secondary gear being co-axial with a corresponding one of the primary gears and rotatable therewith with respect to the carrier, the secondary gears engaging the static gear and thereby enabling the rotation of the carrier with respect to the motor.

2. The grinding apparatus of claim 1, wherein the plurality of primary gears comprises:
   a) a set of inner gears, each inner gear engaging the motor output and operable to be driven thereby; and
   b) a set of outer gears, each outer gear engaging a respective one of the inner gears and drivable thereby, each outer gear being co-axial with a corresponding one of the satellites.

3. The grinding apparatus of claim 2, wherein the static gear is a crown gear.

4. The grinding apparatus of claim 3, wherein each secondary gear is mounted to a respective one of the outer gears by an outer axle, each secondary gear and respective outer gear thereby being operable to rotate together with respect to the carrier.
5. The grinding apparatus of claim 4, wherein each satellite is mounted to its respective outer gear by a respective outer axle.

6. The grinding apparatus of claim 5, wherein the carrier comprises a lower plate, an upper plate and an enclosing wall.

7. The grinding apparatus of claim 6, wherein each outer axle extends through the upper plate such that each secondary gear is mounted outside the carrier.

8. The grinding apparatus of claim 7, wherein each outer axle extends through the lower plate such that each satellite is mounted outside the carrier opposite the secondary gears.

9. The grinding apparatus of claim 1, further comprising an outer casing, the outer casing being fixed to the motor and operable to enclose the top plate and the enclosing wall.

10. The grinding apparatus of claim 9, wherein the static gear is fixed to the outer casing.

11. The grinding apparatus of claim 1, wherein the plurality of primary gears, the static gear and the plurality of secondary gears are helical gears.

12. The grinding apparatus of claim 2, wherein each secondary gear is mounted to a respective one of the inner gears by an inner axle, each secondary gear and respective inner gear thereby being operable to rotate with respect to the carrier.

13. The grinding apparatus of claim 1, further comprising an edging attachment, the edging attachment comprising an edging disk and a bevel gearing assembly mounted to the carrier and operable to drive the rotation of the edging attachment.
INTERNATIONAL SEARCH REPORT

International application No
PCT/CA2008/002216

A CLASSIFICATION OF SUBJECT MATTER
According to International Patent Classification (FPC) or to both national classification and IPC

B FIELDS SEARCHED
Minimum documentation searched (classification system followed by classification symbols)
IPC B24B all, F16H all

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic database(s) consulted during the international search (name of database(s) and, where practicable, search terms used)
DELPFHON, Canadian patent database Keywords gear*, grind*, motor, surface, planetary, epicycl*, orbital AND screed*, "compound planetary", "crown gear", Russotti, Silver, Boukni, Chakhtoura

C DOCUMENTS CONSIDERED TO BE RELEVANT

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[X] Further documents are listed in the continuation of Box C

Y late document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
X document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
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Date of the actual completion of the international search
12 March 2009 (12-03-2009)

Date of mailing of the international search report
14 April 2009 (14-04-2009)

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Roland Jonasch 819-934-4895
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