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(71) Applicant: **Otis Elevator Company**
Farmington, Connecticut 06032 (US)

(72) Inventor: **Gil, Santiago**
Madrid 28033 (ES)

(74) Representative: **Dehns**
10 Old Bailey
London EC4M 7NG (GB)

(54) **ELEVATOR MACHINE**

(57) A gearless elevator machine (1), includes a first bearing stand (14) supporting a first bearing (48a), a second bearing stand (56) supporting a second bearing (48b), a shaft (30), supported by the first bearing (48a) and the second bearing (48a) and a motor (60) arranged

to drive the shaft (30) to rotate. The gearless elevator machine (1) further includes at least one spacer (5), extending between the first bearing stand (14) and the second bearing stand (56), and removably attaching the first bearing stand (14) to the second bearing stand (56).

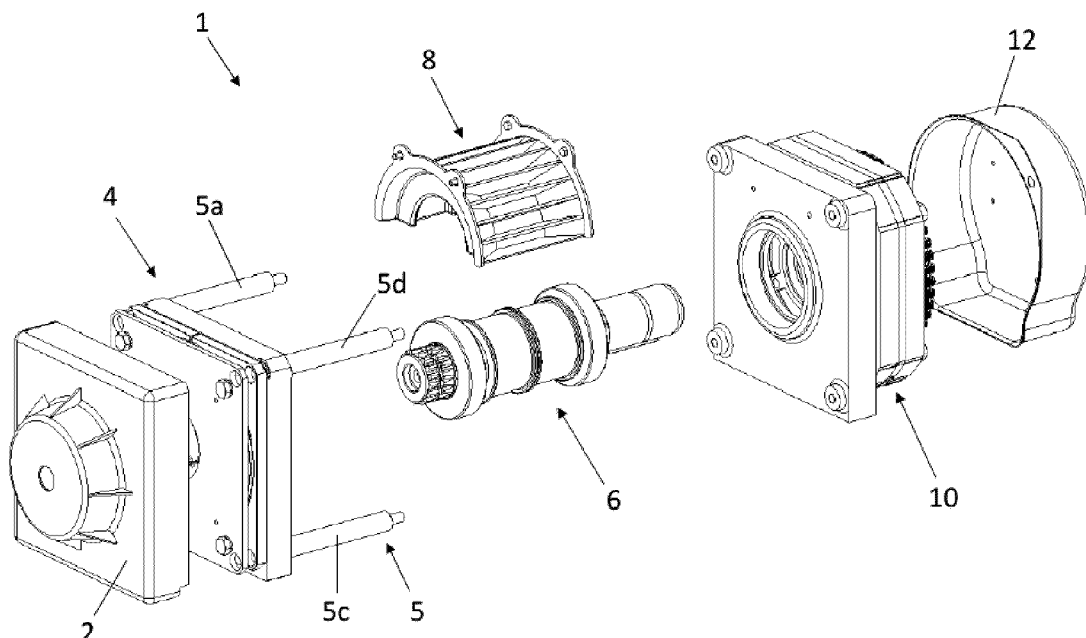


Figure 1

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Description

Technical field

[0001] This disclosure relates to a gearless elevator machine, an elevator system including the gearless elevator machine, a method of assembling a gearless elevator machine, and a kit for assembling a gearless elevator machine.

Background

[0002] It is known to provide elevator systems with gearless elevator machines, arranged to drive movement of tension members, and thereby to move elevator cars. It is known to provide different elevator machine constructions and designs, having different lengths and speeds, to be suitable to meet different requirements of different elevator systems. It is furthermore known in such systems to provide bearing stands, accommodating bearings which support a rotating shaft, where both bearing stands, and an intermediate component between them, are formed as a single integral piece. This piece is sized and shaped specifically for one type and size of elevator machine.

[0003] The present application seeks to provide an improved gearless elevator machine and method for assembling a gearless elevator machine.

Summary

[0004] According to a first aspect of this disclosure there is provided a gearless elevator machine, comprising:

a first bearing stand and a first bearing, the first bearing stand supporting the first bearing,
a second bearing stand and a second bearing, the second bearing stand supporting the second bearing,
a shaft, supported by the first bearing and the second bearing;
a motor arranged to drive the shaft to rotate; and
at least one spacer, extending between the first bearing stand and the second bearing stand, and removably attaching the first bearing stand to the second bearing stand.

[0005] The first bearing stand and the second bearing stand are removably attached together. By this it will be understood that the first bearing stand and the second bearing stand are not formed integrally as a single piece, but rather are two discrete, individual pieces which are then attached together by one or more intermediate components, the spacer(s). By "removably attached" it will be understood that the removal of one part from another is possible, in the sense that they are separate parts that can be separated without needing to break one

integral piece into parts. The removal need not be easy, or require minimal force, for example, the spacer(s) may be glued of fixedly attached to one or both of the bearing stands.

[0006] As a result of forming the bearing stands as separate, independent parts, the same (i.e. identical) bearing stands may be suitable to be used together with different lengths of shafts and spacers arranged between them, in order to create gearless elevator machines of different lengths that are suitable in different applications. This allows only certain parts to be changed between machines of different types or sizes, whilst other parts (e.g. the bearing stands) may be used across a range of different machines, with the other parts being interchangeable, thus providing a modular gearless elevator machine.

[0007] The arrangement of the present disclosure further has the advantage that a lighter material (or materials) may be chosen for the spacers than for the bearing stands, thus reducing the overall weight of the gearless elevator machine compared to known arrangements in which the bearing stands are formed together as a single integral piece, including a connecting portion between them. It also allows the first and second bearing stands to be made of different materials to each other (as well as to the spacer material).

[0008] According to a second aspect of this disclosure there is provided an elevator system comprising:

at least one tension member;
an elevator car, suspended by the tension member; and
the gearless elevator machine as described above and in further detail below, wherein the shaft comprises at least one sheave, and wherein the at least one tension member is engaged with the at least one sheave, such that rotation of the shaft by the motor drives movement of the elevator car.

[0009] The elevator system may further comprise a counterweight, wherein the counterweight is suspended by the tension member.

[0010] In some examples, the gearless elevator machine further comprises a brake coil arranged to engage and disengage a brake to brake rotation of the shaft, wherein the brake coil is accommodated (i.e. housed) within the first bearing stand (e.g. within a recess defined by the first bearing stand). By this it will be understood that the brake coil is integrated within the first bearing stand. Thus, the first bearing stand may define a first bearing stand length (along the axial direction) and optionally also a height and depth, along perpendicular directions, and the brake coil may be accommodated within the first bearing stand length (and optionally also height and depth). In some examples, the first bearing stand forms a recess (or cavity) shaped to accommodate the brake coil. The first bearing stand may be referred to as a brake stand. In some examples, the gearless elevator machine

further comprises the brake.

[0011] In some examples, the gearless elevator machine (e.g. a brake assembly of the gearless elevator machine) comprises a brake disc, a moving plate and a fixed plate, wherein the brake disc is positioned between the moving plate and the fixed plate. The brake coil may be arranged to actuate movement of the moving plate (e.g. in cooperation with one or more biasing springs). In some examples the moving plate and/or the fixed plate have a (substantially) square shape (i.e. in a plane perpendicular to the elongate axis of the gearless elevator machine). In some examples the first bearing stand has a (substantially) square shape (i.e. in a plane perpendicular to the elongate axis of the gearless elevator machine). This allows bushings for supporting the moving plate to be located in the corners of the substantially square shape, leaving a larger inner area which is advantageously able to accommodate a larger brake disc.

[0012] It is advantageous for the brake coil to be accommodated within the first bearing stand since it reduces the overall length (along the axial direction) of the gearless elevator machine, since the brake coil sits within the length of the first bearing stand, and does not require a separate section of length to sit within. Furthermore, it also reduces the volume of material needed to form the first bearing stand, and therefore the weight of required material.

[0013] This advantageous feature is considered to be novel and inventive in its own right and therefore, according to a third aspect, there is provided a gearless elevator machine, comprising:

a first bearing stand and a first bearing, the first bearing stand supporting a first bearing,
a shaft, supported by the first bearing;
a motor arranged to drive the shaft to rotate; and
a brake coil arranged to engage and disengage a brake to brake rotation of the shaft, wherein the brake coil is accommodated within the first bearing stand.

[0014] In some examples of this aspect, the gearless elevator machine further comprises a second bearing stand and a second bearing, the second bearing stand supporting a second bearing. The shaft may also be supported by the second bearing.

[0015] In some examples (i.e. of any of the aspects described herein), the brake coil comprises (or consists of) copper.

[0016] In some examples the first bearing stand comprises (or consists of) steel. This is advantageous, particularly where the first bearing stand accommodates the braking coil, since steel is compatible with the copper coil.

[0017] In some examples, the motor comprises a rotor and a stator, the stator arranged to selectively drive rotation of the rotor. The rotor may be connected to the shaft so that rotation of the rotor drives the shaft to rotate. In some examples, the stator is attached to (i.e. mounted to) the second bearing stand. The second bearing stand

may be referred to as the motor stand. The stator may be attached to the second bearing stand by one or more screws. Thus, the stator and/or the second bearing stand may comprise screw holes to accommodate the screw(s). This second bearing stand therefore advantageously provides a convenient mounting for the stator. Furthermore, by precise and accurate mounting of the stator to the second bearing stand (e.g. by precise positioning of the screw holes) and precise location of the rotor, it may be ensured that the rotor is located concentrically within the stator, without the requirement for additional locating parts, e.g. a flange.

[0018] The rotor may be mounted to (i.e. around) the shaft. The shaft may be supported within the second bearing (i.e. pass through the second bearing). Thus, precise positioning of the bearing relative to the second bearing stand will control the position of the shaft and thereby of the rotor, ensuring its concentric position relative to the stator.

[0019] The first bearing stand may comprise a (first bearing) recess to accommodate the first bearing. The second bearing stand may comprise a (second bearing) recess to accommodate the first bearing. The recess(es) may be positioned centrally relative to the corresponding bearing stand (e.g. aligned along the axis of the gearless elevator machine).

[0020] In some examples, the second bearing stand comprises (or consists of) cast iron or forged steel. The first bearing and the second bearing may have (substantially) the same outer diameter and/or inner diameter. The first bearing and the second bearing may be (substantially) identical.

[0021] The shaft is supported (i.e. in a rotatable manner) by the first bearing and the second bearing. The shaft may be supported within the bearings, i.e. pass through the bearings. The shaft extends (at least) between the first bearing and the second bearing, and therefore between the first bearing stand and the second bearing stand. The shaft may comprise (or consist of) steel. The shaft may extend through (i.e. all the way through) the stator.

[0022] In some examples the shaft comprises a motor key groove. In some examples, the gearless elevator machine comprises a motor key, accommodated (at least partially) within the motor key groove. The motor key may be arranged to engage with the motor (e.g. with the rotor of the motor). This helps to ensure that rotation of the motor drives rotation of the shaft. The motor key groove and therefore the motor key may extend along an axial length of the shaft, i.e. along an axial length of the gearless elevator machine. This helps to improve engagement of the motor key with the motor.

[0023] In some examples, the gearless elevator machine further comprises at least one sheave for engaging with an elevator tension member, wherein the at least one sheave is arranged around the shaft. The elevator tension member may be an elevator rope or an elevator belt.

[0024] Whilst it is possible to form one or more sheaves

integrally with the shaft, in some advantageous examples the sheaves are separate to the shaft (i.e. provided as separate parts). In some examples, the at least one sheave is interference fit around the shaft. This reduces the diameter of the shaft part that must be manufactured, since the sheaves are not manufactured as part of the shaft. This is particularly advantageous where the shaft is machined, since machining of a smaller diameter part reduces wastage and is a simpler manufacturing process. Furthermore, since the sheaves are interference fit onto the shaft a different number of sheaves can be introduced onto the shaft, for different machines using the same shaft, to make the machine more suitable for different applications (e.g. able to accommodate different belt widths). Moreover, the same sheaves can be used for different lengths of shaft, each of which are compatible with the machine, as described above. Interference fitting also allows different types of sheave to be fitted onto the same shaft to make it suitable for a particular purpose. For example, different (sets of) sheaves may be fitted where they are intended to engage with an elevator rope as opposed to an elevator belt.

[0025] In some examples, the shaft comprises a key groove, wherein the gearless elevator machine further comprises a sheave key (at least partially) accommodated within the key groove. In some examples each at least one sheave comprises an inner groove, wherein the sheave key is arranged to engage with the inner groove. This sheave key improves engagement between the shaft and the sheaves so that even if the interference fit itself is insufficient to keep the sheaves rotating together with the shaft, this engagement is ensured by the sheave key. The key groove and therefore the sheave key may extend along an axial length of the shaft, i.e. along an axial length of the gearless elevator machine. This helps the sheave key to engage with all sheaves.

[0026] In some examples, the gearless elevator machine further comprises a belt guard, extending between the first bearing stand and the second bearing stand, wherein the belt guard is formed as a single integral (i.e., unitary) piece. The belt guard may be aligned over the shaft (and therefore over the sheaves, and, in use, over the elevator tension member). The belt guard may be a hollow half-cylinder. The elongate axis of the half-cylinder may extend parallel to the axial length of the shaft (i.e. of the gearless elevator machine).

[0027] The belt guard may be removably attached (e.g. screwed) to the first bearing stand and/or the second bearing stand. Thus, the belt guard may be removed in order to install an elevator tension member onto the sheave(s). The belt guard may also be removed in order to carry out maintenance on elements of the gearless elevator machine or on the tension member. In some examples, the belt guard comprises (or consists of) plastic.

[0028] The at least one spacer extends between, and removably attaches, the first and second bearing stands. In some examples, each spacer comprises a screw or

bolt. In some examples, each spacer comprises a housing. The screw or bolt may be positioned within the housing. Thus, in some examples, the first bearing stand and the second bearing stand may be removably attached together by screws or bolts. In some examples, each spacer is an elongate cylinder.

[0029] This disclosure extends to a method of assembling a gearless elevator machine. Thus, according to a fourth aspect of this disclosure there is provided a method of assembling a gearless elevator machine, comprising:

selecting a shaft having a first shaft length from a plurality of shafts, wherein at least two shafts of the plurality of shafts have different shaft lengths;
selecting at least one spacer having a first spacer length from a plurality of spacers, wherein at least two spacers of the plurality of spacers have different spacer lengths, the first spacer length corresponding to the first shaft length;
arranging the shaft to be supported by a first bearing of a first bearing stand and a second bearing of a second bearing stand; and
arranging the at least one spacer to extend between the first bearing stand and the second bearing stand so as to removably attach the first bearing stand to the second bearing stand.

[0030] It will be understood that the shaft may be arranged to be supported by the bearing stands before or after (or simultaneously with) arranging the spacer(s) to extend between and removably attach the bearing stands. Similarly the selecting steps need not be carried out in the order in which they are recited.

[0031] According to a fifth aspect of the present disclosure, there is provided a kit for assembling a gearless elevator machine, comprising:

a plurality of shafts, wherein at least two shafts of the plurality of shafts have different shaft lengths;
a plurality of spacers, wherein at least two spacers of the plurality of spacers have different spacer lengths, the spacer lengths corresponding to the shaft lengths;
a first bearing stand and a first bearing, the first bearing stand supporting the first bearing,
a second bearing stand and a second bearing, the second bearing stand supporting the second bearing,
wherein the first bearing and the second bearing are configured to support any selected one (i.e. each) of the plurality of shafts; and
wherein the first bearing stand and the second bearing stand are configured to be removably attachable together by any selected one (i.e. each) of the plurality of spacers.

[0032] It will be appreciated that where a plurality of spacers are assembled to form the gearless elevator

machine each of these spacers will have (substantially) the same length as all of the other spacers. Thus, a plurality of spacers are selected, in which each spacer has the first spacer length.

[0033] The first spacer length corresponds to the first shaft length. By this it will be understood that the lengths are compatible so that both are an appropriate length to fulfil their respective functions when they are used together to form a gearless elevator machine. Thus, there is a corresponding relationship between the spacer length and the shaft length, but the two lengths are not necessarily the same. There may be a one-to-one pairing of corresponding first shaft length and first spacer lengths.

[0034] It will be appreciated that any of the components described above, having any of the described features, may be present in the kit, and likewise that the method may comprise assembling any of the components described above, having any of the described features, into (the described position within) the gearless elevator machine.

[0035] In some examples, the kit further comprises a plurality of motors, wherein at least two motors of the plurality of motors have different motor lengths (i.e. axial lengths). In some examples, the second bearing stand is attachable to any selected one of the plurality of motors. Thus, all of the motors are compatible with the same bearing stand. All of the motors of the plurality of motors may have (substantially) the same outer (or envelope) diameter (i.e. perpendicular to the axial direction).

[0036] Similarly, in some examples, the method further comprises selecting a motor having a first motor length from the plurality of motors. The method may comprise attaching the second bearing stand to the selected motor. This allows a motor having a suitable power output to be selected for a particular gearless elevator machine, thereby selectively driving the shaft at a desired speed. The motor length may refer to the length of the stator of the motor, or the rotor of the motor, or both. Thus, the motors may all have different stator lengths, but the same rotor length, or different rotor lengths and the same stator lengths, or the stator length and motors lengths may both be different for each motor length (e.g. the stator and rotor lengths may correspond in each motor of a given motor length).

[0037] In some examples, the kit further comprises a plurality of belt guards, wherein at least two belt guards of the plurality of belt guards have different belt guard lengths (i.e. axial lengths), each belt guard length corresponding to a spacer length and/or a shaft length. In some examples, the method comprises selecting a belt guard having a first belt guard length from the plurality of belt guards. The method may further comprise arranging the belt guard to extend between the first bearing stand and the second bearing stand. This may be the final stage in assembly of the gearless elevator machine (e.g. possibly after the elevator tension members have been arranged over the sheaves). Thus, where different lengths of spacer and shaft are selected, a belt guard of an

appropriate, corresponding length, may also be chosen to be fitted within the gearless elevator machine.

Detailed description

[0038] Certain preferred examples of this disclosure will now be described, by way of example only, with reference to the accompanying drawings, in which:

Figure 1 shows an exploded view of an elevator machine according to an example of the present disclosure;

Figure 2 shows an external view of the elevator machine of Figure 1, in a fully assembled configuration;

Figure 3a is an end-on view of the brake assembly of the elevator machine of Figure 1;

Figure 3b is a cross-sectional view of the brake assembly of the elevator machine of Figure 1, taken along the line AA of Figure 3a;

Figure 4 is a cross-sectional view showing part of a brake assembly of a prior art elevator machine (left) compared to a part of the brake assembly of the elevator machine of Figure 1 (right);

Figure 5 is an exploded view of the shaft assembly of the elevator machine of Figure 1;

Figure 6 is a perspective view of the shaft assembly of Figure 5, in a fully assembled configuration;

Figure 7 is an end-on cross-sectional view showing the belt guard assembly of the elevator machine of Figure 1, together with one of the bearing stands;

Figure 8 is an exploded view of the motor assembly of the elevator machine of Figure 1, which does not show the rotor;

Figure 9 is a cross-sectional view showing part of a motor assembly of a prior art elevator machine (left) compared to a part of the motor assembly of the elevator machine of Figure 1 (right);

Figure 10 is a cross-sectional view of the elevator machine of Figure 1, in a fully assembled configuration;

Figure 11 is a schematic diagram of an elevator system according to an example of the present disclosure;

Figure 12 is an external perspective view showing examples of three different gearless elevator machines made according to the present disclosure; and

Figure 13 is a flow diagram showing a method according to an example of the present disclosure.

[0039] Figure 1 shows a gearless elevator machine 1 according to the present disclosure. The gearless elevator machine 1 includes a cover 2, a brake assembly 4, a shaft assembly 6, a belt guard assembly 8, a motor assembly 10, and a motor cover 12, which will be described in greater detail below. Spacers 5 extend between the brake assembly 4 and the motor assembly 10.

[0040] These components are also visible in the external view of Figure 2.

[0041] As set out in greater detail below, this gearless elevator machine 1 has an advantageous design which allows various types (e.g. speeds) of machine to be provided based on this single structure, in a modular manner, so that the different machines may be adapted to different requirements. Furthermore, there are features of the design which make it lighter weight and axially smaller, and also which facilitate easier maintenance and replacement of component parts.

[0042] The shaft assembly 6 is selectively rotated by (a rotor within) the motor assembly 10, in order to drive movement of a rope or belt which is in contact with a part of the shaft assembly 6. The brake assembly 4 selectively brakes rotation of the shaft assembly 6 so as to prevent movement of an elevator driven by ropes or belts in contact with the shaft assembly. The operation of each of the components of the gearless elevator machine 1 is described in greater detail below.

[0043] The cover 2 is a cover that covers the brake assembly 4 and prevents foreign objects, such as dust, from getting into the brake assembly 4 and potentially interfering with its functioning. It also protects electrical components located on that side of the gearless elevator machine 1, for example it may protect an encoder or a brake monitoring switch.

[0044] Figures 3a and 3b show the brake assembly 4. Figure 3b shows a cross-section of the brake assembly 4 along the line AA shown in Figure 3a. Certain components positioned behind the fixed plate 24 in the view of Figure 3a are shown with dashed lines for clarity.

[0045] The brake assembly 4 includes a first bearing stand 14, which may be referred to as a brake bearing stand. The first bearing stand 14 includes a recess 16 arranged to accommodate a bearing of the shaft assembly 6, described further below. The first bearing stand 14 also includes a braking coil 18 integrated (i.e. accommodated) within it. In this example, the braking coil 18 is a copper coil. It is advantageous for the brake coil to be accommodated within the first bearing stand since this reduces the overall length (along the axial direction) of the gearless elevator machine 1 and reduces the volume (and therefore weight) of material (e.g. steel) needed to form the first bearing stand 14.

[0046] The brake assembly 14 further includes a moving plate 20, arranged to move axially relative to the gearless elevator machine 1 (i.e. left and right with respect to the view of Figure 3b). The moving plate 20 is magnetic such that its axial movement is controlled by either activating, or deactivating, the braking coil 18, as appropriate depending on the biasing of the moving plate 20 and its polarity. In this example the moving plate 20 is biased towards the left of the view of Figure 3b by springs 21 seen in Figure 3a. These springs 21 are not visible in the cross-section of Figure 3b, since they are located towards the outer circumference of the moving plate 20, not along the axis AA of the cross-section.

[0047] The brake assembly 4 further includes a brake disc 22, which is engaged with (and therefore moves with) a shaft 30 of the shaft assembly 6. The brake assembly 4 also includes a fixed plate 24.

[0048] In order to brake movement of the shaft 30, in this example the brake coil 18 is deenergized. As a result the springs 21 actuate movement of the moving plate 20 to the left (with reference to Figure 3b), towards the fixed plate 24. This brings the brake disc 22 into contact with both the fixed plate 24 and the moving plate 20. Friction from the contact between the fixed plate 24, the moving plate 20 and the brake disc 22 slows, and eventually stops, rotation of the brake disc 22. As the brake disc is connected to the shaft 30, this stopping translates to the shaft 30, and ultimately stops the movement of the elevator car driven by the gearless elevator machine 1. When the elevator needs to move again, the controller sends a signal, and current is sent to the brake coil 18 to pull the moving plate 20 away from the brake disc 22 and the fixed plate 24, allowing rotational movement of the brake disc 22 and shaft 30, and therefore movement of the car.

[0049] Figure 4 is a cross-sectional view showing part of a brake assembly of a prior art elevator machine (left) compared to a part of the brake assembly 4 of the elevator machine of Figure 1 (right), in order to demonstrate an advantage of the brake assembly 4 of the present disclosure.

[0050] In the prior art arrangement, the brake disc 22' has a radius 28'. This only extends as far as a fixing means 20', which is required to attach the brake assembly to the bearing stand.

[0051] In contrast, in the brake assembly 4 of the present disclosure, the brake disc 22 has a radius 28, which is larger than the achievable brake disc radius 28' of prior art arrangements. This larger radius 28 is achieved since the brake assembly 4, in particular the moving plate 22, the fixed plate 24, and the first bearing stand 14, have a square cross-sectional shape, in contrast to the prior art arrangement in which they have a circular shape. As a result, bushings 23 (seen in Figure 3a) that are used to support and guide the moving plate 20 are able to be placed towards the corners of the moving plate 22 and the fixed plate 24, leaving a larger inner diameter available for the brake disc 22. Since the brake disc 22 has a relatively large area compared to brake discs of prior art elevator machines, heat dissipation of the brake disc 22 is improved. Also, since the braking area is increased, the force required to be applied by the springs is decreased, and therefore the size (and thus weight) of the braking coil 18, which must act against these springs, is reduced, reducing the weight of copper required for the gearless elevator machine 1.

[0052] Figure 5 shows an exploded view of the shaft assembly 6. The shaft assembly 6 includes a shaft 30. The shaft 30 includes a first key groove 34, and a second key groove 36 (which is not visible from the perspective shown in Figure 1).

[0053] A motor key 38 is (at least partially) accommodated within the second key groove 36. The motor key 38 engages with a rotor 68, of the motor assembly 10, so that as the rotor 68 rotates this causes rotation of the shaft 30.

[0054] The shaft assembly 6 further comprises a sheave key 40, which is partially accommodated within the first key groove 34, such that it still extends beyond the outer surface of the shaft 30. The sheaves 32a, 32b each include an internal groove 42a, 42b (i.e. on their inner surface), which is shaped and positioned to accommodate the sheave key 40, and thereby engage with it, when they are positioned around the shaft 30. As a result of the engagement of the sheave key 40 with this internal groove 42a, 42b, as the shaft 30 rotates, it drives rotation of the sheaves 32a, 32b. Each of the sheaves 32a, 32b also includes an external groove 44a, 44b. These external grooves 44a, 44b are arranged to accommodate respective belts or ropes (not shown) which are used to hoist and lower an elevator car.

[0055] The sheaves 32a, 32b are independent of the shaft 30, i.e. they are separate, non-integrally formed parts. The sheaves 32a, 32b are mounted onto the shaft 30 by interference fit. Although two sheaves 32a, 32b are shown in the example of Figure 5, it will be appreciated that it is an advantage of the sheaves 32a, 32b being separate from the shaft 30 that any number of sheaves 32a, 32b may be provided on the shaft 30, as desired for a particular gearless elevator machine 1. Shafts 30 of different lengths may be selected, from a range of available shafts all having the same diameter, in order to be able to accommodate the desired number of sheaves 32, 32b for a particular use case. Since each shaft has the same diameter, all will be able to accommodate the same sheaves. Since the spacers 5 are used to attach the brake assembly 4 (i.e. the brake bearing stand 14) and the motor assembly 10 (i.e. the motor bearing stand 56, discussed below) together, rather than both parts being formed integrally, this allows different spacer lengths to be selected to match (i.e. correspond to) the selected length of shaft 30, so that the same bearing stands can be used to accommodate different lengths of shaft 30. It is also advantageous that since the sheaves 32a, 32b are independent of the shaft, the shaft part, which is machined, is of a smaller diameter.

[0056] The shaft 30 and the sheaves 32a, 32b may be made, for example, of cast iron or steel. It will be appreciated that since the parts are independent they may be made of different materials, although they may alternatively be made of the same material.

[0057] The shaft 30 includes a brake engagement portion 46. As can be seen in the view of Figure 5, this part includes radially extending teeth or splines, which are configured to engage with the brake disc 22, in order to ensure that the brake disc 22 and the shaft 30 rotate (or stop rotating) together.

[0058] The shaft assembly 6 also includes two bearings 48a, 48b. A first bearing 48a of the two bearings is accommodated within the recess 16 of the bearing stand

14, described above. A second bearing 48b of the two bearings is accommodated within a second bearing recess 17 of the motor assembly 10 as described further below. In this example, the bearings 48a, 48b are identical to each other. The bearings 48a, 48b are circular, and define an inner circular opening through which the shaft 30 is inserted. It is advantageous that these same bearings 48a, 48b are suitable to support various lengths of shaft 30, which may be selected for the gearless elevator machine 1 as described above.

[0059] The shaft assembly 6 further includes a ring 50. The ring 50 is metallic (e.g. made of steel), so that it has sufficient stiffness to support axial forces coming from the second bearing 48b and from the second sheave 32b. The function of the ring 50 is to guide the axial forces from the second sheave 32b to the bearing inner ring (i.e. the rotational part of the second bearing 32b).

[0060] Figure 6 shows the parts of Figure 5 in an assembled configuration, rather than an exploded view. The sheave key 40, which is located internally in the view of Figure 6, is shown with dashed lines.

[0061] A belt guard assembly 8 is positioned above the shaft assembly 6, as shown in Figure 1 and also in the side view of Figure 7. The first bearing stand 14 is visible in the view of Figure 7, as is one of the sheaves 32a, 32b. It will be appreciated that this view of the belt guard assembly 8 would be much the same viewed in the opposite direction along the same axis, due to its symmetry, but showing a second bearing stand (e.g. motor bearing stand), discussed below, rather than the first bearing stand 14.

[0062] The belt guard assembly 8 includes a belt guard 52. The belt guard 52 is a hollow half-cylinder, as seen in Figure 1, shaped to cover a top half of the shaft 30, without contacting the sheaves 32a, 32b. Two screws 54a, 54b, attach the belt guard 52 to the bearing stand 4. Similarly, at the other axial end (not visible) two more screws similarly attach the belt guard to the other bearing stand.

[0063] Figure 8 is an exploded view showing parts of the motor assembly 10. The motor assembly 10 includes a motor 60, which includes a stator 64 and a rotor 68 (seen in Figure 10). The rotor 68 is connected to the shaft 30, is concentrically positioned within the stator 64 and is driven, by the operation of the stator 64, to rotate, causing rotation of the shaft 30. The rotor is not shown in Figure 8.

[0064] The stator 64 includes stator coils 61, which are wound around stator teeth 63. The stator coils 61 and stator teeth 63 are located within a stator housing 62, which is part of the stator 64.

[0065] The motor assembly 10 includes a second bearing stand 56, referred to as a motor stand. Although not visible in the view of Figure 8, the second bearing stand 56, like the first bearing stand 14, includes a (second) bearing recess 17 to accommodate a bearing that supports the shaft 30, in this case the second bearing 48b. The second bearing recess 17 is seen in Figures 9 and 10 with the second bearing 48b positioned within it. Forming

the bearing recess 17 accurately within the second bearing stand 56, i.e. in a precisely defined position, ensures that the second bearing 48b, the shaft 30 which is supported on the second bearing 48b, and the rotor 68 which is arranged on the shaft 30 (as described below), are all precisely aligned concentrically around the central (axial) axis of the second bearing stand 56, and therefore relative to the internal diameter of the stator 64 (i.e. of the stator coils 61). This precise alignment guarantees a constant rotor/stator airgap (the thin radial gap between rotor 68 and stator 64) and therefore guarantees correct motor performance.

[0066] The second bearing stand 56 also includes a circular stator recess 58, which is arranged to accommodate end turns of the stator coils 61 of the stator 64.

[0067] The stator 64 (in particular the housing 62 of the stator 64), is attached to the second bearing stand 56 by four screws 66a, 66b, 66c, 66d, which are positioned at respective corners of the stator housing 62. By precise alignment of the screw holes (e.g. during machining) and by machining the circular bearing stand recess 17 in a precisely central position relative to the inner diameter of the stator 64, accurate alignment of the stator 64 concentrically around the rotor 68 is achieved, without the requirement for additional locating parts, e.g. a flange.

[0068] This difference is illustrated in Figure 9, in which a part of a prior art motor assembly 10' is shown on the left-hand side and a part of the motor assembly 10 of Figure 8 is shown on the right.

[0069] The prior art motor assembly 10' includes a rotor flange 90', which is used to ensure concentric alignment of the stator 64' around the rotor, by connecting to the bearing stand 56'. By contrast, in the present example, the second bearing recess 17 is precisely positioned centrally in the second bearing stand 56. Once the stator housing 62, and therefore the stator 64, is mounted to the second bearing stand 56 by the four screws 66a, 66b, 66c, 66d, precise machining is performed in the bearing recess 17 in reference to the inner diameter of the stator 64 in order to guarantee concentricity between these two diameters. Since the rotor 68 is mounted to the shaft 30, which itself is supported by the second bearing 48b which is accommodated within the second bearing recess 17, precise placement of this second bearing recess 17 ensures precise central placement of the rotor 68 relative to the stator 64, and therefore provides an air gap between them which is constant.

[0070] All of the parts of the gearless elevator machine 1 can be seen together in the cross-sectional view of Figure 10.

[0071] As seen in Figure 10, the gearless elevator machine 1 further includes an encoder 26, which is positioned within the shaft 30. The encoder 26 rotates with the shaft 30, and monitors this rotation, so as to track the position of a rope or belt in contact with the shaft assembly 6, and therefore of an elevator that is moved by said rope or belt.

[0072] In this cross section the sheave key 40 is visible,

engaged with both of the sheaves 32a, 32b, which it can be seen are press-fit around the shaft 30. The motor key 38 is also visible. This motor key is engaged with the rotor 68, which is positioned concentrically within the stator 64.

[0073] As described above, the stator 64 causes the rotor 68 within it to rotate, by generating a varying magnetic field. As a result of the engagement between the shaft 30 and the rotor 68, provided by the motor key 38, the shaft 30 rotates together with the rotor 68. This causes the sheaves 32a, 32b to rotate.

[0074] Belt recesses 70a, 70b are visible in Figure 10. In use elevator belts (which may, in alternative examples, be ropes) are arranged in these belt recesses 70a, 70b, in the external grooves 44a, 44b of respective sheaves 32a, 32b, and are therefore driven in a certain direction, either upwards or downwards, depending on the direction of rotation of the shaft 30. Alternative sheaves 32a, 32b may be provided where ropes are used in place of belts, for example having deeper, more rounded grooves. These elevator belts suspend an elevator car (not shown) and optionally also an elevator counterweight, so that as the motor 60 drives motion of the belts in the described manner, this causes upwards or downwards motion of the elevator car.

[0075] In this example, four spacers 5a, 5b, 5c, 5d, each extend between respective corners of the bearing stands 14, 56. All four of these spacers 5a, 5b, 5c, 5d are visible in Figure 2, and two of these are visible in the cross-sectional side view of Figure 10. Each spacer 5a, 5b, 5c, 5d includes an outer cylinder, or housing, and a bolt contained within the outer cylinder. This bolt extends between the bearing stands 14, 56 (e.g. from the brake bearing stand 14 side through to the motor bearing stand 56) and removably attaches the bearing stands 14, 56 together by being screwed and unscrewed through respective screw holes in the first bearing stand 14, and engaging with a respective nut portion 57 on the second bearing stand 56, having an inner thread.

[0076] As explained above, different lengths of shaft 30 may be chosen, for different types and sizes of machine, i.e. for different applications. Corresponding lengths of spacer 5 will be selected, so that the bearing stands 14, 56 are separated by an appropriate length to accommodate the selected shaft length.

[0077] It can also be seen in Figure 10 that although the shaft 30 and the spacers 5 are not the same length, they are of corresponding lengths, meaning that their lengths are such that the shaft 30 is able to be accommodated extending through both the first and second bearing stands 14, 56 when the first and second bearing stands 14, 56 are separated by the distance defined by the spacers 5. If the spacers were longer or shorter, i.e. not of a corresponding length with the shaft 30, they would either not cover the required distance between the stands, so there would not be space to accommodate the shaft portion that needs to be accommodated between the bearing stands 14, 56 or they would create too large of a gap, so that the shaft 30 did not extend suffi-

ciently far into either the brake assembly 4 or the motor assembly 10.

[0078] Figure 11 is a schematic diagram of one example of an elevator system 100 including a gearless elevator machine 1 as described above. The elevator system 100 includes an elevator car 102, a counterweight 104 and a tension member 106 extending between the elevator car 102 and the counterweight 104, and suspending them both. The tension member 106 may be located in the belt recesses 70a, 70b shown in Figure 10.

[0079] The tension member 106 is engaged with the gearless elevator machine 1, and in particular passes over the sheaves 32a, 32b (optionally by comprising multiple separate belts each accommodated in a respective sheave). The tension member 106 also passes over a deflection sheave 108. Driving the gearless elevator machine 1 moves the tension member 106, so as to raise and lower the elevator car 102 and correspondingly lower or raise the counterweight 104.

[0080] Figure 12 is an external perspective view showing examples of three different gearless elevator machines 1a, 1b, 1c, made according to the present disclosure, using a number of identical modular parts. All of the gearless elevator machines 1a, 1b, 1c in the illustrated examples are formed using the same bearing stands 14, 56, and covers 2, 12, although this need not necessarily be the case.

[0081] As seen in Figure 12, each of the three gearless elevator machines 101a, 101b, 101c has a different length along the axial direction. Thus, different sets of spacers 105a, 105b, 105c, are used in each gearless elevator machine 101a, 101b, 101c, where each set of spacers 105a, 105b, 105c has a different spacer length. Similarly, different shafts 130a, 130b, 130c, each having different lengths, are used, which may each have a different number of sheaves fit to them. The lengths of spacer used in a given gearless elevator machine and the length of the selected shaft correspond to one another. By this it is meant that the lengths are compatible so that both are an appropriate length to fulfil their respective functions when they are used together to form a gearless elevator machine, not that the lengths are the same.

[0082] To correspond to the different lengths of spacers 105a, 105b, 105c and shafts 130a, 130b, 130c, belt guards 152a, 152b, 152c of different lengths are used in each of the respective gearless elevator machines 101a, 101b, 101c.

[0083] Each different gearless elevator machine 101a, 101b, 101c, also includes a different (axial) length of motor 160a, 160b, 160c. It will be understood that each motor 160a, 160b, 160c has substantially (or exactly) the same diameter in order that they can each be accommodated on an identical bearing stand 56, but that each has a different axial extent (e.g. the rotor 68 and/or the stator 64 extend further along the axial direction for a longer motor). This allows stators having different power levels to be provided. The power of the stator affects the speed at which it is able to drive the motor and therefore

the corresponding shaft.

[0084] Figure 13 is a flow diagram showing a method according to an example of the present disclosure.

[0085] First, at stage 200, a shaft 30 having a first shaft length is selected from a plurality of shafts 130a, 130b, 130c, wherein at least two shafts of the plurality of shafts have different shaft lengths. The shaft 30 may be selected based on the desired width of elevator belt or rope to be accommodated.

[0086] Next, at stage 202, a spacer, or a plurality of spacers 5, having a first spacer length corresponding to the first shaft length (i.e. compatible with the first shaft length) are selected from a plurality of spacers 105a, 105b, 105c, wherein at least two spacers of the plurality of spacers have different spacer lengths. The first bearing 48a and the second bearing 48b are configured to support any selected one of the plurality of shafts (i.e. each of the plurality of shafts). The first bearing stand 14 and the second bearing stand 56 are configured to be removably attachable together by any selected one (i.e. each) of the plurality of spacers.

[0087] At stage 204, a belt guard 52 is selected from a plurality of belt guards 152a, 152b, 152c of different lengths, where the belt guard has a first belt guard length which is compatible with (i.e. corresponds to) the first shaft length and the first spacer length. The first belt guard length may be the same as the first spacer length (since both the spacers and the belt guard extend between the first bearing stand 14 and the second bearing stand 56). Each belt guard 152a, 152b, 152c is compatible with the first and second bearing stands 14, 56.

[0088] Next, at stage 206, a motor 60 is selected from a plurality of motors 160a, 160b, 160c, where at least two motors of the plurality of motors have different motor lengths (i.e. axial lengths). The second bearing stand 56 is attachable to (i.e. compatible with) any selected one (i.e. each) of the plurality of motors 160a, 160b, 160c. The motors 160a, 160b, 160c may have different power output levels (e.g. due to their respective lengths).

[0089] At stage 208, the selected components, and any other required components, are assembled together to form the gearless elevator machine 1. This stage may include arranging the shaft 30 to be supported by the first bearing 48a and the second bearing 48b and arranging the at least one spacer 5 to extend between the first bearing stand 14 and the second bearing stand 56 so as to removably attach the first bearing stand 14 to the second bearing stand 56. This stage may comprise attaching the second bearing stand 56 to the selected motor 68 (e.g. to the stator 64). This stage may comprise arranging the belt guard 52 to extend between the first bearing stand 14 and the second bearing stand 56.

[0090] It will be appreciated by those skilled in the art that the disclosure has been illustrated by describing one or more specific aspects thereof, but is not limited to these aspects; many variations and modifications are possible, within the scope of the accompanying claims.

Claims

1. A gearless elevator machine (1), comprising:

a first bearing stand (14) and a first bearing (48a), the first bearing stand (14) supporting the first bearing (48a),
a second bearing stand (56) and a second bearing (48b), the second bearing stand (56) supporting the second bearing (48b),
a shaft (30), supported by the first bearing (48a) and the second bearing (48a);
a motor (60) arranged to drive the shaft (30) to rotate; and

at least one spacer (5), extending between the first bearing stand (14) and the second bearing stand (56), and removably attaching the first bearing stand (14) to the second bearing stand (56).

2. The gearless elevator machine (1) of claim 1, further comprising a brake coil (18) arranged to engage and disengage a brake (20, 22) to brake rotation of the shaft (30), wherein the brake coil (18) is accommodated within the first bearing stand (14).

3. The gearless elevator machine (1) of claim 1 or 2, wherein the first bearing stand comprises steel.

4. The gearless elevator machine (1) of any preceding claim, wherein the motor (60) comprises a rotor (68) and a stator (64), wherein the stator (64) is arranged to selectively drive rotation of the rotor (68), wherein the rotor (68) is connected to the shaft (30) so that rotation of the rotor drives the shaft (30) to rotate, and wherein the stator (64) is attached to the second bearing stand (56).

5. The gearless elevator machine (1) of any preceding claim, wherein the second bearing stand comprises cast iron or forged steel.

6. The gearless elevator machine (1) of any preceding claim, further comprising a belt guard (52), extending between the first bearing stand (14) and the second bearing stand (56), wherein the belt guard (52) is formed as a single integral piece.

7. The gearless elevator machine (1) of any preceding claim, wherein the shaft comprises a key groove (34), wherein the gearless elevator machine (1) further comprises a sheave key (40) at least partially accommodated within the key groove (34).

8. The gearless elevator machine (1) of any preceding claim, further comprising at least one sheave (32a, 32b) for engaging with an elevator tension member (106), wherein the at least one sheave (32a, 32b) is

arranged around the shaft (30).

9. The gearless elevator machine (1) of claim 8, wherein the at least one sheave (32a, 32b) is interference fit around the shaft (30).

10. The gearless elevator machine (1) of claim 8 or 9, when further dependent on claim 7, wherein each at least one sheave (32a, 32b) comprises an inner groove (42a, 42b), wherein the sheave key (40) is arranged to engage with the inner groove (42a, 42b).

11. An elevator system (100) comprising:

at least one tension member (106);
an elevator car (102), suspended by the tension member (106); and
the gearless elevator machine (1) as claimed in any of claims 8 to 10, wherein the at least one tension member (106) is engaged with the at least one sheave (32a, 32b), such that rotation of the shaft (30) by the motor (60) drives movement of the elevator car (102).

12. A method of assembling a gearless elevator machine (1), comprising:

selecting a shaft (30) having a first shaft length from a plurality of shafts (130a, 130b, 130c), wherein at least two shafts of the plurality of shafts have different shaft lengths;
selecting at least one spacer (5a, 5b, 5c, 5d) having a first spacer length from a plurality of spacers (105a, 105b, 105c), wherein at least two spacers of the plurality of spacers have different spacer lengths, the first spacer length corresponding to the first shaft length;
arranging the shaft (30) to be supported by a first bearing (48a) of a first bearing stand (14) and a second bearing (48b) of a second bearing stand (56); and
arranging the at least one spacer (5a, 5b, 5c, 5d) to extend between the first bearing stand (14) and the second bearing stand (56) so as to removably attach the first bearing stand (14) to the second bearing stand (56).

13. A kit for assembling a gearless elevator machine (1), comprising:

a plurality of shafts (130a, 130b, 130c), wherein at least two shafts of the plurality of shafts have different shaft lengths;
a plurality of spacers (105a, 105b, 105c), wherein at least two spacers of the plurality of spacers have different spacer lengths, the spacer lengths corresponding to the shaft lengths;
a first bearing stand (14) and a first bearing

(48a), the first bearing stand (14) supporting the first bearing (48a),
a second bearing stand (56) and a second bearing (48b), the second bearing stand (56) supporting the second bearing (48b),
wherein the first bearing (48a) and the second bearing (48b) are configured to support any selected one of the plurality of shafts (130a, 130b, 130c); and
wherein the first bearing stand (14) and the second bearing stand (56) are configured to be removably attachable together by any selected one of the plurality of spacers (105a, 105b, 105c).

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14. The kit of claim 13, further comprising a plurality of motors (160a, 160b, 160c), wherein at least two motors of the plurality of motors have different motor lengths; wherein the second bearing stand is attachable to any selected one of the plurality of motors (160a, 160b, 160c).

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15. A gearless elevator machine (1), comprising:

a first bearing stand (14) and a first bearing (48a), the first bearing stand (14) supporting a first bearing (48a),
a shaft (30), supported by the first bearing (48a);
a motor (60) arranged to drive the shaft (30) to rotate; and
a brake coil (18) arranged to engage and disengage a brake (20, 22) to brake rotation of the shaft (30), wherein the brake coil (18) is accommodated within the first bearing stand (14).

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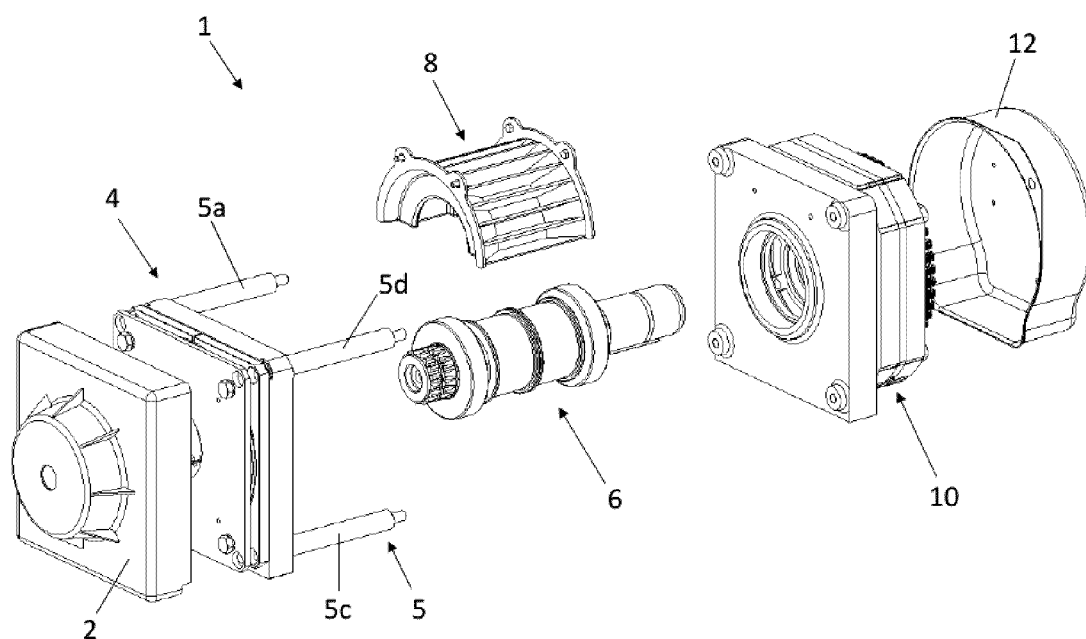


Figure 1

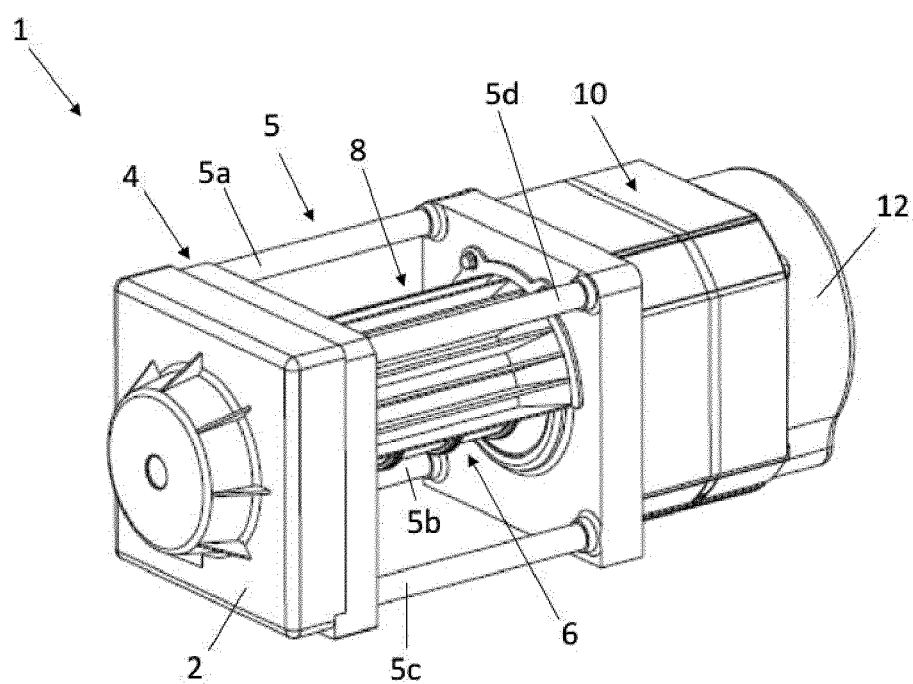


Figure 2

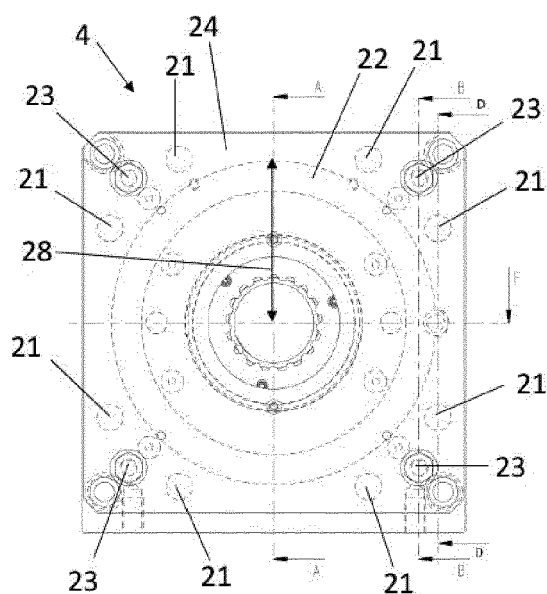


Figure 3a

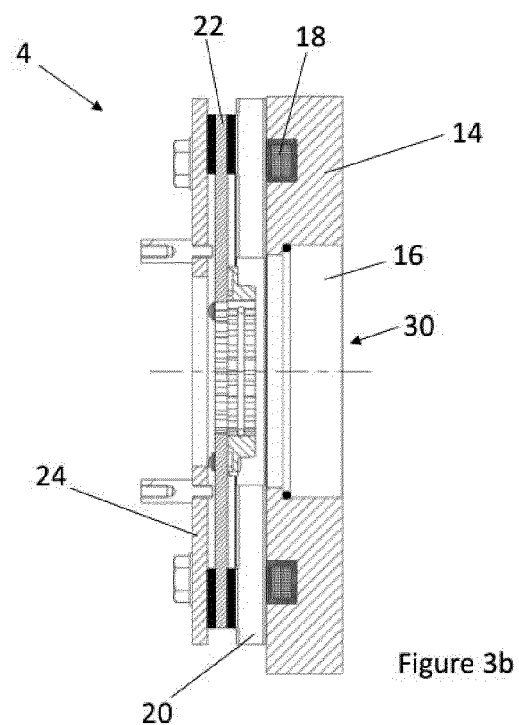


Figure 3b

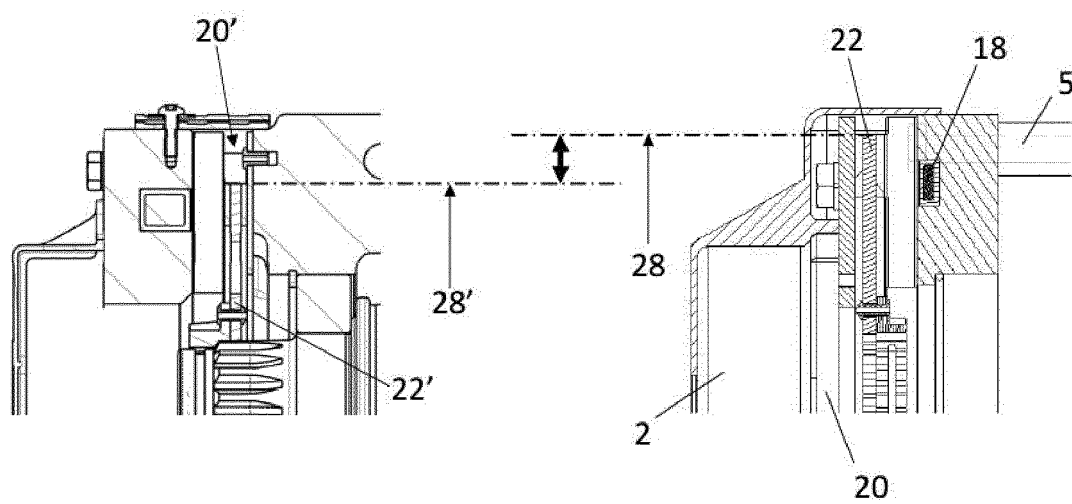


Figure 4

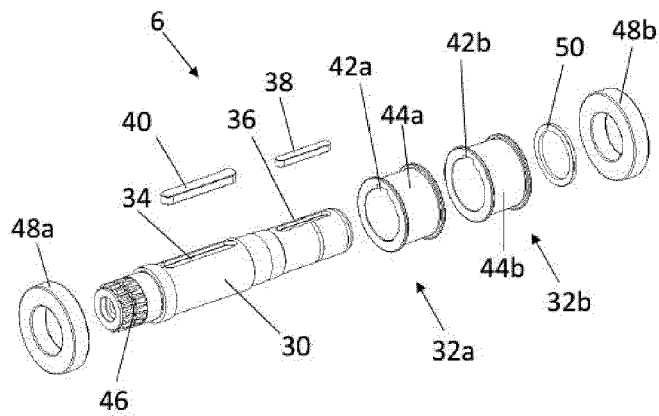


Figure 5

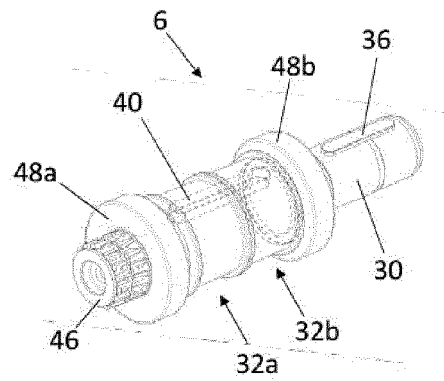


Figure 6

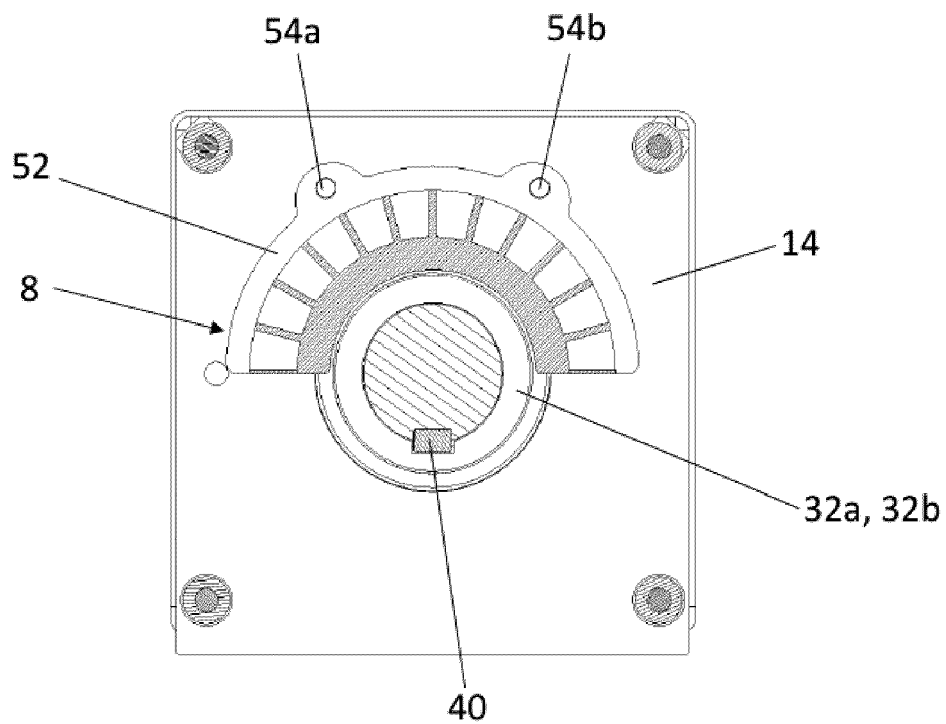


Figure 7

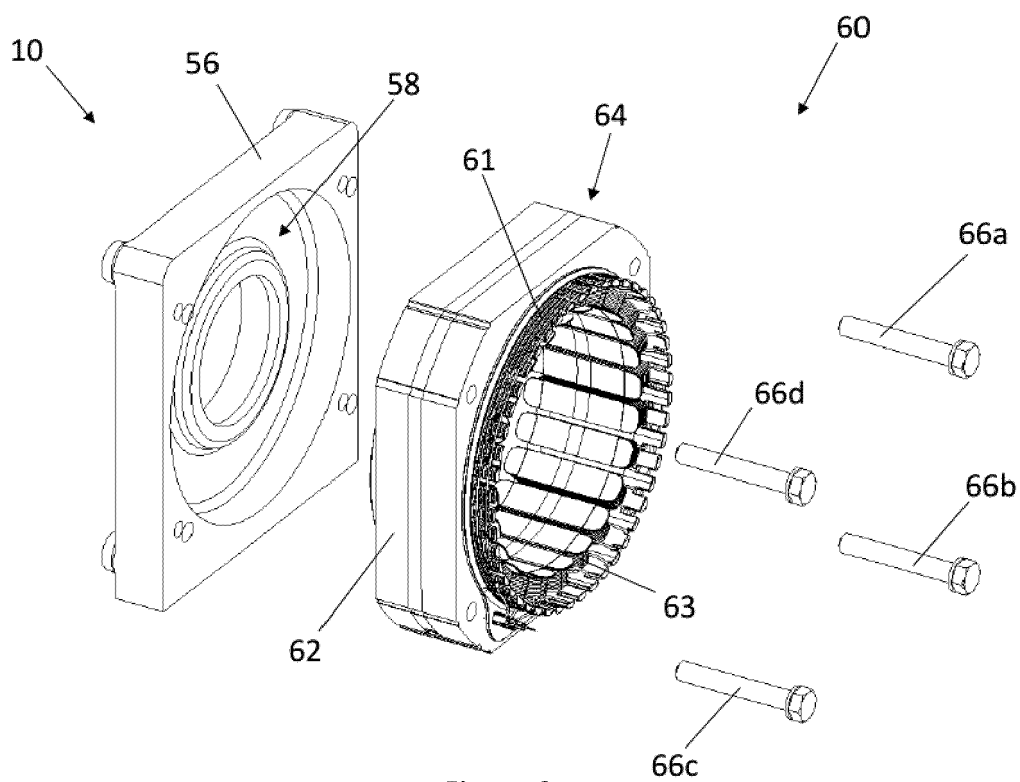


Figure 8

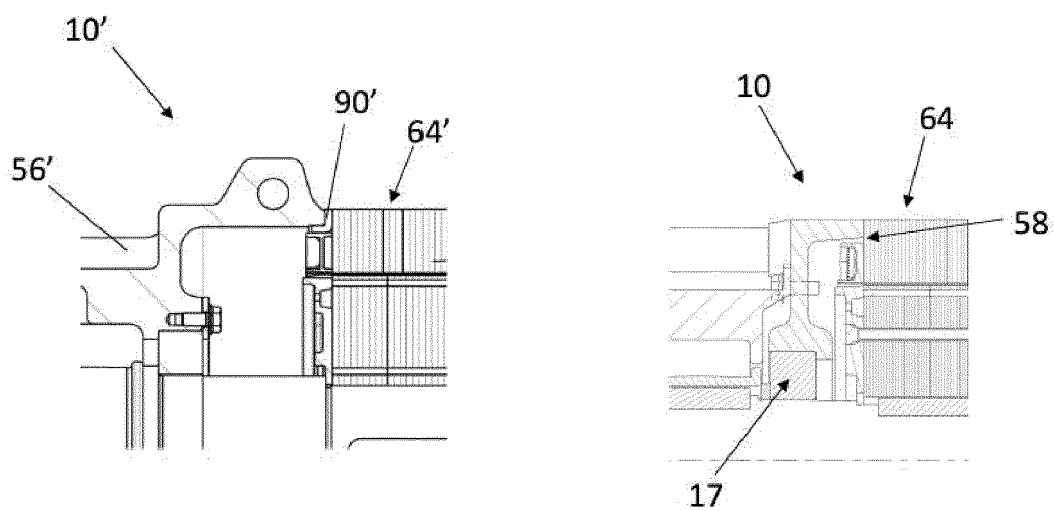


Figure 9

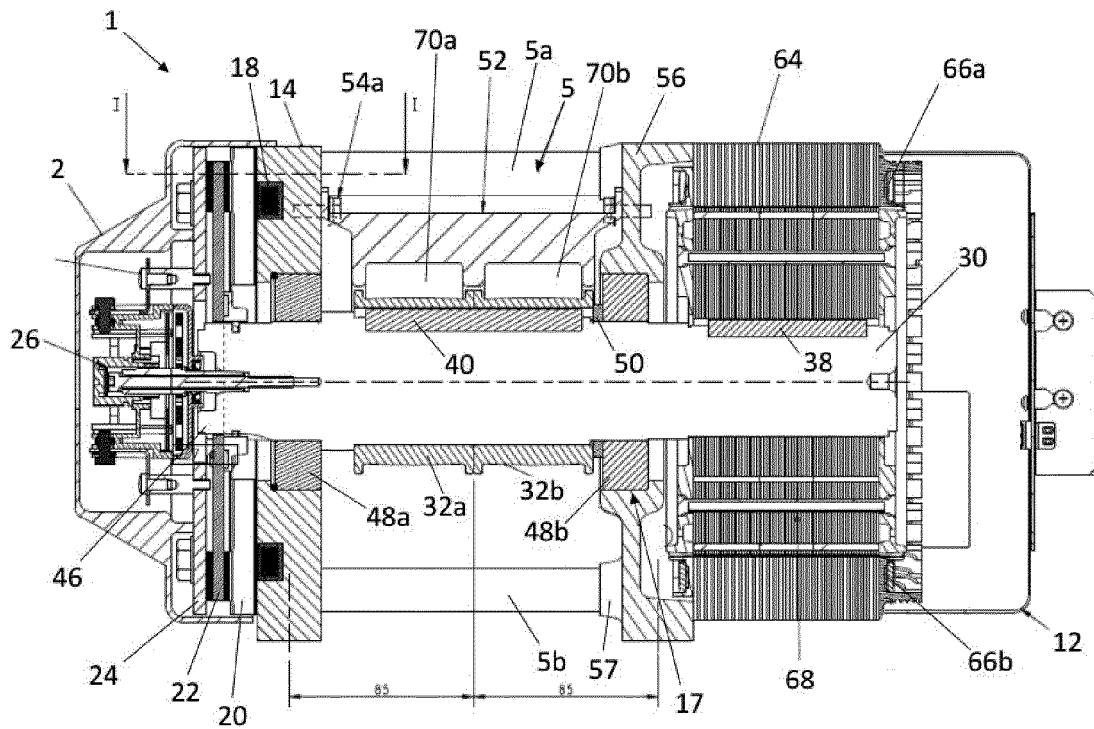


Figure 10

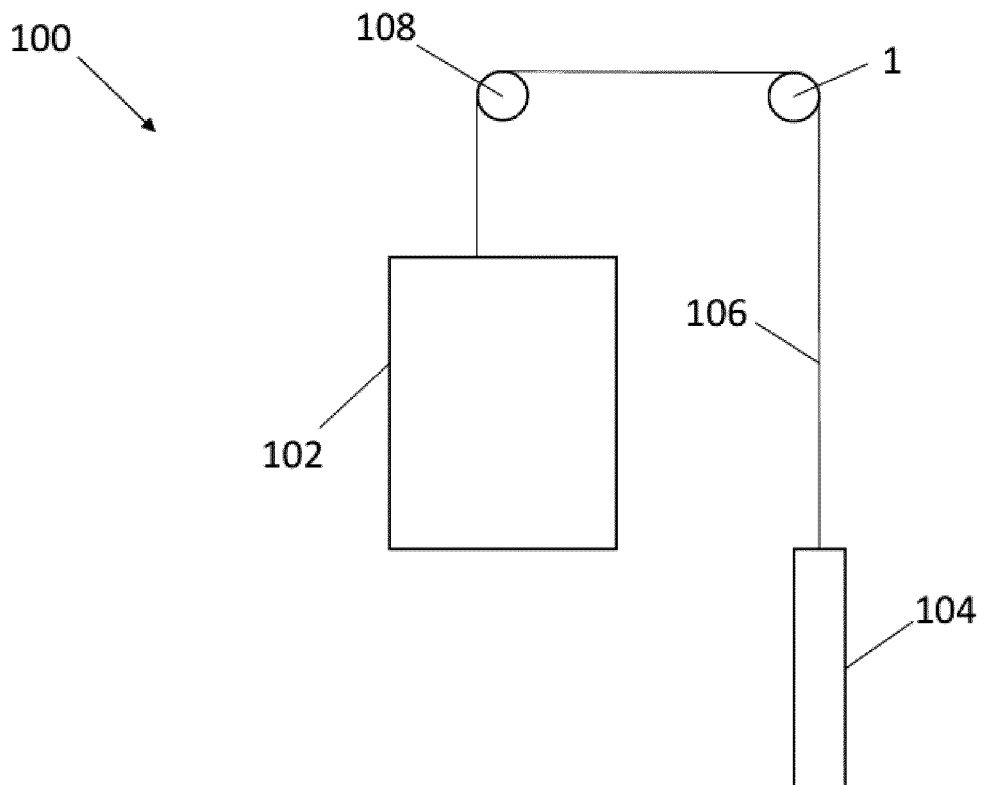


Figure 11

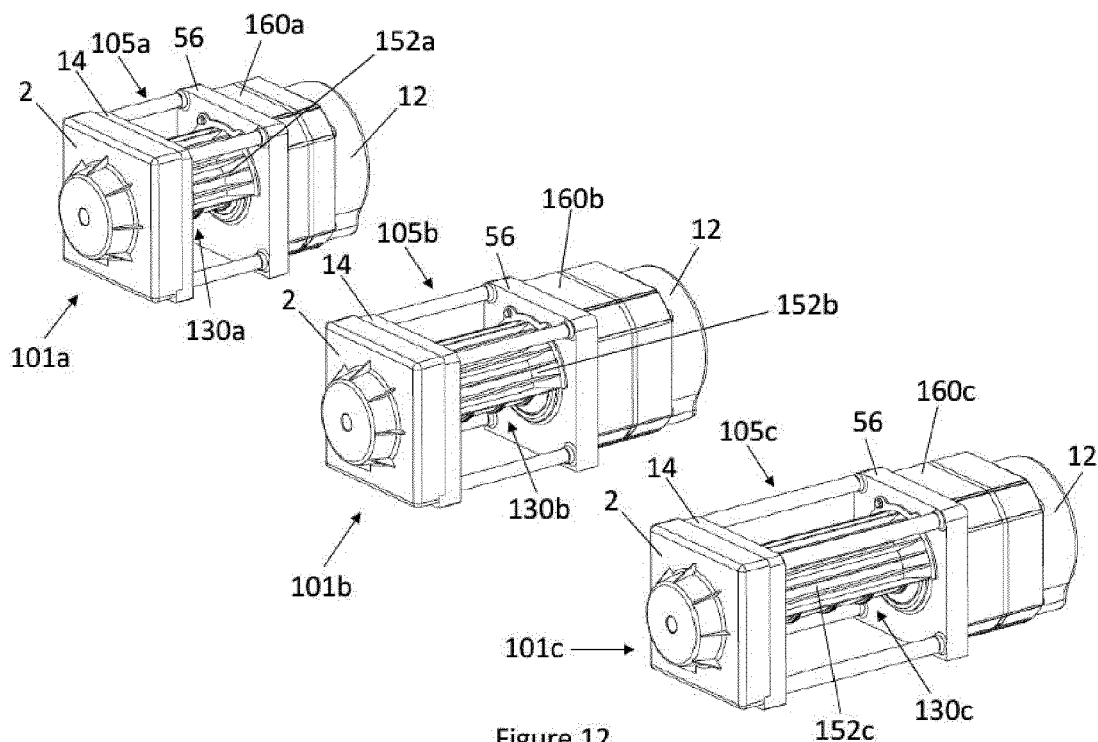


Figure 12

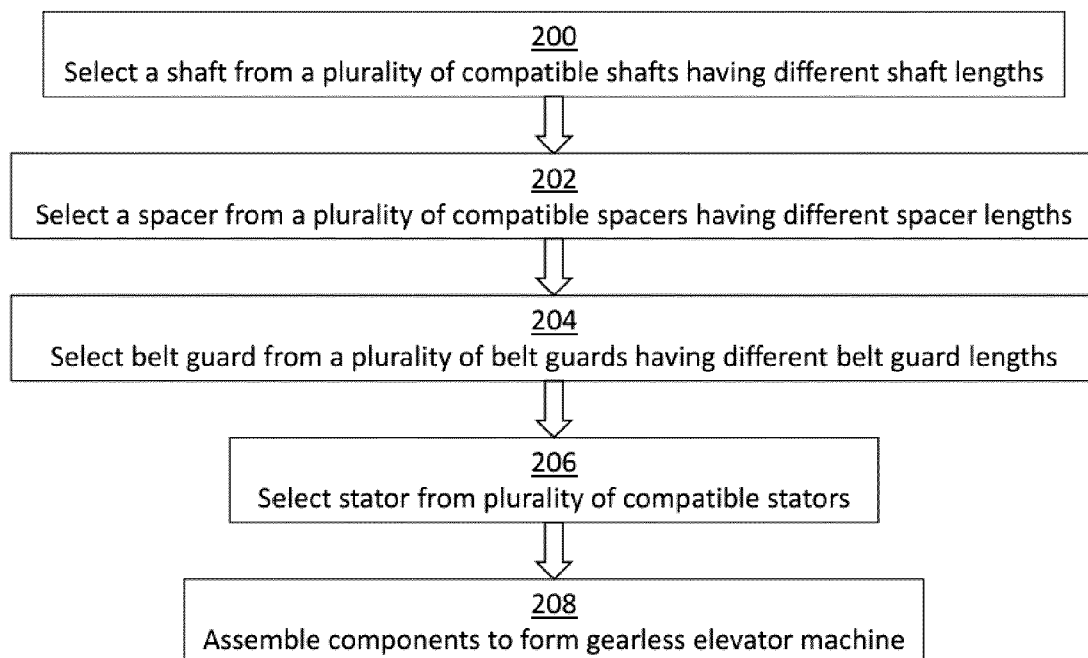


Figure 13



EUROPEAN SEARCH REPORT

Application Number

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			B66B
The present search report has been drawn up for all claims			
Place of search		Date of completion of the search	Examiner
The Hague		5 March 2024	Nelis, Yves
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