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(71) Applicant: **GENERAL ELECTRIC TECHNOLOGY GMBH** [CH/CH]; Brown Boveri Strasse 7, 5400 Baden (CH).

(72) Inventors: **JAAMEI, Said**; Chemin de la Duchesne, 15, 1806 St-Légier (CH). **BAER, Wolfgang, Theodor**; Breitenfeld 45, 79761 Waldshut-Tiengen (DE). **KOENIG, Andre**; Krenkingen 72, 79761 Waldshut-Tiengen (DE).

(74) Agent: **GENERAL ELECTRIC TECHNOLOGY GMBH**; Brown Boveri Strasse 7, 5400 Baden (CH).

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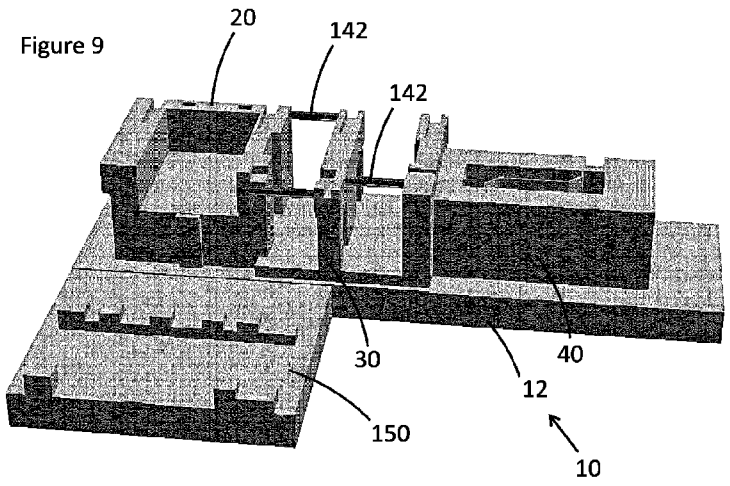
(54) Title: STEAM TURBINE FOUNDATION

Figure 9



(57) Abstract: The invention concerns a steam turbine foundation (10) adapted to support a steam turbine system (100). The steam turbine foundation (10) comprises a base plate (12), a first support (20), a second support (30) and a third support (40). The first support (20), second support (30) and third support (40) are each standalone, are spaced apart from one another and are adapted to support a low pressure steam turbine, a high pressure steam turbine, an intermediate pressure steam turbine and a generator. A method of assembly is also described.

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Steam Turbine Foundation

TECHNICAL FIELD

The present disclosure relates to steam turbine foundations, and particularly to steam turbine foundations with a base plate and three standalone supports.

BACKGROUND OF THE INVENTION

Steam turbines for use in power plants can commonly weigh tens or hundreds of tonnes. These power plants can be constructed in a wide variety of locations, including difficult locations such as on soft or waterlogged ground or in earthquake zones. In addition to this, steam turbines are designed to maximise efficiency, which requires minimisation of efficiency losses such as minimisation of blade clearance. To enable reliable running of such a steam turbine in view of these considerations, the steam turbine needs a very stable base.

As a result, it is not only necessary to consider the challenges of constructing and running the steam turbine itself during steam turbine design and construction, but also to consider how to construct appropriate supporting structures, and in modern steam turbine power plants very considerable expense is involved in providing a suitable support structure.

One part of a successful support structure is a steam turbine foundation. The steam turbine foundation is the base on which much of the steam turbine and its supporting array of pipes is supported. Over the years, standard designs for the steam turbine foundation have been developed by the steam turbine industry. The standard design of steam turbine foundation does, however, have its limitations. The steam turbine foundation is a very complex shape to support the various components and to allow pipe access in appropriate locations, meaning that construction is also complex and lengthy. A complete power plant typically takes months to construct, with steam turbine foundation construction taking a significant chunk of this time. There is a continuing need to reduce this construction time.

SUMMARY OF THE INVENTION

The invention is defined in the appended independent claims to which reference should now be made. Advantageous features of the invention are set forth in the dependent claims.

A first aspect concerns a steam turbine foundation adapted to support a steam turbine system, the steam turbine foundation being a single integral piece and having a length in an x direction, a width in a y direction and a height in a z direction, the steam turbine foundation comprising: a base plate extending in the x direction from a first end to a second end, the base plate having a first face extending from the first end to the second end, and a second face distal from the first face in the z direction, the second face extending from the first end to the second end; a first support extending from the first face of the base plate at the first end of the base plate; a third support extending from the first face of the base plate at the second end of the base plate; and a second support extending from the first face of the base plate between the first support and the third support; in which the first support, second support and third support are each standalone and are spaced apart from one another in the x direction, and wherein the first support is adapted to support a low pressure steam turbine of said steam turbine system, and wherein the steam turbine foundation is arranged to support a high pressure steam turbine between the second support and the third support and to support an intermediate pressure steam turbine between the first support and the second support, and wherein the third support is arranged to support a generator..

The steam turbine foundation can very significantly reduce construction time compared to the prior art described above, perhaps by 30% or 40%, and reductions of 10% or 15% of the overall cost may be possible. Man-hour savings could be in the region of 4000 hours. One of the reasons for these savings is that the table of the prior art is no longer in the way during subsequent installation of the steam turbine system. This can allow more flexibility in the erection schedule, less form working such as bending of bars, and a simpler steam turbine foundation compared to the prior art described above; specifically, it is no longer necessary to construct a complex table as provided in the prior art. The steam turbine foundation can provide the required static and dynamic stiffness for the foundation, and can conform to safety requirements for oil channels. Also, the width of the HP (high pressure) steam turbine and IP (intermediate pressure) steam turbine can be reduced.

Preferably, the width of the first support is larger than the width of the low pressure

steam turbine.

Preferably, the steam turbine foundation is monolithic and is concrete, preferably reinforced concrete.

Preferably, the distance from the first face to the second face of the base plate is greater in a region where the first face is between the first support and the second support and/or in a region where the first face is between the second support and the third support, compared to elsewhere on the base plate.

Preferably, the widths of the first support, the second support and the third support are the same or substantially the same as the width of the base plate in the region (154) of the third support (30). Preferably, the second end of the base plate extends beyond the end of the third support in the x direction. Preferably, the first support, the second support and the third support each extend the same or substantially the same distance from the base plate, so that the top of the first support, the second support and the third support are at the same or substantially the same height. Preferably, the first support, the second support and the third support are each arranged to support bearings for a shaft that extends from the generator to the low pressure steam turbine. Preferably, the base plate comprises a portion (150) adapted to support a condenser

A second aspect concerns a steam turbine power plant comprising the steam turbine foundation described above and a steam turbine system.

A third aspect concerns a method of assembling a steam turbine power plant, comprising the steps of providing a steam turbine foundation as described above , and installing a steam turbine system on the steam turbine foundation.

Preferably, the steam turbine system comprises a piping system and the method comprises installing the piping system as part of the step of installing a steam turbine system, wherein at least part of the piping system is installed as prefabricated pipe racks. Preferably, the steam turbine system comprises a low pressure steam turbine, an intermediate pressure steam turbine, a high pressure steam turbine and a generator, and at least part of the piping system is installed before the low pressure steam turbine, the intermediate pressure steam turbine, the high pressure steam turbine and the generator are installed. This can allow for rapid installation of a piping system by introduction of piping racks. Pipes could be transported to the construction site in prefabricated pipe racks. Modularisation of piping, including steam piping, was not possible in the prior art steam turbine foundations due to space restrictions in and around the steam turbine foundation,

particularly due to the table. Enablement of a high degree of modularisation can significantly reduce construction time. Pipe racks can be installed from the side or the top, whereas before the table was in the way of installing pipe racks and many pipes were within trenches or recesses in the table, or extended through holes in the table, all of which made modularisation impractical.

BRIEF DESCRIPTION OF THE DRAWINGS

An embodiment of the invention will now be described by way of example only and with reference to the accompanying drawings in which:

Figure 1 shows a perspective view of part of a steam turbine foundation with steam turbines attached;

Figures 2 to 6 show various views of the steam turbine foundation of Figure 1.

Figure 7 shows a steam turbine foundation with a generator portion, a steam turbine portion and a condenser portion, along with an attached generator and steam turbines;

Figures 8 to 12 show various views of the steam turbine foundation of Figure 7.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Firstly, an example of the steam turbine foundation will be provided in general terms, showing the steam turbine foundation with (Figure 1) and without (Figures 2 to 6) a steam turbine attached. The steam turbine foundation of Figures 1 to 6 is then shown in Figures 7 to 12 with the foundation extending to support a condenser (not shown) and a generator.

Figure 1 shows a partial view of a steam turbine power plant, comprising a steam turbine foundation 10 with a steam turbine system 100 in place on the steam turbine foundation 10. The steam turbine system 100 comprises an intermediate pressure (IP) steam turbine 110, a low pressure (LP) steam turbine 120 and a high pressure steam turbine 130, all of which are within outer housings. A shaft (not shown) also connects the low pressure steam turbine, the intermediate pressure steam turbine, the high pressure steam turbine and the generator (not shown), and the shaft is supported by the steam turbine

foundation and the three supports. Part of the supporting pipework 140 (piping system) is also shown; the pipework 140 comprises pipes and can include steam pipes and/or oil pipes in particular, some of which may also be supported by the steam turbine foundation 10. Some features of the steam turbine foundation are also labelled, and are described in more detail below with reference to other Figures.

Figure 2 shows a cross-section of the steam turbine foundation 10. The steam turbine foundation 10 comprises a base plate 12 attached to a first support 20, a second support 30 and a third support 40. The combination of the three supports 20, 30, 40 is designed to support the steam turbine system 100, namely the low pressure steam turbine in position 60, the intermediate pressure steam turbine in position 62 and the high pressure steam turbine in position 64. As a result, the gap 63 between the first support 20 and the second support 30 is large enough to fit an intermediate pressure steam turbine and the gap 65 between the second support 30 and the third support 40 is large enough to fit a high pressure steam turbine.

Figures 3 to 6 show different views of the example shown in Figures 1 and 2.

The specific example shown in Figure 2 in particular will now be described in more detail. The base plate 12 is horizontal during use, primarily extending in a horizontal x-y plane. The base plate has a thickness in the z direction. The base plate has a first end 14 and a second end 16. The base plate has a first face 18 and a second face 19. After installation, the first face 18 is the lower face and the second face 19 is the upper face. The first, second and third supports 20, 30, 40 extend from the second face 19.

The first support 20 is arranged and shaped to support a low pressure steam turbine, meaning that it extends in the x, y and z directions. It is substantially cuboid in shape, and includes a recess to fit the low pressure steam turbine. The first support normally extends further in the x direction (which is also the longitudinal direction of the steam turbine foundation) than the low pressure steam turbine it is designed to support.

The second support 30 and the third support 40 are each standalone portions of the steam turbine foundation 10 that extend primarily in the z and y directions, with only a thickness in the x direction, meaning that the second and third supports tend to effectively be walls. The supports are spaced apart, and none of the supports contact each other – in particular, the second support 30 does not contact the third support 40 or the first support 20. The steam turbine foundation 10 is structured so that the intermediate pressure steam turbine can fit between the first support 20 and the second support 30, and so that the high

pressure steam turbine can fit between the second support 30 and the third support 40. The first, second and third supports would generally support bearings for the steam turbine system.

Generally, the first, second and third supports are directly attached to the steam turbine system. That is, there are no other parts of the steam turbine foundation between the first, second and third supports and the steam turbine system. Normally, the first support is adapted to be attached to the low pressure steam turbine, the second support is adapted to be attached to the intermediate pressure steam turbine and the high pressure steam turbine, and the third support is adapted to be attached to the high pressure steam turbine. That is, these components or their support structures (bearings, housing etc.) are directly attached to the steam turbine system. For the steam turbines, particularly the intermediate pressure steam turbine and the high pressure steam turbine which are in gaps 63, 65 between the supports 20, 30, 40, the stator portion would be supported directly on the supports and the rotor portion would be supported via the bearings.

The base plate 12 may be thicker (in the z direction) in a region 11 between the first and second supports 20, 30 and between the second and third supports 30, 40. That is, the distance from the first face 18 to the second face 19 of the base plate 12 is greater in a region where the first face 18 is between the first support 20 and the second support 30 and/or in a region where the first face 18 is between the second support 30 and the third support 40, compared to elsewhere on the base plate 12. This can provided added stiffness for this portion of the base plate.

Figure 7 shows a full steam turbine foundation 10 with portions 150, 154 for supporting the condenser (not shown) and the generator 132 in addition to the portion 152 for supporting the steam turbines 110, 120, 130. The portion 150 for supporting the condenser is preferable but not essential. The third support 40 is made up of two parts, namely a steam turbine part 42 (as shown in Figures 1 to 6) and a generator part 44. The generator part 44 supports the generator 132. Figures 8 to 12 show various views of the steam turbine foundation in Figure 7.

When constructing a steam turbine foundation as described above, the steam turbine foundation is typically constructed as a single integral part and is typically constructed in-situ. The steam turbine foundation comprises at least the turbine portion 152 and the generator portion 154. Ground preparation work may take place before

construction of the steam turbine foundation.

Following construction of the steam turbine foundation, the steam turbine system can be installed on the steam turbine foundation. The steam turbine system normally comprises various components, including turbines, a shaft, a generator, housings for the turbines and the generator, bearings for the shaft and so on. The steam turbine system also comprises a piping system (including pipes 140, for example) for piping various fluids, including steam and oil, around the steam turbine system.

Many of the parts of the steam turbine system are partly or completely supported on the steam turbine foundation. For example, the bearings can be attached on the supports at their ends distal to the base plate. After the steam turbine foundation has been provided, the parts can be attached to steam turbine foundation. These parts are generally removably attached to the steam turbine foundation and/or to one another, allowing for partial or complete dismantling of the steam turbine system during maintenance.

Adding the piping system is a significant part of construction. Examples of parts of the piping system include pipes supplying steam from the high pressure steam turbine to the intermediate pressure steam turbine, or pipes supplying steam from a boiler to the high pressure steam turbine. The piping system may also include oil pipes.

The piping systems can be installed before, during and/or after installation of the other parts of the steam turbine system, such as the low pressure steam turbine, the intermediate pressure turbine, the high pressure steam turbine and the generator. Rather than individually installing pipes, some or all of the piping system may be prefabricated in prefabricated units such as prefabricated pipe racks, with these prefabricated units then installed on the steam turbine foundation. The prefabricated pipe racks may contain a supporting structure to hold the pipes. The prefabricated pipe racks could also include other features beyond pipes, for example oil pipe trenches. Oil trenches for oil pipes can alternatively be prefabricated and installed on the steam turbine foundation separately, for example as side wards of a steam turbine foundation. The oil trenches can contain lubrication oil and power oil piping, to help contain the oil in case of any failure and to help avoid spillages of oil on to hot steam pipes and steam turbine casings.

Various support structures (made of steel, for example) can be attached to the steam turbine foundation, for example to help support and/or attach the pipes, valves and/or access means such as access walkways. Examples of support structures include pedestals for the thrust bearing and the HP and IP turbine casings. In some embodiments, for

example for use in areas where high earthquake risk means particularly stringent earthquake proofing requirements, further bracing or reinforcement parts could also be added after the pipes have been installed. Such bracing or reinforcement parts could be made of concrete or steel, for example.

The general shape of the steam turbine foundation 10 is as described above and shown in the Figures. However, the shape of the various parts of the steam turbine foundation may vary; for example, the portion of the first support adjacent to the base plate may be wider than the portion of the first support furthest from the base plate. Various recesses, holes, grooves and other features may also be provided in one or more of the supports. Various possible features are shown in the Figures, such as holes through the second support (see Figure 1, for example) and recesses in the end of the second and third supports at the ends furthest from the base plate (also see Figure 1, for example). Many of these features are for pipes or to accommodate the shape of other parts of the steam turbine system 100. Besides the exemplary features shown in the Figures, other features are possible depending on the precise arrangement of the steam turbine system and the steam turbine foundation.

The steam turbine foundation is typically constructed as a single integral piece. The steam turbine foundation may be made of concrete (preferably reinforced concrete), would typically be monolithic (one piece). The steam turbine foundation is typically constructed in-situ and arranged with the first face of the base plate on the ground and horizontal (extending in an x-y plane as shown in the Figures). The second face is opposite the first face and faces towards the steam turbine system. Normally, the first, second and third supports are standalone (free standing), as described above. That is, the first, second and third supports are not directly connected to each other apart from by the base plate, and the end of the first, second and third supports furthest from the base plate are not connected to one another. This is in direct contrast to the prior art, where it has always been considered essential to provide a very substantial table structure joining the supports. Various features of the steam turbine system (such as the shaft) will extend across the end of the first, second and third supports furthest from the base plate, including the pipe supports 142 shown in Figures 7 to 12, but such features are not part of the steam turbine foundation.

Several specific features of the steam turbine foundation can be seen in the Figures, and will now be described in more detail. The portion of the base plate 12 of the steam turbine foundation 10 on which the steam turbines 110, 120, 130 and the generator 132 are

supported typically extends in the x and y directions to form a rectangular or substantially rectangular shape, as can be seen in the Figures. Similarly, the portion 150 of the steam turbine foundation on which the condenser is supported typically extends in the x and y directions to form a rectangular or substantially rectangular shape. The complete base plate therefore typically forms an L shape when the condenser portion is included. The condenser portion is preferably the same thickness in the z direction as the steam turbine and generator portions 152, 154.

The steam turbine system 100 normally comprises low, intermediate and high pressure steam turbines 120, 110, 130 and a generator 132. The steam turbine system extends in the y direction from one end of the generator to the low pressure steam turbine. The base plate 12 normally extends beyond the end of the steam turbine system at one or both ends in the x direction and generally also beyond the end of the first support 20 and the third support 40, although ancillary parts such as pipework may extend beyond the base plate. That is, the first end 14 of the base plate extends beyond the end of the first support, and the second end 16 of the base plate extends beyond the end of the third support.

The first, second and third supports 20, 30, 40 generally extend in the y direction from one side of the base plate to the other, but do not extend across the condenser portion 150. Specifically, the first, second and third supports extend in the y direction across or substantially across the portion 152, 154 of the base plate of the steam turbine foundation on which the steam turbines and the generator are supported. The first, second and third supports 20, 30, 40 generally extend the same or substantially the same distance from the base plate 12, so that the top of the first support, second support and third support are at the same or substantially the same height (i.e. the steam turbine system can be arranged horizontally on the supports, with the shaft horizontal).

The footprint of some of the supports is normally greater than the footprint of the parts they support. For example, the first support 20 will normally extend further in both the x and y directions than the low pressure steam turbine 120. The third support 40 (and also the generator part 44 of the third support) will normally extend further in both the x and y directions than the generator 132.

The third support 40 comprises a steam turbine part 42 and a generator part 44. The steam turbine part 42 generally extends further from the base plate 12 in the z direction than the generator part 44. The steam turbine part 42 is generally wider in the y direction than the generator part 44.

Most or all of the base plate 12 may be a uniform thickness. Normally the top of the first, second and third supports 20, 30, 40 are at the same or substantially the same distance from the base plate (from the second face of the base plate). The steam turbine foundation may be adapted to support a near-floor steam turbine; that is, the shaft is elevated around 4 to 8 metres (preferably 5 to 7 metres, most preferably 6 metres) off the floor. Depending on the elevation of the shaft, the foundation may be placed in an excavation on the floor or on the floor without an excavation.

Various modifications to the embodiments described are possible and will occur to those skilled in the art without departing from the invention which is defined by the following claims.

REFERENCE NUMERALS

10	steam turbine foundation	65	gap
11	thicker region of the base plate	100	steam turbine system
12	base plate	110	intermediate pressure steam turbine
14	first end of the base plate	120	low pressure steam turbine
16	second end of the base plate	130	high pressure steam turbine
18	first face	132	generator
19	second face	134	bearings
20	first support	140	pipework
30	second support	142	pipe support
40	third support	150	condenser portion of the base plate
42	steam turbine part of the third support	152	turbine portion of the base plate
44	generator part of the third support	154	generator portion of the base plate
60	low pressure turbine position		
62	intermediate pressure turbine position		
63	gap		
64	high pressure turbine position		

HP = high pressure

IP = intermediate pressure

LP = low pressure

CLAIMS

1. A steam turbine foundation (10) adapted to support a steam turbine system (100), the steam turbine foundation (10) being a single integral piece and having a length in an x direction, a width in a y direction and a height in a z direction, the steam turbine foundation (10) comprising:

a base plate (12) extending in the x direction from a first end (14) to a second end (16), the base plate (12) having a first face (18) extending from the first end (14) to the second end (16) and a second face (19) distal from the first face (18) in the z direction, the second face (19) extending from the first end (14) to the second end (16);

a first support (20) extending from the first face (18) of the base plate (12) at the first end (14) of the base plate (12);

a third support (40) extending from the first face (18) of the base plate (12) at the second end (16) of the base plate (12); and

a second support (30) extending from the first face (18) of the base plate (12) between the first support (20) and the third support (40);

in which the first support (20), the second support (30) and the third support (30) are each standalone and are spaced apart from one another in the x direction, and

wherein the first support (20) is adapted to support a low pressure steam turbine (120) of said steam turbine system (100), and

wherein the steam turbine foundation (10) is arranged to support a high pressure steam turbine (130) between the second support (30) and the third support (40) and to support an intermediate pressure steam turbine (110) between the first support (20) and the second support (30), and

wherein the third support (40) is arranged to support a generator (132).

2. The steam turbine foundation (10) of claim 1, wherein the width of the first support (20) is larger than the width of the low pressure steam turbine (120).

3. The steam turbine foundation (10) of claim 1 or 2, wherein the steam turbine foundation (10) is monolithic and is concrete.

4. The steam turbine foundation (10) of any of claims 1 to 3, wherein the distance from the first face (18) to the second face (19) of the base plate (12) is greater in a region where the first face (18) is between the first support (20) and the second support (30) and/or in a region where the first face (18) is between the second support (30) and the third support (40), compared to elsewhere on the base plate (12).

5. The steam turbine foundation (10) of any of claims 1 to 4, wherein the widths of the first support (20), the second support (30) and the third support (40) are the same or substantially the same as the width of the base plate (12) in the region (154) of the third support (30).

6. The steam turbine foundation (10) of any of claims 1 to 5, wherein the second end (16) of the base plate (12) extends beyond the end of the third support (40) in the x direction.

7. The steam turbine foundation (10) of any of claims 1 to 6, wherein the first support (20), the second support (30) and the third support (40) each extend the same or substantially the same distance from the base plate (12), so that the top of the first support (20), the second support (30) and the third support (40) are at the same or substantially the same height.

8. The steam turbine foundation (10) of any of claims 1 to 7, wherein the first support (20), the second support (30) and the third support (40) are each arranged to support bearings (134) for a shaft that extends from the generator (132) to the low pressure steam turbine (120).

9. The steam turbine foundation (10) of any of claims 1 to 8, wherein the base plate comprises a portion (150) adapted to support a condenser.

10. A steam turbine power plant comprising the steam turbine foundation (10) of claim 1 and a steam turbine system (100).

11. A method of assembling a steam turbine power plant, comprising the steps of providing a steam turbine foundation (10) according to claim 1, and installing a steam turbine system (100) on the steam turbine foundation (10).

12. The method of claim 11, wherein the steam turbine system (100) comprises a piping system (140), the method comprising installing the piping system (140) as part of the step of installing a steam turbine system (100), wherein at least part of the piping system (140) is installed as prefabricated pipe racks

13. The method of claim 12, wherein the steam turbine system (100) comprises a low pressure steam turbine (120), an intermediate pressure steam turbine (110), a high pressure steam turbine (130) and a generator (132), and wherein at least part of the piping system (140) is installed before the low pressure steam turbine (120), the intermediate pressure steam turbine (110), the high pressure steam turbine (130) and the generator (132) are installed.

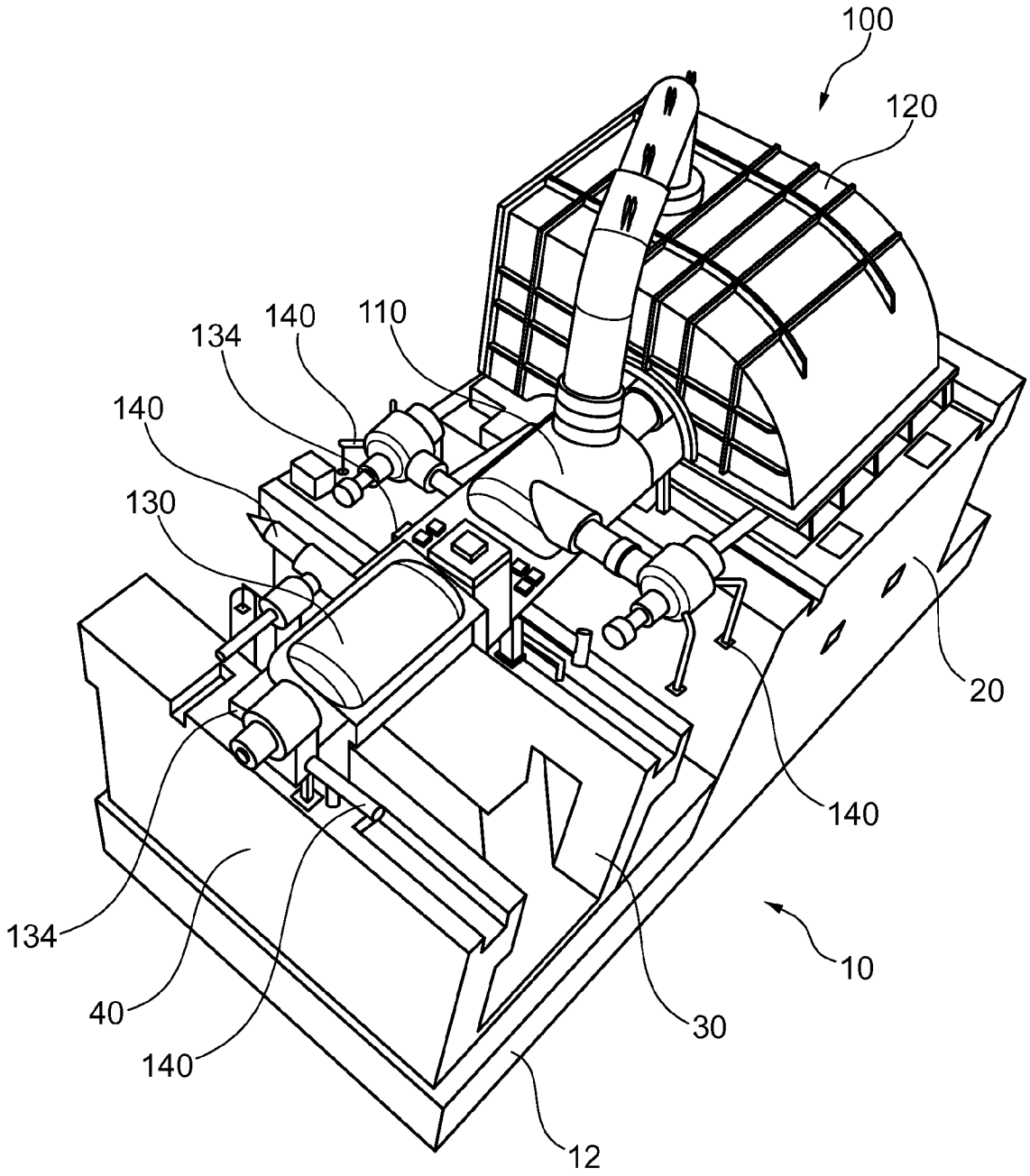


Fig. 1

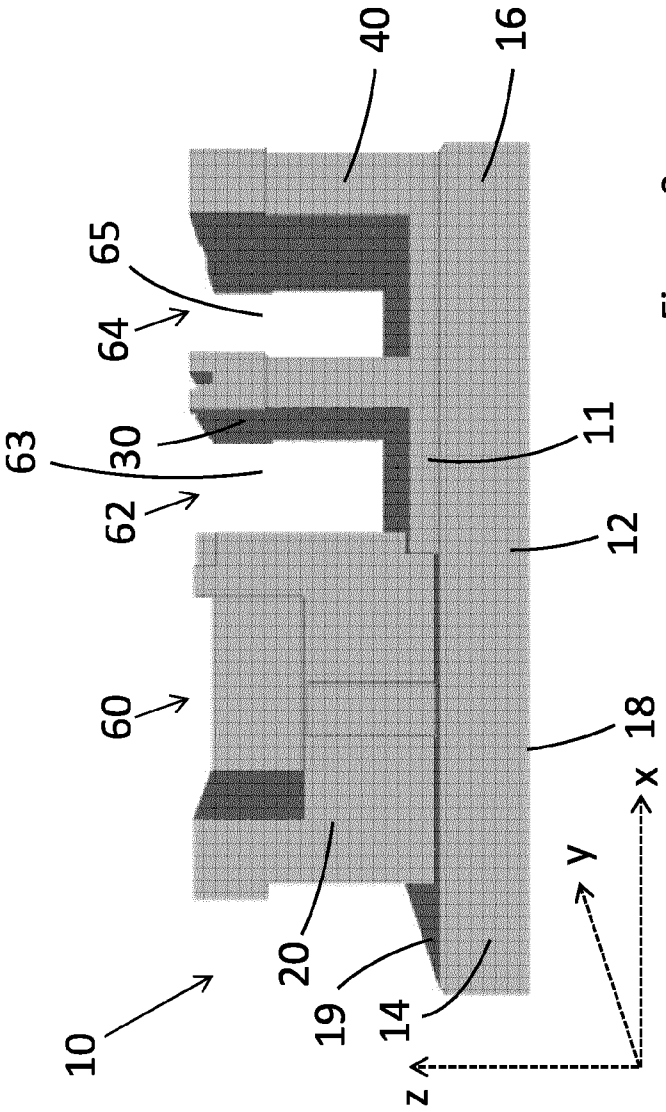


Figure 2

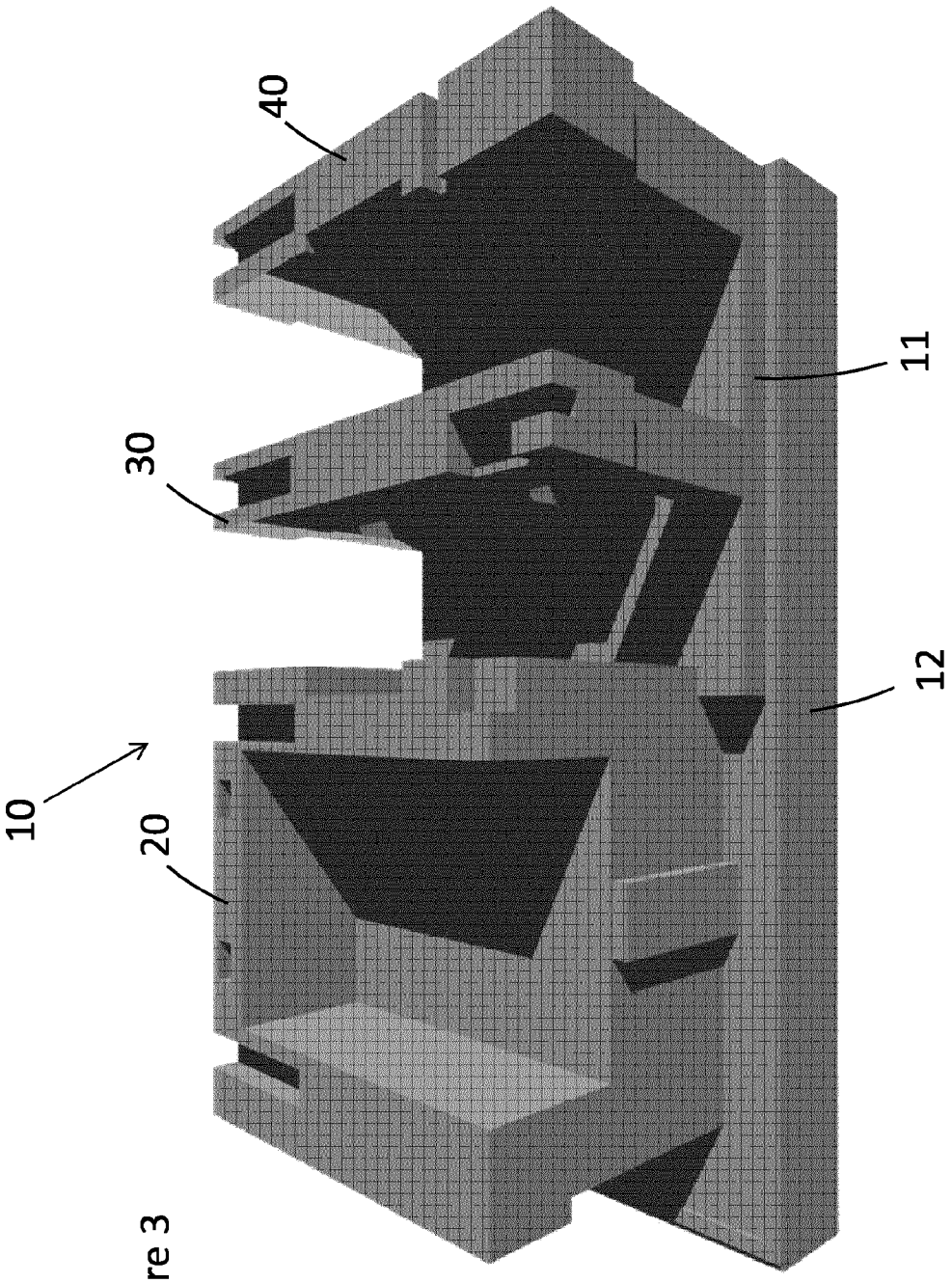


Figure 3

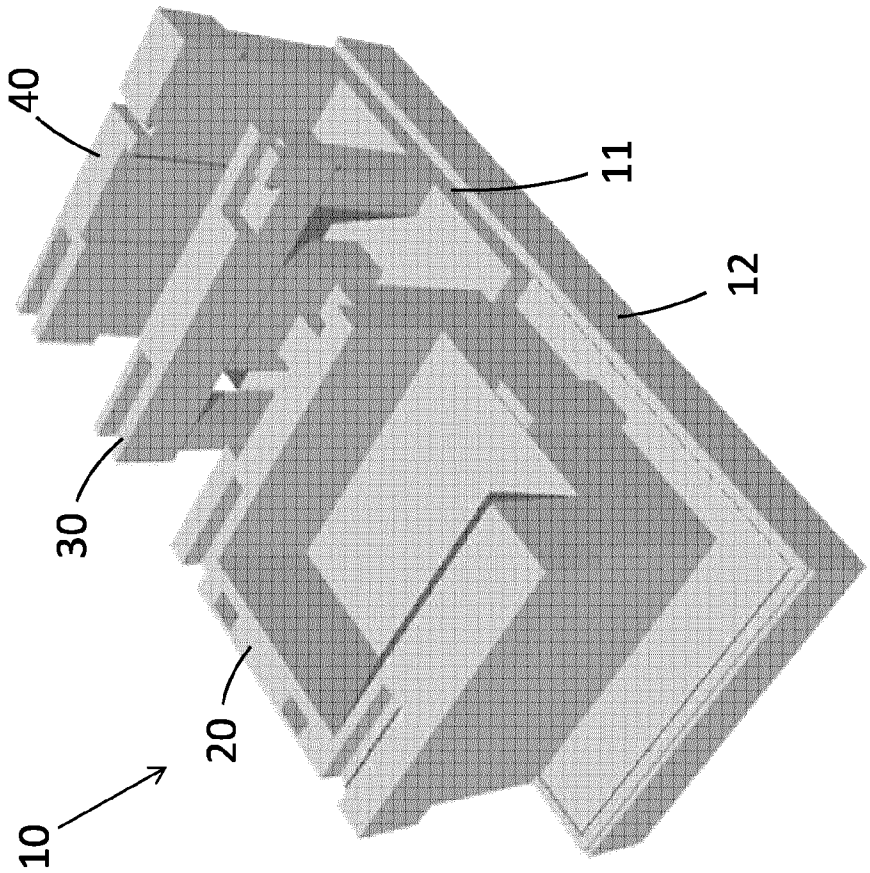


Figure 4

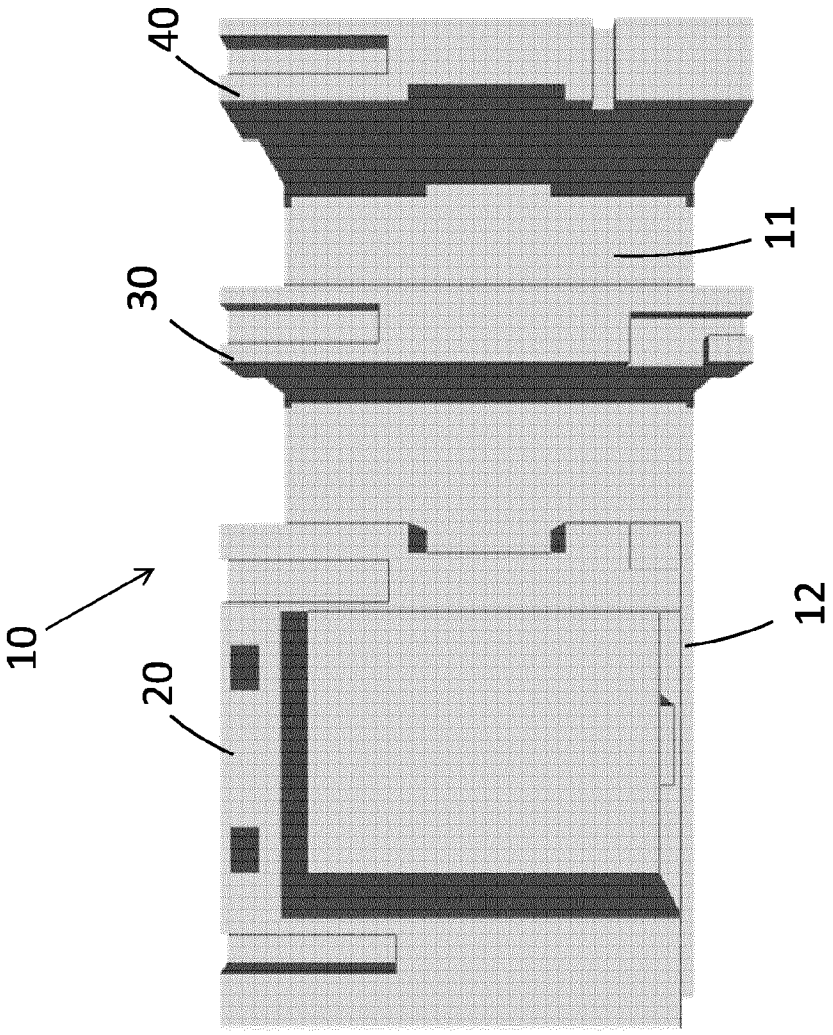


Figure 5

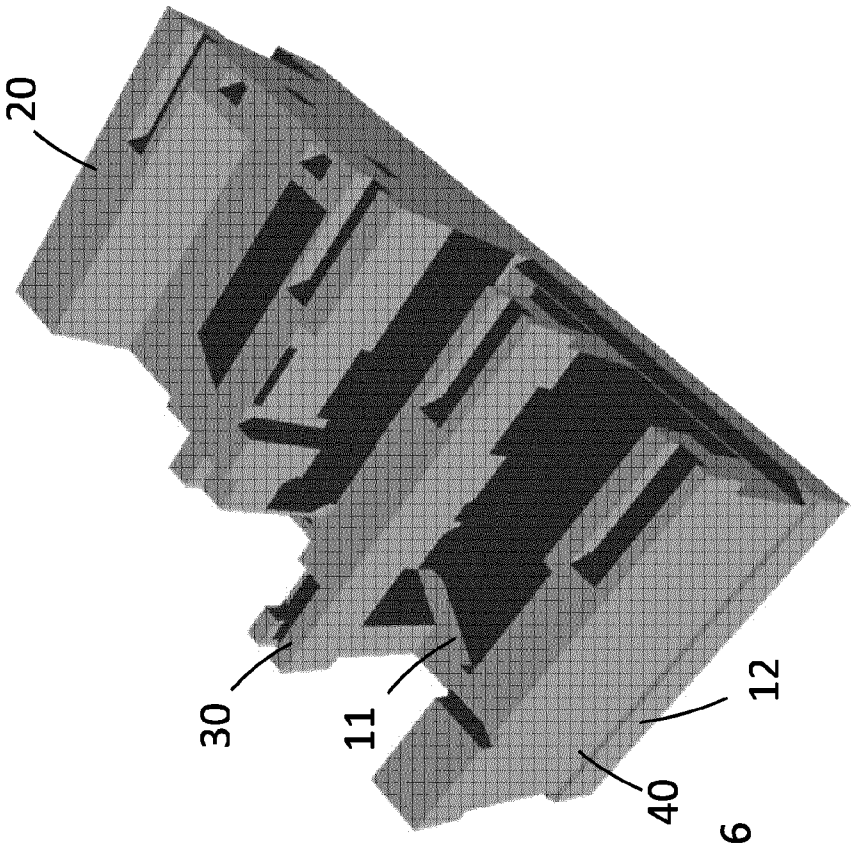
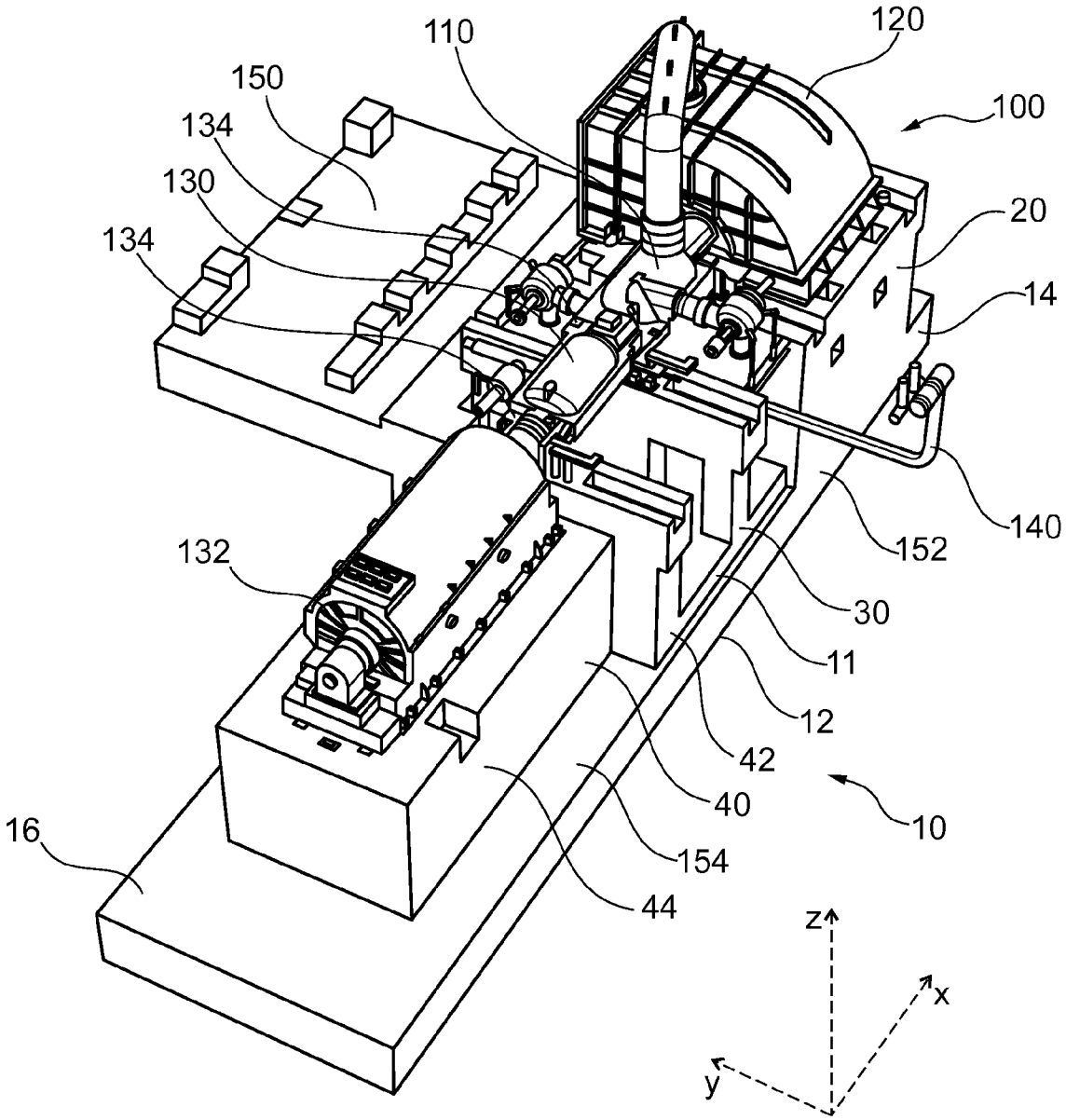


Figure 6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154
44
z
x
y

Fig. 7

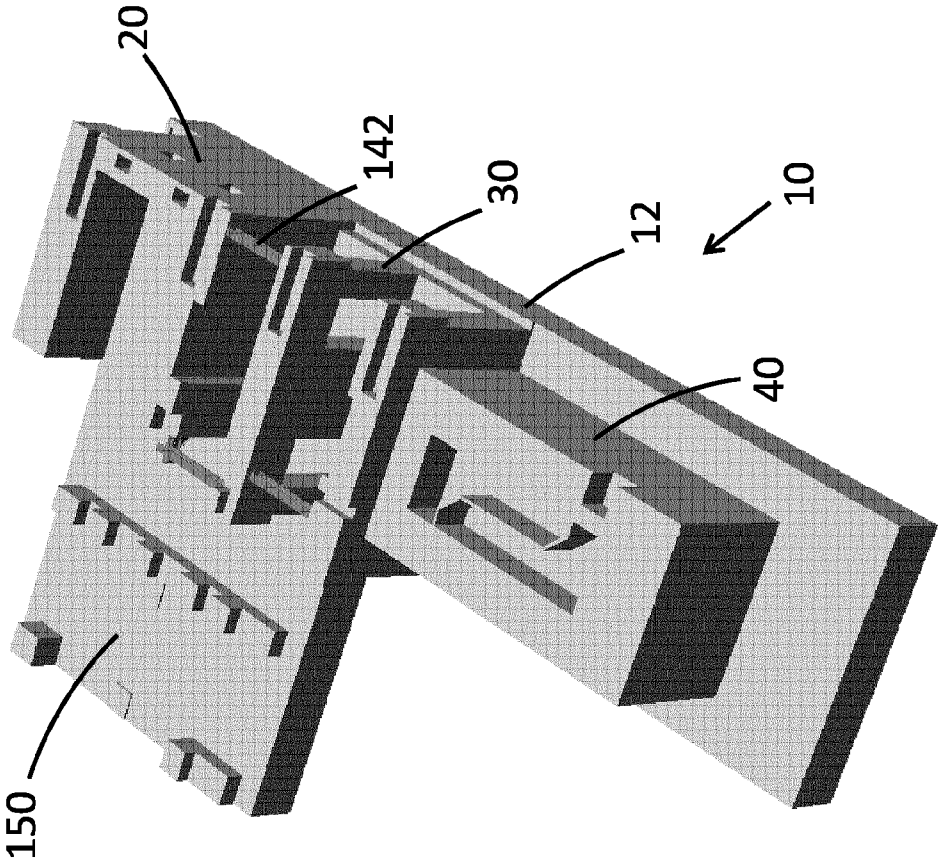

Figure 8

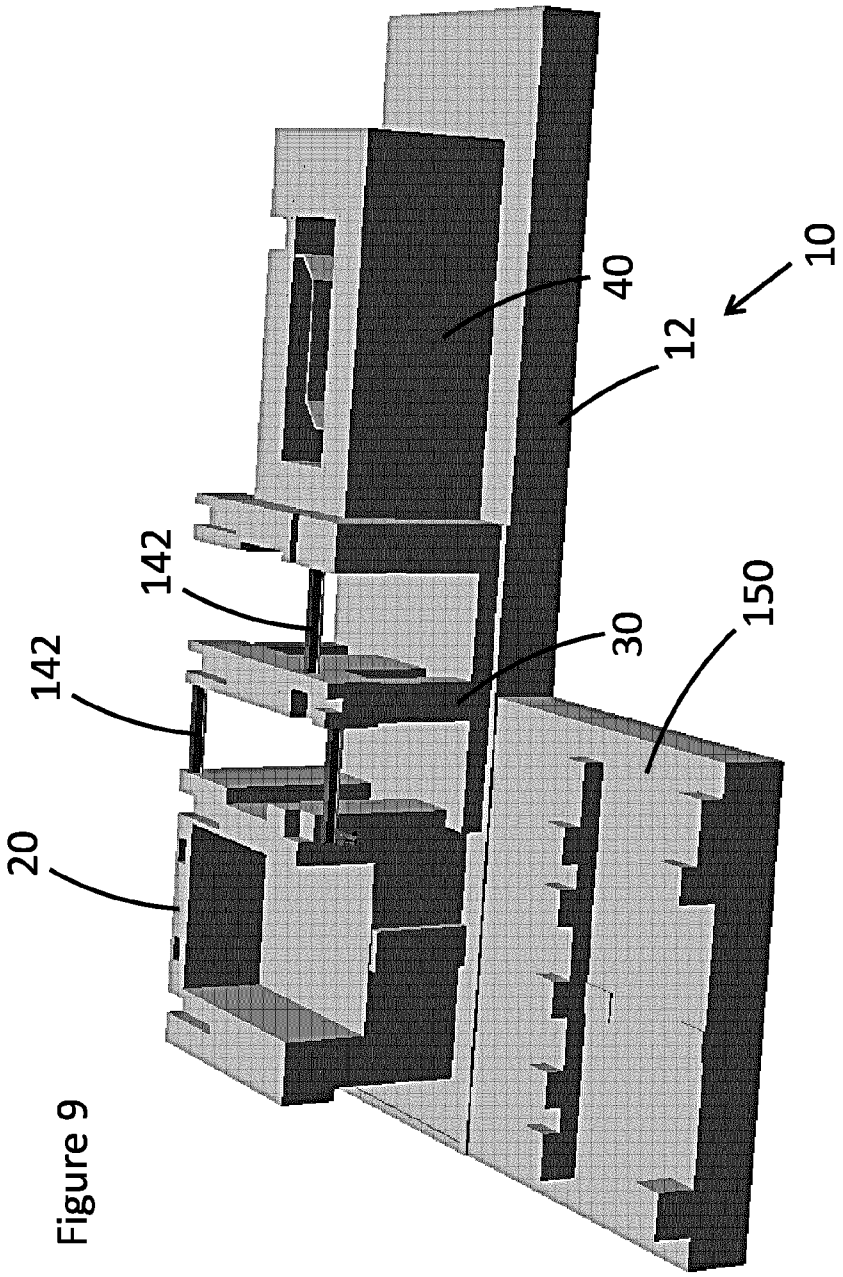

Figure 9

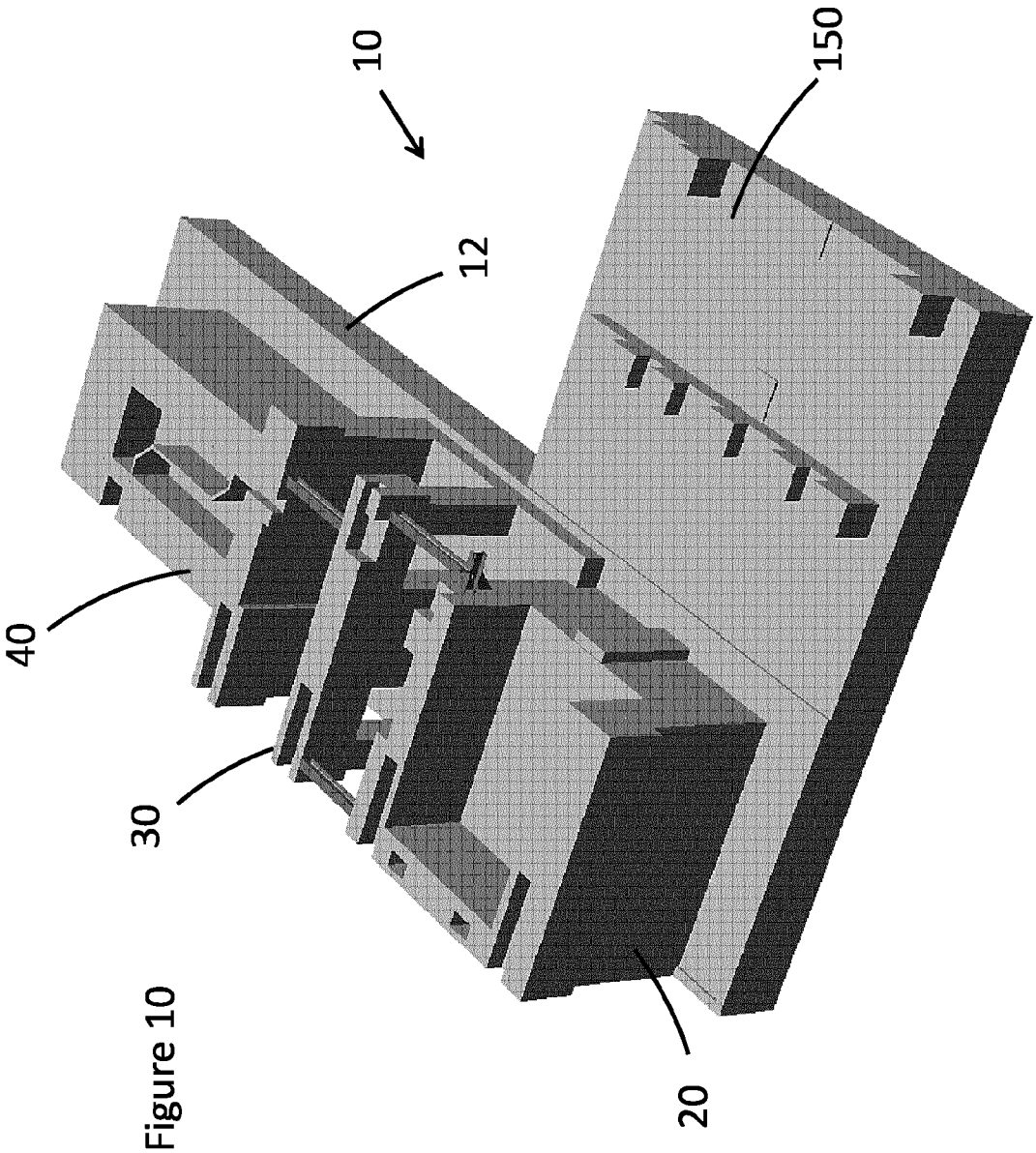

Figure 10

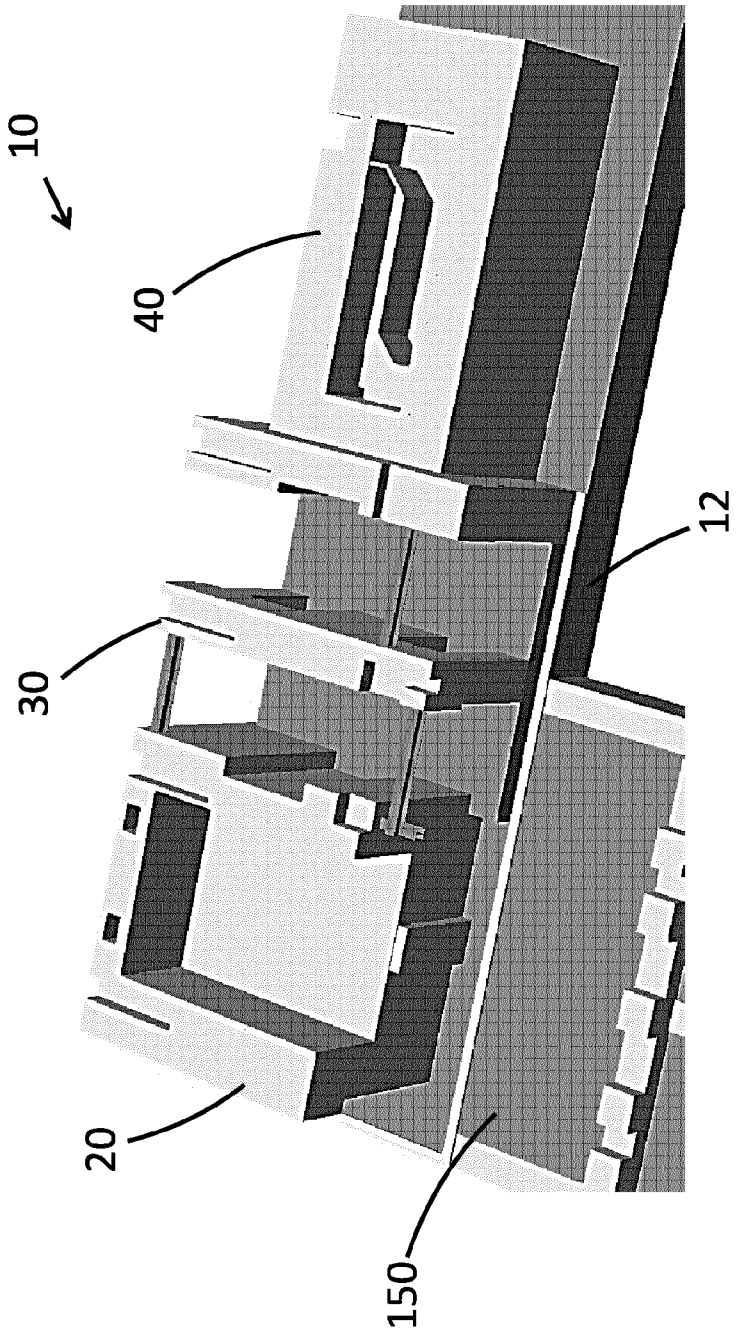

Figure 11

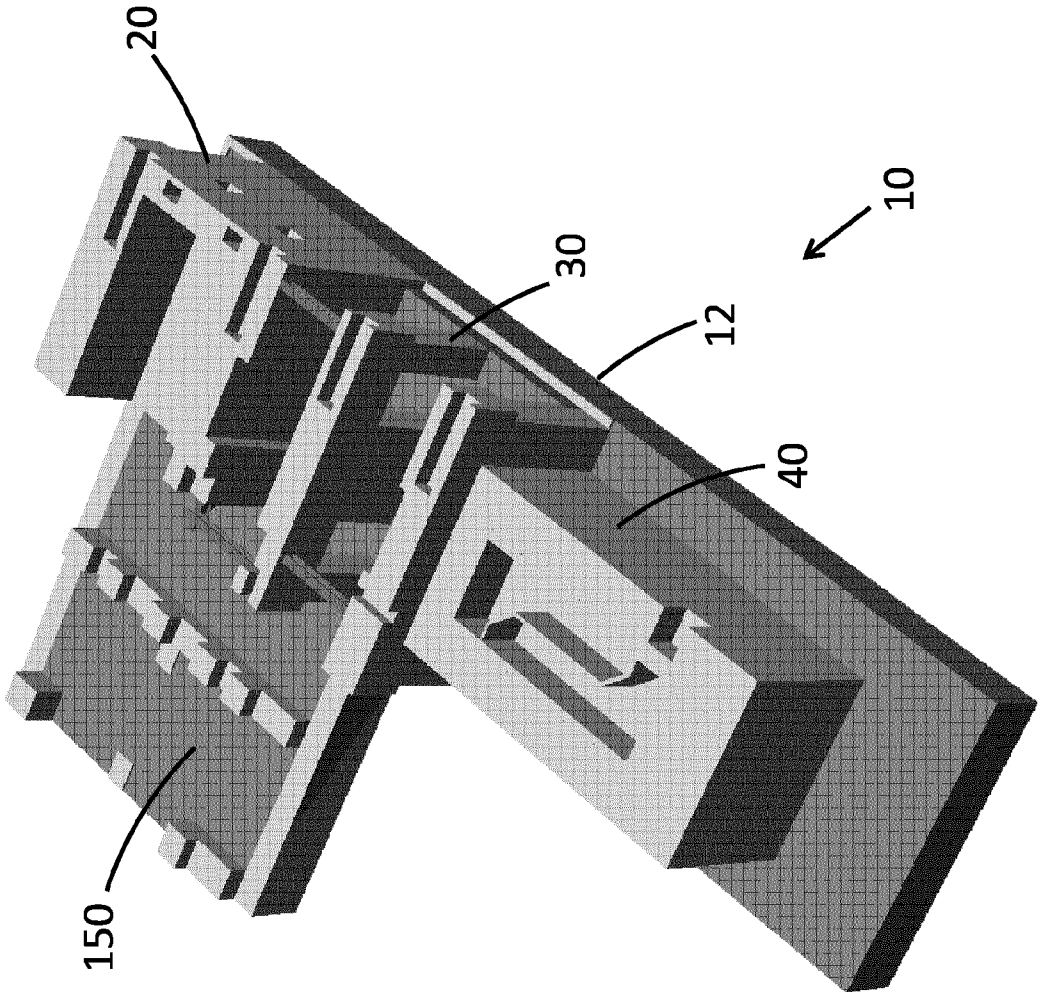

Figure 12

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2016/059861

A. CLASSIFICATION OF SUBJECT MATTER
INV. F01D25/28 F02C7/20 E02D27/44 F16M5/00 F16M9/00
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
F01D F02C F16M E02D

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

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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

[X] See patent family annex.

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
29 June 2016	11/07/2016

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Koch, Rafael

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C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

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Y	US 2013/340405 A1 (SACKMANN HANS-JUERGEN [DE] ET AL) 26 December 2013 (2013-12-26) paragraphs [0010], [0017], [0035]; figure 2	1,3,7, 9-13
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