(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) **EP 3 689 487 A1**

(12) **EUROPEAN PATENT APPLICATION**
published in accordance with Art. 153(4) EPC

(43) Date of publication:
05.08.2020 Bulletin 2020/32

(21) Application number: **17801070.8**

(22) Date of filing: **25.09.2017**

(51) Int Cl.:
B21D 3/16 *(2006.01)* ***B21D 11/16*** *(2006.01)*

(86) International application number:
PCT/ES2017/070632

(87) International publication number:
WO 2019/058005 (28.03.2019 Gazette 2019/13)

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME
Designated Validation States:
MA MD

(71) Applicant: **Cie Automotive, S.A.**
48009 Bilbao (Vizcaya) (ES)

(72) Inventors:
- **LARRUCEA DE LA RICA, Francisco**
  48009 Bilbao (Vizcaya) (ES)
- **MANSO RODRIGUEZ, Virginia**
  48009 Bilbao (Vizcaya) (ES)

(74) Representative: **Herrero & Asociados, S.L.**
Cedaceros, 1
28014 Madrid (ES)

(54) EQUIPMENT AND METHOD FOR TWISTING CRANKSHAFTS

(57) The present invention relates to equipment and a method for twisting crankshafts (A), comprising three modules (1), each comprising an upper tool (1') and a lower tool (1"), both having an inner face by means of which they are facing one another, each tool (1', 1") having a cavity on said inner face the geometry of which corresponds with the outer shape of a crankpin of the crankshaft (A) to be twisted, such that the cavity defined by the facing tools (1', 1") of one and the same module (1) corresponds with the complete outer shape of the crankpin, where the tools (1', 1") of each module (1) are arranged on a supporting element (2) that can rotate independently with respect to an axis of rotation (3) coinciding with a longitudinal axis (A') of the crankshaft (A) when said crankshaft (A) is arranged in the equipment, where the tools (1', 1") of each module (1) can only effect a linear displacement with respect to the supporting element (2) in which they are arranged, said linear displacement being perpendicular to the axis of rotation (3).

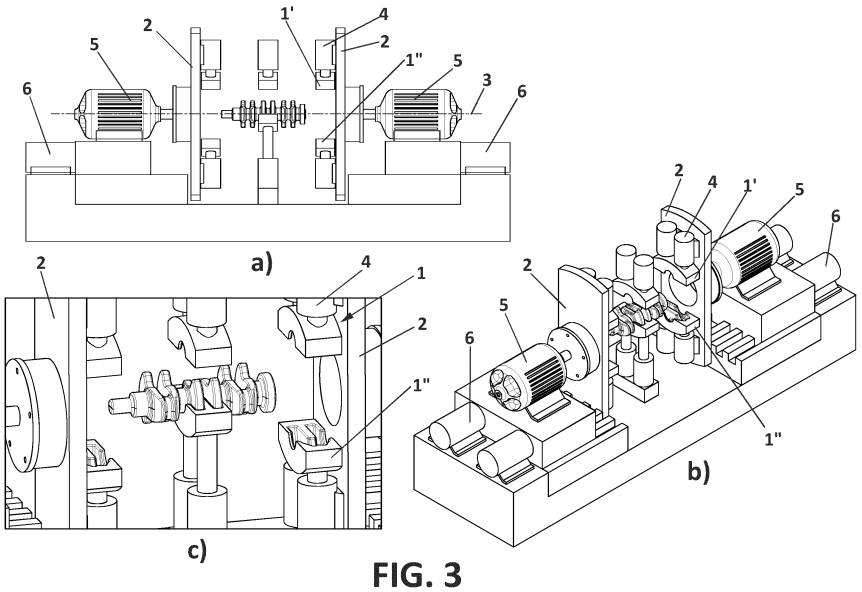


FIG. 3

EP 3 689 487 A1

Description

Technical Field of the Invention

[0001] The present invention is applicable in the mechanical industry, and more specifically in the field of equipment for manufacturing crankshafts.

Background of the Invention

[0002] Today there are different crankshaft configurations or types, determined by the characteristics of the engine of which the crankshaft is part. The main characteristic of the crankshaft is the number of crankpins, which corresponds with the number of cylinders the engine has. Furthermore, the crankpins can be arranged according to different angles, depending on how many there are, in correspondence with the number of cylinders of the engine and the arrangement thereof, i.e., either inline for 3- to 6-cylinder engines, or in a V shape for 6 and 8-cylinder engines.

[0003] In some cases, once the crankshaft has been forged and excess burr has been cut away, one of the final operations in manufacturing crankshafts is the twisting operation. Twisting consists of making a torsion in the crankshaft with respect to its longitudinal axis in order to place each crankpin in the corresponding angular position. In other words, by means of said operation the different crankpins are rotated according to the final orientation they are supposed to have depending on the type of engine. The crankshaft twisting equipment used today is formed primarily by a hydraulic press with a main cylinder, the corresponding frame thereof, an upper base plate and a lower base plate. The main cylinder of the press usually acts directly on the upper base plate, to which there is fixed an upper tool holder, also referred to as upper rest, which remains steady. For rotating the crankpins, the equipment usually comprises two twisting shafts, located on each side of the lower base plate. Said twisting shafts transmit the rotation to a lower tool holder and are actuated by means of two or four twisting cylinders.

[0004] Bearing in mind the equipment for manufacturing a crankshaft described above, one of the critical aspects that must be taken into consideration in crankshaft design is the stressing resulting from the moments created by performing the twisting with the press in two phases, i.e., by means of two strokes, one for actuating the main cylinder and another one for the twisting cylinders, so the phases do not occur simultaneously. The immediate drawback of this aspect is that the two-phase operation that is performed in equipment available today involves certain inherent and significant deformations that make a final calibration operation necessary to achieve the required tolerances in the crankshaft, which makes the method of manufacture expensive and slow. Furthermore, as can be deduced from the preceding disclosure, large, heavy and expensive machinery is required.

[0005] In turn, as mentioned above the twisting tooling used today comprises split tooling formed by upper and lower rests, some of which are steady rests and others are follow rests, i.e., they can rotate with respect to the longitudinal axis of the crankshaft, where the follow rests are supported on rollers. All the rests are mounted on a lower base plate and an upper base plate. The distances between rests are adjustable, such that the distances and the number of rests are secured to the base plates depending on the type of crankshaft to be twisted.

[0006] The forged crankshaft is initially placed on the inner portion of the split tooling. At the beginning of the stroke of the movable upper head of the press, the crankshaft is positioned by means of the lower rests once the upper head has completely descended and the crankshaft is fixed in place, the twisting process is performed by means of the rotation of the follow rests, which are embodied as split discs rotating a pre-set angle by means of the front twisting shaft and the rear twisting shaft incorporated in the equipment. The twisting shafts are located on both sides of a central axis of the machine and are supported on the frame of the actual press. These shafts are what transmit torque to the twisting rests. The crankpins fixed in place by the follow rests therefore describe an arc of circumference until being situated in the required angular position. The twisting angle is regulated by adjusting the stroke of the twisting cylinder. By way of example, in the cases of crankshafts with three, four or six crankpins with angles of 120°, 90° or 60°, respectively, twisting can be performed with just two twisting shafts, such that all the crankpins can be positioned with a given twisting angle value, i.e., other than 0°. However, in the case of crankshafts with five crankpins and an angle of 72°, two additional twisting shafts are required, since only two crankpins can be positioned with the same twisting angle. Obviously this further complicates the equipment and the process.

[0007] Once the twisting process has ended, the upper head is again displaced to the top dead center, the lower and upper ejectors being simultaneously activated. The now twisted crankshaft is suspended above the lower ejectors. The lower follow rests return to their initial position as a result of the descent of the twisting shafts. The half follow rests of the upper head are retracted to their initial position through pneumatic cylinders. The crankshaft can be removed after this point.

[0008] After having described the entire process in detail, it is understood that due to the geometric complexity of the required tooling, excessive deformations are generated in the twisted crankshaft, which makes it necessary to perform a final calibration operation. Said deformations are largely due to the gaps that have to be performed in the tooling for opening same and to the stressing inherent to the twisting process. Furthermore, as discussed, the case of twisting of crankshafts with five cylinders entails an added difficulty, since forging must be performed with a nonplanar parting surface, in addition

to a final twisting being necessary, which even further complicates the entire process.

Description of the Invention

[0009] A first aspect of the present invention relates to equipment for twisting crankshafts, which allows reducing deformations in a twisted crankshaft and simplifying the design of the corresponding tooling. The equipment proposed by the invention comprises a tooling comprising at least three twisting modules, where each twisting module in turn comprises an upper tool and a lower tool. The tools have an inner face by means of which they are facing one another. Each tool a cavity on said inner face the geometry of which corresponds with a portion of the specific outer shape of a crankpin of the crankshaft to be twisted, such that the cavity defined by the facing tools of one and the same twisting module corresponds with the complete outer shape of the crankpin. In other words, the shape of the mark left by the tooling coincides 100% with that of the crankshaft segment.

[0010] Significant allowances between the tooling and the shapes of the crankshaft segment to be twisted therefore do not occur.

[0011] In turn, the crankshaft has a longitudinal axis and can be arranged such that a crankpin is housed in the cavity defined by the lower tool of one of the twisting modules, preferably one that is not going to rotate, as explained below. According to the invention, the tools of each twisting module are arranged on a supporting element, where at least two supporting elements, also referred to as rotating frames, can rotate independently, in relation to rotating speed, angle and direction, with respect to an axis of rotation coinciding with the longitudinal axis of the crankshaft when said crankshaft is arranged in the equipment. Likewise, the tools of one and the same twisting module can only effect a linear displacement with respect to the supporting element in which they are arranged, said linear displacement being perpendicular to the axis of rotation.

[0012] So instead of using a press with adapted gripping devices in which the crankshaft is obtained after several rotations and upward movements of the driving mechanism, as is done in the state of the art, the invention proposes a modular solution in which all the rotations are performed at the same time, i.e., simultaneously, which reduce stressing and allowances, preventing excessive deformations. All this enables dispensing with subsequent calibration.

[0013] Furthermore, as regards opening the tools, the equipment and the process are much simpler given that there is a relative movement in the separation of the tools according to an axis perpendicular to the axis of rotation. The gripping device design of the state of the art was much more complicated and led to very significant stressing due to the complication in the gripping device separation phase. By overcoming this, the invention allows making simpler gripping devices, such as those described above and even dispensing with subsequent calibration. In the case of the invention, the tooling allows the opening thereof in the radial direction with respect to longitudinal axis of the crankshaft, after rotation. The tooling in the state of the art had to be designed so as to allow the opening thereof always according to the vertical direction. Therefore, in the case of the invention the dimensional tolerances of the part are much more precise, with this being what allows eliminating the subsequent calibration process.

[0014] The possibility that at least one supporting element can be longitudinally displaced in the direction of the axis of rotation is contemplated.

[0015] Likewise, it is contemplated that the longitudinal displacement of the tools of each twisting module is performed by first driving means mounted on the actual supporting element. This allows independent actuation of each twisting module.

[0016] In this sense, it is also contemplated that the independent rotational movement of each supporting element with respect to the axis of rotation is performed by second driving means.

[0017] In turn, the longitudinal displacement of each supporting element in the direction of the axis of rotation can be performed by third driving means.

[0018] A second aspect of the invention relates to a method for twisting crankshafts, where said method comprises using equipment such as the one described above.

[0019] The method comprises the following steps:

- arranging a forged crankshaft to be twisted with a crankpin partially housed in the cavity of a lower tool of a twisting module which cannot be displaced or rotate with respect to the axis of rotation,
- longitudinally displacing the tools of each twisting module so that they are located at the required distance, according to the crankshaft to be twisted (the third driving means act),
- radially displacing the tools of each twisting module such that their inner faces are facing one another and each crankpin is housed entirely in its corresponding cavity defined by the facing tools of each twisting module (the first driving means act),
- simultaneously rotating each supporting element, with an independent direction of rotation, although it is also contemplated that the speed and therefore the angle are, with respect to the axis of rotation according to the required angular position for each crankpin (the second driving means act),
- radially displacing the tools of each twisting module such that their inner faces are in the open position and each crankpin is housed only in the module that does not rotate (the first driving means act),
- longitudinally displacing the tools of each twisting module so that they are separated from one another at the same time the supporting elements rotate in the direction opposite from before (the second and third driving means act together).

[0020] Stressing is thereby reduced, as has already been mentioned, taking into account the simultaneity and combination of displacement and rotational movements. In the case of the state of the art, there is no combination or simultaneity of rotational and longitudinal movements, which makes the crankshaft suffer more and leads to the generation of unnecessary stressing.

[0021] Likewise, it is contemplated that in combination with the longitudinal displacement of the tools of each twisting module so that they are separated from one another, the method comprises longitudinally displacing the corresponding supporting elements in the direction of the axis of rotation for their relative movement away from one another.

[0022] The foregoing means that all the movements are even more integrated, thereby contributing to reducing process times and minimizing the stressing generated.

Description of the Drawings

[0023] To complement the description that is being made and for the purpose of helping to better understand the features of the invention according to a preferred practical embodiment thereof, a set of drawings is attached as an integral part of said description, where the following is depicted with an illustrative and non-limiting character:

Figure 1 shows two exploded schematic views of an embodiment of the tooling proposed by the invention, in which the upper and lower tools corresponding to three twisting modules are depicted, where it can be seen in view a) that the inner shape of said tools corresponds with the outer shape of the corresponding crankpin of the crankshaft depicted in view b).

Figures 2 to 10 show a sequence of operation of an embodiment of the equipment of the invention, which comprises three twisting modules and the driving mechanism thereof is an electrical and hydraulic driving mechanism, where each figure consists of three views corresponding with an elevational view in a), a perspective view in b), and an perspective view of an enlarged detail of the same instant depicted in each figure.

Figure 11 shows three views corresponding with an instant, such as the one depicted in Figure 9, of another embodiment of the equipment of the invention, which in this case comprises three twisting modules and has only hydraulic driving mechanism.

Figures 12 shows three views corresponding with an instant, such as the one depicted in Figure 2, of another embodiment of the equipment which comprises five twisting modules and has only hydraulic driving mechanism.

Preferred Embodiment of the Invention

[0024] In view of the described drawings, it can be seen how in one of the possible embodiments of the invention, the equipment for twisting crankshafts (A) proposed by the invention comprises at least three twisting modules (1); in the case depicted in Figures 1 to 11 there are three, whereas in Figure 12 there are five.

[0025] Each twisting module (1) in turn comprises an upper tool (1') and a lower tool (1"), where said tools (1', 1") have an inner face by means of which they are facing one another, each tool (1', 1") having a cavity on said inner face the geometry of which corresponds with a portion of the outer shape of a crankpin of the crankshaft (A) to be twisted, such that the cavity defined by the facing tools (1', 1") of one and the same twisting module (1) corresponds with the complete outer shape of the crankpin.

[0026] As seen in the drawings, the crankshaft (A) has a longitudinal axis (A') and can be arranged such that a crankpin is housed in the cavity defined by the facing tools (1', 1") of said at least one twisting module (1).

[0027] It can be seen in the drawings how the tools (1', 1") of each twisting module (1) are arranged on a supporting element (2) that can rotate independently with respect to an axis of rotation (3) coinciding with the longitudinal axis (A') of the crankshaft (A) when said crankshaft (A) is arranged in the equipment.

[0028] In the case of the drawings, the supporting element (2) corresponding to the central twisting module (1) does not rotate nor is it displaced in any case in the direction of the axis of rotation (3), although the invention likewise contemplates an embodiment in which it can rotate and be displaced. Likewise, in the case of Figures 2 to 11, for the sake of clarity, the supporting element (2) corresponding to the central module (1) is not depicted. In summary, except in a specific type, usually there is always a crankpin that does not have to rotate.

[0029] The tools (1', 1") of one and the same twisting module (1) can only effect a linear displacement with respect to the supporting element (2) in which they are arranged, said linear displacement being perpendicular to the axis of rotation (3).

[0030] The supporting elements (2) can be longitudinally displaced in the direction of the axis of rotation (3) in order to move closer to one another in the direction towards the central twisting module (1). To that end, the equipment obviously has a bed serving as a base and support for the entire structure and elements of the equipment and incorporates the corresponding guides for longitudinal displacement of the supporting elements (2).

[0031] In turn, the longitudinal displacement of the tools (1', 1") of each twisting module (1) is performed by first driving means (4) mounted on the actual supporting element (2).

[0032] The independent rotational movement of each supporting element (2) with respect to the axis of rotation (3) is performed by second driving means (5).

[0033] Likewise, the longitudinal displacement of each supporting element (2) in the direction of the axis of rotation (3) is performed by third driving means (6).

[0034] In all the depicted embodiments, the first driving means (4) and third driving means (6) are hydraulic driving means but they could be pneumatic or of another type. Likewise, in the embodiment depicted in Figures 2 to 10 the second driving means (5) are electric driving means, whereas in the embodiment of Figure 11 they are hydraulic driving means.

[0035] As previously mentioned, in the embodiments depicted in Figures 2 to 11, the equipment comprises three twisting modules (1), the central one of which cannot be displaced or rotate with respect to the axis of rotation (3).

[0036] In the embodiment depicted in Figure 12, the equipment comprises five twisting modules (1), the central one of which, likewise, cannot be displaced or rotate with respect to the axis of rotation (3).

[0037] As can be deduced from the foregoing and from the sequences depicted in the drawings, it is understood in the case of the invention that the untwisting, i.e., the rotation of the supporting elements (2) in the opposite direction with respect to the twisting, once the required rotations have been effected, is done in combination with the expulsion/opening, which furthermore allows gaining access to the crankshaft from the front.

[0038] Among the different design possibilities, tooling with a double guide in the rear portion, as well as the possibility of including stiffening centering elements, such as pins as well as square/tension member-type elements, are contemplated.

[0039] The closing and opening cylinder not going through the central area of the module, but rather arranging two cylinders and having them go through the outer area of the module, is also proposed as an alternative in order to prevent interferences.

[0040] In view of this description and set of drawings, the person skilled in the art will understand that the embodiments of the invention that have been described can be combined in many ways within the object of the invention. The invention has been described according to several preferred embodiments thereof, but it will be evident for the person skilled in the art that many variations can be introduced in said preferred embodiments without exceeding the object of the claimed invention.

Claims

1. Equipment for twisting crankshafts (A), **characterized in that** it comprises at least three twisting modules (1), where each twisting module (1) comprises an upper tool (1') and a lower tool (1"), where said tools (1', 1") have an inner face by means of which they are facing one another, each tool (1', 1") having on said inner face a cavity the geometry of which corresponds with a portion of the outer shape of a crankpin of the crankshaft (A) to be twisted, such that the cavity defined by the facing tools (1', 1") of one and the same twisting module (1) corresponds with the complete outer shape of the crankpin, where the tools (1', 1") of each twisting module (1) are arranged on a supporting element (2), where at least two supporting elements (2) can rotate independently with respect to an axis of rotation (3) coinciding with a longitudinal axis (A') of the crankshaft (A) when said crankshaft (A) is arranged in the equipment, where the tools (1', 1") of each twisting module (1) can only effect a linear displacement with respect to the supporting element (2) in which they are arranged, said linear displacement being perpendicular to the axis of rotation (3).

2. Equipment according to claim 1, wherein at least one supporting element (2) can be longitudinally displaced in the direction of the axis of rotation (3).

3. Equipment according to any of the preceding claims, wherein the radial displacement of the tools (1', 1") of each twisting module (1) is performed by first driving means (4) mounted on the actual supporting element (2).

4. Equipment according to any of the preceding claims, wherein the independent rotational movement of each supporting element (2) with respect to the axis of rotation (3) is performed by second driving means (5).

5. Equipment according to any of the preceding claims, wherein the longitudinal displacement of each supporting element (2) in the direction of the axis of rotation (3) is performed by third driving means (6).

6. Equipment according to any of the preceding claims, wherein the first driving means (4) and third driving means (6) are hydraulic driving means.

7. Equipment according to any of the preceding claims, wherein the second driving means (5) can be selected from electrical and hydraulic driving means.

8. Equipment according to any of the preceding claims, comprising three twisting modules (1), the central one of which cannot be displaced or rotate with respect to the axis of rotation (3).

9. Equipment according to any of the preceding claims, comprising five twisting modules (1), the central one of which cannot be displaced or rotate with respect to the axis of rotation (3).

10. Method for twisting crankshafts (A) which comprises using the equipment according to any of claims 1 to 9, wherein the method comprises the following steps:

- arranging a forged crankshaft (A) to be twisted with a crankpin partially housed in the cavity of a lower tool (1") of a twisting module (1) which cannot be displaced or rotate with respect to the axis of rotation (3),
- longitudinally displacing the tools (1', 1") of each twisting module (1) so that they are located at the required distance
- radially displacing the tools (1', 1") of each twisting module (1) such that their inner faces are facing one another and each crankpin is housed entirely in its corresponding cavity defined by the facing tools (1', 1") of each twisting module (1),
- simultaneously rotating each supporting element (2), with an independent direction of rotation, with respect to the axis of rotation (3) according to the required angular position for each crankpin,
- radially displacing the tools (1', 1") of each twisting module (1) such that their inner faces are open and each crankpin is housed only in the module that does not rotate,
- longitudinally displacing the tools (1', 1") of each twisting module (1) so that they are separated from one another at the same time the supporting elements (2) rotate in the direction opposite from before.

11. Method according to claim 10, where said method comprises, in combination with the longitudinal displacement of the tools (1', 1") of each twisting module (1) such that their inner faces are facing one another, longitudinally displacing the corresponding supporting elements (2) in the direction of the axis of rotation (3) for their relative movement closer to one another.

12. Method according to any of claims 10 and 11, where said method comprises, in combination with the radial displacement of the tools (1', 1") of each twisting module (1) so that they are separated from one another, longitudinally displacing the corresponding supporting elements (2) in the direction of the axis of rotation (3) for their relative movement away from one another.

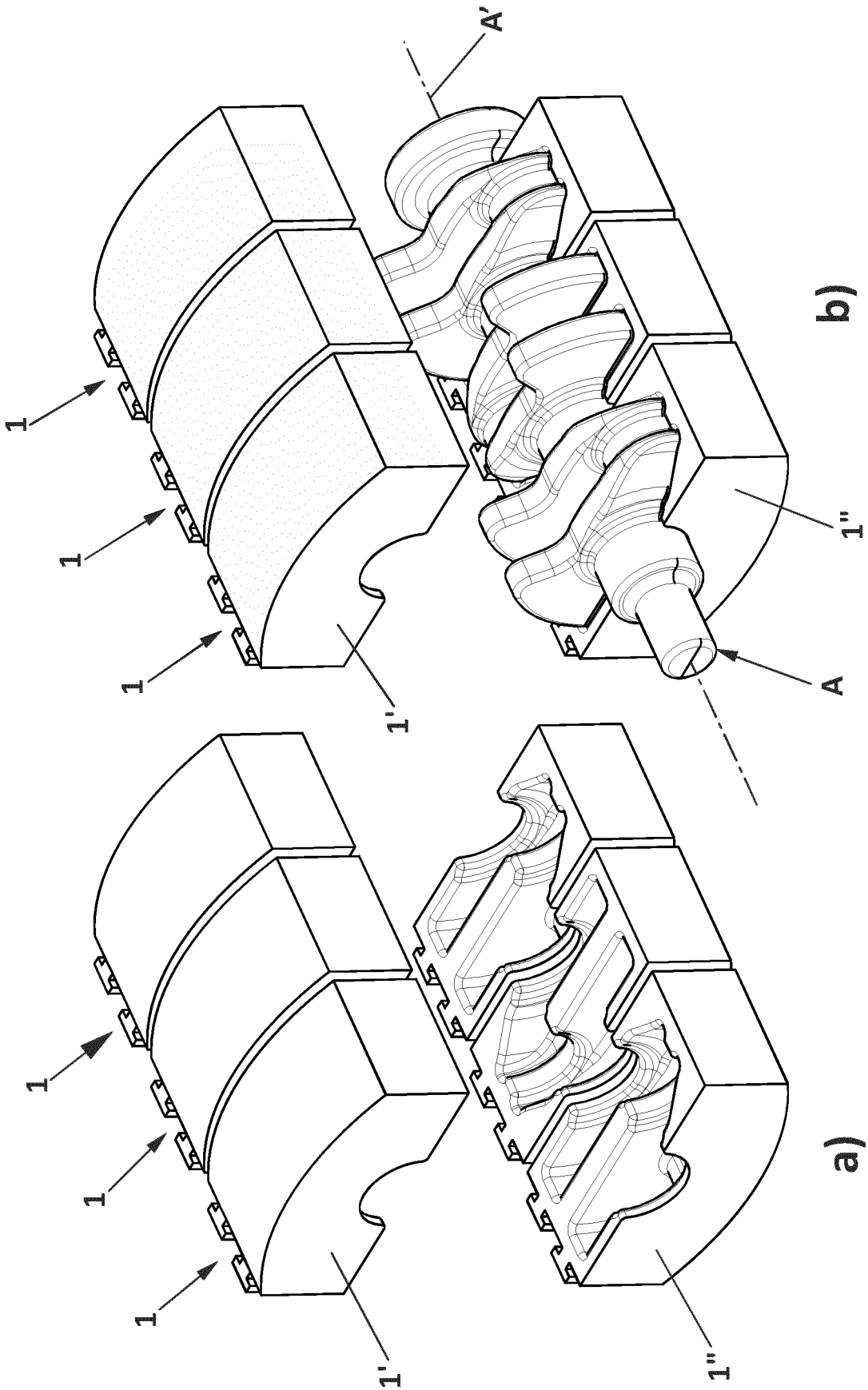


FIG. 1

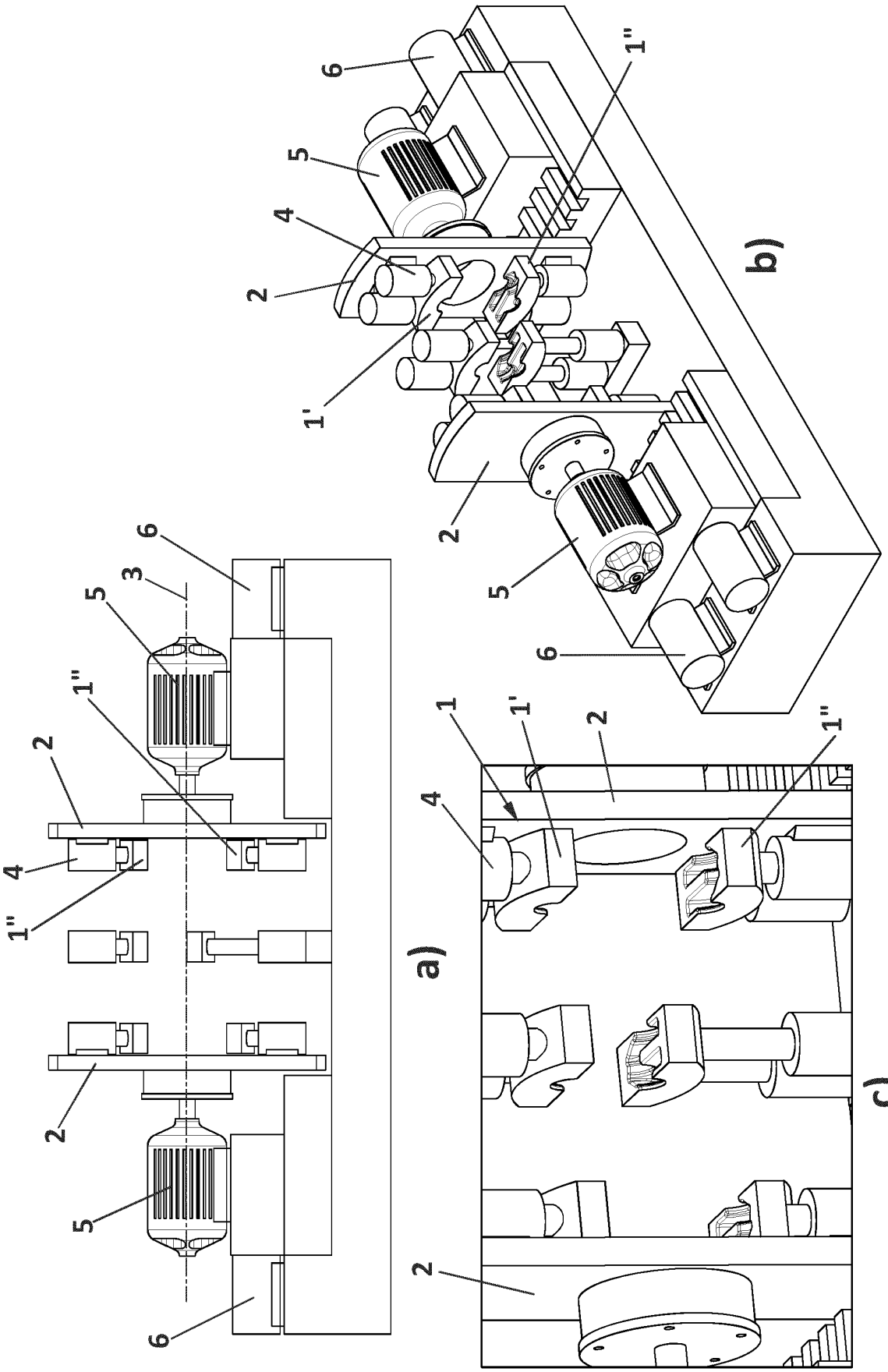


FIG. 2

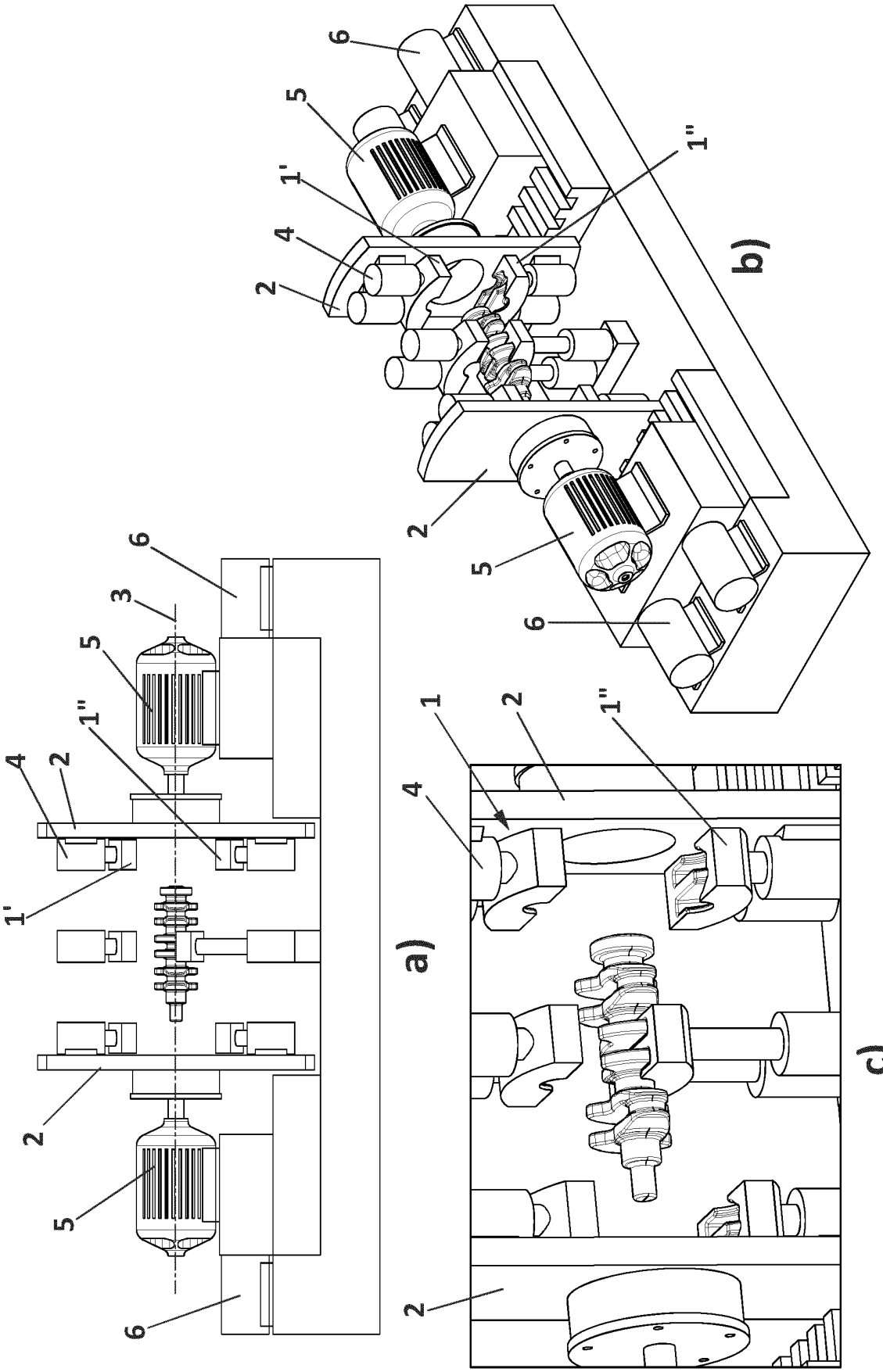


FIG. 3

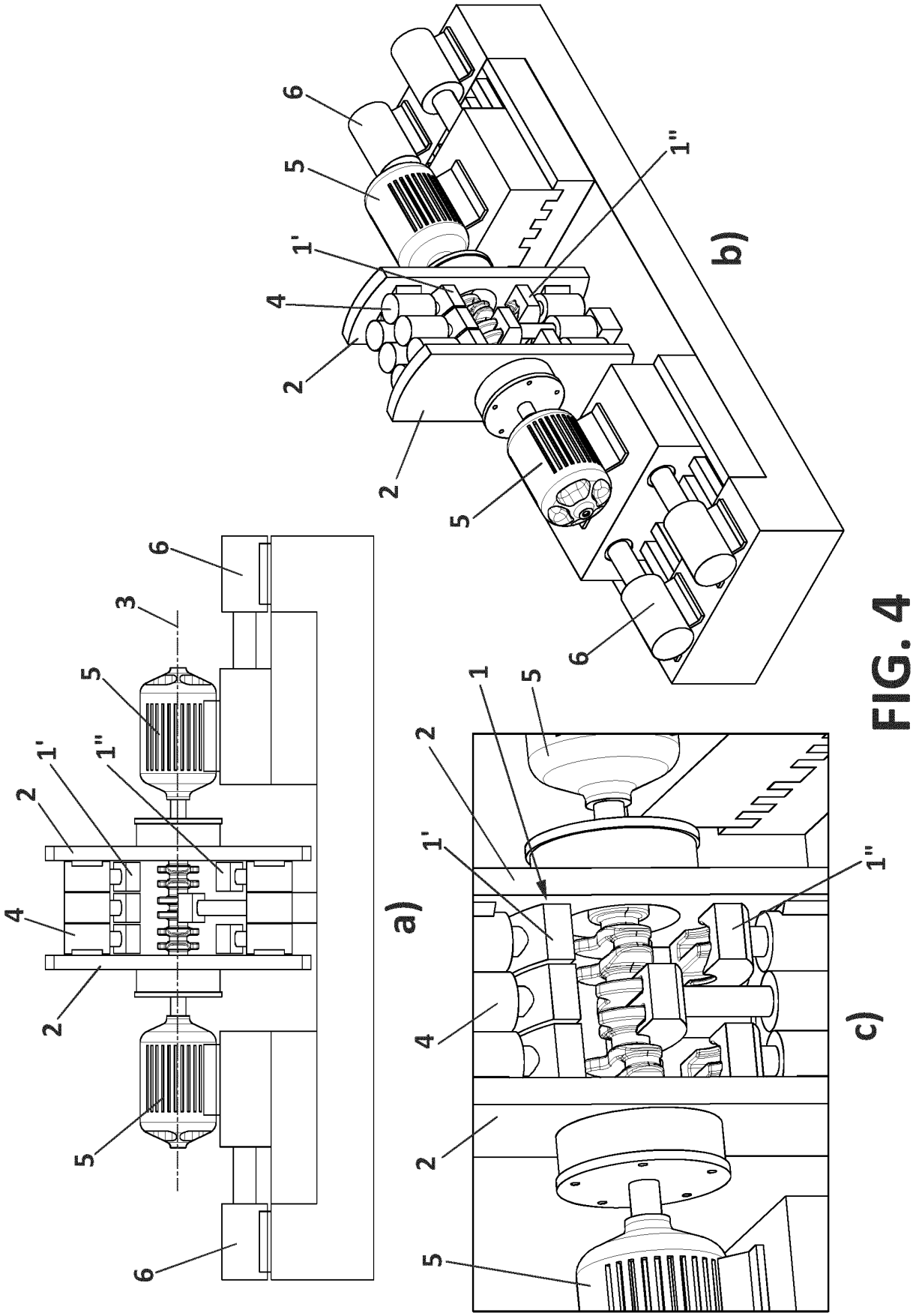


FIG. 4

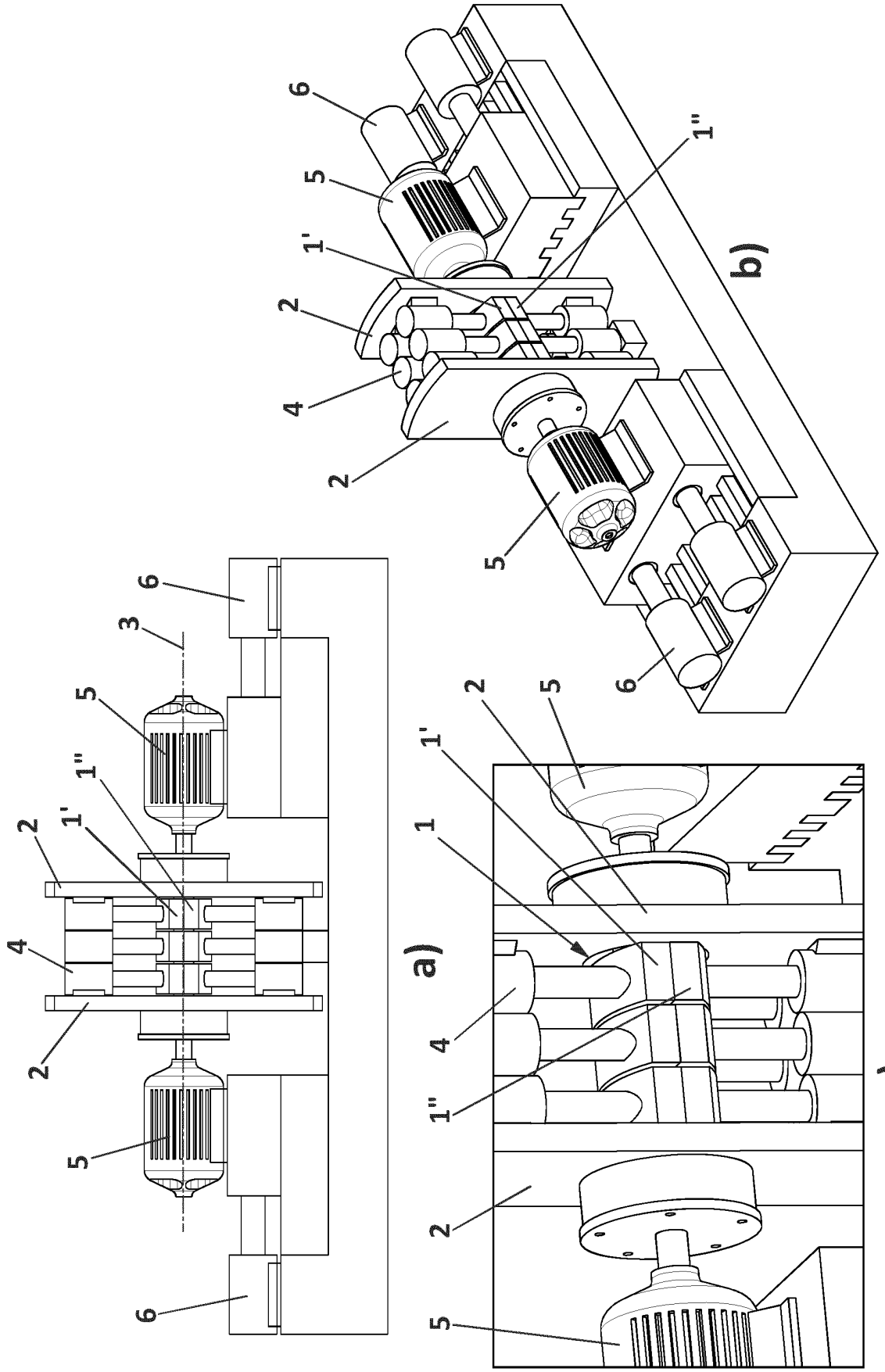


FIG. 5

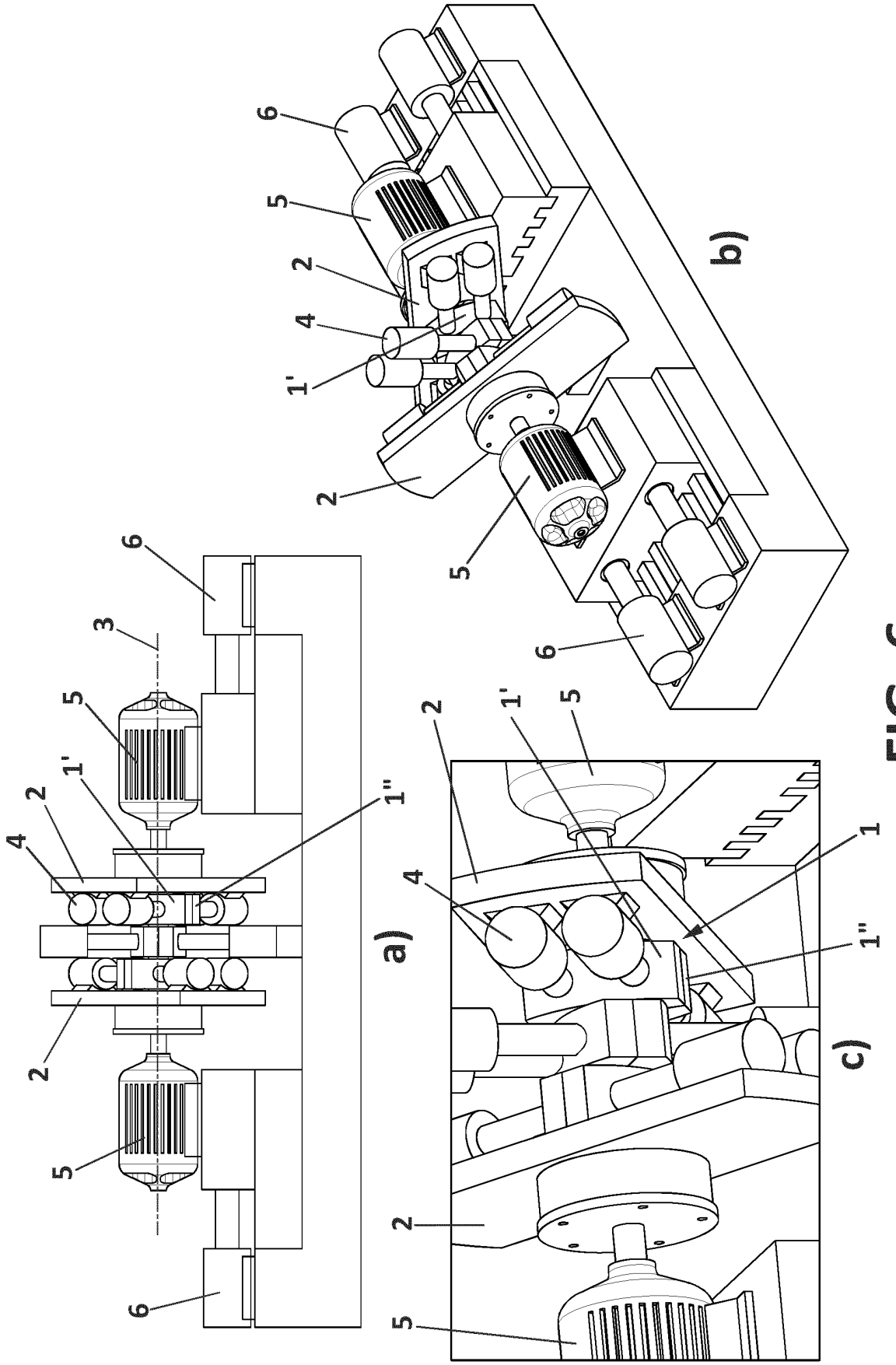


FIG. 6

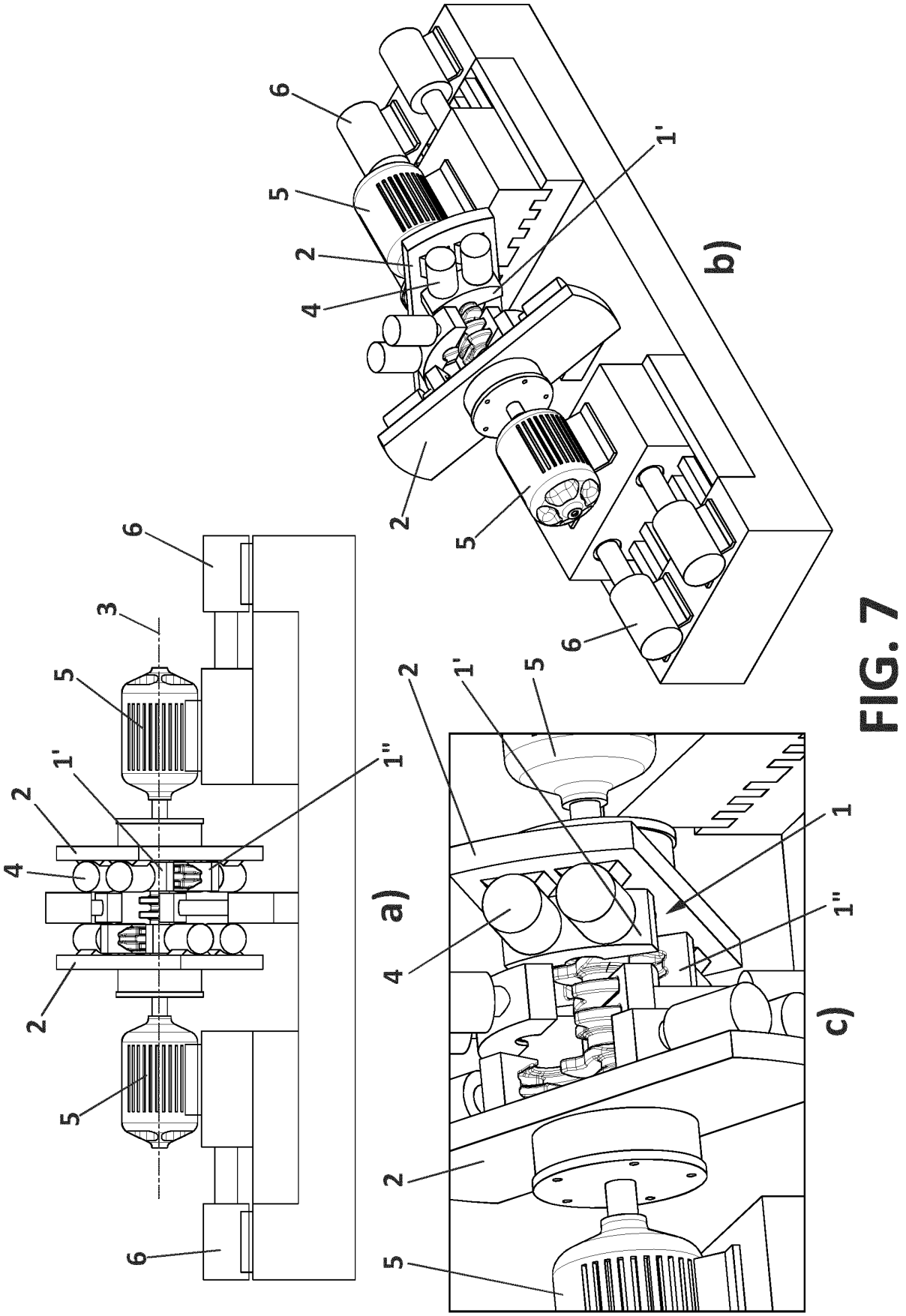


FIG. 7

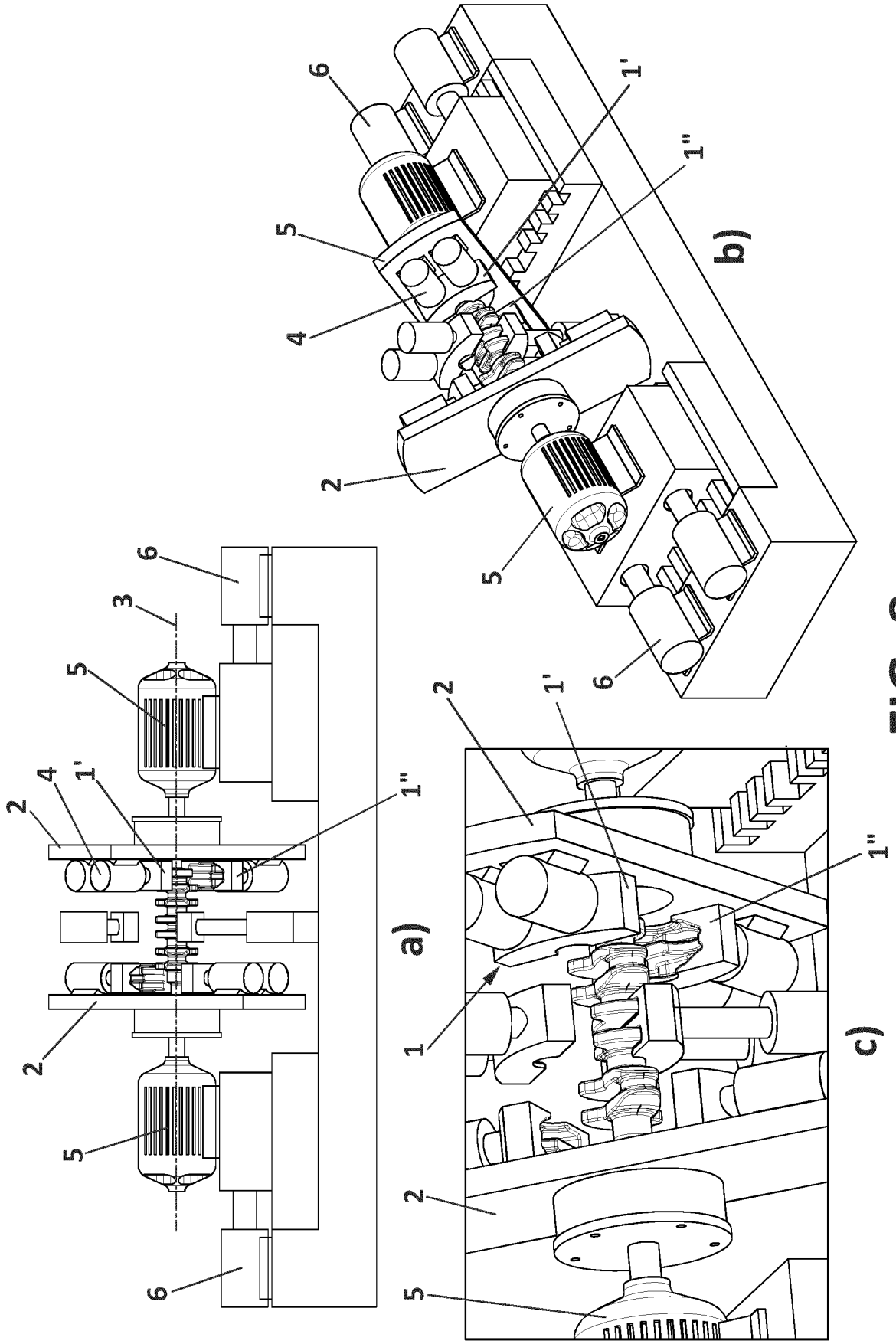


FIG. 8

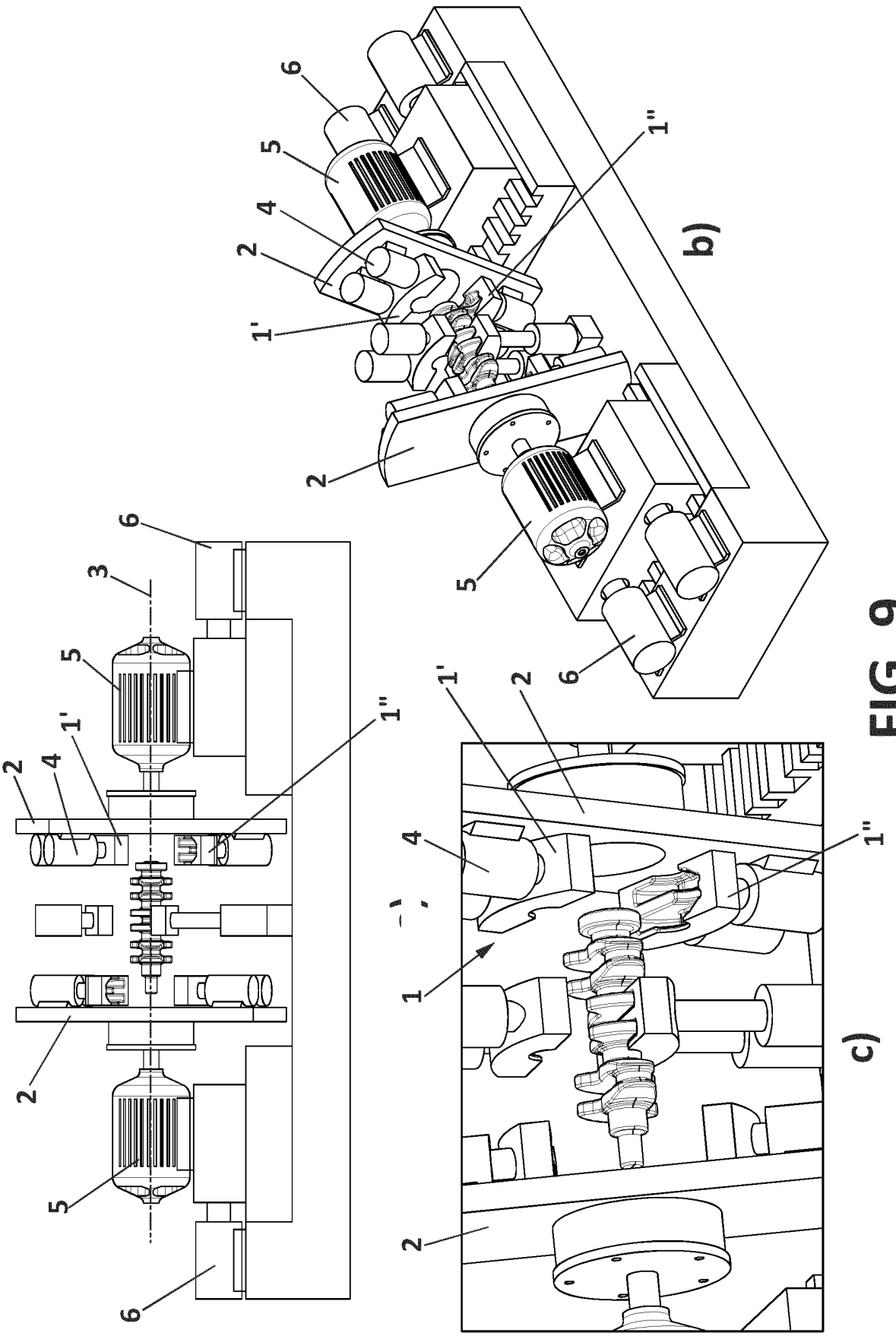


FIG. 9

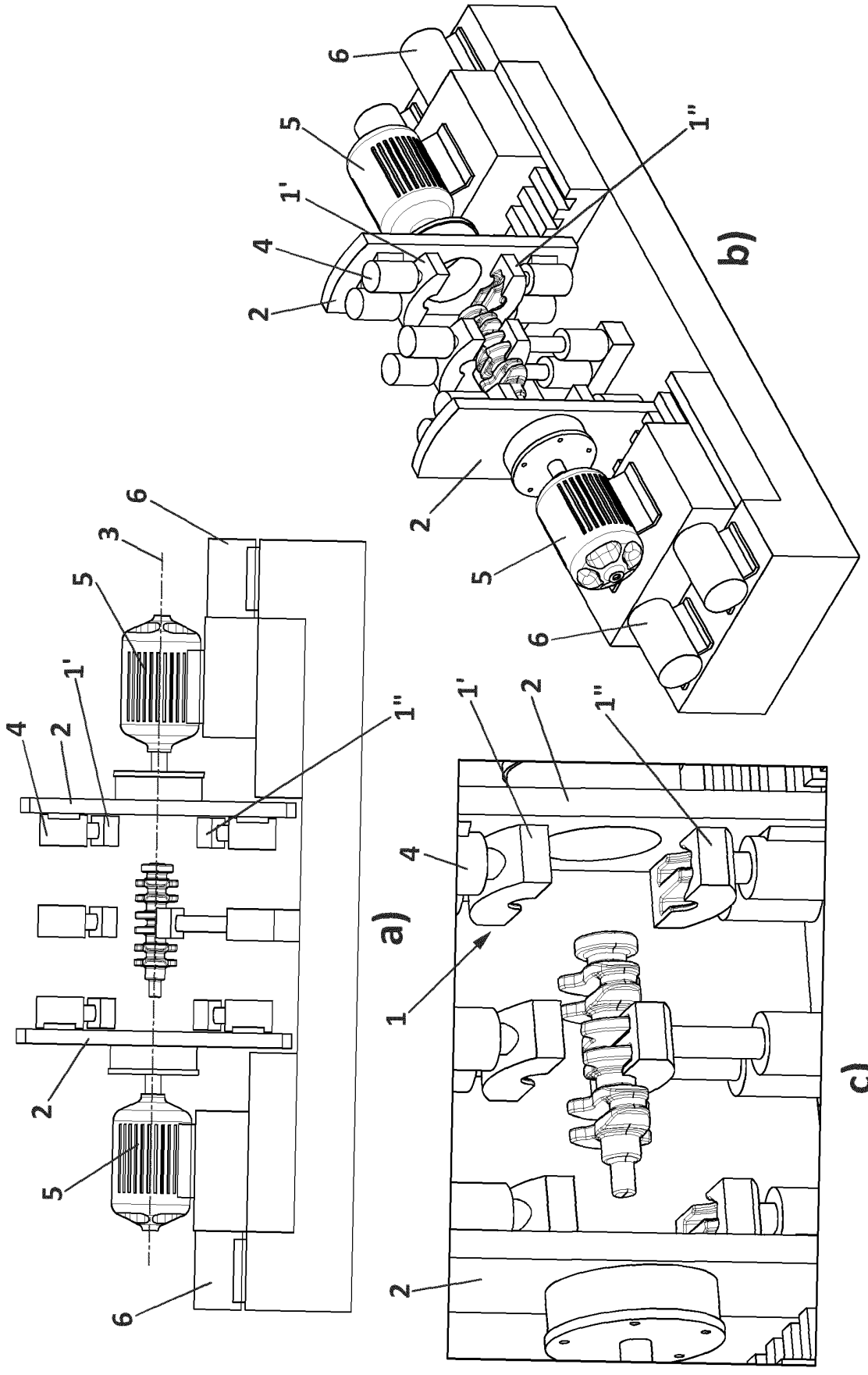


FIG. 10

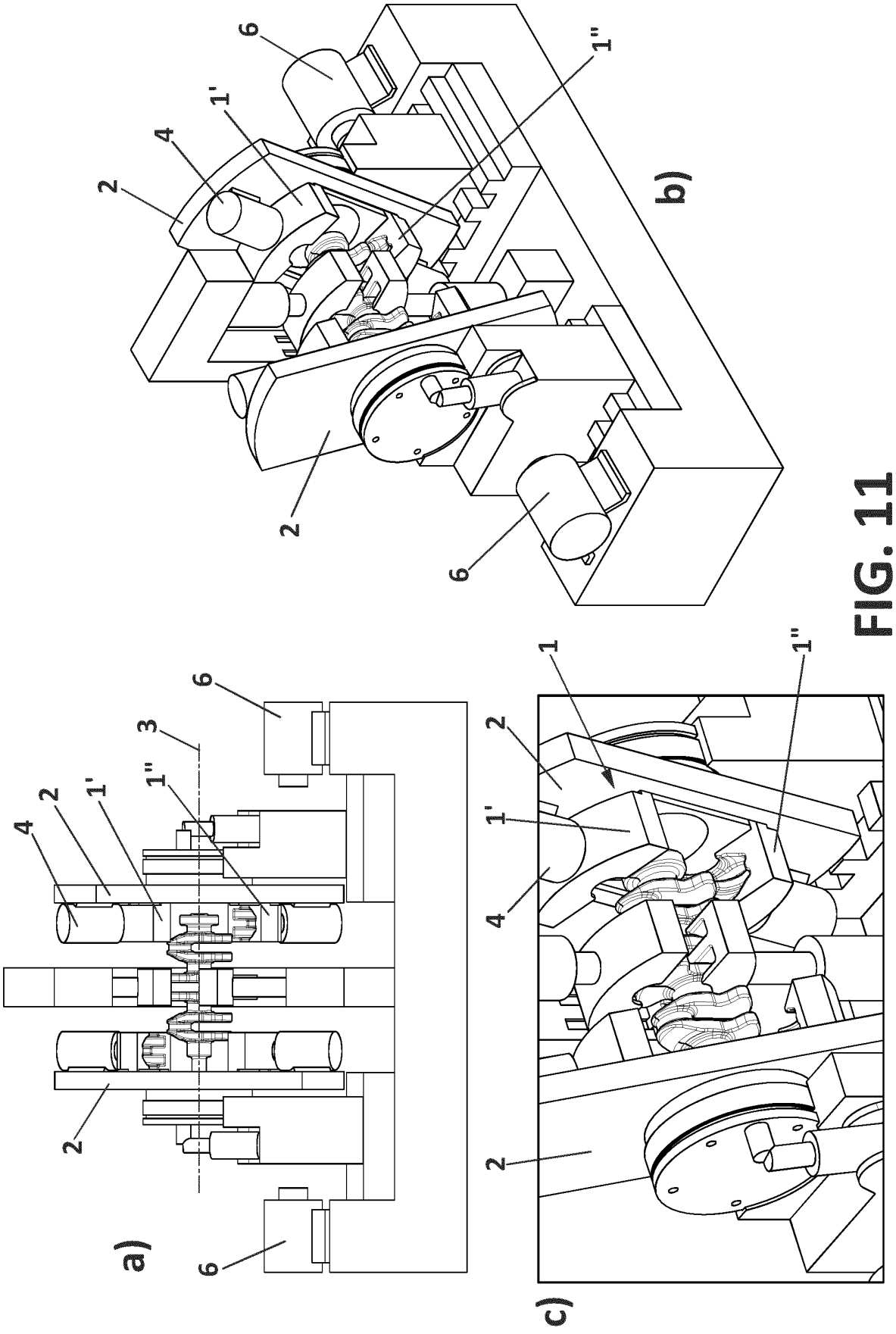


FIG. 11

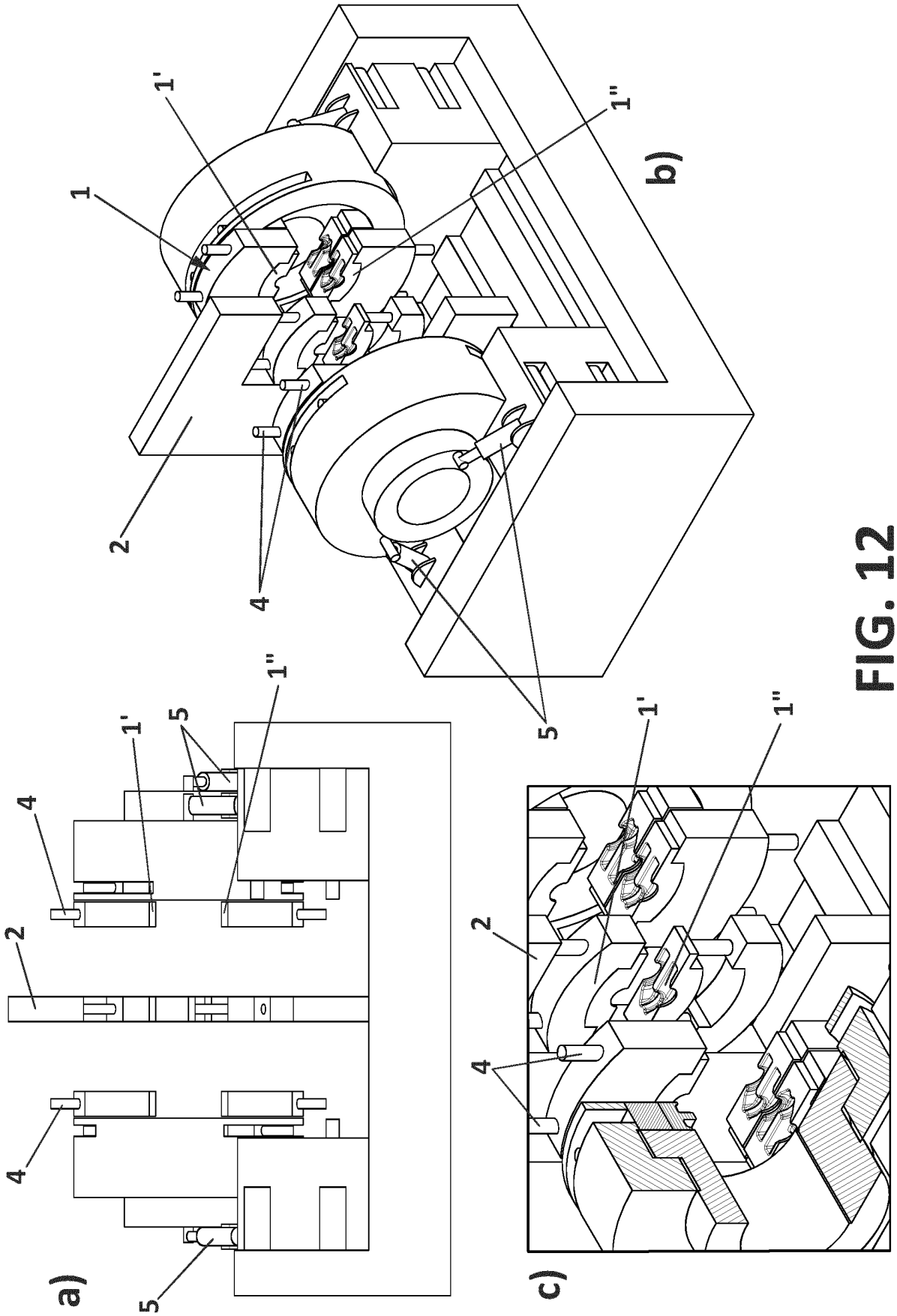


FIG. 12

INTERNATIONAL SEARCH REPORT

International application No
PCT/ES2017/070632

A. CLASSIFICATION OF SUBJECT MATTER
INV. B21D3/16 B21D11/16
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)
B21D

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

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 2001 259747 A (SUMITOMO HEAVY INDUSTRIES) 25 September 2001 (2001-09-25) abstract; figures 1,2,4-6	1-12
A	JP S57 160537 A (SUMITOMO METAL IND; HITACHI SHIPBUILDING ENG CO) 2 October 1982 (1982-10-02) figures 9-13	1-12
A	DE 199 58 681 A1 (SUMITOMO HEAVY INDUSTRIES [JP]) 3 August 2000 (2000-08-03) figures 1,5-11	1-12
A	GB 2 145 018 A (HONDA MOTOR CO LTD) 20 March 1985 (1985-03-20) abstract; figures 1-7	1-12

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
18 May 2018	04/06/2018

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	Cano Palmero, A

Form PCT/ISA/210 (second sheet) (April 2005)

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/ES2017/070632

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
JP 2001259747 A	25-09-2001	JP 3737667 B2	18-01-2006
		JP 2001259747 A	25-09-2001
JP S57160537 A	02-10-1982	JP S6238049 B2	15-08-1987
		JP S57160537 A	02-10-1982
DE 19958681 A1	03-08-2000	DE 19958681 A1	03-08-2000
		US 6220072 B1	24-04-2001
GB 2145018 A	20-03-1985	CA 1215866 A	30-12-1986
		GB 2145018 A	20-03-1985
		JP S6021142 A	02-02-1985
		JP S6219246 B2	27-04-1987
		US 4580430 A	08-04-1986

Form PCT/ISA/210 (patent family annex) (April 2005)