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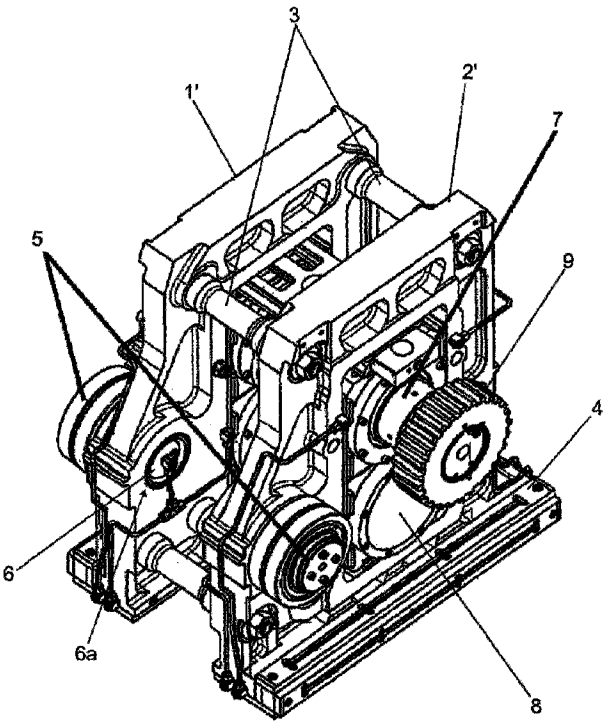


(57) **Abrégé/Abstract:**
The invention relates to a roll stand (10), wherein at least two rolls (7, 8) for forming a workpiece are accommodated in the stand, and wherein a rolling force acting during the forming is supported by the roll stand (10), wherein the roll stand (10) is produced by means of additive manufacturing.

ABSTRACT

The invention relates to a roll stand (10), wherein at least two rolls (7, 8) for forming a workpiece are accommodated in the stand, and wherein a rolling force acting during the forming is supported by the roll stand (10), wherein the roll stand (10) is produced by means of additive manufacturing.

(Fig. 1)

Date Reçue/Date Received 2020-05-05

ROLL STAND

The invention relates to a roll stand as described herein and a method for improving an existing rolling mill.

DE-OS-1 287 541 describes a roll stand for a multiple cold Pilger rolling mill. A rolling mill is constructed from two roll stands or stand sides, which are connected to one another by means of installed spacer bolts. In such a cold Pilger rolling mill, the roll stand is not arranged to be stationary, but rather is alternately moved by means of a drive.

It is the object of the invention to specify a roll stand which has a low weight at given rolling forces.

This object is achieved according to the invention for a roll stand mentioned at the outset by the characterizing features as described herein. A particularly high degree of freedom in the shaping is achieved by the production of the roll stand by means of additive manufacturing, so that the quantity of material required for the roll stand can be reduced.

Additive manufacturing is understood in the present case to mean that a shape and/or design definition provided as a data set is successively built up by adding ultrasmall quantities of material according to the principle of "3D printing".

A roll in the meaning of the present invention is understood in particular as a unit accommodated rotatably in the roll stand, which moreover comprises a tool surface for executing the rolling procedure. In an advantageous construction, such a roll can be formed from a roll shaft and a roll body attached thereon as a tool. The roll body can preferably be formed as a replaceable component. The connection to the roll shaft can particularly preferably be produced by shrinking the roll body onto the roll shaft.

In a first embodiment of the invention, it is provided that the additive manufacturing takes place indirectly, wherein the roll stand is at least partially, preferably completely, formed as a cast part and a casting mold of the roll stand is directly produced by additive manufacturing. By way of this procedure, conventional, well-controllable casting methods for achieving a high material strength can be combined with expanded flexibility of the shaping. Preferred

Date reçue / Date received 2021-12-20

casting materials are steel or cast iron. Cast iron is particularly preferably used in the present case.

In a further embodiment of the invention, it is provided that the roll stand is at least partially, preferably completely, formed directly by additive manufacturing. This permits a maximum level of flexibility of the shaping, wherein a corresponding compatibility with the additive method has to exist with respect to the utilized material.

It is possible in particular to combine the above-explained methods, i.e., direct and indirect additive manufacturing, on the same roll stand.

Depending on the requirements, parts of the roll stand which are less critical with respect to strength and/or weight, can consist of conventional components, in particular standard semi-finished products such as plates.

In general, the invention advantageously relates to roll stands made of an iron-based material having a total mass of greater than 0.5 tons.

It is generally advantageously provided that the roll stand is formed to be a unit drivably movable in the course of a rolling procedure. In this case, it can particularly preferably be a cold Pilger roll stand.

In such movable roll stands, the achievable speed of the rolling procedure is predominantly dependent on the mass and strength of the roll stand, so that an optimized roll stand according to the invention permits an increase of the throughput. In particular, it is possible by way of the optimization according to the invention of cold Pilger roll stands to achieve an increase of the stroke rates during cold Pilger rolling of greater than 10%, in particular greater than 15%, wherein the mass of the roll stand at given rolling forces is reduced by more than 10% in relation to conventional roll stands.

In one preferred refinement, it is provided in this case that at least one crank pin for moving the roll stand is accommodated on the roll stand, wherein the crank pin is particularly preferably not formed by means of additive manufacturing. This permits a particularly resilient design of the crank pin or also the design as a replaceable wearing part. In an

Date Reçue/Date Received 2020-05-05

alternative embodiment, the crank pin can also be formed by means of additive manufacturing, however.

In one generally advantageous embodiment, it is provided that the roll stand comprises two stand sides, wherein the rolls extend between the stand sides and are mounted in the stand sides. In this case, the stand sides are particularly preferably integrally connected to one another by transverse struts made of uniform material, wherein the transverse struts are produced jointly with the stand side by means of additive manufacturing. This permits a particularly high level of rigidity of the roll stand at low weight.

It is generally preferably provided that a shape of the roll stand is optimized with regard to mass and/or strength by means of a computer optimization using the finite element method. This permits an ideal combination with the advantages of additive manufacturing.

The object of the invention is moreover achieved by a method for improving an existing roll stand, comprising the following steps:

a. recording framework parameters of an existing roll stand;

b. designing a roll stand optimized with respect to at least one property, preferably mass and/or strength, while maintaining the framework parameters recorded in step a.;

c. manufacturing a new roll stand by means of additive manufacturing, preferably as claimed in any one of the preceding claims,

d. replacing the existing roll stand with the new roll stand.

In this manner, an existing cold Pilger rolling mill can be increased in its performance. The new roll stand can be lighter and/or stronger than the existing roll stand due to corresponding optimization, so that after replacement of the roll stands, for example, a higher stroke rate can be used. This permits the improvement of the productivity of existing mills at relatively low costs.

According to an embodiment, there is provided a roll stand, wherein at least two rolls for forming a workpiece are accommodated in the stand, and wherein a rolling force acting during

Date reçue / Date received 2021-12-20

the forming is supported by the roll stand, wherein the roll stand is produced by means of additive manufacturing, wherein the additive manufacturing is performed indirectly, wherein the roll stand is formed at least partially as a cast part and a casting mold of the roll stand is produced directly by additive manufacturing, or wherein the roll stand is formed at least partially directly by additive manufacturing, wherein the roll stand is formed as a unit which is drivably movable in a course of a rolling procedure, and wherein the roll stand is formed as a cold pilger roll stand.

According to another embodiment, there is provided a method for improving an existing rolling mill, comprising the following steps: a. recording framework parameters of an existing roll stand; b. designing a roll stand optimized with respect to at least one property, in particular mass and/or strength, while maintaining the framework parameters recorded in step a.; c. manufacturing a new roll stand as described herein by means of additive manufacturing; d. replacing the existing roll stand with the new roll stand.

According to another embodiment, there is provided a method for the production of a rolling stand, wherein at least two rolls for forming a workpiece are accommodated in the stand, and wherein a rolling force acting during the forming is supported by the roll stand, wherein the roll stand is produced by means of additive manufacturing, wherein the additive manufacturing is performed indirectly, wherein the roll stand is formed at least partially as a cast part and a casting mold of the roll stand is produced directly by additive manufacturing; or wherein the roll stand is formed at least partially, directly by additive manufacturing.

A preferred exemplary embodiment of the invention will be described hereafter and explained in greater detail on the basis of the appended drawings.

Fig. 1 shows a three-dimensional view of a cold Pilger roll stand having installed rolls according to the prior art.

Date reçue / Date received 2021-12-20

Fig. 2 shows a three-dimensional view of a cold Pilger roll stand according to the invention, which can replace the roll stand from Fig. 1.

Fig. 3 shows a further three-dimensional view of the roll stand from Fig. 2.

Fig. 4 shows a view from the side of the roll stand from Fig. 2.

Fig. 5 shows a further three-dimensional view of the roll stand from Fig. 2.

The previously known roll stand shown in Fig. 1 of a cold Pilger rolling device comprises two stand sides 1', 2', which are assembled by a number of separate connecting bolts 3 to form a stand. The roll stand is drivably movable as a whole, wherein retaining elements for the movable mounting on a stationary rail system (not shown) are provided in a lower region. Connecting rods of a drive unit (not shown) engage on bearings 5 to drive the roll stand. The bearings 5 are accommodated on crank pins 6, which are in turn fixed in receptacles 6a in the stand sides 1', 2'. The roll stand is alternately moved translationally at a defined stroke frequency by the connecting rods.

At least two rolls 7, 8 are accommodated or mounted in the stand sides 1', 2'. A rotation of the two rolls 7, 8 is coupled via gear wheels 9 and stationary toothed racks (not shown) to the translational movement of the roll stand

A tubular workpiece (not shown) runs between the rolls 7, 8 and over a mandrel (not shown). Forming according to the cold Pilger rolling method is performed in a known manner by the alternating movement of the roll stand in conjunction with a corresponding guide of the workpiece. In this case, the rolling force occurring between the rolls 7, 8 is supported by the roll stand 1', 2', 3.

In the present example, the previously known roll stand 1', 2', 3 (without rolls and further fittings) has a mass of approximately 890 kg. The alternating movement takes place at a maximum stroke frequency of 200 strokes per minute.

Fig. 2 to Fig. 5 show a roll stand 10 according to the invention made of cast iron. The shape of this roll stand 10 was optimized on a computer with aid of the finite element method to minimize the mass of the stand at given strength.

Date Reçue/Date Received 2020-05-05

Known framework data for the dimensions and minimum strengths of the previously known roll stand 1', 2', 3 were the starting point for the optimization. The shape of the stand was then optimized by means of the finite element method. One criterion in the optimization was that the stand is supposed to be castable in principle, nearly complete design freedom prevailed in the production of the casting mode with respect to undercuts, etc.

As a specification, the achievable stroke frequency was increased to 250 strokes per minute. This required a reinforced design, in particular of the regions around the crank pins 6.
The production of the computed stand according to Fig. 2 through Fig. 5 was then performed via indirect additive manufacturing. In this case, the casting mold was produced by a facility for 3D printing by additive manufacturing. The roll stand 10 was then cast by means of this additively manufactured casting mold. In the present case, cast iron was used as the casting material.

The roll stand 10 manufactured in this manner had a mass of approximately 800 kg and increased strength in spite of the stroke frequency, which was increased to 250 strokes per minute.

According to a method according to the invention for improving existing rolling mills, the existing stand 1, 2, 3 shown in Fig. 1 of an existing rolling mill in operation was replaced by the new stand 10. Because of the reduced stand mass, this generally permitted an increase of the stroke frequency of the rolling mill, without the drive device having to experience significant modifications.

The crank pins 6 are also provided in the additively manufactured roll stand 10 as separate components which are fixed in receptacles 6a. These crank pins and the receptacles 6a thereof are among the most strongly mechanically strained points of the roll stand. The shaping ascertained by the finite element method resulted in a bionic shaping of the roll stand 10 having many rounded regions. In particular critical points such as the region around the receptacles 6a of the crank pins 6 are relatively reinforced in this case. In less critical regions, it was possible to thin out and save the stand material.

In contrast to the conventional roll stand 1', 2', 3, stand sides 1, 2 of the roll stand 10 according to the invention are connected by means of integrally formed transverse struts 11

Date Reçue/Date Received 2020-05-05

made of uniform material. The transverse struts 11 are produced together with the stand size 1, 2 by the (indirect) additive manufacturing and/or by the casting procedure.

The rolls 7, 8 are understood in the present case as a unit rotatably accommodated in the roll stand 10, which is formed from a roll shaft and a roll body (not shown) attached thereon. A tool surface for executing the rolling procedure is formed by the roll body as a tool. The roll body is formed as a replaceable component. The connection to the roll shaft is produced in the present case by shrinking of the roll body onto the roll shaft. If the roll body is detached from the roll shaft, the roll shaft can be removed laterally from the roll stand 10. It is thus not necessary to separate the stand sides 1, 2.

It is obvious that the above-described roll stand can also be produced by direct additive manufacturing. The properties of the additively joined stand material are to be taken into consideration accordingly in the computed shaping.

Date Reçue/Date Received 2020-05-05

List of reference signs

1'	first stand side of prior art
1	first stand side according to the invention
2'	second stand side of prior art
2	second stand side according to the invention
3	connecting bolt
4	retaining element
5	bearing for drive unit
6	crank pin
6a	receptacle for crank pin
7	first roll
8	second roll
9	gear wheel for roll drive
10	additively manufactured roll stand
11	integral transverse struts made of uniform material

Date Reçue/Date Received 2020-05-05

CLAIMS:

1. A roll stand, wherein at least two rolls for forming a workpiece are accommodated in the stand, and
wherein a rolling force acting during the forming is supported by the roll stand,
wherein the roll stand is produced by means of additive manufacturing,
wherein the additive manufacturing is performed indirectly, wherein the roll stand is formed at least partially as a cast part and a casting mold of the roll stand is produced directly by additive manufacturing, or
wherein the roll stand is formed at least partially directly by additive manufacturing,
wherein the roll stand is formed as a unit which is drivably movable in a course of a rolling procedure, and
wherein the roll stand is formed as a cold pilger roll stand.

2. The roll stand as claimed in claim 1, wherein at least one crank pin for moving the roll stand is accommodated on the roll stand.

3. The roll stand as claimed in claim 2, wherein the crank pin is formed by means other than additive manufacturing.

4. The roll stand as claimed in any one of claims 1 to 3, wherein the roll stand comprises two stand sides, wherein the at least two rolls extend between the stand sides and are mounted in the stand sides.

5. The roll stand as claimed in claim 4, wherein the stand sides are integrally interconnected by transverse struts made of a uniform material, wherein the transverse struts are produced jointly with the stand sides by means of additive manufacturing.

6. The roll stand as claimed in any one of claims 1 to 5, wherein a shape of the roll stand is optimized with regard to mass and/or strength by means of a computer optimization using the finite element method.

Date reçue / Date received 2021-12-20

7. The roll stand as claimed in any one of claims 1 to 6, wherein the roll stand is formed completely as a cast part or completely directly by additive manufacturing.

8. A method for improving an existing rolling mill, comprising the following steps:

a. recording framework parameters of an existing roll stand;

b. designing a roll stand optimized with respect to at least one property, in particular mass and/or strength, while maintaining the framework parameters recorded in step a.;

c. manufacturing a new roll stand as claimed in any one of claims 1 to 7 by means of additive manufacturing;

d. replacing the existing roll stand with the new roll stand.

9. A method for the production of a rolling stand,
wherein at least two rolls for forming a workpiece are accommodated in the stand, and
wherein a rolling force acting during the forming is supported by the roll stand,
wherein the roll stand is produced by means of additive manufacturing,
wherein the additive manufacturing is performed indirectly, wherein the roll stand is formed at least partially as a cast part and a casting mold of the roll stand is produced directly by additive manufacturing; or
wherein the roll stand is formed at least partially, directly by additive manufacturing.

10. The method as claimed in claim 9, wherein the roll stand is formed completely as a cast part or completely directly by additive manufacturing.

Date reçue / Date received 2021-12-20

FIGURES

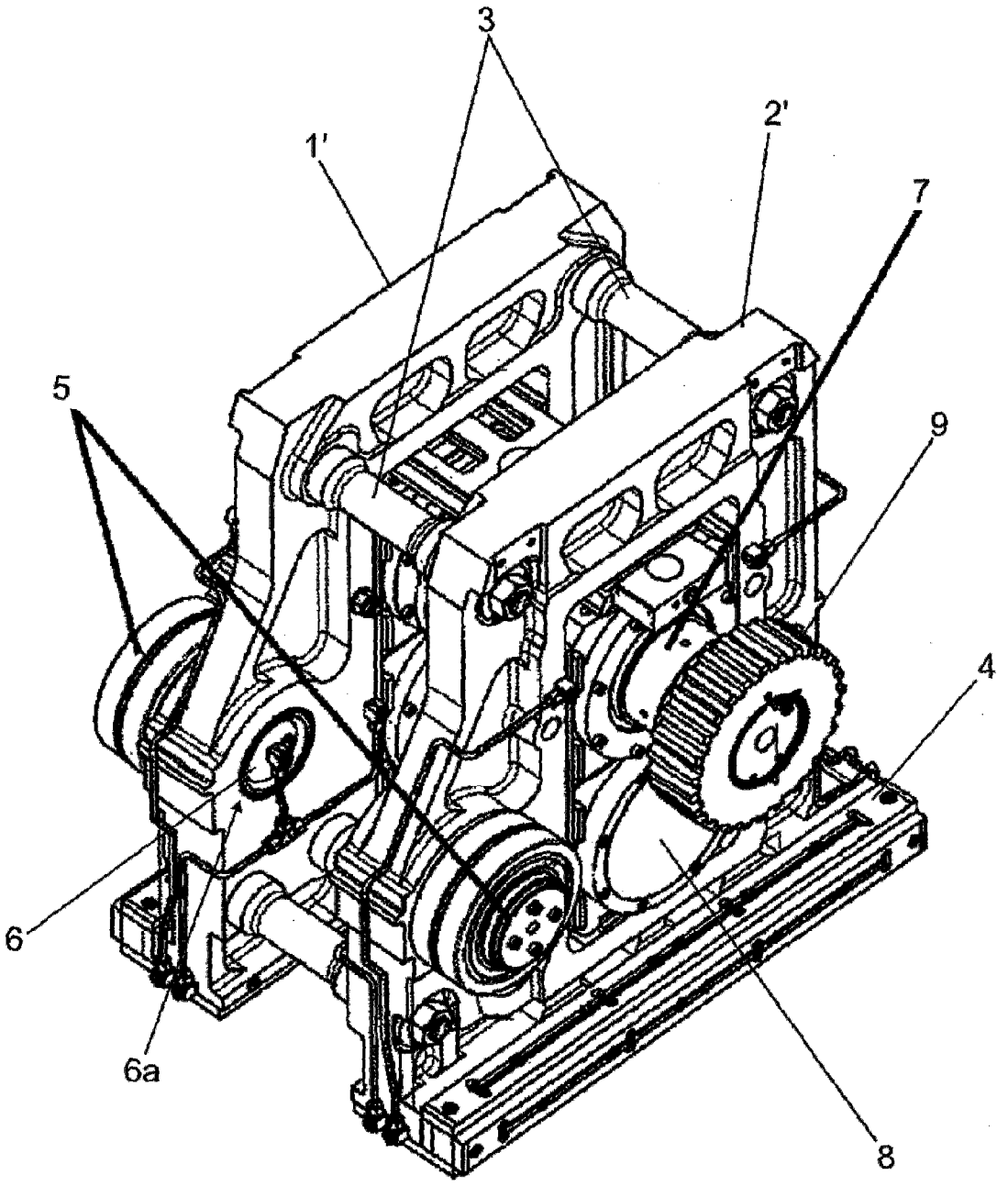


Fig. 1

Date Reçue/Date Received 2020-05-05

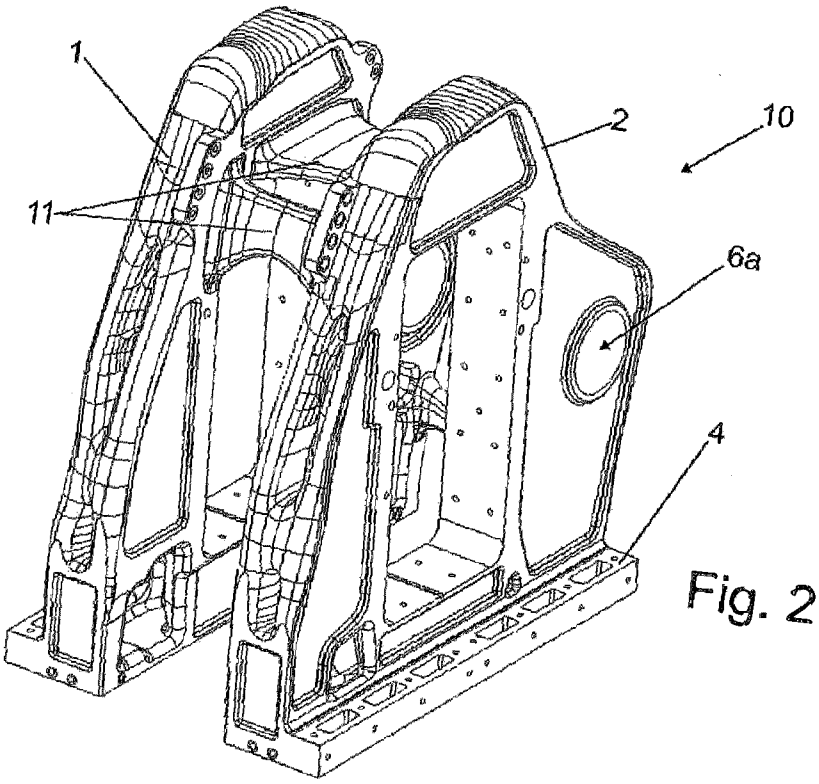


Fig. 2

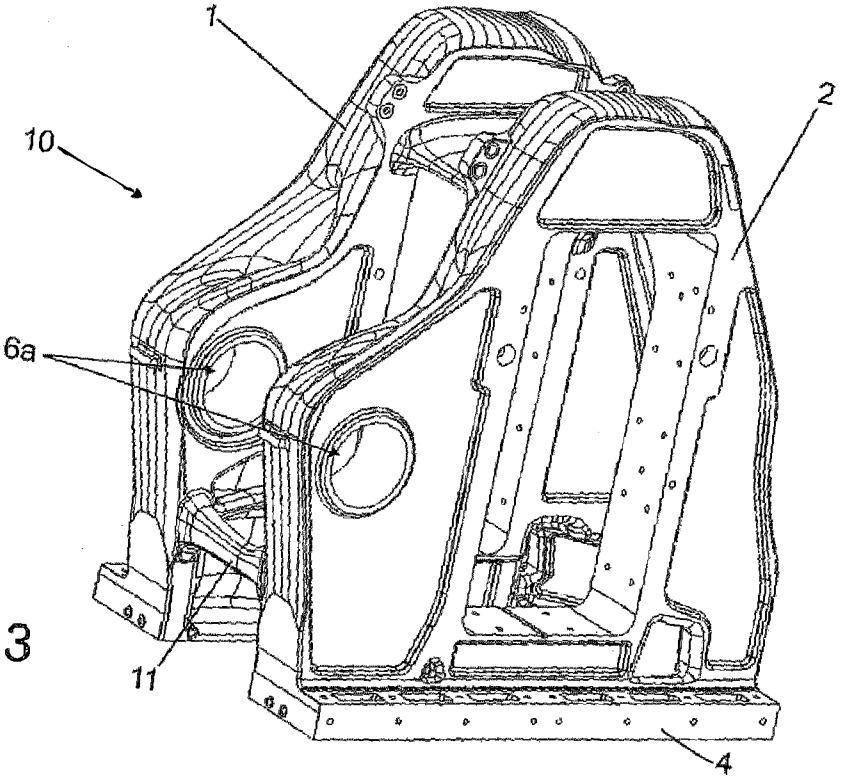


Fig. 3

Date Reçue/Date Received 2020-05-05

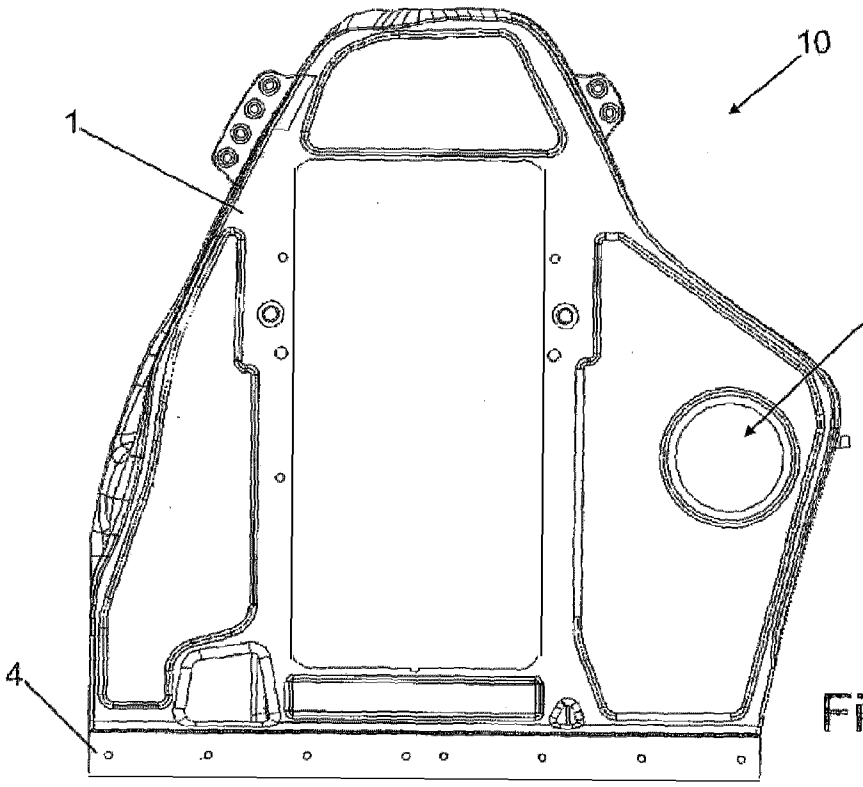


Fig. 4

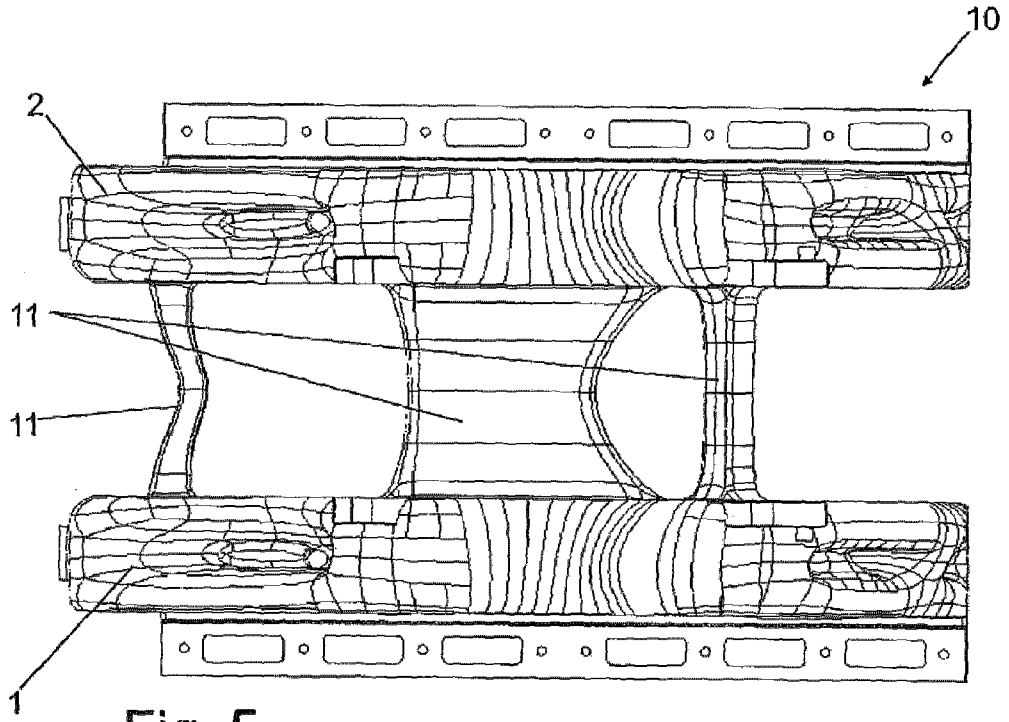
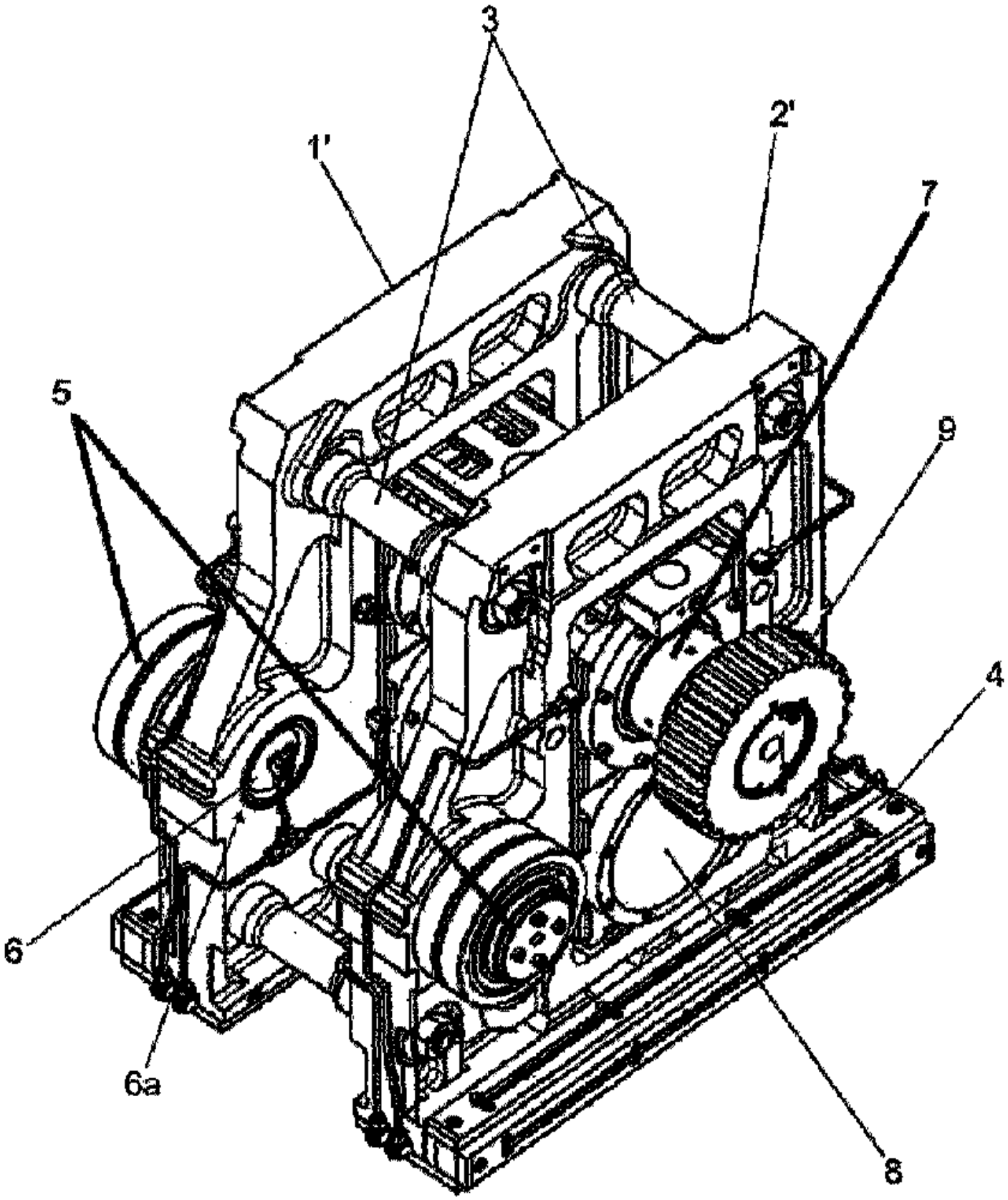


Fig. 5

Date Reçue/Date Received 2020-05-05


3
1'
2'
7
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9
4
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6a
8