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(71) Applicant: **FTAProcessing, s.r.o.**
720 00 Ostrava, Hrabová (CZ)

(72) Inventors:
- **Radev, Radoslav**
  724 00 Ostrava (CZ)
- **Bocek, Jaromir**
  724 00 Ostrava (CZ)

(74) Representative: **Musil, Dobroslav**
Zabrdovicka 801/11
615 00 Brno (CZ)

(54) METHOD OF EMBEDDING SOLID METAL PARTICLES INTO THE MELT DURING THE MELTING OF METALS AND A DEVICE FOR PERFORMING IT

(57) The invention relates to a method of embedding (immersing) solid metal particles into the melt during the melting of metals, in which the melt flow is directed into a continuous curve, and solid melt particles are placed on the melt surface in the continuous curve, whereupon the curved melt with the solid particles is conveyed back to the melting furnace. The invention consists in that after the solid metal particles have been added to its surface and before the melt is taken to the melting furnace, the continuous curved flow of the melt is guided onto a barrier to disrupt the continuous curved flow of the melt.

The invention also relates to a device for immersing solid metal particles during the melting of metals comprising a melt inlet conduit (1) which is adjoined by a melt drive conduit (5) which is associated with a drive melt device, whereby the melt drive conduit (5) opens into a feed chamber (6) with a curved rear wall (63) and a melt outlet conduit (2) leads out of the feed chamber (6). The rear wall (63) of the feed chamber (6) is on the side facing away from the drive conduit (5) provided with a projection (62) extending into the free space of the feed chamber (6).

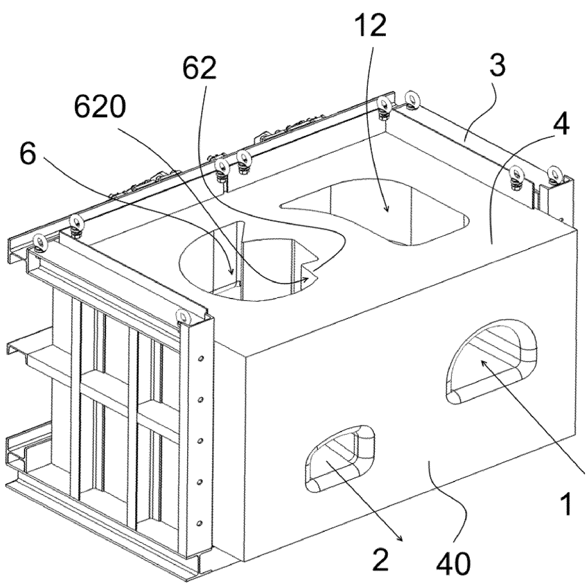

Fig. 5

EP 3 553 441 A1

Description

Technical field

[0001] The invention relates to a method of embedding (immersing) solid metal particles into the melt during the melting of metals, in which the melt flow is directed into a continuous curve, and in this continuous curve the solid melt particles are added to its surface, whereupon the curved melt with the solid particles is taken back to the melting furnace.

[0002] The invention also relates to a device for immersing solid metal particles into a melt during the melting of metals comprising a melt inlet conduit which is adjoined by a melt drive conduit which is associated with a drive melt device, whereby the melt drive conduit opens into a feed chamber with a curved rear wall and a melt outlet conduit is led out of the feed chamber.

Background art

[0003] In the melting of metals, especially in the so-called secondary metallurgy in which also sources of metal from secondary raw materials are used to melt, such as waste products of processing, e.g. metal shavings, metal chips, etc., these raw materials are added into the metal melt in the form of solid metal particles. As a rule, these solid metal particles are relatively small and due to the surface properties of the metal melt take a while to immerse (embed, plunge) into the melt volume. During the immersing of such solid metal particles, these relatively small added particles begin to burn before immersing into the melt, and, consequently, part of such particles deteriorate by burning instead of melting in the melt. The problem of burning, etc., when immersing the added particles into the melt is aggravated by the fact that in the preceding processing of the metal from which the added metal particles originate, e.g. machining, a number of auxiliary substances, such as cutting fluids, containing flammable and combustible materials are used. Since it is not possible or not economically or ecologically advantageous or suitable to use this proportion of added particles completely without the auxiliary substances from the preceding processing, these auxiliary substances get to the process of adding particles to the melt and increase the flammability of the added metal particles, etc., thereby further reducing the efficiency of adding such solid metal particles to the melt.

[0004] Various methods are used to add solid metal particles to the melt, such as adding solid particles directly to the melting charge or adding solid particles to the melt flow during its mixing, etc. Known is also a method of adding solid particles by loosely pouring these particles into a cylindrical feed chamber which is incorporated into a plurality of conduits through which the melt flows in an electromagnetic melt mixer.

[0005] The electromagnetic melt mixer is a non-contact melt mixer, where the motion of the melt occurs due to the use of magnetohydrodynamic phenomena in the liquid metal which are induced by an external time and space varying electromagnetic field. As a result, eddy currents are induced in the electrically conductive melt, the interaction of which with the excitation magnetic field generates force effects acting on the melt particles. These effects are then utilized for streamlined melt flow. At present, such technologies applying electromagnetic mixing of molten metals are already common and are used to homogenize various metal alloys as well as pure metals during their melting and casting, wherein the melt motion positively affects the metallurgical structure of the cast.

[0006] Electromagnetic melt mixing technology uses the principle of an induction motor, where a harmonic current of a selected frequency flows through the inductor, thereby exciting a time varying magnetic field, the eddy currents in the melt having the opposite direction to the excitation current in the inductor. The forces induced by the interaction of the magnetic field and the eddy currents on the molten metal particles then cause the metal (melt) to move through a conduit which is by its inlet and outlet assigned to the melt volume in the melting furnace, whereby this conduit is associated with the above-mentioned inductor. From a structural point of view, such a device constitutes an electric motor whose stator is formed by the above-mentioned inductor and whose rotor is molten metal.

[0007] The main disadvantage of the background art is the insufficiently rapid process of immersing the added solid metal particles into the melt and the resulting losses and other damage in the form of the burning of the added solid metal particles, etc.

Principle of the invention

[0008] The aim of the invention is achieved by a method of immersing solid metal particles into a melt during the melting of metals, whose principle consists in that a continuous curved flow of the melt is after the solid metal particles have been added to its surface and before the melt is taken to the melting furnace directed to a barrier to disrupt the continuous curved flow of the melt.

[0009] The principle of the device for immersing solid metal particles into the melt during the melting of metals consists in that the rear wall of a feed chamber is provided on the side facing away from a drive conduit of the melt with a projection directed to the free space of the feed chamber.

[0010] Using the present invention, the continuous melt flow is disrupted by the impact of the melt flow on a wall, which causes the melt carrying solid metal particles to sharply change the direction of its flow and the intensity of the melt mixing is increased in this area. At the same time, also surface waves and reflected waves of the melt occur, whereby these surface waves of the melt may even overlap each other, thereby increasing the intensity of the immersing of the solid metal particles into the melt and reducing the burning of these solid metal particles.

[0011] Preferred embodiments of the invention are the subject matter of the dependent claims and are described in more detail in exemplary embodiments of the invention.

Description of drawings

[0012] The invention is schematically represented in a drawing, wherein Fig. 0 shows a plan view of the melt flow according to the invention, Fig. Oa shows a detail of a front view of a wall disrupting the continuity of the curved melt flow according to the invention, Fig. 1 is an axonometric view of the front side of one embodiment of the device according to the invention, Fig. 2 is an axonometric view of the rear side of one embodiment of the device according to the invention, Fig. 3 is a front view of one embodiment of the device according to the invention, Fig. 4 shows one embodiment of the device according to the invention with an uncovered charge opening, Fig. 5 shows one embodiment of the device according to the invention with an uncovered upper side, Fig. 6 shows a melt conduit arrangement in a plan view of one embodiment of the device according to the invention, Fig. 7 is a horizontal cross-section through one embodiment of the device according to the invention in a plane above the upper portion of the melt inlet conduit, Fig. 8 is a horizontal cross-section through one embodiment of the device according to the invention in a plane which is above the upper portion of the melt inlet conduit, but closer to the melt inlet conduit than in Fig. 7, Figs. 9 and 9a represent two views from different directions showing a horizontal cross-section through one embodiment of the device according to the invention in a plane above the upper portion of the melt inlet conduit, Fig. 10 is a horizontal cross-sectional view of one embodiment of the device according to the invention in a plane below the lower portion of the melt inlet conduit, Fig. 11 is a horizontal cross-sectional view of one embodiment of the device according to the invention in a plane below the lower portion of the melt inlet conduit and in a plane of the upper portion of the melt outlet conduit, Fig. 12 is a horizontal cross-sectional view of one embodiment of the device according to the invention in a plane of the lower portion of the melt outlet conduit, Fig. 13 is a vertical longitudinal cross-section through one embodiment of the device according to the invention across the inlet and outlet conduits of the melt in a plane beyond the outlet and inlet openings of the conduits, Fig. 14 is a vertical longitudinal cross-section through one embodiment of the device according to the invention across the inlet and outlet conduits of the melt in a plane of the front end of the feed chamber, Fig. 15 is a vertical longitudinal cross-section through one embodiment of the device according to the invention in a plane from the front side of the device in front of a stirring projection of the feed chamber, Fig. 16 is a vertical longitudinal cross-section through one embodiment of the device according to the invention in a plane from the front side of the device behind the stirring projection of the feed chamber, Fig. 17 is a vertical longitudinal cross-section through one embodiment of the device according to the invention in a plane from the front side of the device before the end of the feed chamber, Fig. 18 is a vertical longitudinal cross-section through one embodiment of the device according to the invention at the level of the rear connecting conduit, Fig. 19 is a vertical cross-sectional view of a melt inlet conduit in one embodiment of the device according to the invention in the direction of the melt inlet conduit, Fig. 20 is a vertical cross-section through one embodiment of the device according to the invention at the level of the transition of the melt inlet conduit into a rear connecting conduit, Fig. 21 is a vertical cross-sectional view of one embodiment of the device according to the invention between the inlet and melt outlet conduits, Fig. 22 is a vertical cross-sectional view of one embodiment of the device according to the invention on the right edge of the melt outlet conduit and Fig. 23 is a vertical cross-sectional view of one embodiment of the device according to the invention through the middle section of the melt outlet conduit.

Examples of embodiment

[0013] The method of immersing solid metal particles into a melt during the melting of metals consists in that a melt flow is directed to form a curve and solid particles of the melt are placed on the melt surface in the curve, whereupon the melt flow with the solid particles is guided to a barrier (substantially a wall transversely arranged), which disrupts the direction of the continuous curve of the melt flow and causes increased melt swirl in this region, as well as shock melt waves on the wall and reflected melt waves from the wall, whereby these surface waves of the melt may even overlap each other, thereby increasing the intensity of the immersion of the solid metal particles into the melt and reducing the burning of these solid metal particles.

[0014] From an energy point of view, it is advantageous if the method of immersing solid metal particles into the melt during the melting of metals is carried out by contactless melt mixing, especially contactless electromagnetic melt mixing. In this embodiment of the method according to the invention, the melt from a melting furnace is sucked through an inlet conduit 1 into a drive conduit 5, where the melt is accelerated, whereupon the melt downstream of the conduit 5 is directed into a curve in which solid metal particles are introduced into the melt and subsequently the continuous curved flow of the melt is disrupted by the melt flow impacting the wall, whereby the melt carrying the solid metal particles sharply changes the direction of its flow and increases the intensity of the melt mixing in the region, and surface shock and reflected waves of the melt are formed. Subsequently, the melt is taken back to the melting furnace via the outlet conduit 2 below the level of the melt.

[0015] A device for performing this method of immersing solid metal particles into the melt during the melting of metals will be described with reference to an exemplary embodiment of a separate device which can be connected to a melting furnace. Obviously, the device can also be designed partially or fully integrated into the melting furnace.

[0016] The device according to the invention is integrated together with an electromagnetic melt mixing device in one whole, since it is advantageous for the purposes of the present invention to utilize the magnetic effects of the flowing melt immediately downstream of the electromagnetic melt mixing device. Apparently, the invention can be used also in other arrangements for melt mixing, i.e. without an electromagnetic melt mixing device.

[0017] The illustrated exemplary embodiment of the device according to the invention comprises a frame 3, in which a refractory part 4 is accommodated, in which hollow spaces (conduits, chambers, etc.) are provided for conveying the melt to an inductor 7 which ensures the movement of the melt and constitutes an active part of an electromagnetic melt mixing device. In the refractory part 4, is formed a melt inlet conduit 1 through the inlet opening 10 of which the melt is sucked from an unillustrated melting furnace and through which it is conveyed to a drive conduit 5 which adjoins the inlet conduit 1. The drive conduit 5 is associated with the inductor 7 of the electromagnetic melt mixing device. At its end, the drive conduit 5 enters the feed chamber 6 of the solid metal particles from which the melt outlet conduit 2 emerges, whereby the melt outlet conduit 2 opens with its outlet opening 20 back into the melting furnace. The feed chamber 6 is associated with a means for inserting solid metal particles into the melt, e.g., a filling hopper 60. Thus, the melt is sucked from the melting furnace into the inlet conduit 1 and is forced back from the outlet conduit 2 into the melting furnace, thereby mixing the melt in the melting furnace. In principle, the device according to the invention can be referred to as a melt pump.

[0018] In the illustrated embodiment, the inlet opening 10 of the inlet conduit 1 and the outlet opening 20 of the outlet conduit 2 are located on the same side of the refractory part 4, here on the front wall 40 of the refractory part 4, the inlet and outlet conduits 1, 2 being substantially parallel to each other.

[0019] The inlet and outlet conduits 1, 2 are arranged in a substantially horizontal direction, wherein the inlet conduit 1 is arranged vertically higher than the outlet conduit 2, i.e. the conduits 1, 2 are offset from each other. In the embodiment shown, the bottom 11 of the inlet conduit 1 is arranged substantially at the level of the ceiling 21 of the outlet conduit 2.

[0020] As shown in Figs. 4, 5, and some others, the inlet conduit 1 in the mass of the refractory part 4 is spaced apart from its inlet opening 10 which is upwards open, thus creating a free space 12. Beyond the free space 12, the inlet conduit 1 enters the drive conduit 5, which has a cross-section and a shape corresponding to the associated inductor 7, wherein the bottom 11 of the inlet conduit 1 directly adjoins the bottom 51 of the drive conduit, the side walls 53 of the drive conduit 5 adjoin the side walls of the inlet conduit 1 or the free space 12, and the ceiling wall 52 of the drive conduit 5 begins in the rear wall of the free space 12. The drive conduit 5 adjoins the inlet conduit 1 by a curved transition R1. In the exemplary embodiment shown, the inductor 7 is already assigned with its front part to the transition of the inlet conduit 1 into the drive conduit 5.

[0021] The drive conduit 5 opens with its curved outlet 54 into the feed chamber 6 which has a stepped bottom 61 which in its first portion 611 adjoins the bottom 51 of the drive conduit 5 and in its second portion 612 it lowers abruptly to the level of the bottom 21 of the outlet conduit 2. The side wall 6120 of this abrupt transition between the first and second portions 611, 612, the bottom 61 of the feed chamber 6 is also rounded so as not to disrupt the swirling flow of the melt in the area before entering the outlet conduit 2.

[0022] The feed chamber 6 has a curved rear wall 63 which smoothly adjoins the curved outlet 54 of the drive conduit 5, the main purpose of the curved rear wall 63 being to direct the melt flow into the circular flow direction in the feed chamber 6, which in combination with the melt outlet through the outlet conduit 2 adjoining in the lower portion of the feed chamber 6 results in the melt swirl formation.

[0023] The curved rear wall 63 of the feed chamber 6 is interrupted on the side of the feed chamber 6 facing away from the drive conduit 5 by a projection 62 extending into the free space of the feed chamber 6. In the exemplary embodiment shown, the projection 62 is in a plan view arranged in the area of the melt flow beyond the level of the melt outlet conduit 2, ideally along the entire height of the feed chamber 6 in this area. In an unillustrated exemplary embodiment, the projection 62 is in a plan view located in the area above the melt inlet conduit 2, or even in the area situated in a plan view in front of it.

[0024] The projection 62 comprises a front wall 620 projecting from the rear wall 63 of the feed chamber 6 and arranged substantially across the melt flow P along the rear wall 63 of the feed chamber 6. Thus, when flowing along the rear wall 63 of the feed chamber 6, the melt not only acquires a circular direction of flowing, etc., but in the respective portion of the path it substantially strikes the front wall 620 of the projection 62 and suddenly changes its flow direction, thereby significantly increasing the intensity of the melt mixing in this area, and forming even surface shock waves of the melt. If under these conditions solid metal particles are fed to the feed chamber 6, then all this contributes substantially to a considerably faster process of immersing the solid metal particles into the melt. Furthermore, it results in limiting remarkably the burning of these solid particles. Overall, it improves the efficiency of adding solid metal particles to the melt in comparison with the embodiments known in the art.

[0025] The second portion 612 of the bottom 61 of the feed chamber 6 is adjoined by the bottom 21 of the melt outlet conduit 2.

Claims

1. A method of immersing solid metal particles into the melt during the melting of metals, in which the melt flow is directed into a continuous curve, and in this continuous curve, solid melt particles are placed on the melt surface, whereupon the curved melt flow with the solid particles is conveyed back to the melting furnace, **characterized in that** after the solid metal particles have been placed on the melt surface and before the melt is conveyed to the melting furnace, the continuous curved flow of the melt is guided onto a barrier to disrupt the continuous curved flow of the melt.

2. The method according to claim 1, **characterized in that** the curved melt flow is formed downstream of a drive conduit of a melt mixing electromagnetic device.

3. A device for immersing solid metal particles during the melting of metals comprising a melt inlet conduit (1) which is adjoined by a melt drive conduit (5) which is associated with a drive melt device, whereby the melt drive conduit (5) opens into a feed chamber (6) with a curved rear wall (63) and a melt outlet conduit (2) leads out of the feed chamber (6), **characterized in that** the rear wall (63) of the feed chamber (6) is provided on the side facing away from the drive conduit (5) with a projection (62) extending into a free space of the feed chamber (6).

4. The device according to claim 3, **characterized in that** the projection (62) comprises a front side (620) projecting from the rear wall (63) of the feed chamber (6) and arranged substantially transversely to the melt flow (P) along the rear wall (63) of the feed chamber (6).

5. The device according to claim 3 or 4, **characterized in that** the projection (62) is in a plan view arranged in the area of the melt flow beyond the level of the melt outlet conduit (2).

6. The device according to claim 3 or 4, **characterized in that** the projection (62) is in a plan view arranged in the area of the melt flow above the melt outlet conduit (2).

7. The device according to any of claims 3 to 6, **characterized in that** the feed chamber (6) has a stepped bottom (61) which in its first portion (611) adjoins the bottom (51) of the drive conduit (5) and in its second portion (612) lowers abruptly to the level of the bottom (21) of the outlet conduit (2).

8. The device according to claim 7, **characterized in that** the abrupt transition between the first and second portions (611, 612) of the bottom (61) of the feed chamber (6) is formed by a rounded side wall (6120).

9. The device according to claim 7 or 8, **characterized in that** the bottom (11) of the melt inlet conduit (1) adjoins smoothly the bottom (51) of the melt drive conduit (5).

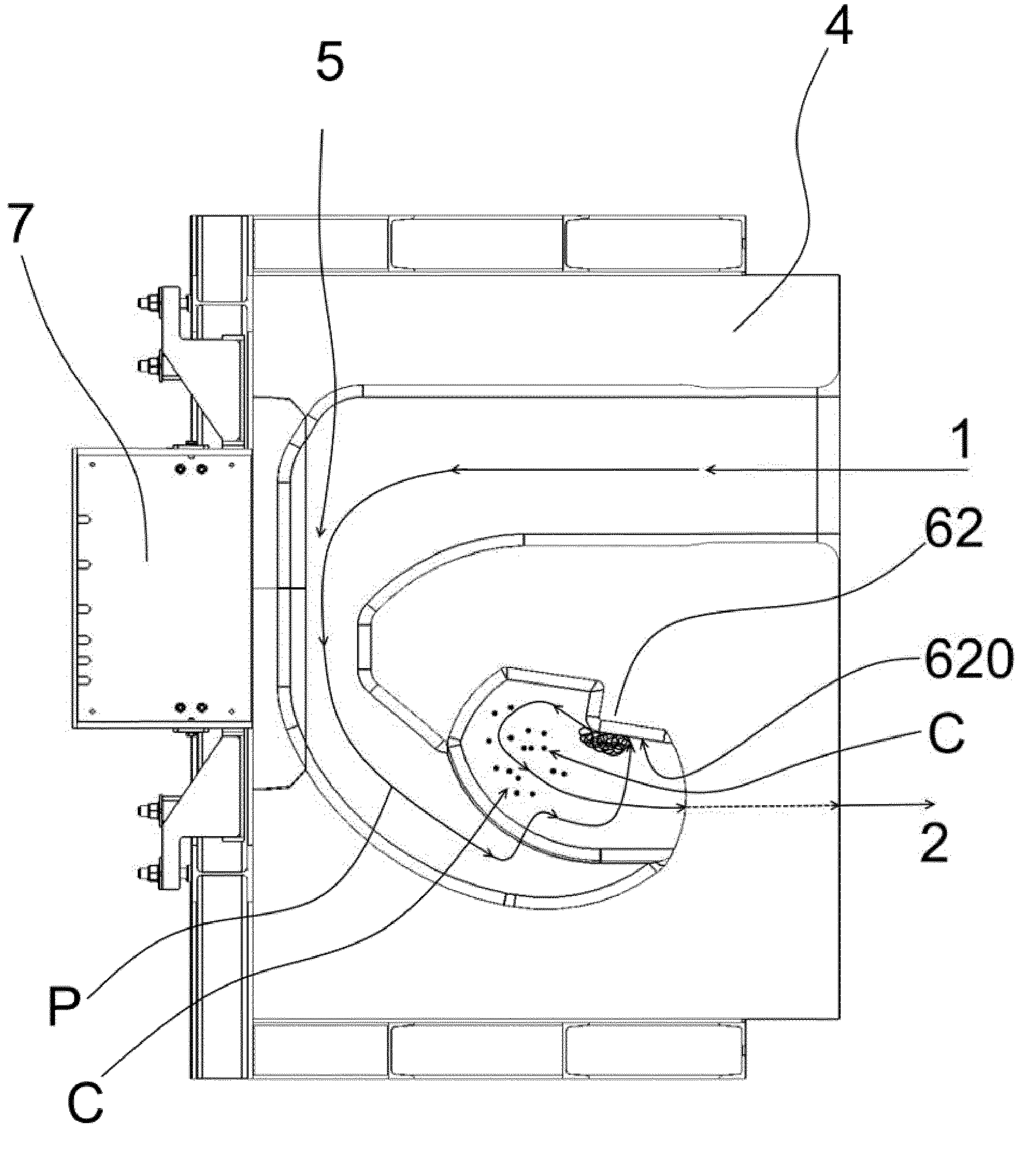

Fig. 0

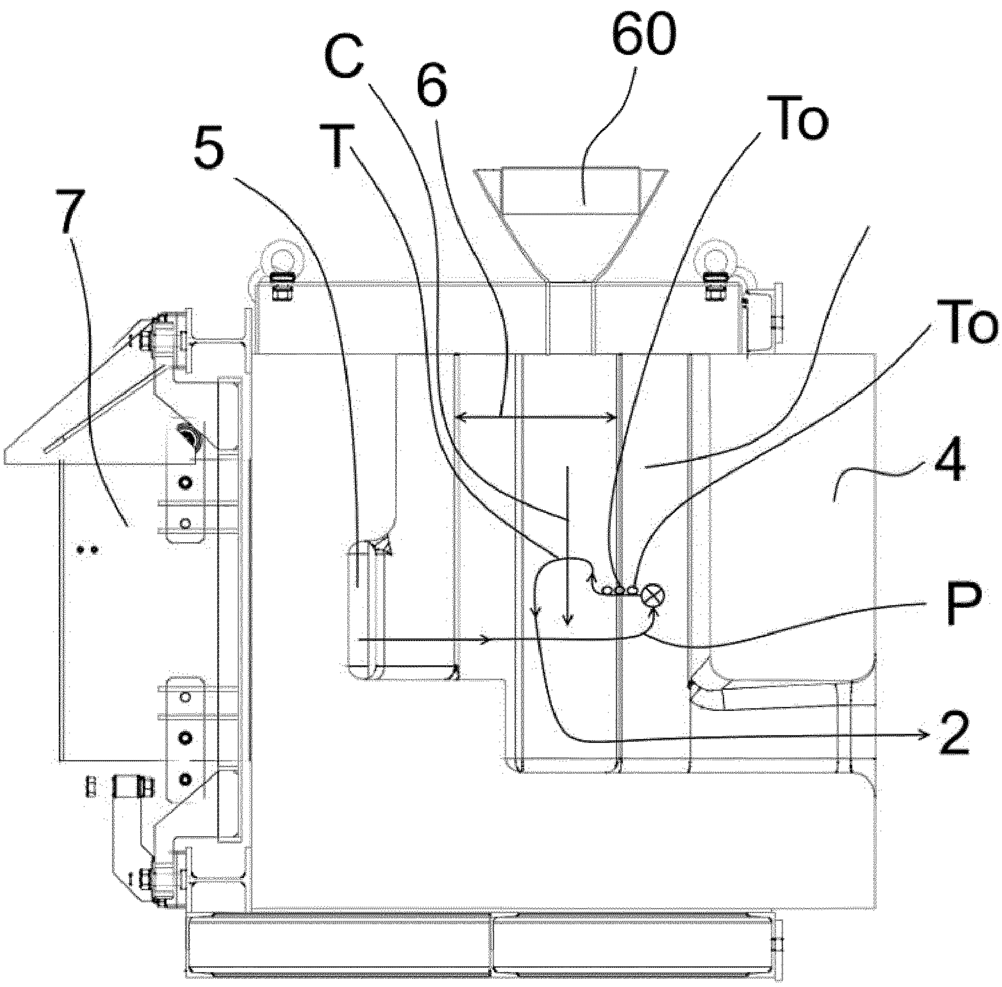

Fig. 0a

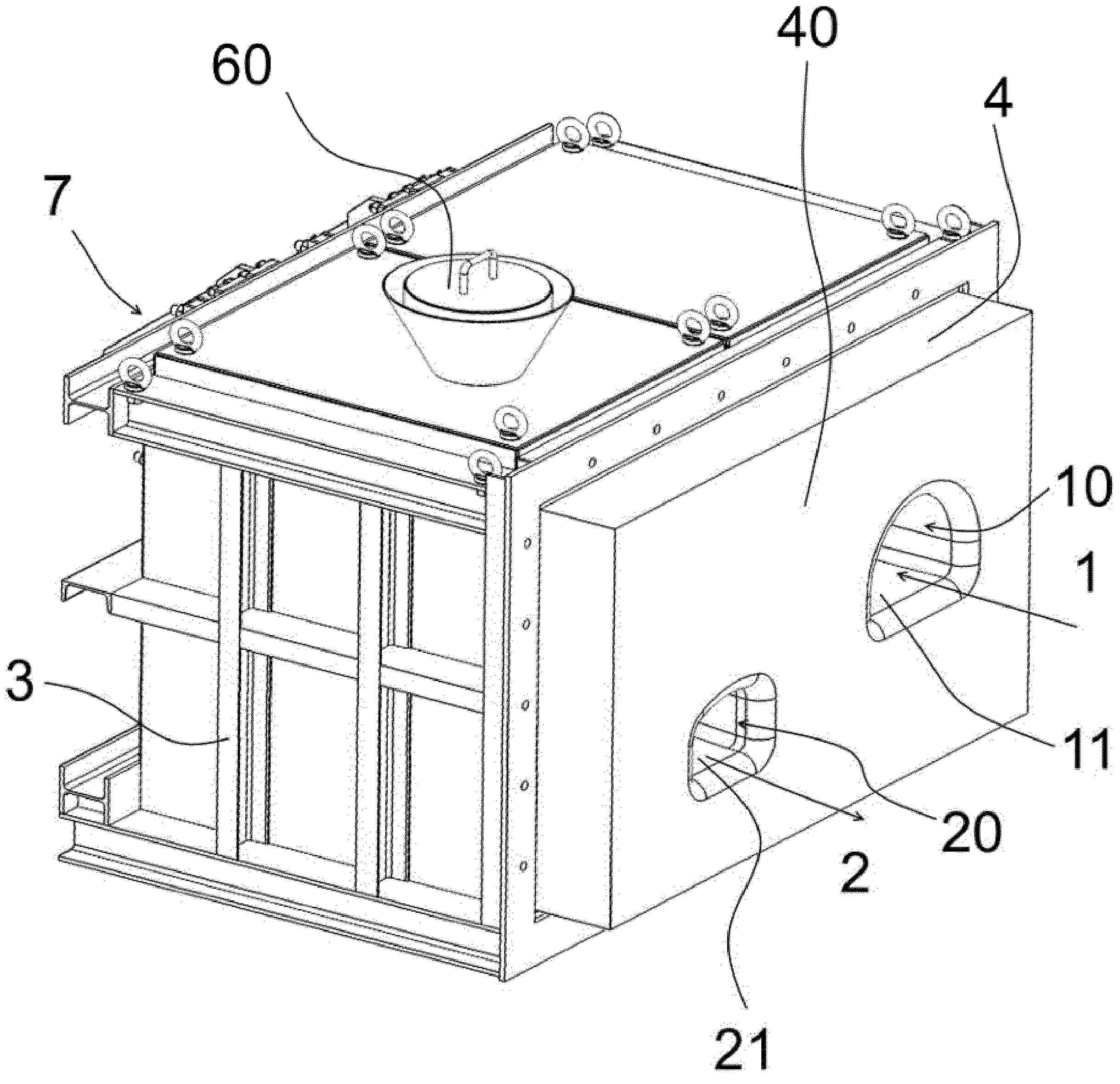

Fig. 1

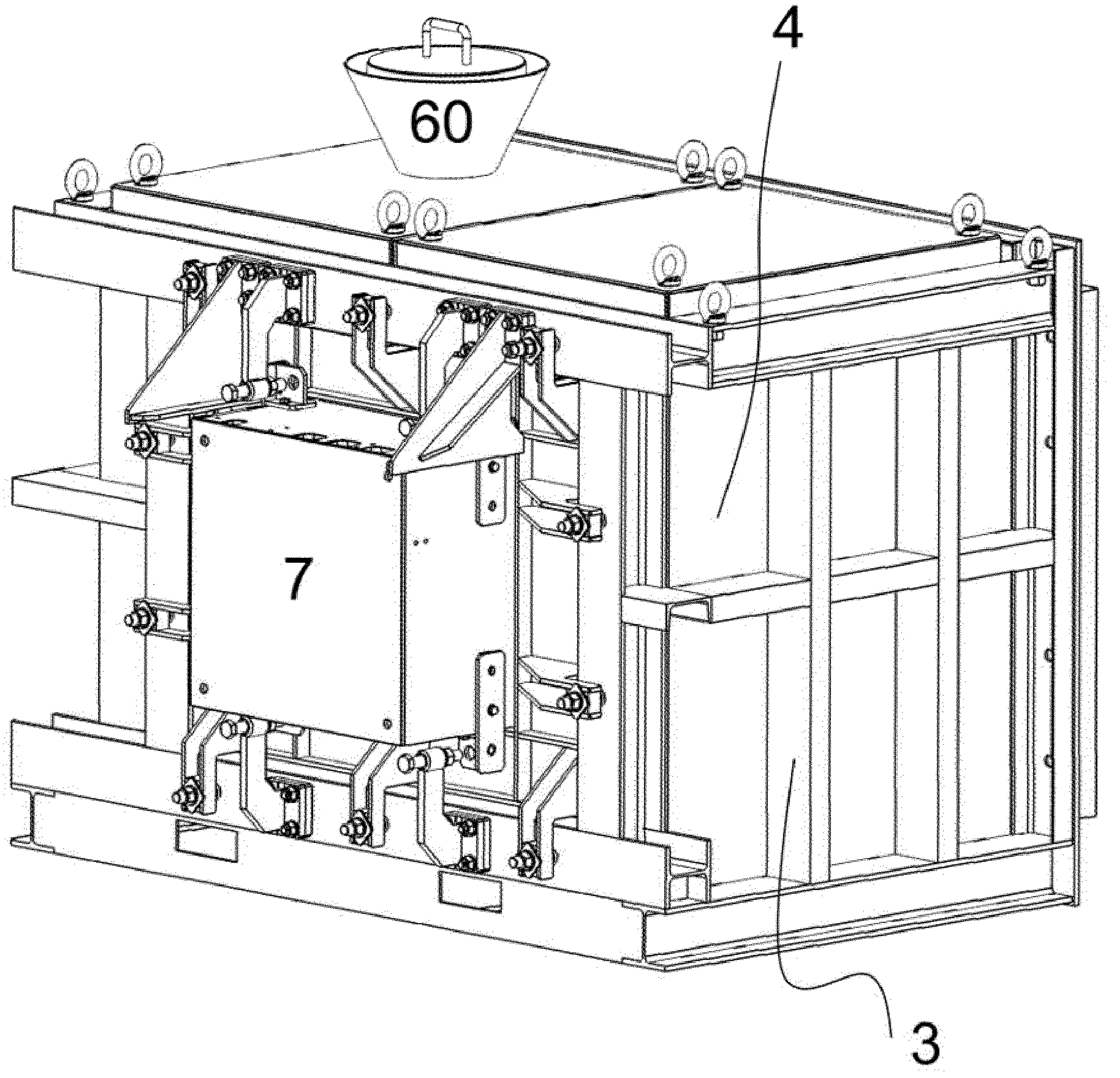

Fig. 2

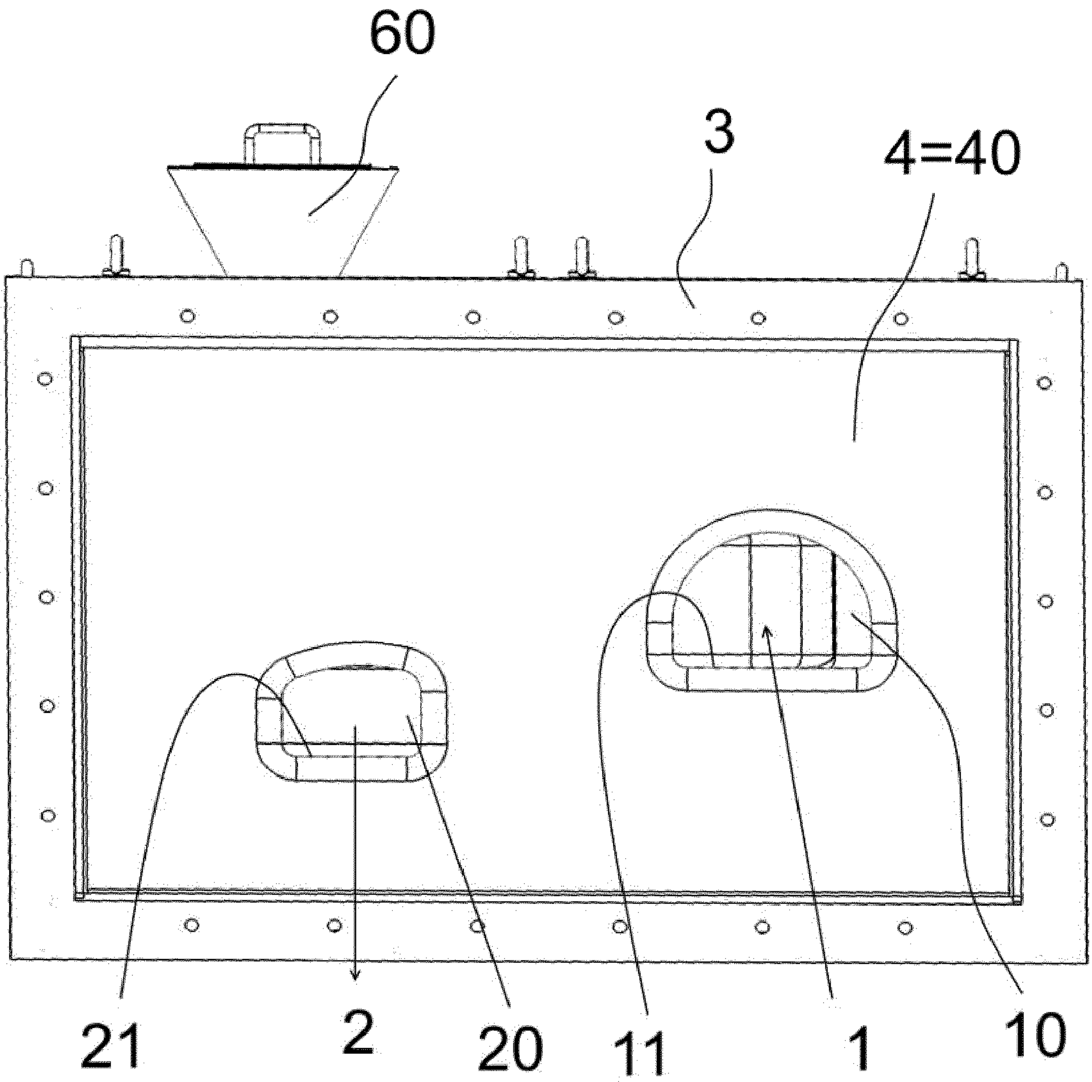

Fig. 3

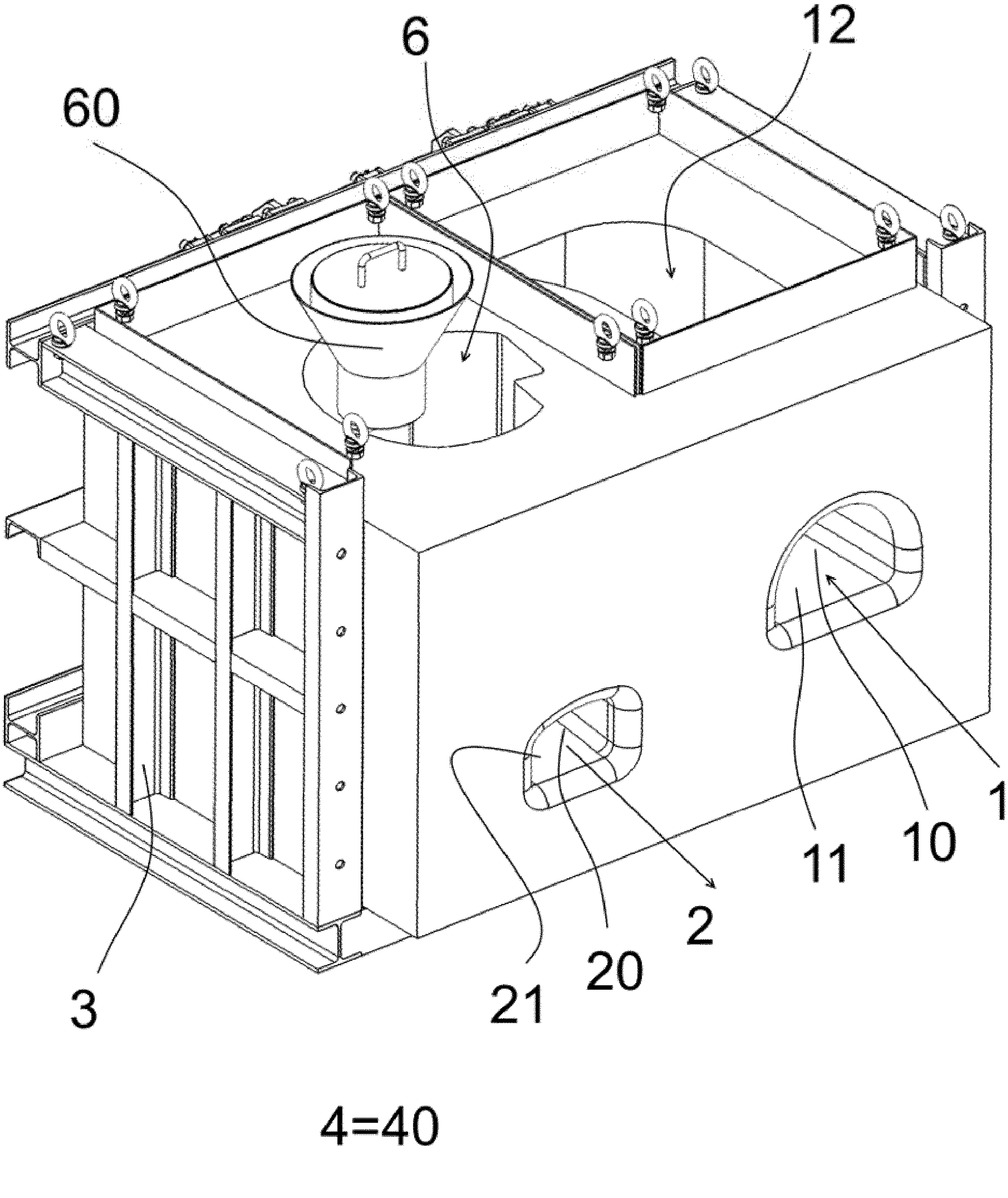

Fig. 4

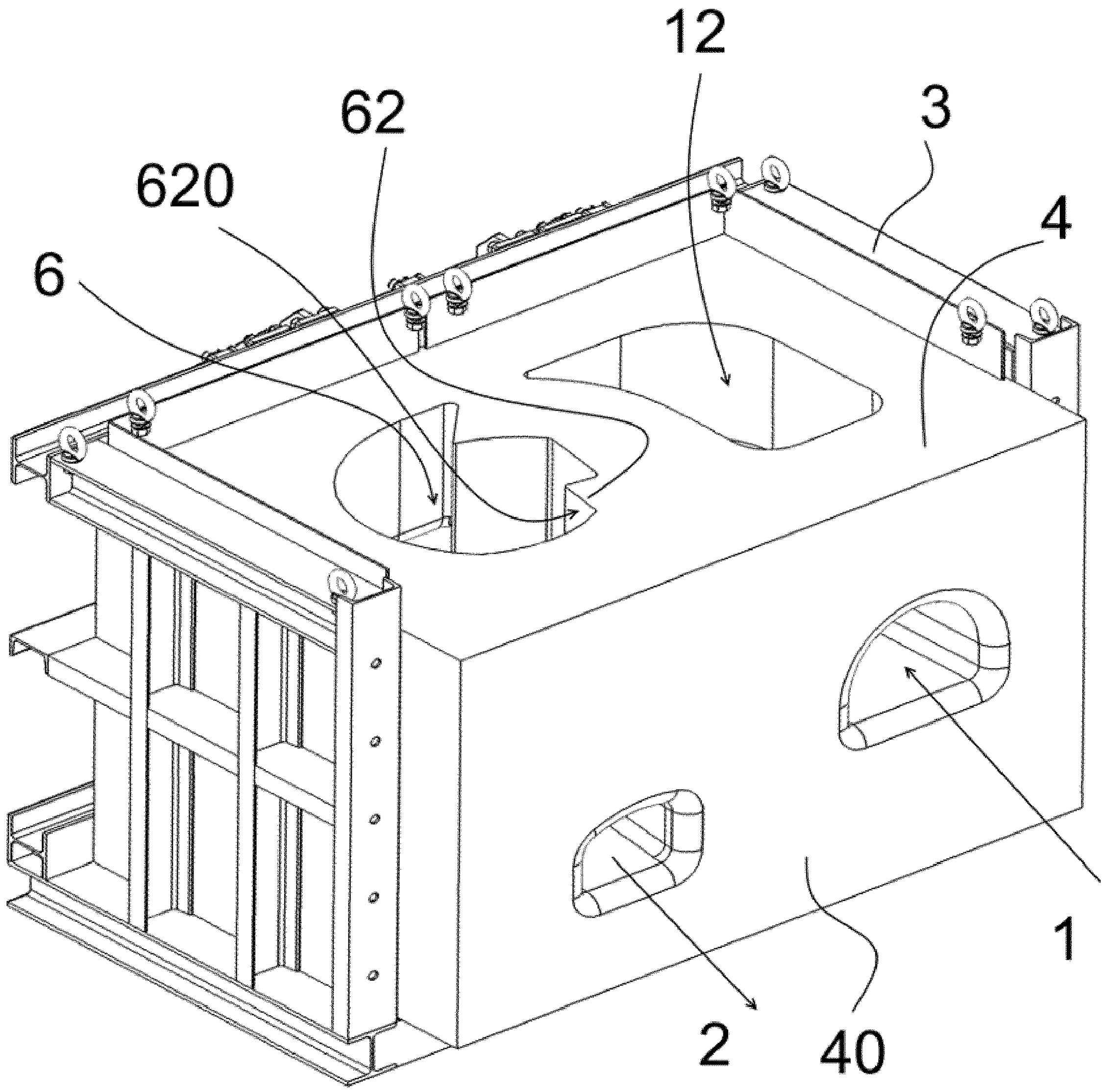

Fig. 5

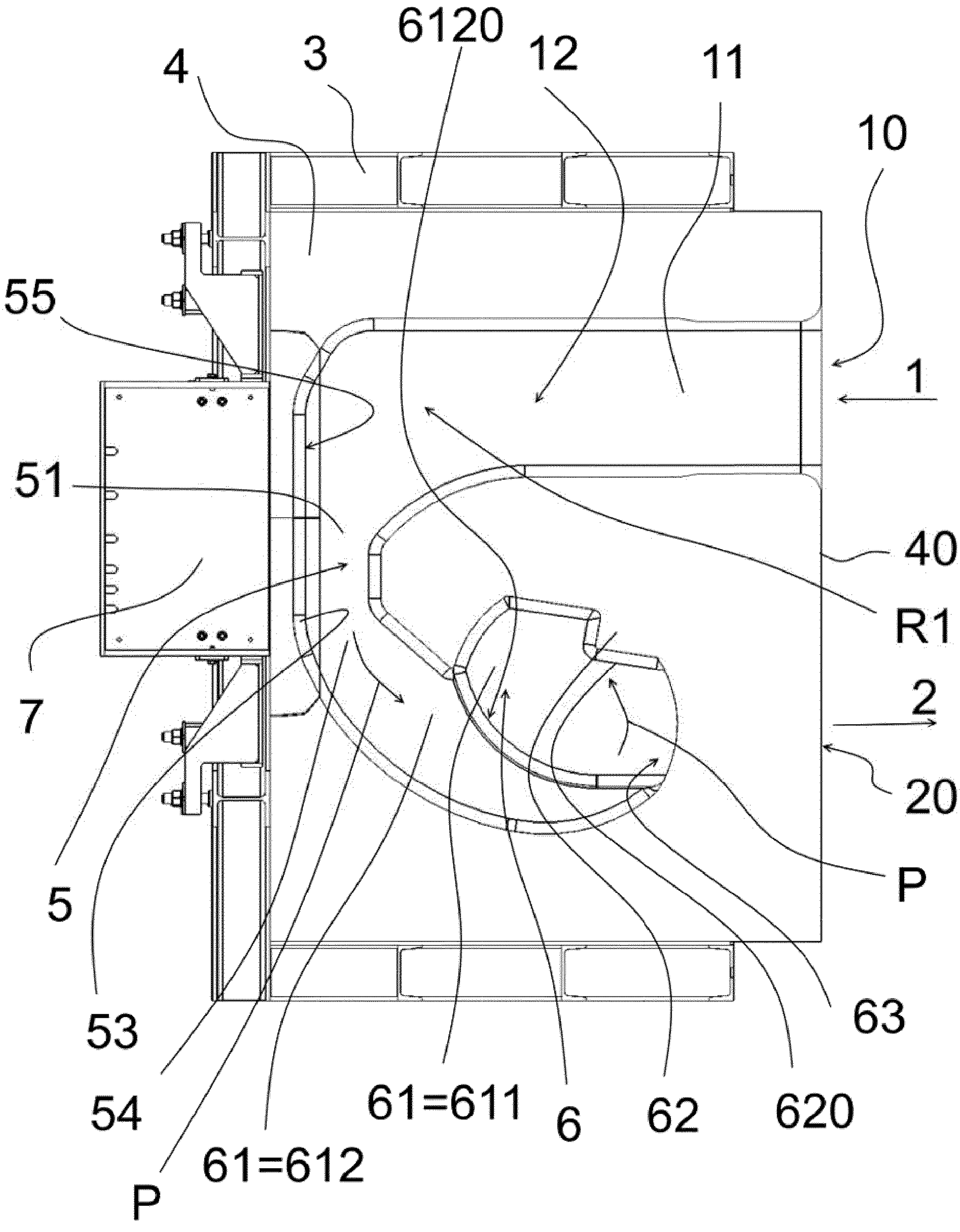
6120
3
4
12
11
10
55
1
51
40
R1
7
2
20
5
P
53
63
54
61=611
6
62
620
P
61=612

Fig. 6

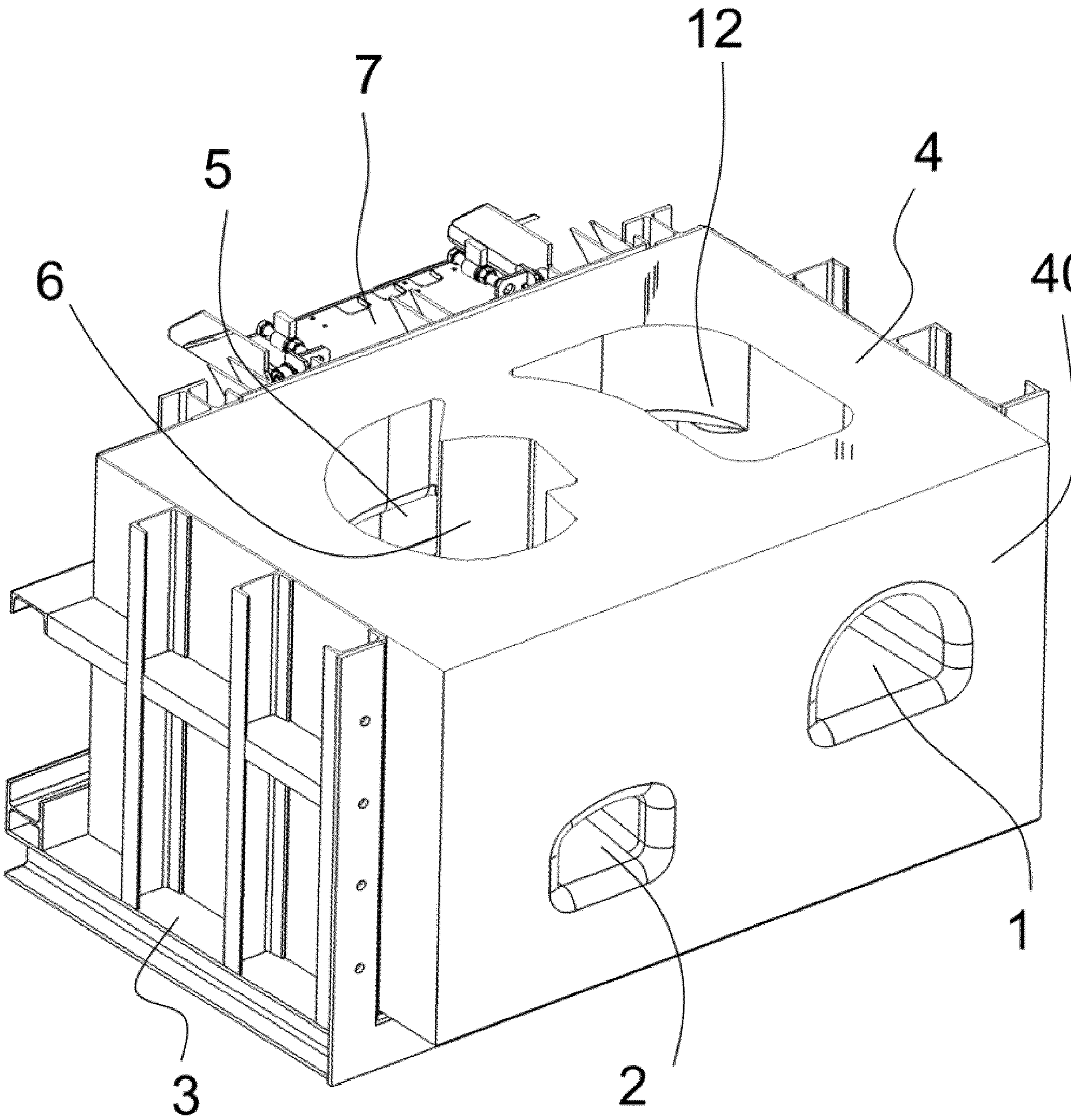

Fig. 7

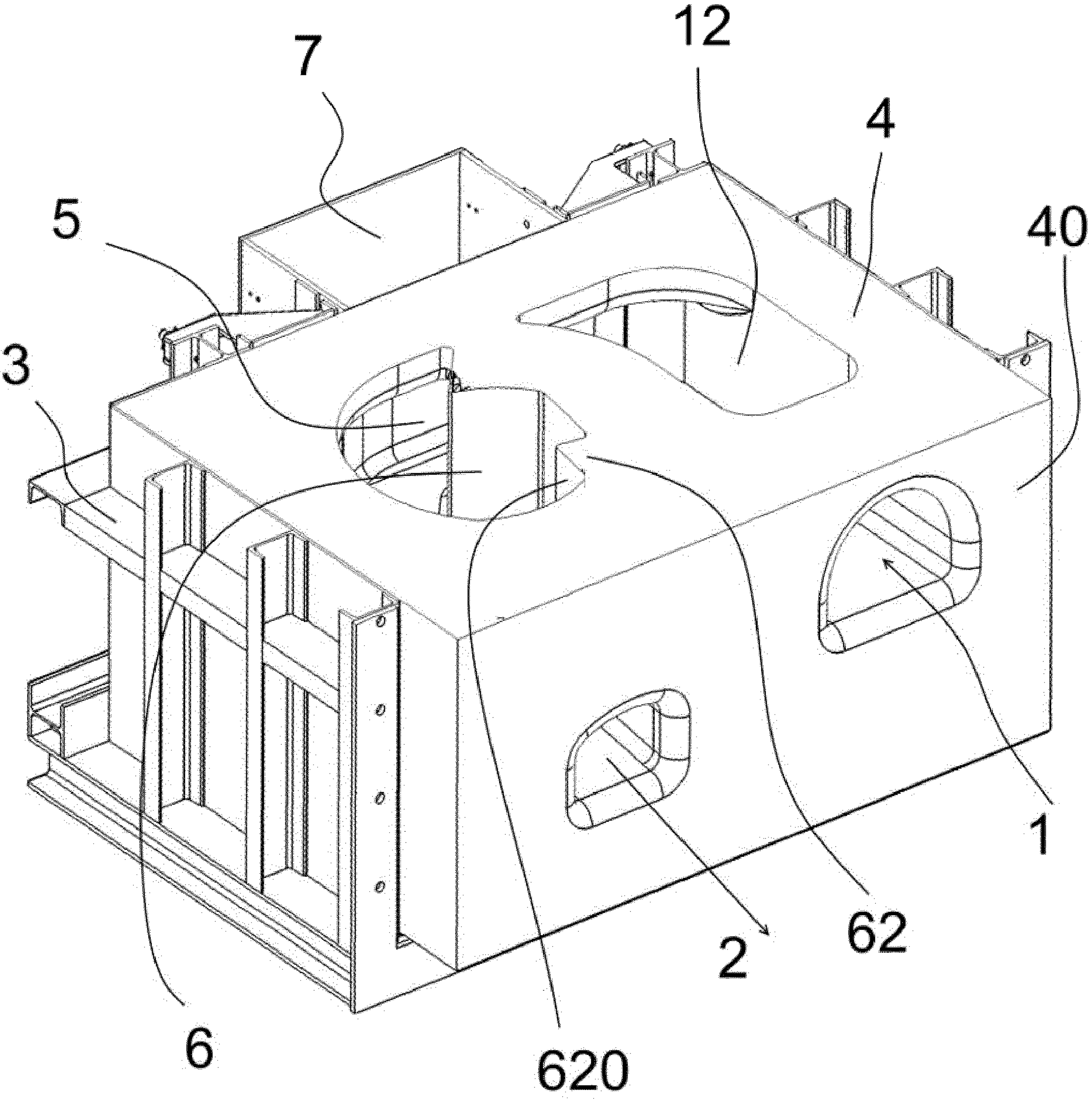

Fig. 8

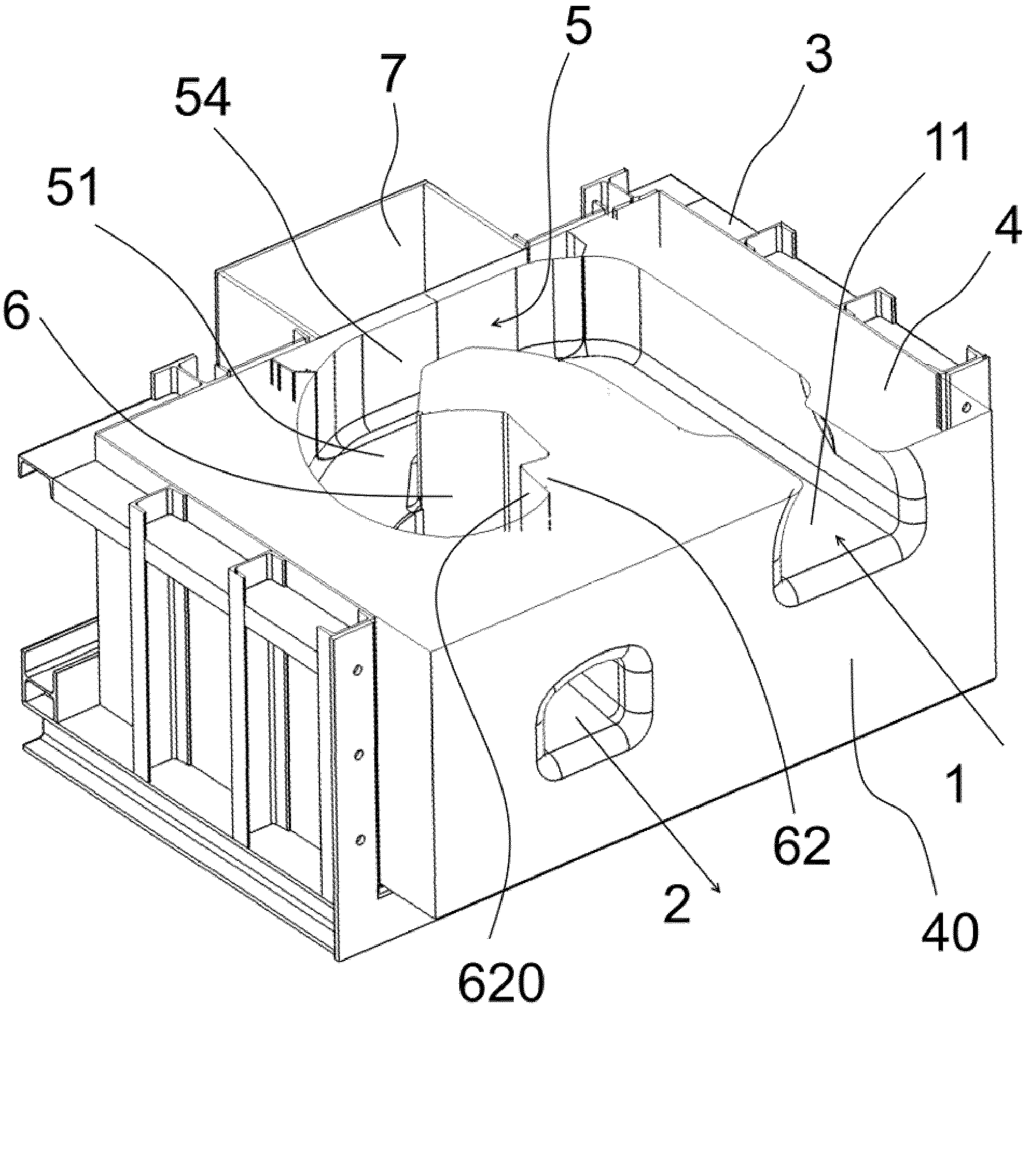

Fig. 9

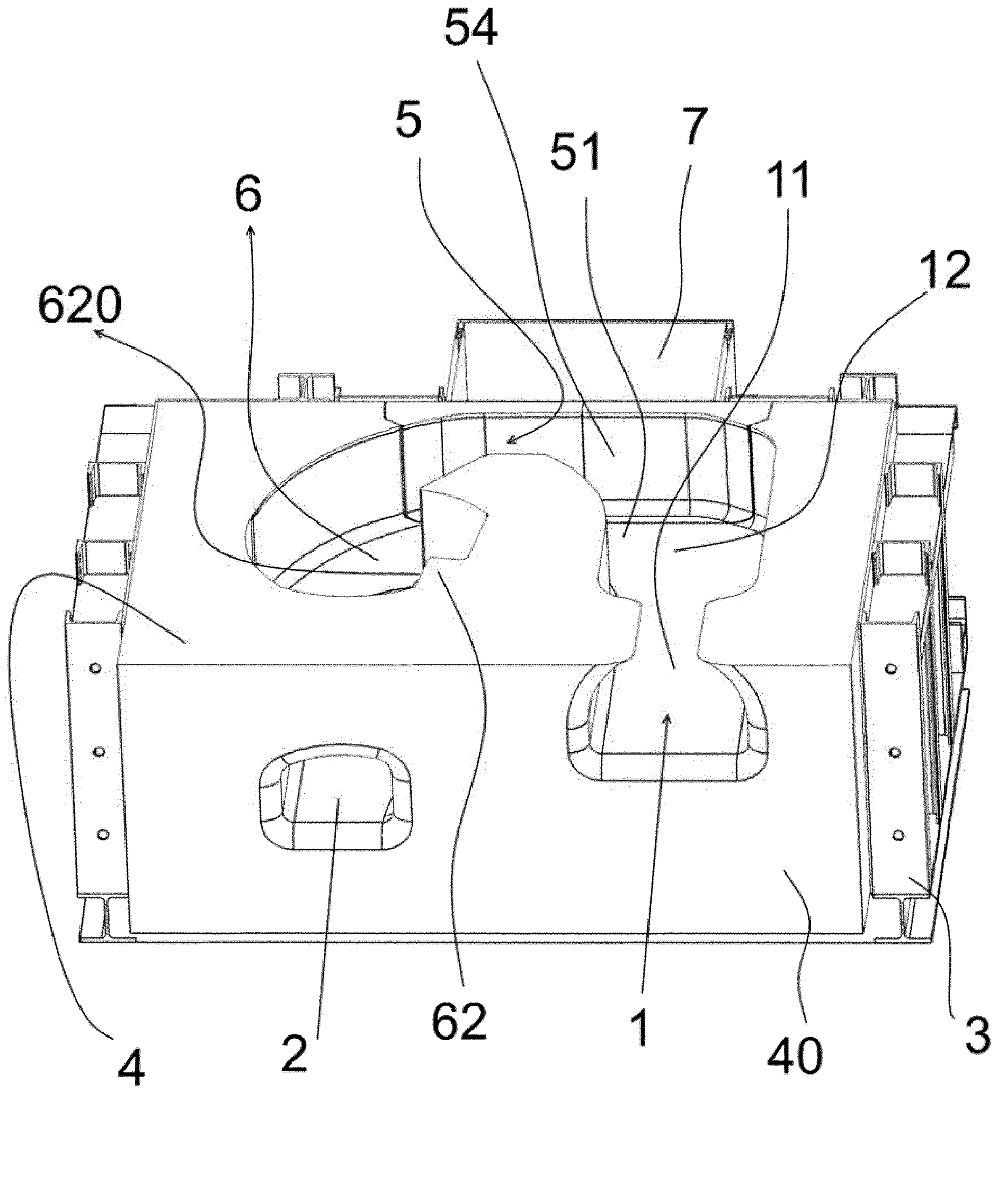

Fig. 9a

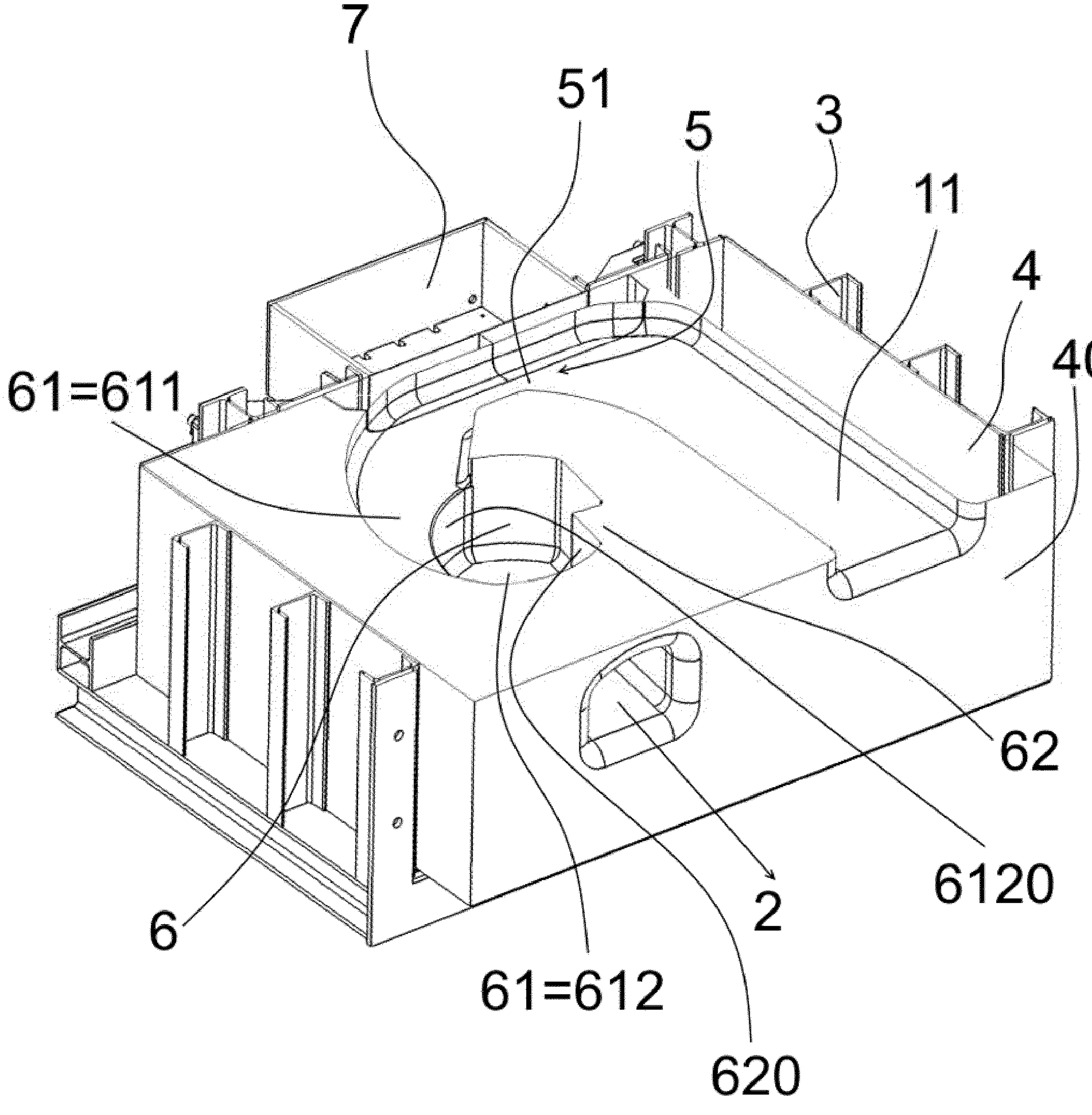

Fig. 10

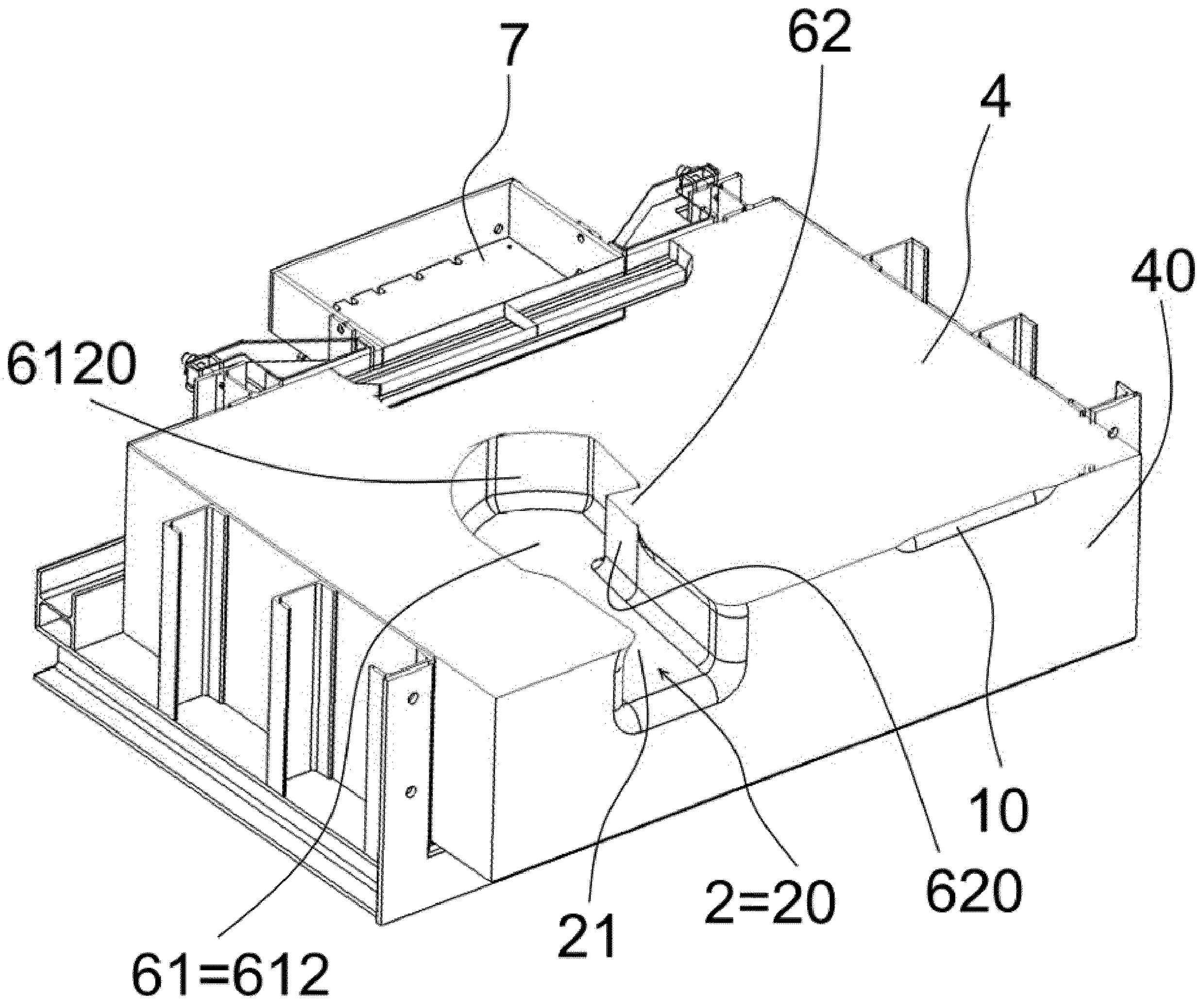

Fig. 11

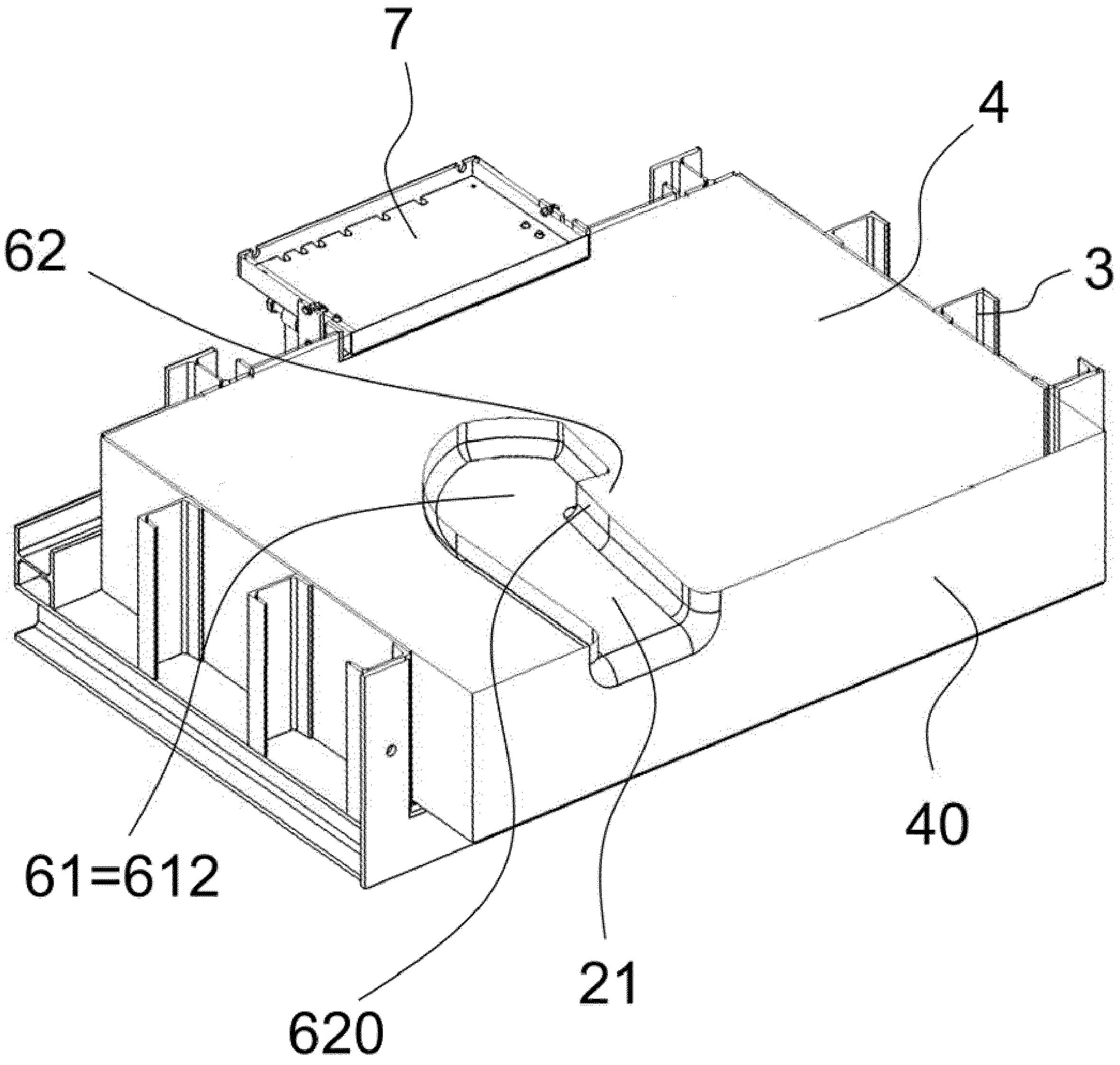

Fig. 12

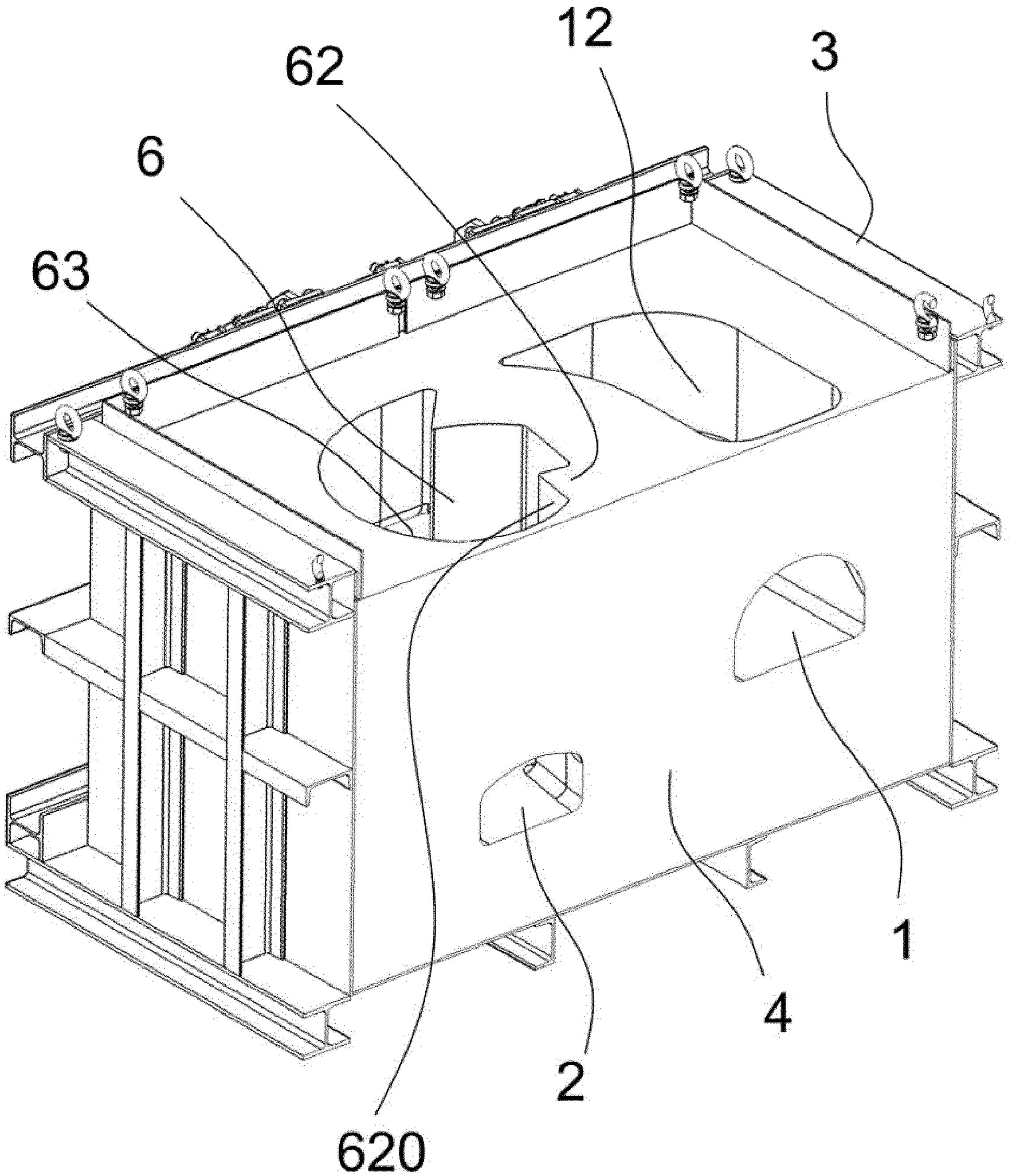

Fig. 13

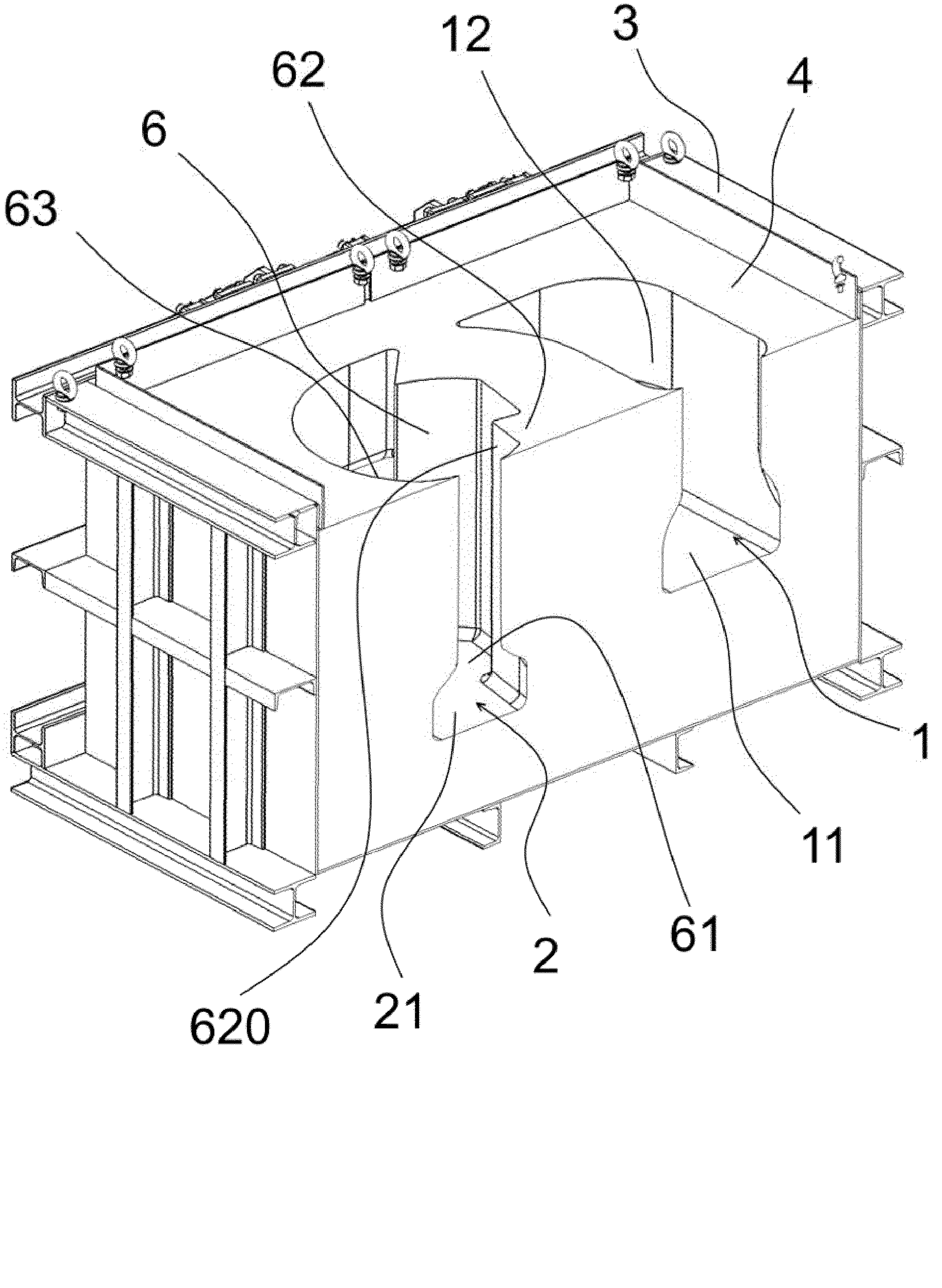

Fig. 14

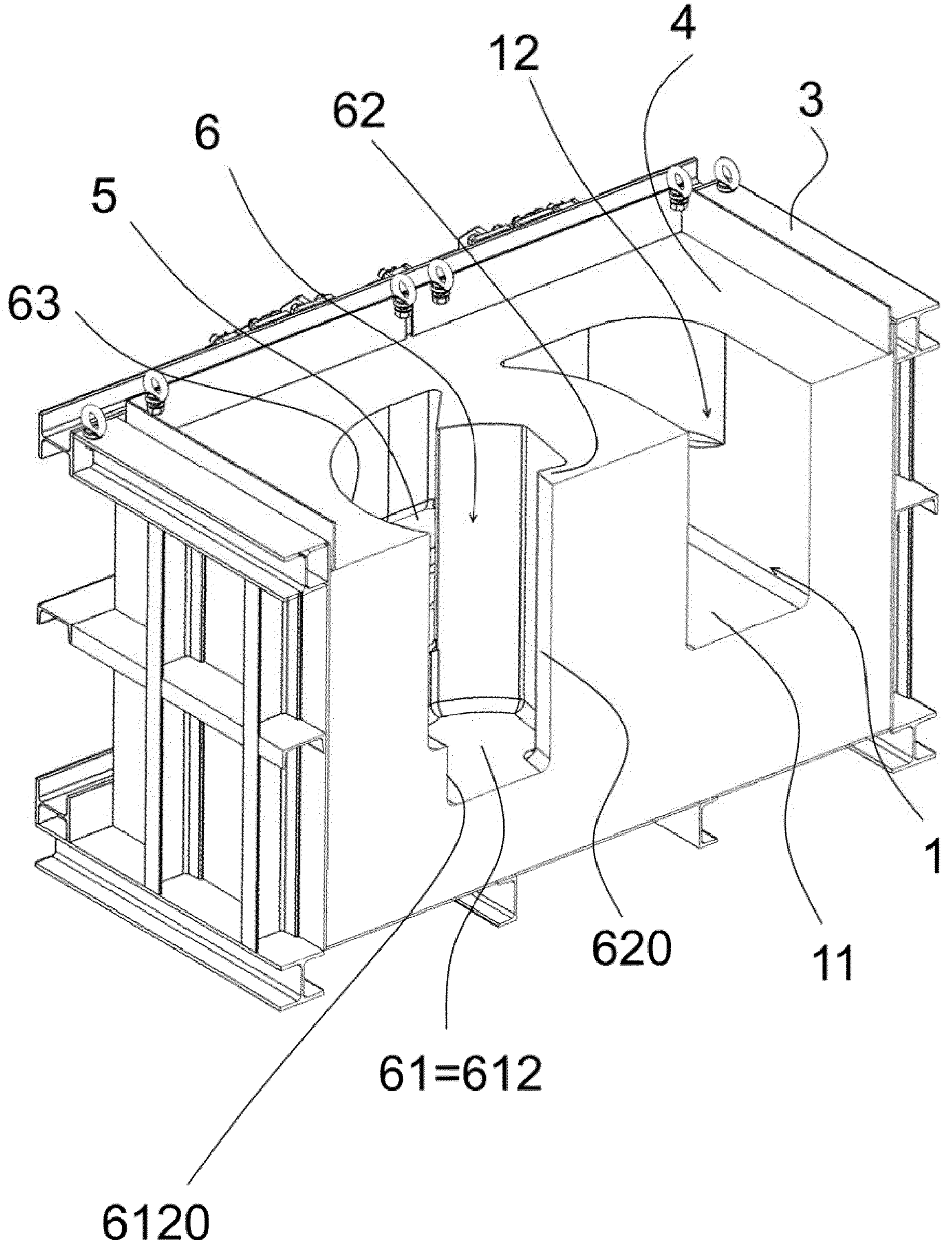

Fig. 15

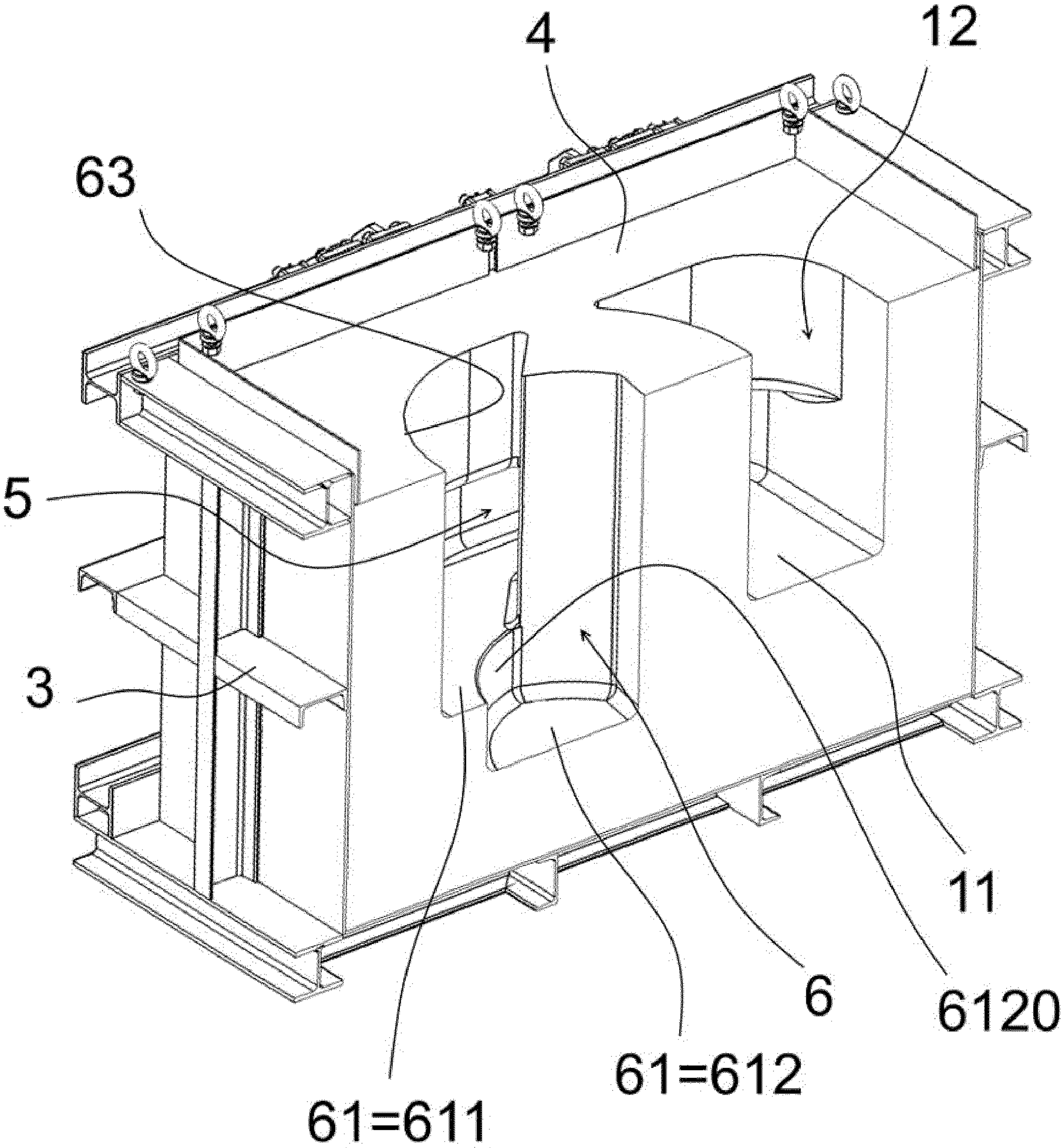

Fig. 16

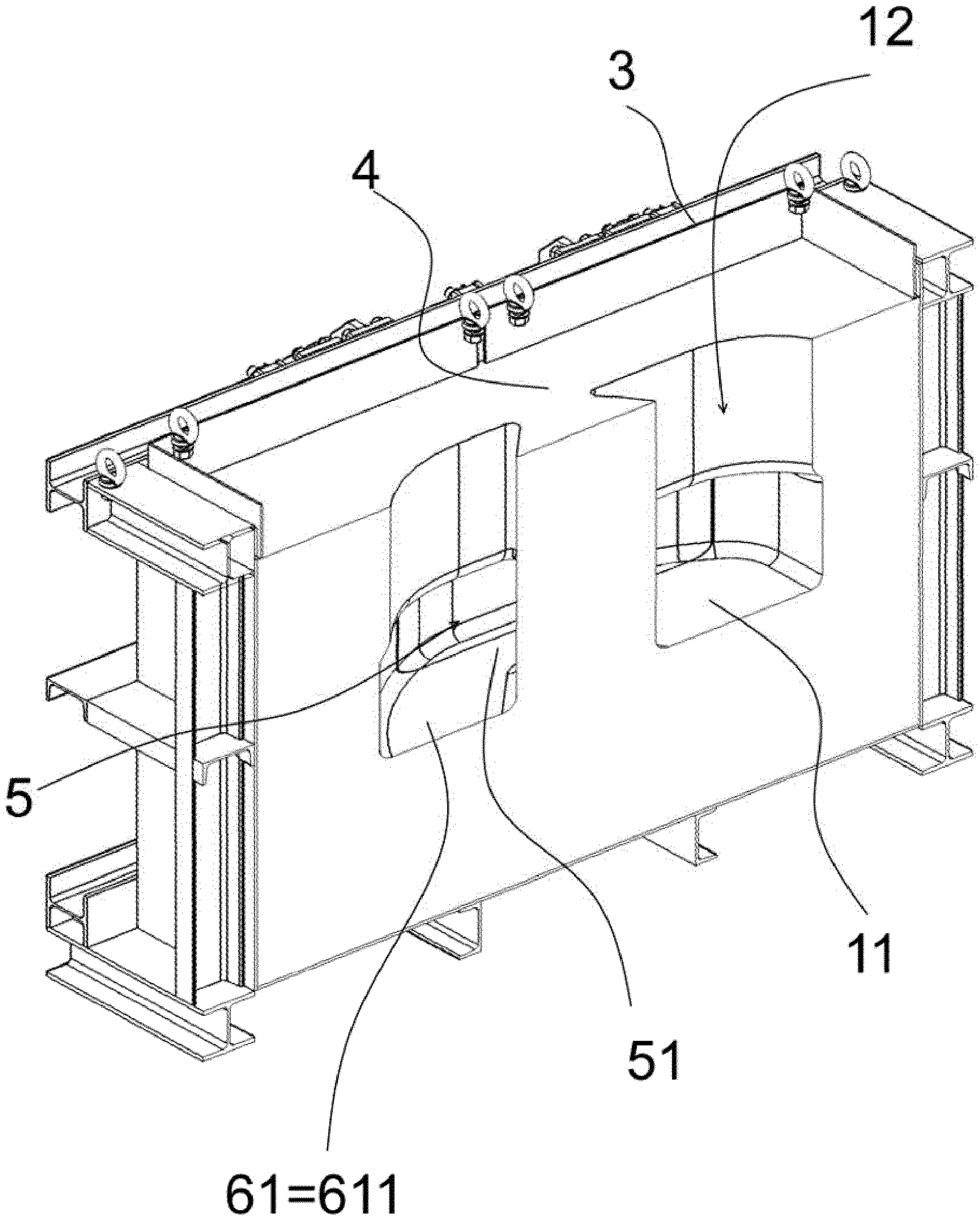

Fig. 17

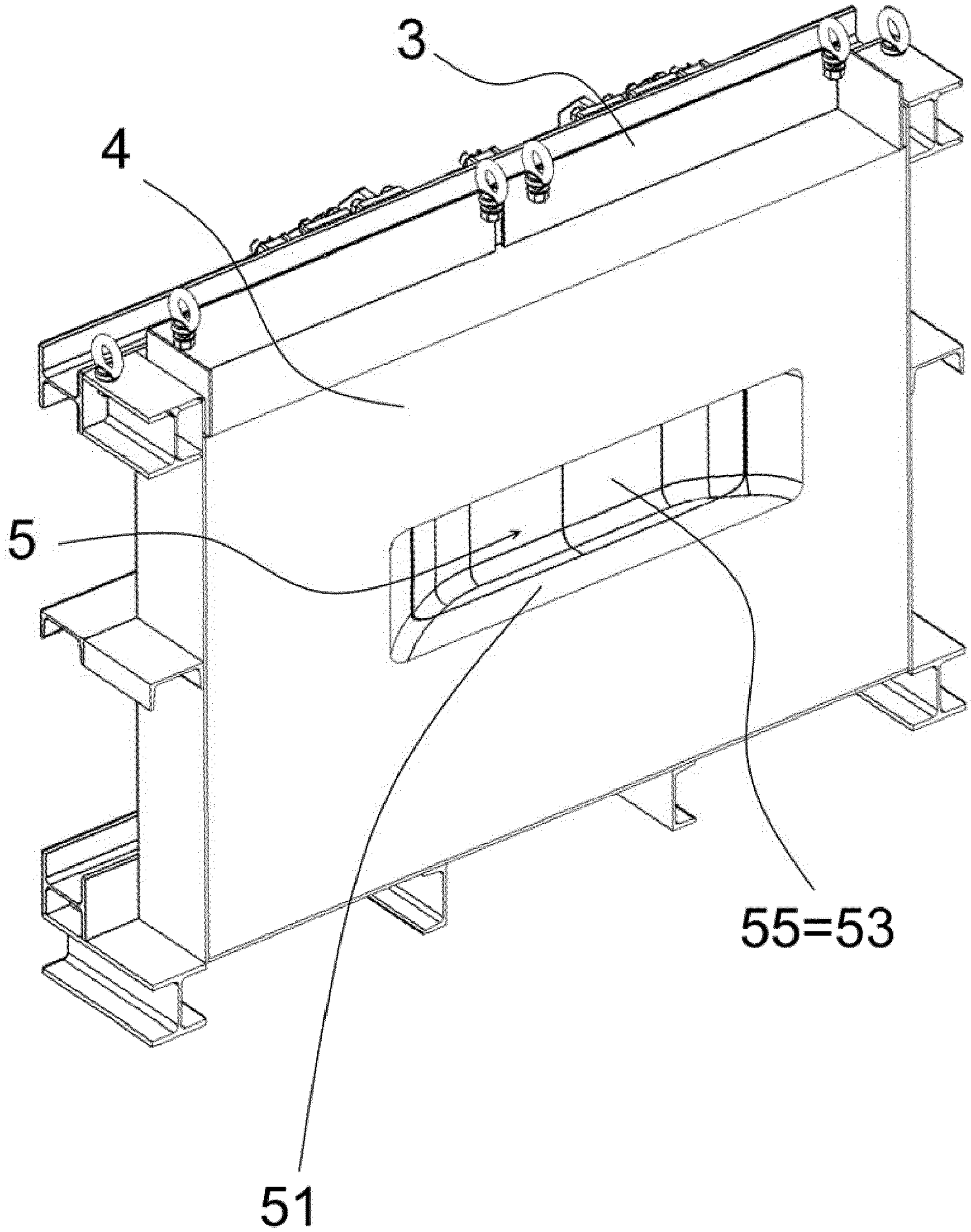

Fig. 18

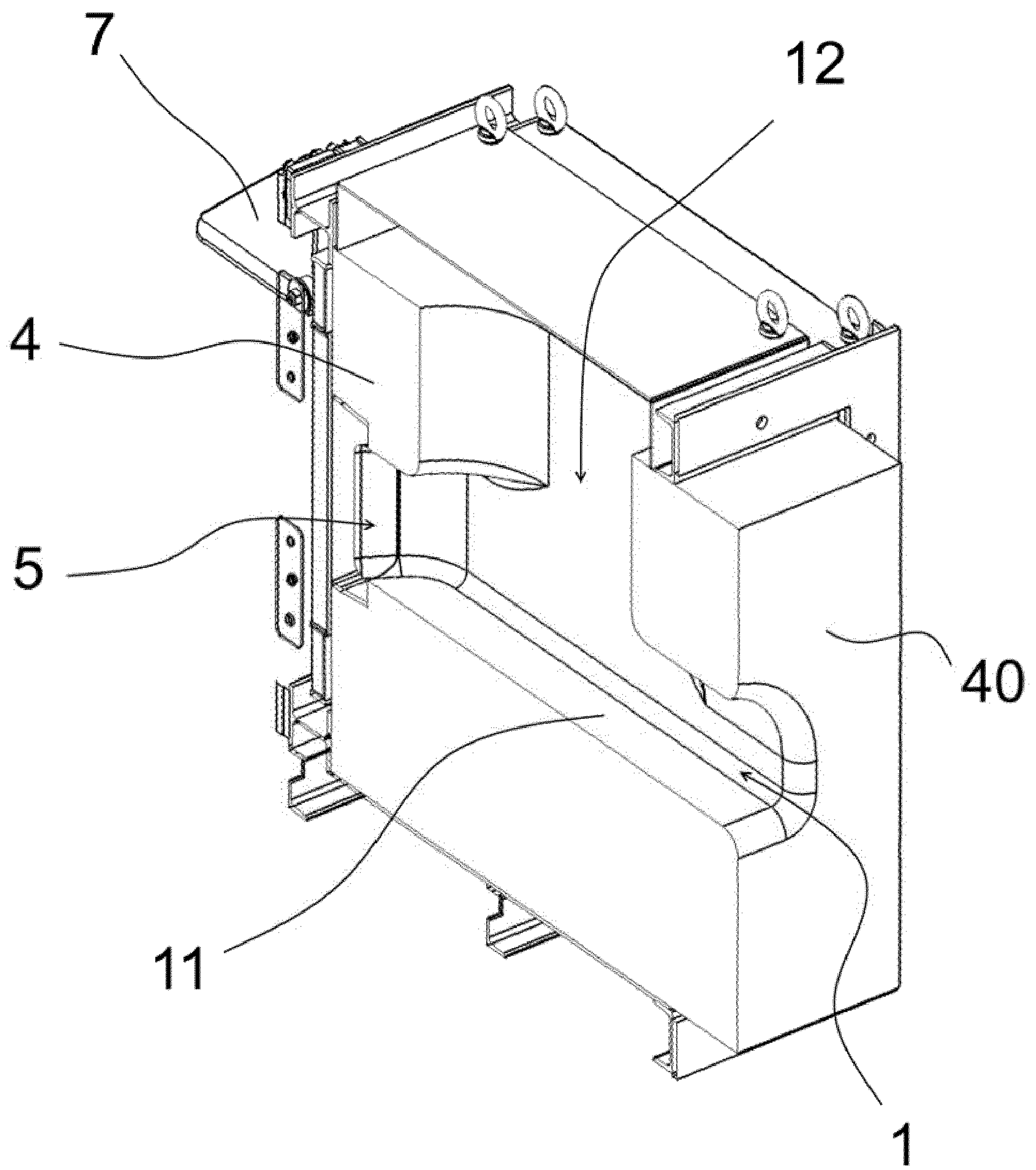

Fig. 19

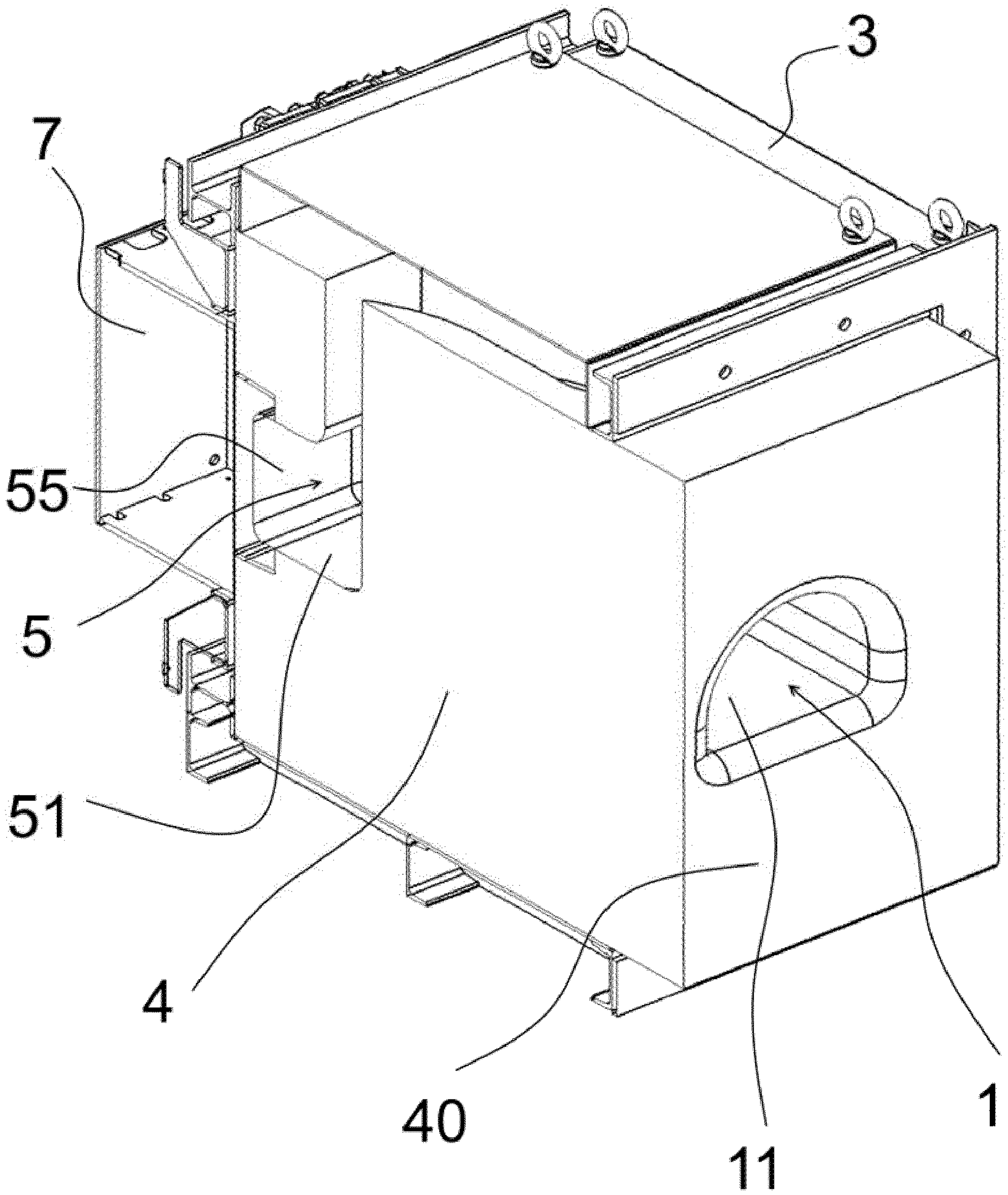

Fig. 20

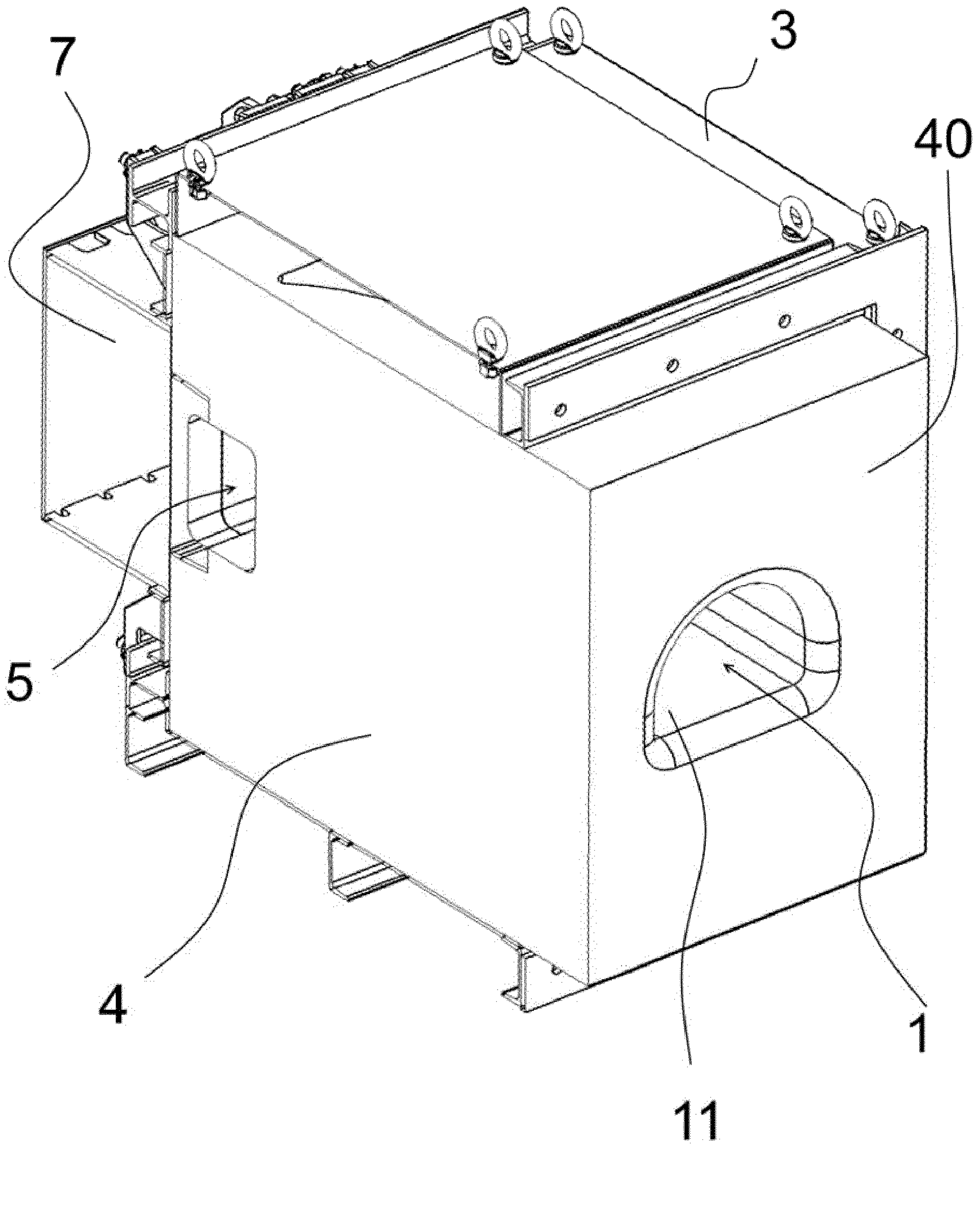

Fig. 21

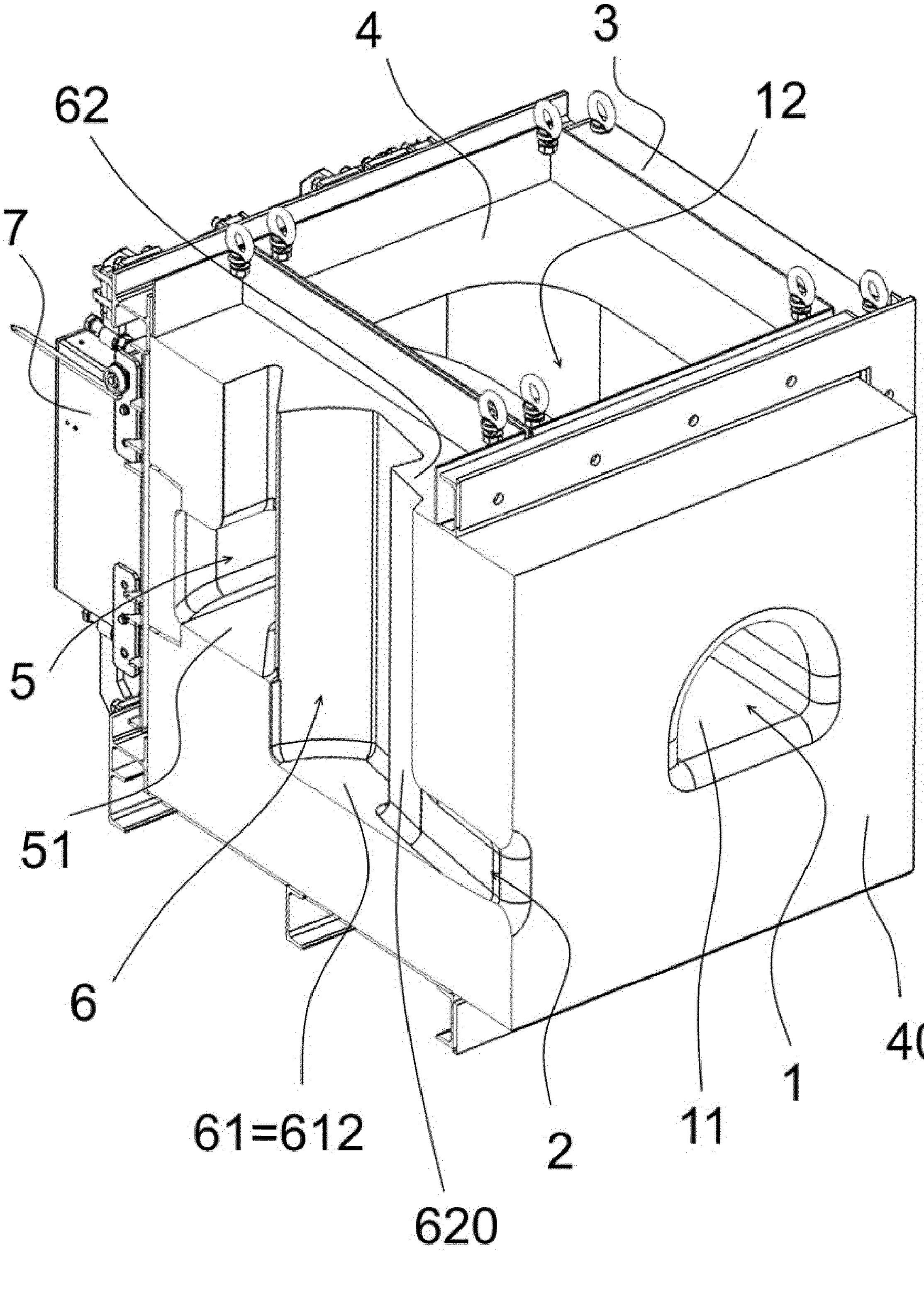

Fig. 22

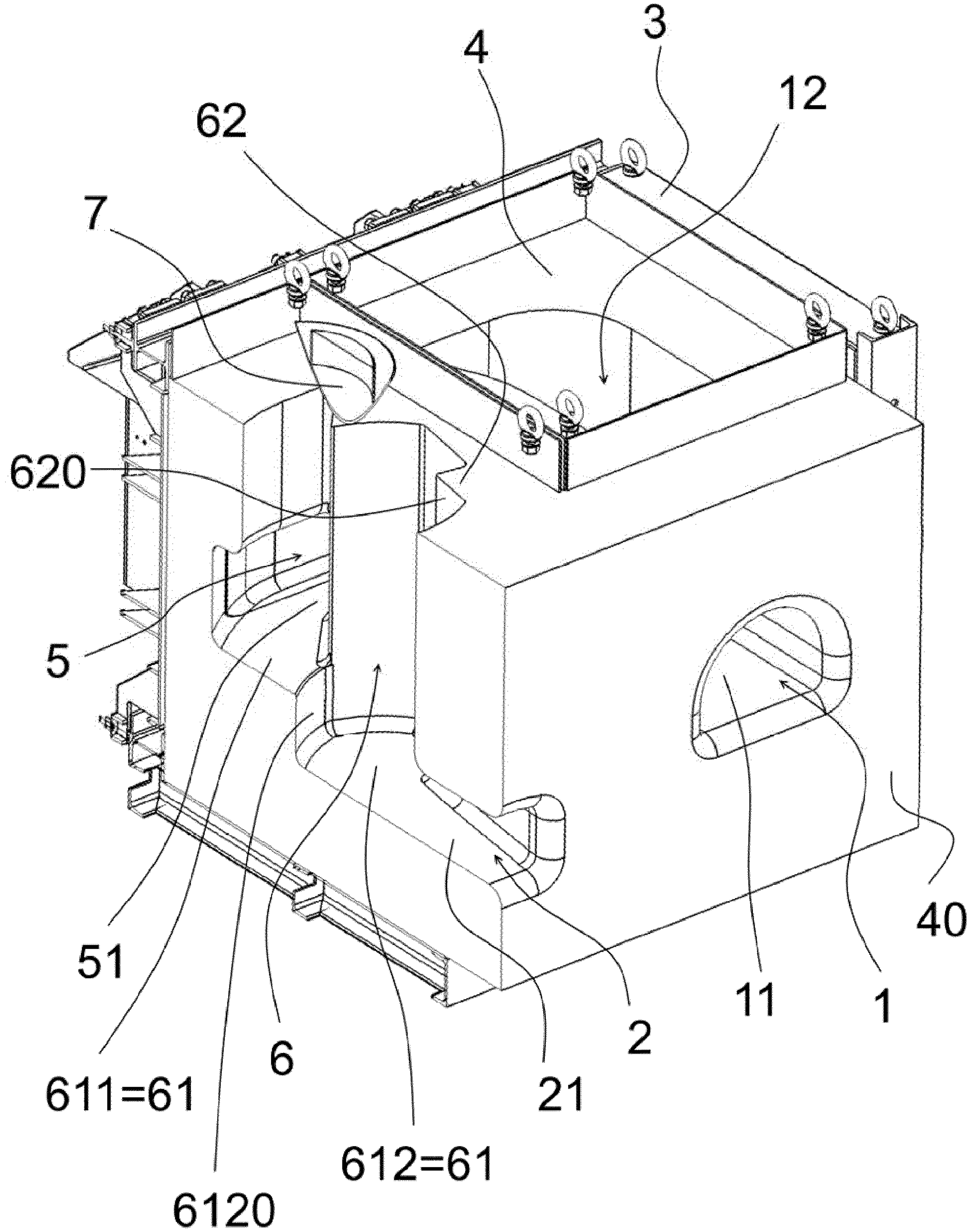

Fig. 23

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EUROPEAN SEARCH REPORT

Application Number
EP 19 16 8403

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X Y	EP 0 658 216 B1 (CALDER ALUMINIUM LTD [GB]) 23 October 1996 (1996-10-23) * column 4, line 34 - column 5, line 29; claims 1,10; figures 1-9 *	1-6 8,9	INV. F27D3/00
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Place of search	Date of completion of the search	Examiner
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