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(54) **Foolproof nozzle exchange device and nozzle unit**

(57) The present invention concerns a nozzle unit (1) for use in a nozzle exchange device (100) in a continuous metal casting apparatus, said nozzle exchange device (100) being of the type comprising a loading opening and guiding means (7) for sliding the nozzle unit through said opening into casting position with respect to the nozzle exchange device, wherein said nozzle unit (1) comprises a nozzle plate (1) made of a refractory material clad in a metal can. In order to prevent said plate from being presented to the loading opening with the wrong orientation, i.e., with the trailing edge (2d) first, said plate is provided with at least one lug (6) at or adjacent the trailing edge (2d), said at least one lug (6) being transverse to said first major axis (X1) and extending substantially beyond the perimeter defining the base of the prism such that the loading opening (16) allows engagement of the base (2c, 2d) of the nozzle plate (2) but not of the at least one lug (6). The flexural yield point or ultimate flexural force of said at least one lug (6) is comprised between 10 and 2000 kgf (100 N and 20 kN), which is too high for an operator to reach by hand, but which can be handled very easily by a hydraulic, mechanical, or pneumatic arm (31) which can thus bend or break said at least one lug (6) to push the plate into its casting position, only if loaded with its leading edge first.

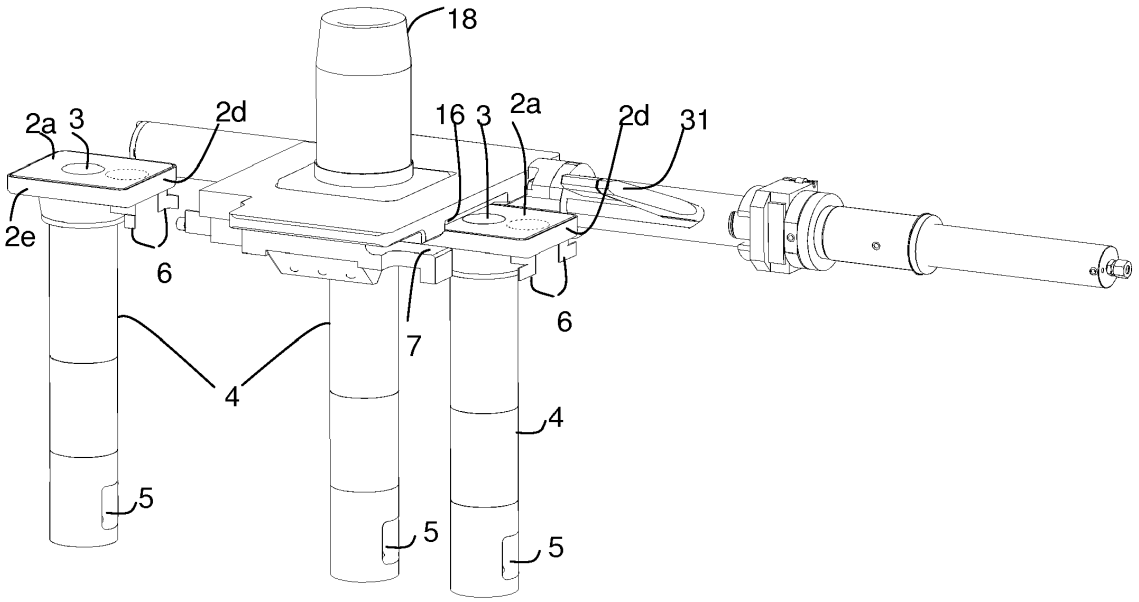

Fig. 7

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Description

FIELD OF THE INVENTION

[0001] The present invention generally relates to continuous metal casting lines. In particular, it relates to a nozzle unit suitable for being used with a nozzle exchange device and provided with means for preventing said nozzle unit from being loaded in said exchange device with a wrong orientation.

BACKGROUND OF THE INVENTION

[0002] Tundish vessels (10) are used to hold a quantity or bath of molten metal such as molten iron or steel, delivered from a ladle (11) through a ladle shroud (12) (cf. Figure 1). The ladle (11) is positioned a few meters above a tundish (10) and delivers the molten metal to the tundish (10) through a ladle shroud (12), in the form of a long tube leading from the ladle (11) into the tundish (10). The tundish (10) is disposed between the ladle (11) and the casting apparatus or mould (13) which is fed with molten metal from the tundish (10) through an inner nozzle (18) located inside the tundish in fluid communication with a pouring nozzle (1) located outside and below the tundish and supplying the molten metal to be formed.

[0003] The pouring nozzle (1) may wear or the tube openings (5) may get obstructed during casting of a metal and it may have to be changed during the process. For solving this problem, nozzle exchange devices (100) may be used, which comprise an opening (16) for loading a new shroud nozzle, pushing means (31) and guiding means (7) for sliding the new nozzle into casting position and a discharge opening at the opposite end of the guiding means (7) for discharging the nozzle after use upon pushing it with a new nozzle unit (1). The loading and unloading of a nozzle unit is usually made manually with the help of long clamps and requires substantial force and accuracy from the operator.

[0004] A nozzle unit (1). suitable for being used with such nozzle exchange device is actually composed of a tubular portion (4) with a central axial bore open in the axis at one end and in the axis or by transverse windows (5) at the lower, outlet end (compare Figures 3(a) and (b)). Said tubular portion is topped at its inlet end by a plate (2) suitable for snugly fitting into the opening (16) of the corresponding nozzle exchange structure. The plate comprises a top, sliding surface (2a) suitable for sliding along a corresponding fixed plate, usually part of the inner nozzle outlet. The plate (2) of the nozzle unit (1) comprises a through bore matching the through bore of the inner nozzle and suitable for being brought into fluid communication therewith upon pushing into its casting position. In the present application, the combination of a pouring tube (4) with a plate (2) is referred to as "exchangeable nozzle unit" (1), or simply "nozzle unit" (1) when no confusion with other nozzles is possible.

[0005] In case of emergency, it must be possible to obturate the inner nozzle opening. To this purpose, it is possible to introduce into the loading opening (16) a blank plate similar to the plate (2) topping the pouring tube (4) as discussed above, but with no through hole, and to push it in registry with the inner nozzle. Some exchangeable nozzle units comprise a plate (2) wherein the through hole is offset with respect of its axis parallel to the direction of introduction into the guiding means. This allows to combine a blank plate with an exchangeable nozzle unit in one piece, as in its casting position, the through hole (3) of the exchangeable nozzle plate (2) is in fluid communication with the inner nozzle outlet and, in its obturating position, the inner nozzle outlet faces a blank surface of the nozzle plate and the metal melt flow is thus interrupted.

[0006] Since, in the illustrated case, the pushing means (31) are suitable for pushing the exchangeable nozzle unit, the whole exchanging operation always runs in a same direction. For this reason, the through hole (3) of the plate must necessarily be positioned upstream from the blank portion of the plate top surface (2a). Indeed, in case of emergency, the pushing means (31) must be suitable for pushing the exchangeable nozzle unit from its casting position to its obturating position. Although very advantageous, this kind of exchangeable nozzle units is not without danger for the following reasons.

[0007] The offset position of the through hole (3) of the nozzle plate (2) and the constrain that it should be presented to the nozzle exchange device (100) upstream from the blank portion of the sliding surface (2a) imposes that the nozzle unit be loaded onto the nozzle exchange device (100) in one single orientation. Indeed, if loaded with the through hole (3) downstream from the blank portion, the consequences could be disastrous. No or little fluid communication would be established between the inner nozzle (18) and the pouring nozzle (1) thus disrupting the casting operation, and in case of emergency, the pushing means (31, 32) would push further the plate in its theoretical obturating position, but bringing the through hole (3) instead of the blank surface in registry with the inner nozzle outlet, thus opening full blast the metal flow path instead of interrupting it.

[0008] US5188743 and W09304805 propose to provide the bottom of an exchangeable nozzle plate with an anti-reversal collar. The collar may be elliptical or provided with a pair of diametrically opposed bubbles. This solution, however, restricts the total number of orientations the plates may be presented to the tube exchange device from four without constrains, to two with the collar. This solution therefore is not applicable to the case of an exchangeable nozzle unit provided with an elongated plate provided with a through hole and a blank surface, since one orientation out of four only is allowed in this case.

[0009] US5211857 or US5174908 propose gate safety arrangements wherein the gate comprises asymmetrical leading and trailing edges, mating an asymmetrical loading opening of a tube exchange device. These solutions,

however, do not solve the problem satisfactorily for the following reasons. First, such systems would not be compatible with existing tube exchange devices (100) already in place in the industry, and do require the installation of an ad hoc tube exchange device which represents a substantial investment from the customers. Second, unless the asymmetry between the starboard and leeboard side edges (2e) is substantial enough, there is a risk that an operator, in the heat of the action surrounding the change of a tube may force a plate wrongly inserted into the opening (16) of the tube exchange device and damage the system. Note that starboard (right) and leeboard (left) side edges (2e) are defined herein with respect to looking towards the leading edge (2c) to be presented first to the opening (16) of the tube exchange device (100).

[0010] The present invention proposes a solution for the loading of a exchangeable nozzle unit onto a tube exchange device in one only of the four possible orientations of the nozzle plate which is entirely fool proof, cheap and compatible with existing tube exchange devices currently in use in metal casting shops.

SUMMARY OF THE INVENTION

[0011] The present invention is defined by the attached independent claims. The dependent claims define preferred embodiments. In particular, the present invention concerns an exchangeable nozzle unit for use in a nozzle exchange device in a continuous metal casting apparatus, said nozzle exchange device being of the type comprising a loading opening and guiding means for sliding the nozzle unit through said opening into casting position with respect to the nozzle exchange device, wherein said nozzle unit comprises

A) a nozzle plate made of a refractory material partly clad in a metal can, said plate having a shape inscribed in a prism, and being defined by:

a) a first leading edge and a second, opposite trailing edge defining the first and second bases of the prism, transverse to a first axis (X1), said bases being preferably polygonal,

b) an upper slide surface defined by a first and a second axes (X1, X2) and a lower support surface forming a first pair of opposite and parallel joining faces of the prism,

c) a first and second side edges substantially parallel to said first major axis (X1) linking the first and second bases of the prisms as well as the first pair of opposite joining faces;

d) a through bore fluidly connecting the upper slide surface and the lower support surface, said through bore being offset along said first axis (X1), and

e) a tubular duct comprising a central bore in fluid communication with the through bore of the plate, one end of the duct being fixed to the lower support surface of the plate, said central bore opening to ambient through at least one opening located at or near the opposite end of the tubular duct; wherein at least one lug is provided at or adjacent the trailing edge, said at least one lug being transverse to said first major axis (X1) and extending substantially beyond the perimeter defining the bases of the prism, and in that the flexural yield point or ultimate flexural force of said at least one lug is comprised between 10 and 2000 kgf (100 N and 20 kN).

[0012] In the present context, and as usually understood by the person skilled in the art, the "yield point" is defined as the point in the stress-strain curve at which the curve levels off and plastic deformation begins to occur. Similarly, the ultimate flexural force is defined herein as the maximum force a material withstands before breaking when subjected to an applied flexural load.

In a preferred embodiment, the flexural yield point or ultimate flexural force of said at least one lug (6) is comprised between 20 and 1000 kgf (200 N and 10 kN), 50 and 500 kgf (500 N and 5 kN), preferably between 75 and 250 kgf (750 N and 2.5 kN), more preferably between 100 and 200 kgf (1 and 2 kN), most preferably, between 125 and 175 kgf (1.25 and 1.75 kN). These forces are meant to prevent an operator from forcing the passage of a wrongly inserted tube into the loading opening, and to allow mechanical, pneumatic or hydraulic pushing means to push the correctly loaded tube into its casting position, by bending or breaking the lugs in the process.

[0013] The geometry of the bases of the prism circumscribing the plate may vary depending on the application. They may for example be any of: (a) a rectangle, (b) a parallelogram, (c) a trapezoid, (d) a rectangle wherein at least the two angles adjacent the lower support surface are cut off to mate the geometry of guiding means of a nozzle exchange device. Varying the geometry of the prism bases may be required to ease the sliding of the plate into the tube exchange device, or for ensuring that the nozzle unit cannot be mounted into the device opening transverse to its proper orientation.

[0014] The at least one lug may extend beyond the basis perimeter in any direction, but in order to preserve the changing device upper sliding surface it is preferred that the lug does not extend over the upper surface of the plate. It is preferably adjacent a side edge, and extends beyond a portion thereof. It may also extend beyond the lower support surface as long as the lug will interfere with some part of the passage in the nozzle exchange device.

[0015] Since the plate of the exchangeable nozzle unit is made of a refractory material clad on all but the upper slide surface by a metal can (sometimes called metal casing), it is advantageous that the at least one lug is made of a ductile metal and is fixed to or is integral part of the metal can cladding the refractory. The lug or lugs may have any geometry extending beyond the perimeter defining the prismatic plate and which is suitable for in-

terfering with the opening of the tube exchange device it is to be used with. In particular, and only as examples, the lug may have one of the following geometries:

(a) L-shaped plate, with the vertical bar of the "L" fixed to the plate at or adjacent the trailing edge and the horizontal bar of the "L" extending outwards beyond the surface of the side edge it is adjacent to, preferably below the level of the lower support surface;
(b) L-shaped plate, with one bar of the "L" running parallel to a side edge and the other bar of the "L" extending outwards beyond the surface of the side edge it is adjacent to, and at or adjacent the trailing edge,
(c) a plate, extending outwards beyond the surface of the side edge it is adjacent to, and substantially flush with the trailing edge;
(d) in case of a nozzle plate wherein the side edges are not flat, two lugs adjacent the trailing edge, each extending beyond the base defining the prism such as to be enclosed within the smallest rectangle circumscribing said base, such as for example:
(e) in case of a nozzle plate wherein the prism basis consists of a rectangle with at least two cut off angles, two lugs (6) adjacent the trailing edge, each having the geometry of the cut off parts and being complementary to form therewith a rectangle,
(f) in case of a nozzle plate wherein the prism bases consist of a rectangle with at least one protrusion jutting out of at least one edge adjacent one side edge, the at least one lug being substantially flush with the protrusion and with the lower edge adjacent the lower support surface;
(g) a curved bar or blade fixed to the support surface;
(h) curved half shells fixed to a side edge.

[0016] The present invention also concerns a nozzle exchange device for changing a nozzle unit during continuous casting of metal in collaboration with an exchangeable nozzle unit as defined supra, said nozzle exchange device comprising:

(a) a first fixed plate comprising a through bore suitable for being brought in fluid communication with a source of metal melt, such as a tundish, said first fixed plate comprising a first lower slide surface;
(b) a loading opening for loading the second, moveable nozzle plate, said loading opening allowing engagement of the base of the nozzle plate but not of the at least one lug,
(c) guiding means for sliding the moveable plate in a direction parallel to the first axis (X1) through said opening into casting position defined as the position wherein the through bores of the first, fixed plate and the second, moveable plate are in fluid communication,
(d) a discharge opening at the opposite end of the guiding means for discharging the nozzle unit after use upon pushing it with a new nozzle unit,
(f) a mechanical, pneumatic, or hydraulic arm suitable for pushing a moveable nozzle unit from its loading position into its casting position and having a pushing force superior to the flexural yield force or ultimate flexural force of the at least one lug and wherein
(g) the upper slide surface of the exchangeable nozzle unit is suitable for sliding along the first slide surface of the first fixed plate and for bringing in fluid communication the through bores of the first and second plates,

[0017] The mechanical, pneumatic, or hydraulic arm of the nozzle exchange device defined in the foregoing, is preferably suitable (a) for pushing a first nozzle unit from the loading position to the casting position, (b) for pushing a first nozzle unit from the casting position to an obturating position wherein the through bore of the first fixed plate faces a blank surface of the upper sliding surface of the nozzle plate, and (c) for pushing a second nozzle unit from the loading position to the casting position, thus pushing the first moveable nozzle unit out through the discharge opening.

[0018] In a preferred embodiment of the present invention, the lug geometry and the opening of the nozzle exchange device do not even allow loading of a nozzle unit for engagement into the loading opening if presented in any other position than with the leading edge first. This way, there is no risk that the hydraulic, pneumatic or mechanic arm forces the exchangeable nozzle unit into the tube exchange device with the wrong orientation and configuration.

[0019] The present invention also concerns a continuous metal casting line comprising a nozzle exchange mechanism and an exchangeable nozzle unit as defined above. The nozzle exchange device is preferably located at an outlet of a tundish.

[0020] The present invention also concerns a metal can or casing for cladding the plate of an exchangeable nozzle unit as discussed supra, having a shape suitable for cladding at least a portion of all the faces of the nozzle plate but the upper sliding surface, and characterized in that it comprises at least one lug provided at or adjacent the trailing edge, said at least one lug being transverse to a first major axis (X1) and extending substantially beyond the perimeter defining the basis of the trailing edge, and in that the flexural yield point or ultimate flexural force of said at least one lug is comprised between 10 and 2000 kgf (100 N and 20 kN). The flexural yield point and ultimate flexural force being understood as defined above.

[0021] The geometry of the metal can and lug is as discussed supra with respect to the exchangeable nozzle unit. The at least one lug can be fixed to the metal box with any fixing means known to the person skilled in the art, such as a soldering or welding line, glue, cement,

rivets, screws. It is, however, preferably an integral part of the metal can. It can be a bent section thereof, optionally cut-off from the main body of the can.

BRIEF DESCRIPTION OF THE FIGURES

[0022] Various embodiments of the present invention are illustrated in the attached Figures:

Figure 1: shows schematically a typical continuous casting line.

Figure 2: show a cut-off view of a nozzle exchange device

Figure 3: shows various embodiments of a nozzle unit according to the present invention.

Figure 4: shows a further embodiment of a nozzle unit according to the present invention.

Figure 5: shows metal cans according to the present invention for cladding the nozzle plates of Figure 3.

Figure 6: shows a nozzle unit according to the present invention (a) erroneously loaded with the trailing edge first, and (b) properly loaded with the leading edge first.

Figure 7: shows the principle of use of a nozzle exchange device according to the present invention.

DETAILED DESCRIPTION OF THE INVENTION

[0023] The present invention solves in a simple and reliable way the problem of preventing the loading with the wrong orientation of an asymmetrical exchangeable nozzle unit onto the loading opening (16) of a nozzle exchange device (100) thus avoiding the terrible consequences that such error could provoke. An exchangeable nozzle unit according to the present invention is of the type comprising a hollow tubular portion (4) with a through bore (3a), one end of said tubular portion being attached to a second main face (2b) of a plate (2) extending substantially normal to the axis of the tubular portion. The through bore (3a) of the tubular portion opens (3) to ambient at a first main surface (2a) of the plate opposite the foregoing second main surface (2b), and opens to ambient at the other end of the tubular portion (4) either in the axis of the tube (cf. Figure 3(b)) or at windows (5) provided on the tube wall close to the end (cf. Figure 3 (a)). Since said first main surface is to enter into fluid tight contact with a corresponding plate surface of an inner nozzle when sliding into casting position in a nozzle exchange device, said first surface (2a) is referred to as the "slide surface". The slide surface is made of refractory and is not clad with metal, lest some molten metal were to leak and damage a metal clad surface. The plate itself therefore consists of two opposite main surfaces (2a, 2b): the slide surface and the surface connecting the plate to the tubular portion (4) of the nozzle; both surfaces are connected by edges (2c-e) defining the perimeter and the thickness of the plate. The side edges comprise a pair of opposite leading edge (2c) and trailing edge (2d) referring to the direction the plate is to be mounted and slid into the nozzle exchange device. The leading and trailing edges actually define the bases of a prism in which the plate can be inscribed. In the vast majority of cases, the prism would be normal, but this feature is not mandatory. As a rather tight contact should be formed between two consecutive plates when the leading edge (2c) of a second plate contacts the trailing edge (2d) of a first plate to be replaced, the two opposite leading and trailing edges must be complementary, and in most cases they will comprise two parallel planar sections. The side edges (2e) extending parallel to a first direction (X), which is transverse, usually normal to the leading and trailing edges (2c, 2d) will usually extend linearly from the leading to the trailing edge, but may have any profile between the two main surfaces (2a, 2b).

[0024] In the present context, a shape is said to be inscribed in a prism if it is enclosed by and "fits snugly" inside said prism, which is the definition generally accepted in geometry by the persons skilled in the art. Specifically, at all points where figures meet, their edges must lie tangent. There must be no object similar to the inscribed object but larger and also enclosed by the outer figure. In the present invention, the plate is said to have a shape inscribed in a prism, because the side edges (2e) do not necessarily meet the leading and/or trailing edges (2c, 2d) directly or forming a sharp angle. On the contrary, in many instances it can be advantageous to smoothen the corners of the plates, either with rounded corners or cut-off corners. This facilitates the handling by operators of a plate having no sharp corner, and it also helps to smoothly aligning the plate within the loading opening and the guiding means. Apart from the corners, however, the plate has an overall generally prismatic geometry.

[0025] The plate is said to be asymmetrical because the opening (3) of the through bore at the slide surface (2a) is not centered on the plate with respect to the first direction (X). Indeed, in many cases, the opening (3) is offset so as to define next to it a blank area allowing to interrupt the flow of metal melt by sliding the plate from its casting position wherein the opening (3) is in fluid communication with the through bore (23) of a corresponding inner nozzle (18), to a blank position wherein the through bore (23) of the inner nozzle faces a blind area of the plate, referred to as blank area, by analogy with blank plates used for the same purpose. Now, if the plate is loaded wrongly into the loading opening of a nozzle exchange device, it follows that when it will be pushed into its casting position, no or limited fluid communication will be formed between the inner nozzle and the opening (3) of the nozzle unit, with the consequence of no or little flow of metal melt. In case of emergency, when the plate must be pushed from its casting position to its blank position, the opening (3) enters in full fluid communication with the inner nozzle through bore (23), thus increasing the metal flow instead of stopping it.

[0026] In order to prevent such mishap to take place,

the present invention proposes to provide at least one lug (6) at or adjacent the trailing edge (2d), said at least one lug (6) being transverse to said first major axis (X1) and extending substantially beyond the perimeter defining the base of the prism, and in that the flexural yield point or ultimate flexural force of said at least one lug (6) is comprised between 10 and 2000 kgf (100 N and 20 kN). Since the at least one lug (6) extends transversally beyond the perimeter defining the base of the prism, it will necessarily interfere with the frame of the loading opening (16) and will have to be bent or broken in order to allow the passage of the plate through said loading opening and along the guiding means (7). If the plate is loaded with the correct orientation, the at least one lug (6) will be positioned at the rear of the plate, adjacent the trailing edge (2d) thereof, and the plate can be snugly introduced by hand through the loading opening and slid along a substantial portion of the length of the side edges (2e) until the at least one lug (6) reaches and interferes with the frame of the loading opening (16). At said point the operator cannot push the plate any further by hand, because 100 N is a substantial force to apply by hand in the conditions encountered in a casting facility. At this stage the mechanical, pneumatic, or hydraulic arm (31) is activated to push the plate until it reaches its casting position. In the process, the at least one lug (6) is bent or broken, because 20 kN is only a fraction of the force arms for such purpose can deploy (cf. Figure 7). Preferably, the at least one lug bends plastically and does not break, in order to prevent the fall of lug fragments into the casting mould below.

[0027] In case the operator loads the plate with the rear in front, i.e., with the trailing edge (2d) facing forward and the leading edge (2c) backwards, terrible consequences could follow if no means is provided to prevent the loading of a plate in the wrong orientation. A nozzle unit according to the present invention cannot be mounted with the rear to front (i.e., with the trailing edge (2d) first), because the at least one lug (6) will interfere with the frame of the loading opening (16), preventing the plate from resting on the guiding means. The at least one lug has a mechanical resistance (bending or fracture resistance) of at least 100 N, which is too high for an operator to bend or break by forcing the wrongly orientated plate through the loading opening, in the working conditions of a casting facility. This way, even after a few attempts, the operator will rapidly understand its mistake and turn the plate to present the plate leading edge (2c) first to the loading opening as described above.

[0028] The working conditions of a casting facility have to be understood in the large way. It includes the working conditions at the time of the assembly of the nozzle exchange device at the outlet of a tundish when the device and the nozzle unit are cold or at room temperature as well as the conditions at the time of the continuous casting operation when the device and the nozzle unit are hot. Indeed, during the assembly of the device, the first nozzle introduced into the nozzle exchange device is usually cold as the device and the nozzle will be preheating together with the tundish at a later stage. On the other hand, on the continuous casting platform, when a device and a nozzle are already in operation and a new nozzle unit has to be introduced into the operating device, the new nozzle unit is preheating first to reduce the thermal shock at molten metal contact. In this respect, there is usually a preheating stand installed on the continuous platform to preheat a new nozzle unit at temperature in the range of 800 °C -1000°C. When a nozzle exchange is required, the preheated nozzle in standby and ready for use is engaged in the loading opening (16).

[0029] A higher value of the lower boundary of the yield point or ultimate flexural force of said at least one lug (6) reduces substantially the capacity of a strong and stubborn operator to force the passage of a plate through the loading opening. Conversely, a lower value of the higher boundary reduces the force required by the arm (31) for bending or breaking the at least one lug. Consequently, the flexural yield point or ultimate flexural force of said at least one lug (6) can be comprised between 20 and 1000 kgf (200 N and 10 kN), 50 and 500 kgf (500 N and 5 kN), preferably between 75 and 250 kgf (750 N and 2.5 kN), more preferably between 100 and 200 kgf (1 and 2 kN), most preferably, between 125 and 175 kgf (1.25 and 1.75 kN).

[0030] In the present application, the values of the flexural yield point or ultimate flexural force of said at least one lug (6) are considered at room temperature. Depending on the working conditions and the force which can be generated for the arm, the skilled person in the art will select the appropriate value or range of values to ensure the principal of the present invention is met both at the time of the assembly as well as at the time of casting (cold stage and hot stage).

[0031] The plate of the nozzle unit (1) may have any shape usual in such nozzles. In particular, the plate geometry is inscribed in a prism which bases correspond to the leading and trailing edges (2c, 2d), joined by, on the one hand, the opposite slide and support surfaces (2a, 2b) and, on the other hand, the side edges (2e). In the present context, the geometrical meaning of the term "prism" is considered, defined by two parallel bases joined by a number of faces, such that all cross-sections parallel to the base faces are the same. The bases may have any geometry, but they will generally be polygonal. The plate needs not be perfectly prismatic, but merely inscribed in a prism, as the corners thereof, joining the side edges (2e) with the leading and trailing edges (2c, 2d) or the sides edges (2e) themselves can be advantageously rounded, or cut-off, to facilitate the loading onto, and introduction through the loading station of the tube exchange device (100).

[0032] The bases (2c, 2d) of the prism can be any of: (a) a rectangle, (b) a parallelogram, (c) a trapezoid, (d) a rectangle wherein at least the two angles adjacent the lower support surface (2b) are cut off to mate the geometry of guiding means (7) of a nozzle exchange device

(100). As mentioned above, however, the exact geometry of the plate is not essential to the present invention which can be applied to any type of exchangeable nozzle unit to be mounted on a corresponding tube exchange device, i.e., it must have:

- a planar slide surface (2a) made of refractory material,
- side edges (2e) and support surface (2b) suitable for sliding on the guiding means (7) of the nozzle exchange device, and
- a leading edge (2c) parallel to an opposite trailing edge (2d) such that a tight contact is formed when the leading edge of a second plate is pressed against the trailing edge of a first plate during change of a nozzle unit.

[0033] The at least one lug (6) must be located at or adjacent the trailing edge (2d) and, as illustrated in Figure 3(d)-(f), is preferably adjacent at least one side edge (2e). Alternatively, the at least one lug can be located below the side edges as illustrated in Figures 3(a)-(c) and 4. Since the at least one lug is preferably ductile and suitable for being bent by a force comprised between 100 N and 20 kN, it is preferred that the lug is made of metal. Since a portion at least of all the faces of the nozzle plate, but the slide face (2a) are clad with a metal casing, the lug can advantageously be integral part of the casing as illustrated in Figure 5(a), (d), and (e), or fixed thereto by any means well known in the art, such as welding, soldering, gluing, riveting, screwing and the like as illustrated in Figure 5(b), (c), and (f).

[0034] The lugs may have many different geometries. In particular, they may have any one of the following geometries:

(a) L-shaped plate, with the vertical bar of the "L" fixed to the plate at or adjacent the trailing edge (2d) and the horizontal bar of the "L" extending outwards beyond the surface of the side edge (2e) it is adjacent to, preferably below the level of the lower support surface (2b); such embodiment is illustrated in Figure 3(a);

(b) L-shaped plate, with the vertical bar of the "L" running parallel to a side edge (2e) and the horizontal bar of the "L" extending outwards beyond the surface of the side edge (2e) it is adjacent to, and at or adjacent the trailing edge (2d), as depicted in Figures 3(b) and 5(a);

(c) elongated plate, extending outwards beyond the surface of the side edge (2e) it is adjacent to, and substantially flush with the trailing edge (2b) as shown in Figures 3(d)-(f) and 5(d)&(e);

(d) in case of a nozzle plate wherein the side edges are not flat, two lugs adjacent the trailing edge, each extending beyond the base defining the prism such as to be enclosed within the smallest rectangle circumscribing said base, such as for example:

(e) in case of a nozzle plate (2) wherein the prism basis consists of a rectangle with at least two cut off angles, two lugs (6) adjacent the trailing edge (2d), each having the geometry of the cut off parts and being complementary to form therewith a rectangle shown in Figure 5(f),

(f) in case of a nozzle plate (2) wherein the prism basis consists of a rectangle with at least one protrusion jutting out of at least one edge adjacent one side edge (2e), the at least one lug (6) being substantially flush with the protrusion and with the lower edge adjacent the lower support surface (2b) shown in Figure 5(b);

(g) a curved bar or blade (6) fixed to the support surface shown in Figures 3(c)-4-5 (c);

(h) curved half shells fixed to a side edge (2e) shown in Figure 5(b).

[0035] For mechanical reasons, at least a portion of all but the upper slide surface (2a) of the plate and sometimes an initial section of the tubular portion (4) are clad with a metal can (12), sometimes also referred to as metal casing, the two terms being considered herein as synonyms. As mentioned supra, it is preferred that at least one metal lug (6) be an integral part of, or be fixed to the metal casing itself. A metal can (12) according to the present invention is therefore similar in shape to corresponding state of the art cans, in the shape of an open box, of geometry matching the one of the refractory plate it is meant to clad, with an opening at the bottom surface to accommodate the tubular portion of the nozzle unit (1). It distinguishes itself from the metal casings of the prior art in that it comprises at least one lug (6) provided at or adjacent the trailing edge (2d), said at least one lug (6) being transverse to a first major axis (X1) and extending substantially beyond the perimeter defining the basis of the prism, and in that the flexural yield point or ultimate flexural force of said at least one lug (6) is comprised between 10 and 2000 kgf (100 N and 20 kN).

[0036] The at least one lug (6) has been discussed extensively in the foregoing, which content applies mutatis mutandis to the at least one lug of the metal casing. In particular, the at least one lug may be an integral part of the can or, alternatively, it may be fixed to the can with fixing means, such as a soldering or welding line, cement, rivets, screws and the like.

[0037] Metal casings can be cast or shaped by techniques such as stamping, folding, punching using a machine press or stamping press, blanking, embossing, bending, flanging, coining, welding, and the like in a metal workshop. They are then usually shipped to the facility of the nozzle units manufacturer, where they are applied to the refractory core of the nozzle units, usually using a cement. In order to reduce the packaging volume during shipment of the casings to the nozzle units manufacturer, it is preferred that the at least one lug is such that the metal casing fits in a rectangular cuboid having one face substantially similar or a little greater than the slide sur-

face (2a). Such examples of casings are illustrated in Figure 5(d)&(f) as well as in Figure 3(e)&(f). In case the casing comprises a tubular section for cladding the top of the tubular portion (4) of the nozzle unit, as can be seen, e.g., in Figure 4, then the lug could also extend from the lower support surface (2b) as illustrated in Figures 3(c), 4, and 5(c).

[0038] The lugs may comprise a pre-cut or weaker portion so as to facilitate the bending or breaking of the lug. This permits to precisely locate the area which will bend or break and reduce the strain on the nozzle plate (2). The position of the fixing means of the lug to the casing can also help to create the weaker portion.

[0039] The preferred shape of the lug is the one illustrated figure 4. The shape allows for an important interference with the loading opening when the nozzle unit is loaded in the wrong orientation. On the other side, when the nozzle unit is loaded in the correct orientation, the lug is pre-shape in the bending direction and permits smooth deformation. There is no or little strain induced on the nozzle plate refractory part. Cracks are thus avoided or reduced. The lug of figure 4 is also rather easy to manufacture.

[0040] The nozzle unit of the present invention is to be used with a nozzle exchange unit (100) comprising:

(a) a first fixed plate (22) comprising a through bore (23) suitable for being brought in fluid communication with a source of metal melt, such as a tundish (10), said first fixed plate comprising a first lower slide surface (22a); such fixed plate is usually part of the inner nozzle (18) of a tundish (10) and comprises a slide surface which is to form a tight interface with the slide surface (2a) of the moveable nozzle unit of the present invention;

(b) a loading opening (16) for loading the plate (2) of the moveable nozzle unit (1) of the present invention, said loading opening allowing engagement of the base of the nozzle plate (2) formed by the leading and trailing edges (2c, 2d) but not of the at least one lug (6),

(c) guiding means (7) for sliding the moveable plate (2) in a direction parallel to the first axis (X1) through said opening (16) into casting position defined as the position wherein the through bores (3, 23) of the first, fixed plate (22) and the second, moveable plate (2) are in fluid communication, the sliding surfaces of the moveable plate (2) and of the fixed plate of the inner nozzle must form a metal melt tight interface when in contact:

(e) a discharge opening at the opposite end of the guiding means (7) for discharging the nozzle unit (1) after use upon pushing it with a new nozzle unit (1), and

(f) a mechanical, pneumatic, or hydraulic arm (31) suitable for pushing a moveable nozzle unit (1) from its loading position into its casting position and having a pushing force superior to the flexural yield force or ultimate flexural force of the at least one lug (6), and wherein,

(g) the upper slide surface (2a) of the exchangeable nozzle unit (1) is suitable for sliding along the first slide surface (22a) of the first fixed plate (22) and for bringing in fluid communication the through bores (3, 23) of the first and second plates,

[0041] The loading opening (16) may be such that if the moveable plate (2) is wrongly presented with its trailing edge (2d) first, the plate cannot be laid onto the guiding means. Alternatively, in order to relieve the operator holding the nozlle unit, the plate may be laid onto the guiding means, but not deep enough to allow the arm (31) to push onto the leading edge (2c), as illustrated in Figure 6(a). Since flexural yield point or ultimate flexural force of said at least one lug (6) is comprised between 10 and 2000 kgf (100 N and 20 kN), which is too high for an operator to force by hand, and that the arm (31) is too far ahead for reaching the leading edge (2d) the plate is stuck there and cannot slide any further. The operator's only option is therefore to retrieve the nozzle unit (1), turn it back to front and introducing it into the loading opening with its leading edge first and laying it onto the guiding means, pushing it deep therethrough by hand force until the at least one lug (5) interferes with the loading opening (16). At said stage, the arm (31) is positioned against the trailing edge (2d) and forces the passage of the at least one lug (6) through the loading opening, by bending or breaking it, until the plate reaches its casting position.

[0042] As shown in Figures 6(b) and 7, if loaded properly onto the loading opening, the arm (31) is therefore suitable for contacting the trailing edge (2c) of the plate of a nozzle unit (1), preferably (a) for pushing a first nozzle unit (1) from the loading position to the casting position, (b) for pushing a first nozzle unit (1) from the casting position to an obturating position wherein the through bore (23) of the first fixed plate (22) faces a blank surface of the upper sliding surface (2a) of the nozzle plate (2), and (c) for pushing a second nozzle unit (1) from the loading position to the casting position, thus pushing the first moveable plate (1) out through the discharge opening.

[0043] A continuous metal casting line comprising a nozzle exchange device (100) and nozzle units (1) according to the present invention is therefore safe from interruptions caused by the erroneous loading of a plate with its trailing edge first, an incident occurring more often than one would think. Such system is particularly suitable for a tundish, wherein the nozzle exchange device (100) is located at an outlet below said tundish.

Claims

1. A nozzle unit (1) for use in a nozzle exchange device (100) in a continuous metal casting apparatus, said nozzle exchange device (100) being of the type com-

prising a loading opening and guiding means (7) for sliding the nozzle unit through said opening into casting position with respect to the nozzle exchange device, wherein said nozzle unit (1) comprises

A) a nozzle plate (2) made of a refractory material partly clad in a metal can, said plate having a shape inscribed in a prism, and being defined by

a) a first leading edge (2c) and a second, opposite trailing edge (2d) defining the first and second bases of the prism, transverse to a first axis (X1), said bases being preferably polygonal,
b) an upper slide surface (2a) defined by a first and a second axes (X1, X2) and a lower support surface (2b) forming a first pair of opposite and parallel joining faces of the prism,
c) a first and second side edges (2e) substantially parallel to said first major axis (X1) linking the first and second bases (2c, 2d) of the prisms as well as the first pair of opposite joining faces (2a, 2b);
d) a through bore (3) fluidly connecting the upper slide surface (2a) and the lower support surface (2b), said through bore being offset along said first axis (X1), and

B) a tubular duct (4) comprising a central bore (3a) in fluid communication with the through bore (3) of the plate, one end of duct (4) being fixed to the lower support surface (2b) of the plate (2), said central bore (3a) opening to ambient through at least one opening (5) located at or near the opposite end of the tubular duct (4);
characterized in that, at least one lug (6) is provided at or adjacent the trailing edge (2d), said at least one lug (6) being transverse to said first major axis (X1) and extending substantially beyond the perimeter defining the base of the prism, and **in that** the flexural yield point or ultimate flexural force of said at least one lug (6) is comprised between 10 and 2000 kgf (100 N and 20 kN).

2. Nozzle unit (1) according to claim 1, wherein the flexural yield point or ultimate flexural force of said at least one lug (6) is comprised between 20 and 1000 kgf (200 N and 10 kN), 50 and 500 kgf (500 N and 5 kN), preferably between 75 and 250 kgf (750 N and 2.5 kN), more preferably between 100 and 200 kgf (1 and 2 kN), most preferably, between 125 and 175 kgf (1.25 and 1.75 kN).

3. Nozzle unit (1) according to any of the preceding claims, wherein the bases (2a, 2b) of the prism are any of: (a) a rectangle, (b) a parallelogram, (c) a trapezoid, (d) a rectangle wherein at least the two angles adjacent the lower support surface (2b) are cut off to mate the geometry of guiding means (7) of a nozzle exchange device (100).

4. Nozzle unit (1) according to any of the preceding claims, wherein the at least one lug (6) is adjacent to at least one side edge (2e).

5. Nozzle unit (1) according to any of the preceding claims, wherein the at least one lug (6) is made of a ductile metal and is fixed to or is integral part of the metal can cladding the refractory, and has one of the following geometries:

(a) L-shaped plate, with the vertical bar of the "L" fixed to the plate at or adjacent the trailing edge (2d) and the horizontal bar of the "L" extending outwards beyond the surface of the side edge (2e) it is adjacent to, preferably below the level of the lower support surface (2b);
(b) L-shaped plate, with one bar of the "L" running parallel to a side edge (2e) and the other bar of the "L" extending outwards beyond the surface of the side edge (2e) it is adjacent to, and at or adjacent the trailing edge (2d).
(c) a plate, extending outwards beyond the surface of the side edge (2e) it is adjacent to, and substantially flush with the trailing edge (2b);
(d) in case of a nozzle plate wherein the side edges are not flat, two lugs adjacent the trailing edge, each extending beyond the base defining the prism such as to be enclosed within the smallest rectangle circumscribing said base, such as for example:
(e) in case of a nozzle plate (2) wherein the prism basis consists of a rectangle with at least two cut off angles, two lugs (6) adjacent the trailing edge (2d), each having the geometry of the cut off parts and being complementary to form therewith a rectangle,
(f) in case of a nozzle plate (2) wherein the prism basis consists of a rectangle with at least one protrusion jutting out of at least one edge adjacent one side edge (2e), the at least one lug (6) being substantially flush with the protrusion and with the lower edge adjacent the lower support surface (2b);
(g) a curved bar or blade (6) fixed to the support surface;
(h) curved half shells fixed to a side edge (2e).

6. A kit of parts comprising an nozzle unit (1) as defined in any of the preceding claims and a nozzle exchange device (100) for changing a nozzle unit during continuous casting of metal, wherein the nozzle exchange device comprises:

(a) a first fixed plate (22) comprising a through bore (23) suitable for being brought in fluid communication with a source of metal melt, such as a tundish (10), said first fixed plate comprising a first lower slide surface (22a);
(b) a loading opening (16) for loading the second, moveable nozzle plate (2), said loading opening allowing engagement of the base (2c, 2d) of the nozzle plate (2) but not of the at least one lug (6),
(c) guiding means (7) for sliding the moveable plate (2) in a direction parallel to the first axis (X1) through said opening (16) into casting position defined as the position wherein the through bores (3, 23) of the first, fixed plate (22) and the second, moveable plate (2) are in fluid communication,
(e) a discharge opening at the opposite end of the guiding means (7) for discharging the nozzle unit (1) after use upon pushing it with a new nozzle unit (1), and
(f) a mechanical, pneumatic, or hydraulic arm (31) suitable for pushing a moveable nozzle unit (1) from its loading position into its casting position and having a pushing force superior to the flexural yield force or ultimate flexural force of the at least one lug (6), and wherein,
(g) the upper slide surface (2a) of the exchangeable nozzle unit (1) is suitable for sliding along the first slide surface (22a) of the first fixed plate (22) and for bringing in fluid communication the through bores (3, 23) of the first and second plates,

7. A kit of parts according to the preceding claim, wherein the arm (31) is suitable (a) for pushing a first nozzle unit (1) from the loading position to the casting position, (b) for pushing a first nozzle unit (1) from the casting position to an obturating position wherein the through bore (23) of the first fixed plate (22) faces a blank surface of the upper sliding surface (2a) of the nozzle plate (2), and (c) for pushing a second nozzle unit (1) from the loading position to the casting position, thus pushing the first moveable plate (1) out through the discharge opening.

8. A kit of parts according to claim 6 or 7, wherein the nozzle unit (1) cannot be loaded for engagement into the loading opening (16) if presented in any other position than with the leading edge (2c) first.

9. Continuous metal casting line comprising a kit of parts according to any of claims 6 to 8.

10. Continuous metal casting line according to the preceding claim, wherein the nozzle exchange device (100) is located at an outlet of a tundish,

11. Metal can (12) for cladding the plate (2) of a nozzle unit (1) according to any of claims 1 to 5, having a shape suitable for cladding at least a portion of all the faces of the nozzle plate (2) but the upper sliding surface (2a) **characterized in that** it comprises at least one lug (6) provided at or adjacent the trailing edge (2d), said at least one lug (6) being transverse to a first major axis (X1) and extending substantially beyond the perimeter defining the basis of the prism, and **in that** the flexural yield point or ultimate flexural force of said at least one lug (6) is comprised between 10 and 2000 kgf (100 N and 20 kN).

12. Metal can (12) according to the preceding claim, wherein the at least one lug (6) is as defined in any of claims 2 to 5.

13. Metal can (12) according to claim 11 or 12, wherein the at least one lug is an integral part of the can.

14. Metal can according to claim 11 or 12, wherein the at least one lug (6) is fixed to the can with fixing means, such as a soldering or welding line, cement, glue, rivets, screws.

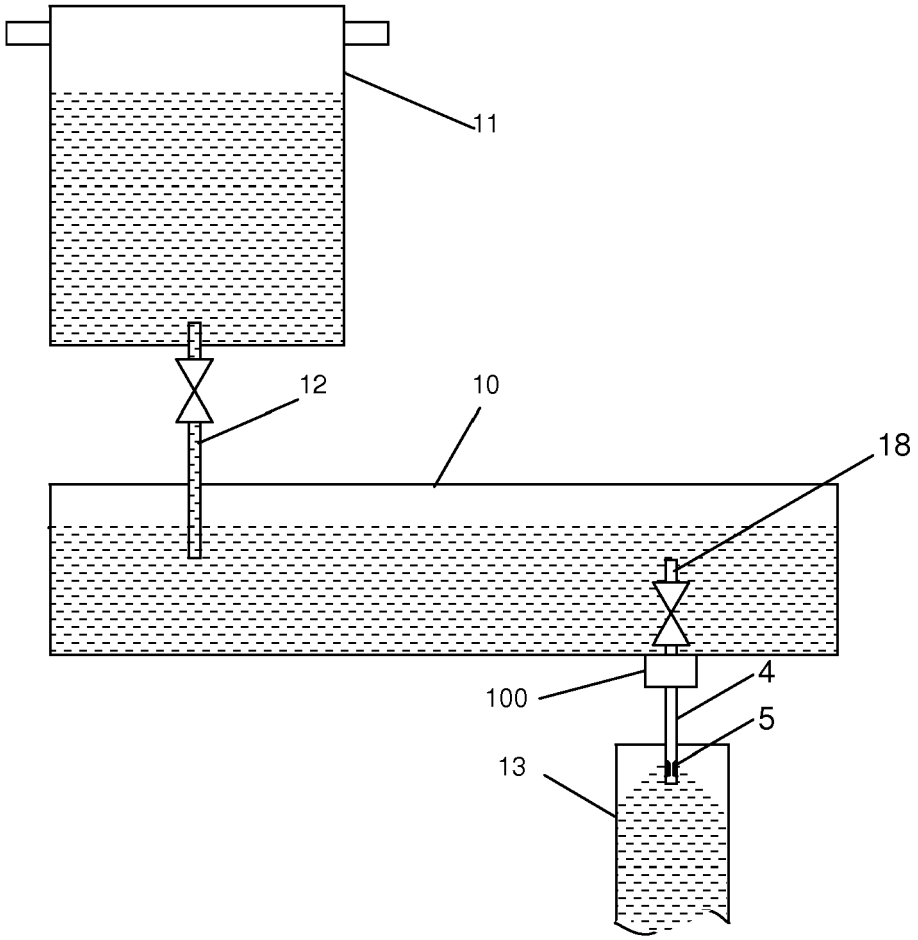


Fig. 1

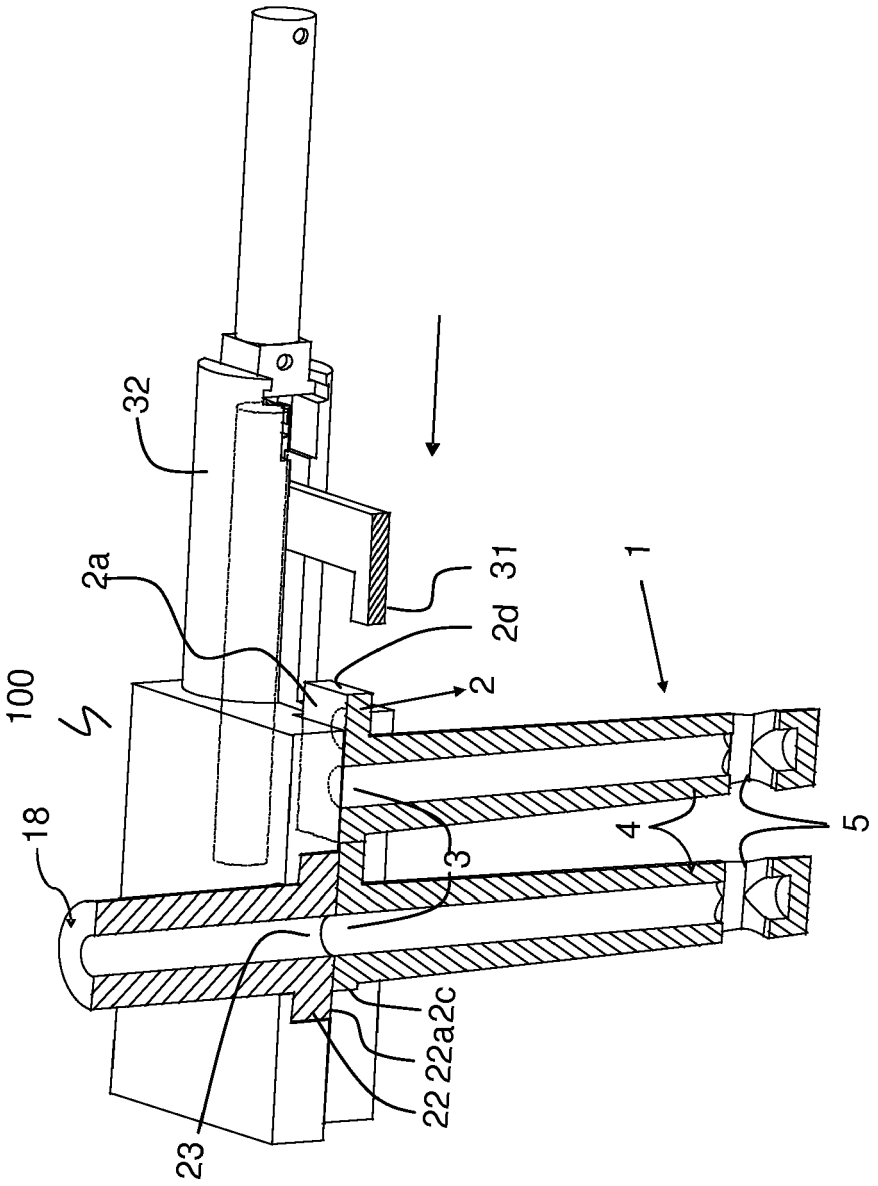
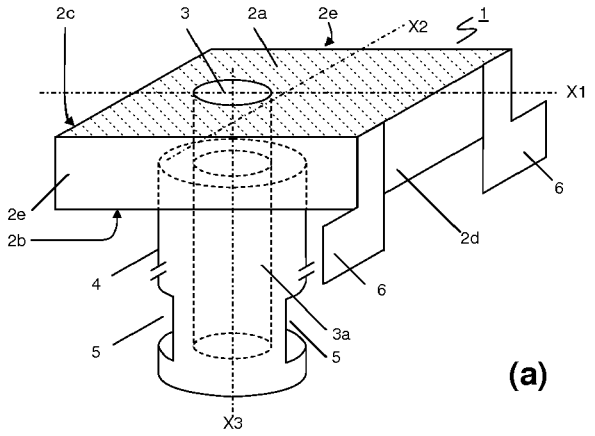
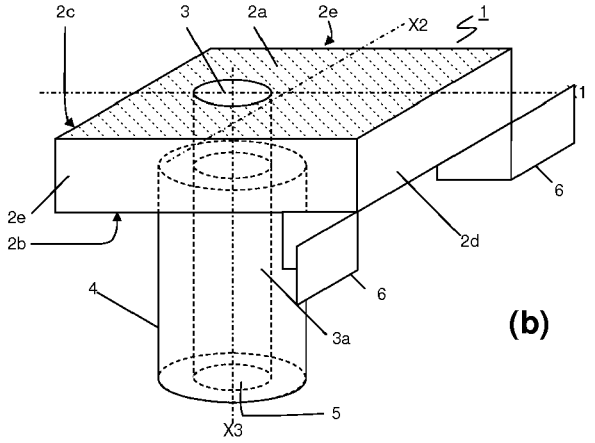


Fig. 2


2c
3
2a
2e
X2
1
X1
6
2e
2b
2d
4
6
3a
5
5
X3

(a)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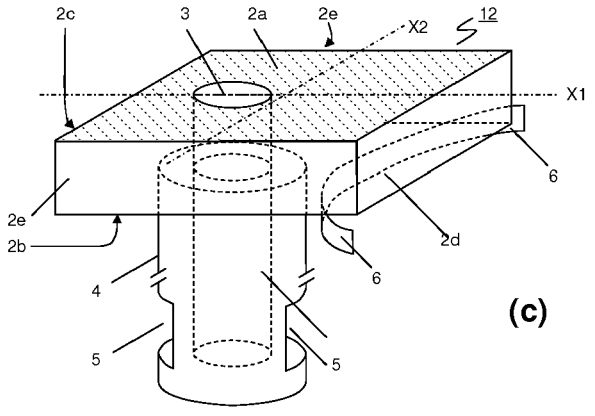
2a
2e
X2
1
11
6
2e
2b
2d
4
6
3a
5
X3

(b)


2c
3
2a
2e
X2
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X1
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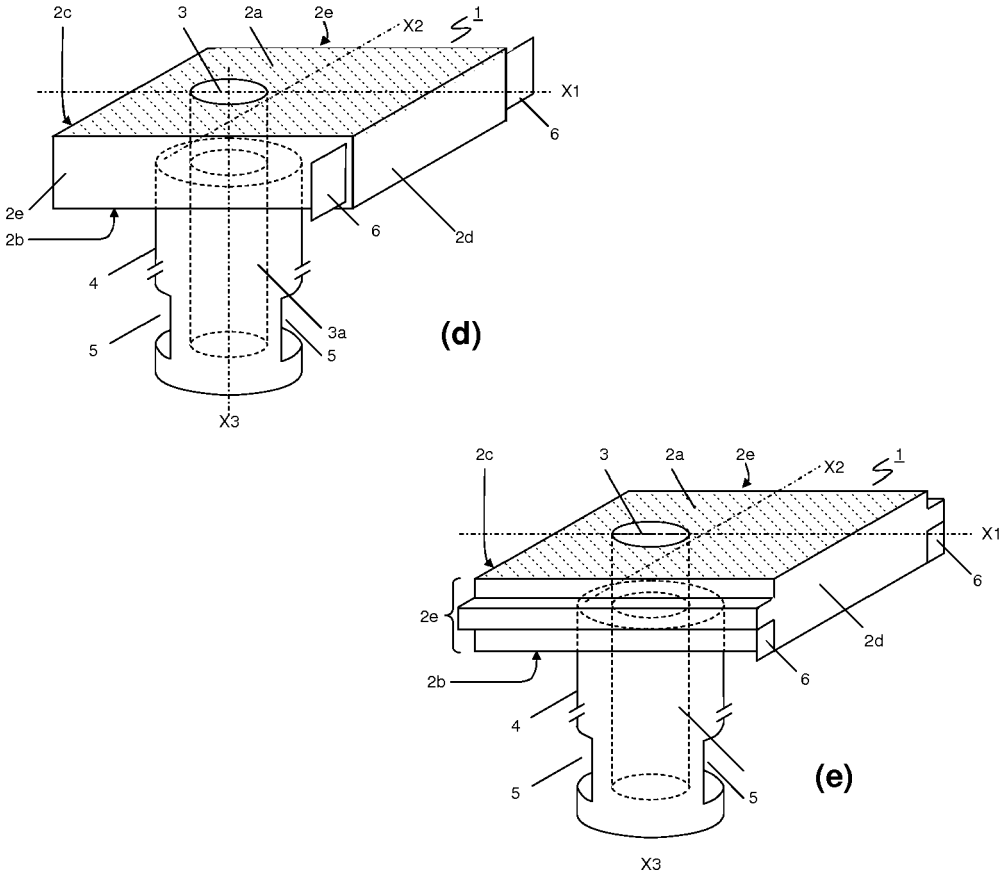
2e
2b
2d
4
6
5
5

(c)

Fig. 3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2a
2e
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X1
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2e
2b
6
2d
4
3a
5
5
X3
(d)
2c
3
2a
2e
X2
1
X1
6
2e
2d
2b
6
4
5
5
X3
(e)
2c
3
2a
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X2
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2d
4
3a
5
5
X3
(f)

Fig. 3

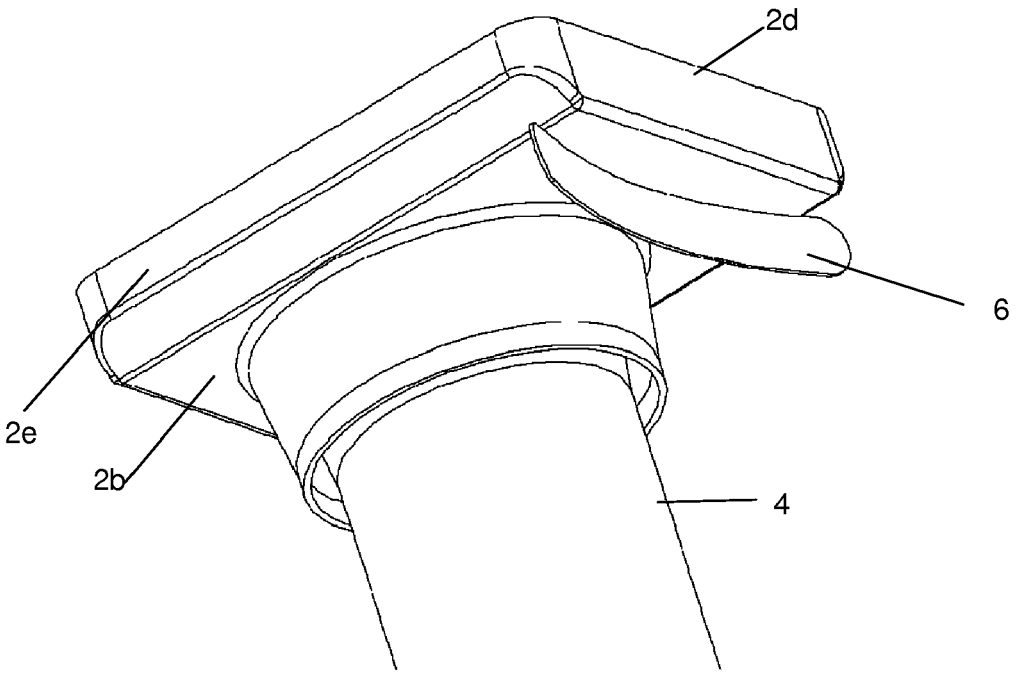
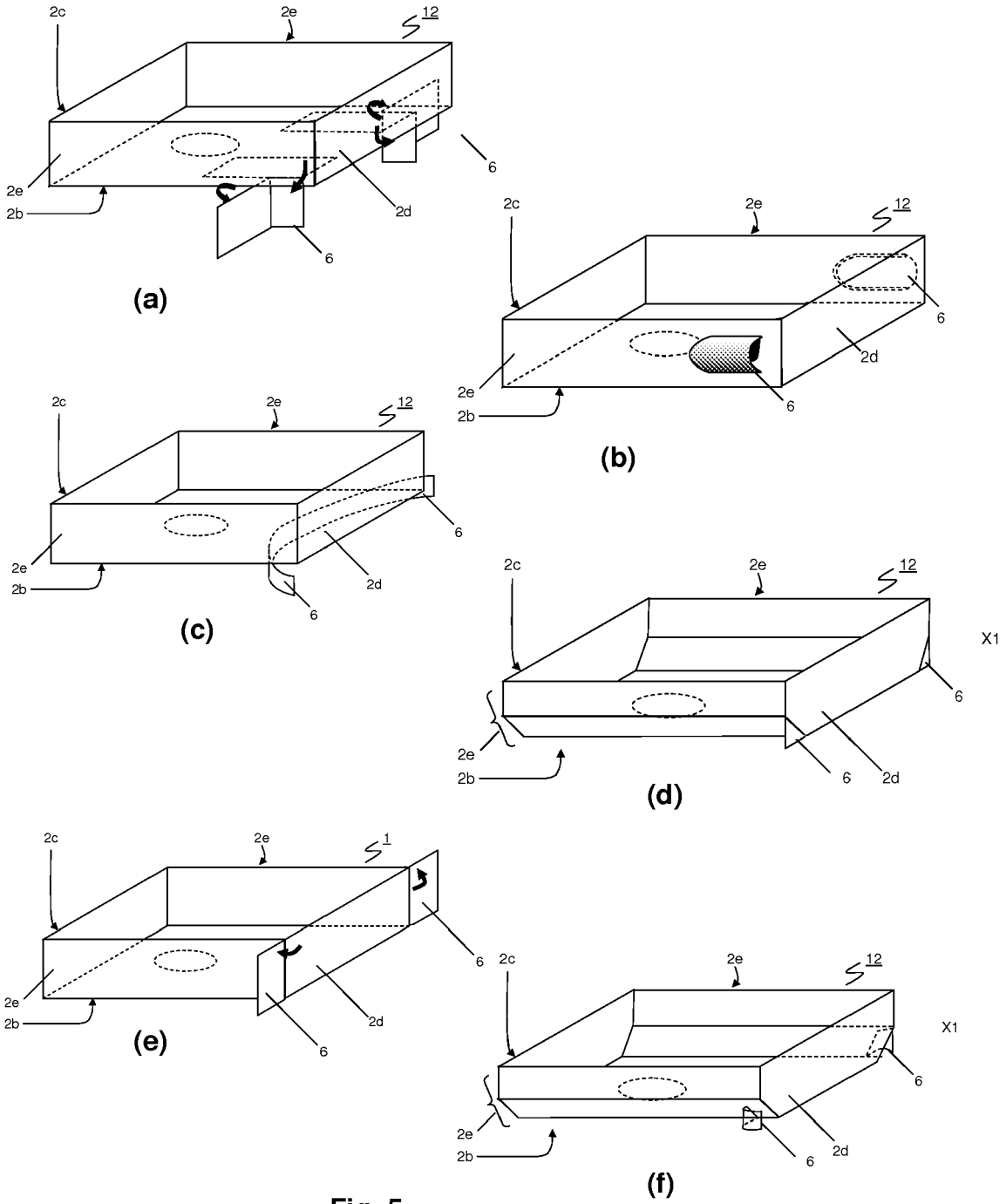


Fig. 4


2c
2e
12
6
2e
2b
2d
6
(a)
2c
2e
12
6
2d
2e
2b
6
(b)
2c
2e
12
6
2e
2b
2d
6
(c)
2c
2e
12
X1
6
2e
2b
6
2d
(d)
2c
2e
1
6
2e
2b
2d
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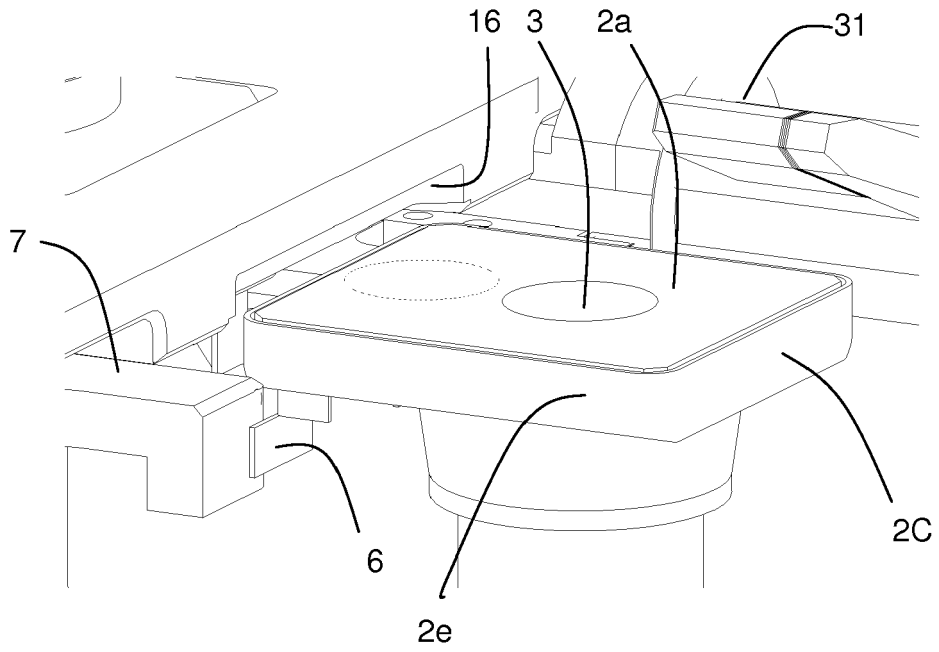
2c
2e
12
X1
6
2e
2b
6
2d
(f)

Fig. 5

a)



b)

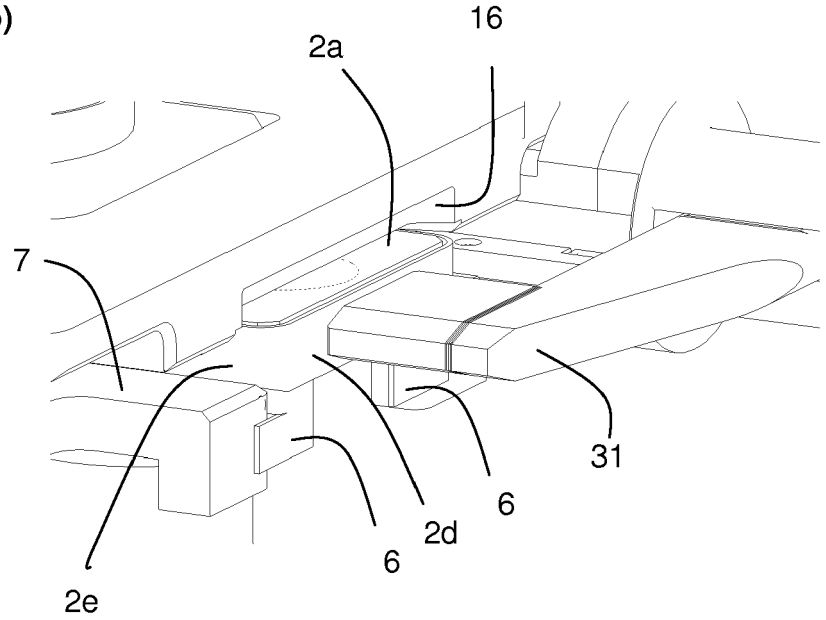


Fig. 6

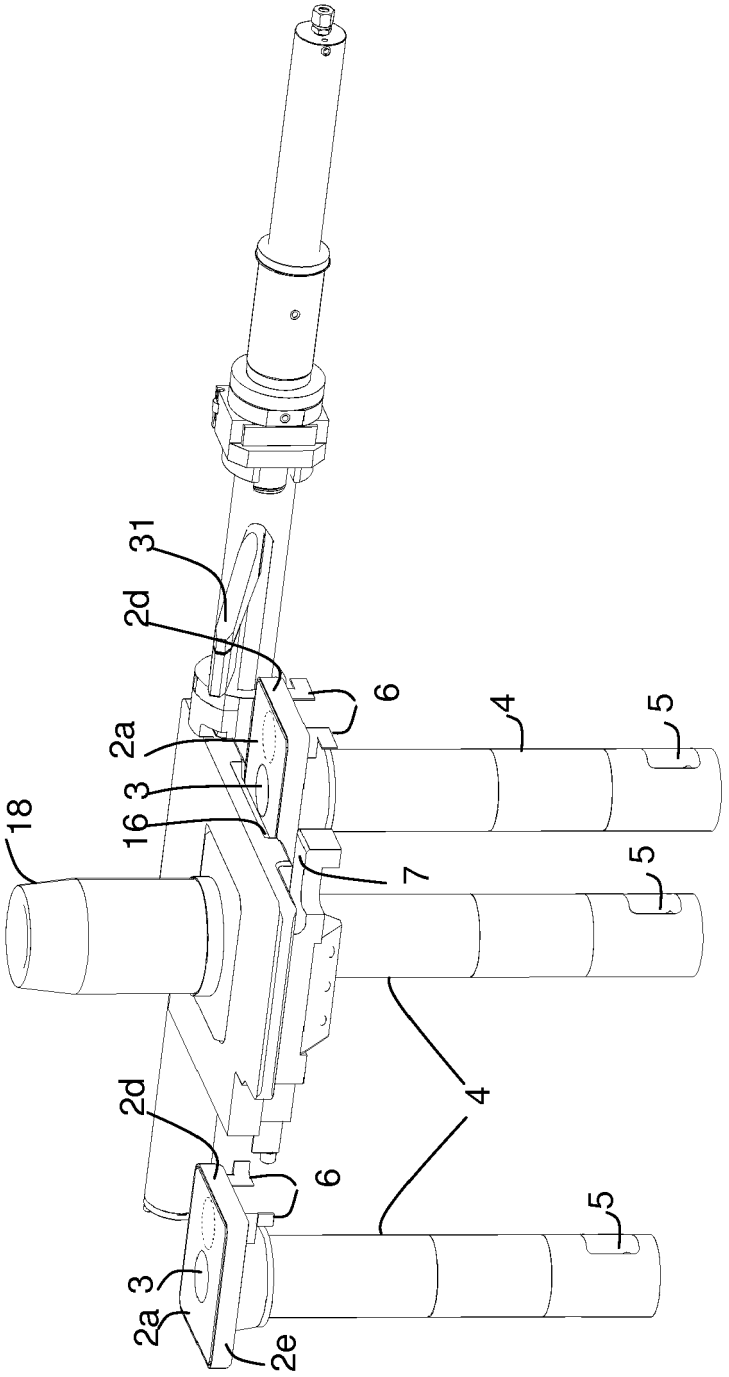


Fig. 7

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EUROPEAN SEARCH REPORT

Application Number
EP 11 16 6213

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Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	9 August 2011	Lombois, Thierry

CATEGORY OF CITED DOCUMENTS

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09-08-2011

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