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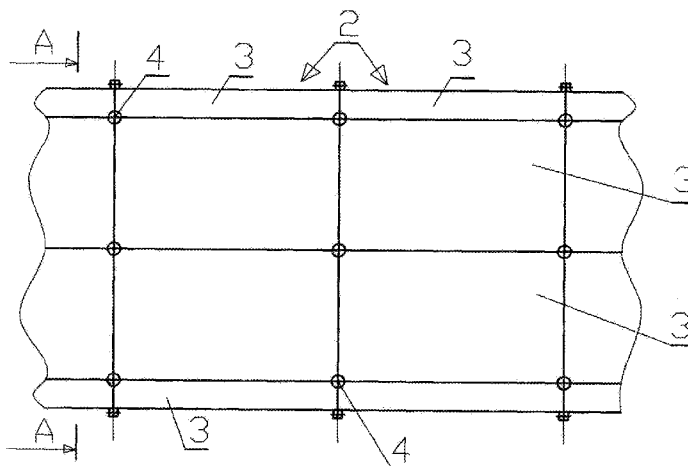


Fig. 1

(57) Abstract: The present invention relates generally to the thermal insulation technology, and more particularly to a thermal insulation for equipment at nuclear power plants (NPPs). The advantages of the present invention includes the widening of the field of application; the simplification of both installation and dismantling of the thermal insulation modules; an increase in the isothermality of an equipment to be thermally insulated; a uniform distribution of a temperature field within the thermal insulation volume along the length thereof; and the possibility of monitoring the state of the equipment body without need to remove the thermal insulation modules.



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Description

Title of Invention: MODULAR REMOVABLE THERMAL INSULATION

Technical Field

- [1] The present invention relates generally to the thermal insulation technology, and more particularly to a thermal insulation for equipment at nuclear power plants (NPPs).

Background Art

- [2] Known from the state of the art is a modular removable thermal insulation comprising a housing in the form of tie bands which have threaded seats and are located with a fixed lead on an outer surface of an equipment to be thermally insulated; and an enclosure which encompasses the equipment to be thermally insulated and comprises an N-face outer surface and an N-face inner surface the enclosure consisting of circular sections which are located sequentially lengthwise of the equipment to be thermally insulated and abut each other, each of the circular sections being made of N identical thermal insulation modules (TIMs) which are butt-jointed to each other with their sidewalls disposed at an angle $\varphi(\text{rad}) = 2\pi/N$ relative to each other. The entire volume of a casing is filled with mats with a net. A bottom and a cover of the casing which are parallel to each other are connected to each other with locking dowels, and, in each TIM, through holes lined with metal tubes and intended for threaded fasteners are made (see Russian Federation Patent RU No.2259510, C1, 2005).
- [3] The drawbacks of the above construction include the inaccessibility to frame members during the operation of equipment for the purpose of adjusting a band tightening force as well as the complexity of TIM installation associated with the necessity of aligning the threaded seats with respect to the through holes in the TIM lined with the metal tubes and intended for the threaded fasteners. The latter circumstance results also in an increase in labor expenditures in the installation of the modular removable thermal insulation since, prior to its installation, the frame should be assembled outside the equipment to be thermally insulated. In addition, the TIMs have a complex construction and, therefore, a high cost and, furthermore, the existence of through holes in the TIMs results in additional heat leakages and, therefore, in the deterioration of the thermal insulation properties.
- [4] Known from the state of the art is also a modular removable thermal insulation which is taken as the prototype and comprises circular sections which are located in series longitudinally on an outer surface of an equipment to be thermally insulated and immediately adjacent to each other, each of the circular sections being made of N identical TIMs which are butt-jointed to each other with their sidewalls disposed at an

angle $\varphi(\text{rad}) = 2\pi/N$ relative to each other and are fastened individually to elements which are welded to the equipment to be thermally insulated. Each TIM has a segment shape and comprises a frame of metal angles which is filled with mineral wool mats or mineral wool thermal inserts in a foil and net and lined all round with facing metal sheets which protect the thermal insulation against exposure to unfavorable environmental factors (see L. M. Faktorovich, Thermal Insulation Design and Installation, Leningrad, National Research and Technological Institute for oil and mining fuel literature, 1960, pp. 320-1). As compared with the above analog, the TIMs that are employed in the prototype has a simpler construction which, on the one hand, makes it possible to reduce labor expenditures in the manufacture of TIMs and, on the other hand, does not require the employment of custom parts manufactured using an expensive press equipment.

- [5] The prototype has, however, a limited field of application because of fastening the TIMs to elements which are welded to the equipment to be thermally insulated. In other words, the prototype can not be employed for thermal insulation of power-generating equipment, in particular, NPP equipment. Another drawback of the prototype consists of that because of positioning the TIMs directly on the surface of the equipment to be thermally insulated, the isothermality of its surface is not ensured owing to an inhomogeneous distribution of thermal resistance caused by different fits of the TIMs to the surface of the equipment to be thermally insulated. As a result, temperature stresses occur in the housing of the equipment to be thermally insulated, this resulting in a reduction of its service reliability

Disclosure of Invention

Solution to Problem

Technical Solution

- [6] The technical aim of the present invention is therefore to improve the performance parameters of a modular removable thermal insulation through:
- [7] - A free (nonrigid) positioning of TIMs on a surface of an equipment to be thermally insulated;
- [8] - Providing a uniform gap between the thermal insulation and the equipment to be thermally insulated; and
- [9] - Simplifying the installation of TIMs as well as making it possible to remove a minimal number of TIMs in the performance of preventive operations.
- [10] The technical aim is attained by that in a modular removable thermal insulation which comprises circular sections which are located in series longitudinally on an outer surface of an equipment to be thermally insulated and immediately adjacent to each other, each of the circular sections being made of N identical thermal insulation

modules butt-jointed to each other with longitudinal sidewalls located at an angle $\varphi(\text{rad}) = 2\pi/N$ relative to each other; each thermal insulation module including a frame made of metal angles, thin facing metal sheets, and a filler of a thermal insulation material, according to the present invention, the thermal insulation modules in adjacent sections are located opposite to each other; the frame includes four identical corner posts which are located pairwise at an angle φ relative to each other and connected to each other with upper and lower cross members located parallel with each other; each corner post of the above mentioned corner post pair is connected to the corner post of a second corner post pair located opposite to and in parallel with it with upper and lower cross members located in parallel with each other, the upper cross members and longitudinal members being located at the same level as, and at the same distance from, upper ends of the corner posts which are the nearest thereto, and the lower cross members and longitudinal members are also located at the same level as, and at the same distance from, lower ends of the corner posts which are the nearest thereto; a portion of the frame including the upper and lower cross members, respectively, and longitudinal members as well as the lengths of the corner posts located therebetween is lined all around with said metal sheets which form two identical longitudinal sidewalls located at an angle φ relative to each other, two identical cross sidewalls located parallel with each other as well as a back wall facing the equipment to be thermally insulated and a front wall located opposite thereto and parallel therewith; the ends of the corner posts which protrude beyond the back wall form first end sections of the same length and the ends of the corner posts which protrude beyond the front wall forming second end sections of the same length; each first end section comprises two identical teeth of a triangular shape with a lower face and an upper face of different lengths whose intersection forms a tip of the respective tooth; each tooth being provided aside from a flange corresponding thereto of the angle of which the respective corner post is made and the intersection of the lower side of the tooth with the end of said angle forms a lower edge of the tooth located from the angle rib at a distance which is less than the distance between the upper edge of the tooth and the same angle rib; each second end section is provided with a spring position lock configured in the form of a symmetrical closed cross-shaped contour with four identical loop sections of an elongated shape which are located orthogonally relative to each other; said thermal insulation modules which abut each other with both longitudinal and cross sidewalls form a thermal insulation enclosure which encompasses the equipment to be thermally insulated with an N-face front surface and an N-face back surface as well as with bundles, which are located regularly along the length of each rib of the back surface, of the first end sections facing the equipment to be thermally insulated, and with bundles, which are located regularly along the length of

each rib of the front surface, of the second end sections facing to the opposite direction; four first end sections which are located parallel with each other and form each bundle are connected detachably to each other by means of a suitable latch-support simply supported by the surface of the equipment to be thermally insulated; each latch-support comprising an axially symmetrical body wherein, from the side of the end face located opposite to its end face which engages with the surface of the equipment to be thermally insulated, a seat of a cross-shaped cross section is provided in which seat the first end sections of the respective bundle are received and a circular groove is provided in the latch-support body from the side of the side surface so as to ensure a partial intersection with peripheral sections of the seat in which groove a spring is located with the possibility of changing reversibly its diameter in the installation and dismantling of the thermal insulation modules the spring being in the form of an open wire ring with end sections which overlap each other within the entire range of change in its diameter; four second end sections which form each bundle and are parallel with each other being also connected detachably to each other with the help of said spring corresponding to each bundle in the form of a symmetric closed cross-shaped contour which spring engages with it position locks provided at the second end sections, the circular groove being located at a distance H from the bottom of the seat which distance satisfies the following relation: $(L_3 - d/2) \leq H \leq L_3$, where L_3 is the distance between the upper edge of each tooth located at the first end section and the end face of the angle of which the respective corner post is made; d is the cross-sectional dimension of the wire of which the spring located in the groove is made.

- [11] Furthermore, the technical aid is attained by that:
- [12] - The seat is provided in the form of a blind axial hole and four identical rectangular radial slots extending from the axial hole and disposed at right angles relative to each other; the seat dimension in the direction of each pair of the radial slots located opposite to each other being more than the maximum outer diameter of the wire ring and a radius R of the axial hole satisfying the following relation: $R > h + h_1/2$, where h is the thickness of the angle of which the corner posts are made in the plane which extends through an outer rib of the angle and at an angle of 45° with the outer surfaces of the angle flanges; h_1 is the thickness of the metal sheets with which the portion of the frame of the thermal insulation modules is lined;
- [13] - The seat is configured so that a sliding fit or a running fit between the mating surfaces of the seat and the first end sections is ensured when inserting the first end sections into and removing the first end sections out of the seat;
- [14] - The spring position lock is configured in the form of a stop located between the flanges of the angle of which the corner post is made;
- [15] - The stop is configured in the form of a projection formed by welding a metal on a

surface area located between the angle flanges;

- [16] - The stop is configured in the form of a projection made of a plate of a square shape or a triangular shape welded to the angle flanges from inside them; and
- [17] - The spring position lock is configured in the form of a depression located aside from each flange of the angle and at the same distance from its end face.
- [18] The advantage of the modular removable thermal insulation in accordance with the present invention as compared with the prototype consists of that the configuration of the thermal insulation modules in accordance with the present invention as well as of the means which provide fastening the TIMs to each other ensures:
- [19] - A free positioning of the TIMs at the surface of the equipment to be thermally insulated and, therefore, the widening of the field of application of the thermal insulation in accordance with the present invention, in particular, to include heat and power generating equipment at NPPs;
- [20] - The simplification of both installation and dismantling of the TIMs with a possible dismantling, for the purpose of performing preventive operations, of a minimal number (from 1 to 4) of the TIMs; and
- [21] - A uniform gap between the thermal insulation and the equipment to be thermally insulated this resulting in the isothermality of the surface of the equipment to be thermally insulated and, therefore, a reduction in the likelihood of the occurrence of significant temperature stresses which reduce its service reliability. Furthermore, the existence of such uniform gap between the thermal insulation and the facility to be thermally insulated ensures a uniform distribution of a temperature field within the thermal insulation volume along the entire length thereof and the possibility of monitoring the state of the equipment to be thermally insulated (in particular, the state of welded joints) without need to remove the TIMs for this purpose by placing the respective monitoring system and/or sensors (transducers) into said gap. Moreover, the existence of an air gap between the modular removable thermal insulation and the equipment to be thermally insulated ensures a reduction in thermal losses to the environment.
- [22] The other technical aims attainable with the device in accordance with the present invention will become more apparent from the following description taken in conjunction with the drawings.

Brief Description of Drawings

Description of Drawings

- [23] The present invention will be now explained using specific embodiments thereof which, however, should not be deemed as only possible embodiments and which rather demonstrate the possibility of the attainment of the above technical aims using the set of material features of the present invention.

- [24] Fig. 1 is a side view of a modular removable thermal insulation located on a equipment to be thermally insulated;
- [25] Fig. 2 is a section on the line A-A of Fig.1;
- [26] Fig. 3 is a general view of a TIM;
- [27] Fig. 4 is a general view, partly in section, of the TIM;
- [28] Fig. 5 is a side enlarged view of a first end section of a corner post;
- [29] Fig. 6 is a bottom view of a bundle of four first end sections parallel to each other of the corner posts;
- [30] Fig. 7 is a bottom general view of a bundle of four first end sections parallel to each other of the corner posts;
- [31] Fig. 8 is a general view of a second end section of the corner post;
- [32] Fig. 9 is the same view but with a projection formed by a flange;
- [33] Fig. 10 is the same view with a spring position lock in the form of a depression;
- [34] Fig. 11 is a side view, partly in section, of a latch-support;
- [35] Fig. 12 is a top view, partly in section, of the latch-support;
- [36] Fig. 13 is a partial cross-sectional view of the latch-support with the first end sections of the corner posts fastened to each other thereby;
- [37] Fig. 14 is a top view of the latch-support with a lightened body;
- [38] Fig. 15 is a general view of the latch-support but with a welded body;
- [39] Fig. 16 and 17 are top views of a spring for a detachable connection of the second end sections to each other;
- [40] Fig. 18 is a side view of the spring for a detachable connection of the second end sections to each other; and
- [41] Fig. 19 is a top view of the bundle of the second end sections connected to each other with the spring.

Best Mode for Carrying out the Invention

Best Mode

- [42] The modular removable thermal insulation in accordance with the present invention comprises circular sections 2 which are located in series longitudinally on an outer surface of an equipment to be thermally insulated, for example, a pipeline 1, and immediately adjacent to each other, each of the circular sections being made of N identical thermal insulation modules (TIMs) 3 which abut each other with their sidewalls the TIMs 3 in adjacent sections being located opposite to each other. As a result, each of the four corners between sidewalls of each TIM 3 is butt-joined along a joint line 4 which extends orthogonally to the surface of the equipment to be thermally insulated, on the one hand, with an angle corresponding thereto between the sidewalls of the TIM 3 which is located in the same section and nearby said TIM 3 and, on the

other hand, with two angles corresponding thereto between sidewalls of two TIM 3 located next to each other in an adjacent section and opposite to one corresponding to each of them and the above mentioned TIM 3 from the above mentioned section (Figs.1 and 2).

- [43] Each TIM 3 comprises a frame (Fig. 3) made of commercially available angles (for example, equal steel angles) in the form of four identical corner posts 5 which are located pairwise at an angle $\varphi(\text{rad}) = 2\pi/N$ (in Figs. 1 and 2, $N=8$) relative to each other and connected to each other with upper cross members 6 and lower cross members 7 located parallel with each other both upper cross members 6 and lower cross members 7 being located at the same distance corresponding to each of them from the upper ends and lower ends, respectively, of the corner posts 5 the nearest thereto. Each corner post 5 of one above mentioned pair of the corner posts 5 is connected to the corner post 5 of the other pair of the corner posts, which is located opposite thereto and parallel therewith, with upper longitudinal members 8 and lower longitudinal members 9 which are parallel with each other; all of said upper members 6 and 8 as well as all of said lower members 7 and 9 being located at the same level corresponding to each of them. In accordance with some another preferred embodiments of the invention, it may be advantageous to use a greater number of the longitudinal members and/or cross members to connect the corner posts 5 to each other the longitudinal members and/or cross members used additionally being interposed between said upper and lower longitudinal and/or cross members, respectively. In addition, in the manufacture of said frame, metal inserts (jumpers), for example, made of metal angles, strips, interposed between the respective upper and lower members and connected rigidly thereto, preferably, by means of contact welding, may also be used.
- [44] A portion of the frame which comprises the upper and lower, respectively, cross members 6, 7 and longitudinal members 8, 9 as well as sections of the corner posts 5 located therebetween is lined (faced) all around with thin (of not more than 1.0 mm thick, preferably, between 0.5 mm and 1.0 mm) metal (preferably, stainless steel) sheets forming:
- [45] - Two identical longitudinal sidewalls 10 and 11 located at an angle $\varphi(\text{rad}) = 2\pi/N$ along which sidewalls TIMs 3 in each section 2 are butt-joined to each other and which sidewalls have the shape of a rectangle;
- [46] - Two identical to and parallel with each other cross sidewalls 12 and 13 along which sidewalls TIMs 3 in each section 2 are butt-joined to each other and which sidewalls have the shape of a isosceles trapezoid with the small base facing the equipment to be thermally insulated and the legs at an angle $\varphi(\text{rad}) = 2\pi/N$ relative to each other;
- [47] - A back wall 14 in the shape of a rectangle facing the equipment to be thermally insulated and a front wall 15 in the shape of a rectangle located opposite thereto and

parallel therewith as well as a cavity defined by the walls 10 to 15 containing a filler of a thermal insulation material 16, preferably, of fiber glass (Fig. 4). Preferably, the corner posts 5 are connected to the cross members 6, 7 and the longitudinal members 8, 9 using a contact welding which is also used to line said portion of the frame with the thin metal sheets.

- [48] Each TIM 3 comprises, thus, the frame made of the angles whose portion lined with the metal sheets constitutes a casing filled with thermal insulation material 16 in the form of a segment (having, in its cross section, the shape of a isosceles trapezoid with the small base facing the equipment to be thermally insulated and the legs at an angle $\varphi(\text{rad}) = 2\pi/N$ relative to each other and, in its longitudinal section, the shape of a triangle), and the ends of the corner posts 5 which protrude relative to the back wall 14 and the front wall 15 form identical first end sections 17 which face the equipment to be thermally insulated and have a length L1 relative to the back wall 14 as well as second end sections 18 which are located opposite thereto and have a length L2 relative to the front wall 15 (Figs. 2 and 4).
- [49] Each first end section 17 has two identical teeth (protrusions) 19 of a triangular shape with unequal in length lower side 20 and upper side 21 whose intersection forms a tip 22 of the tooth 19 each tooth 19 being provided aside from a flange 23 corresponding thereto of the angle of which the respective corner post 5 is made (Figs. 5 to 7 Figs. 6, 7 being bottom views). A upper edge 24 of each tooth 19 is located at a distance L3 from an end face 25 of the angle, of which the respective corner post 5 is made, the intersection of said lower side 20 (which has a longer length as compared with the length of an upper side 21 of the tooth 19 and a smaller slope angle α relative to an outer rib 26 of the angle as compared with a slope angle β of the upper side 21 relative to the same outer rib 26) forming, with the end face 25 of the same angle, a lower edge 27 of the tooth 19 which is located at a distance L4 from the outer rib 26 of the angle. The distance L4 is, however, less than a distance between the upper edge 24 of the tooth 19 and the outer rib 26 by W which (as will be shown hereinafter) is selected so as to ensure (after the thermal insulation is installed onto the equipment) a desired compressive force for each bundle of the four first end sections 17 parallel with each other the first end sections 17 in each bundle being located symmetrically about the joint line 4 of the angles between the sidewalls of the four TIMs 3 corresponding thereto which are located pairwise nearby each other in the adjacent sections (in Fig. 7, the adjacent sections are indicated with reference numerals 200 and 201), two TIMs 3 in one section 200 being located opposite to said two TIMs 3 in the adjacent section 201. The joint line 4 is, therefore, also the axis of symmetry of the bundle of the first end sections 17 which corresponds thereto.
- [50] The edges 24 and 27 as well as the tip 22 of the tooth 19 may be configured as round

ones and the maximum distance from the tip 22 of the tooth 19 to the rib 26 of the angle does not exceed the width of the flange 23 of the angle. Said angle α is between 200 and 400; if the angle $\alpha < 200$, the length L1 of the first end sections 17 increases unjustifiably. In most practically important cases, $L1 = (15 - 20)$ mm. If $\alpha > 400$, inconveniences occur in the installation of the TIMs 3 due to the necessity to apply significant forces in the installation of the TIMs 3 onto the equipment to be thermally insulated. As to said angle β , it is between 450 and 600; if $\beta < 450$, the length of the first end sections 17 increases unjustifiably. If $\beta > 600$, inconveniences occur in the dismantling of the TIMs 3 due to the necessity to apply significant forces in the dismantling of the TIMs.

- [51] Each second end section 18 is provided with a spring position lock which is configured either in the form of a stop placed between the flanges 23 of the angle (of which the respective corner post 5 is made), for example, in the form of a protrusion 28 formed by welding a metal on a surface area located between the flanges 23 of the angle; or in the form of a protrusion 29 made of a plate of a square, triangular, or any other suitable shape which is welded to the flanges 23 from inside them; or in the form of a depression 30, for example, of a semicircular shape provided aside from each flange 23 of the angle and at the same distance from its end face 25 (Figs. 8 to 10). In most practically important cases, the length L2 of the second end 18 is between 6 mm and 10 mm.
- [52] As a result of the butt-joining of the TIMs 3 to each other, along both the longitudinal sidewalls 10, 11 and the cross sidewalls 12, 13, both said bundles of the first end sections 17 parallel to each other with the joint line 4 of the angles between the sidewalls of the respective TIMs 3 being the axis of symmetry whereof and the bundles of the second end sections 18 parallel to each other are formed, the bundles of the first end sections 17 and the bundles of the second end sections 18 opposite to each other have the common axis of symmetry which is orthogonal to the surface of the equipment to be thermally insulated.
- [53] Thus, the identical sections 2 which are arranged along the length of the equipment to be thermally insulated, butt-jointed to each other, and consist of N identical TIMs 3 which are also butt-jointed to each other along the longitudinal sidewalls 10 and 11 form an enclosure which encompasses the equipment to be thermally insulated and comprises an N-face front surface and an N-face back surface; the bundles of the first end sections 17 of the corner posts 5 facing the equipment to be thermally insulated being located regularly along the length of each rib of the front surface and the bundles of the second end sections 18 of the corner posts 5 facing to the opposite direction (outwards) (Figs. 1 and 2).
- [54] The first end sections 17, facing the equipment to be thermally insulated, of each

bundle are connected detachably to each other with the aid of the respective latch-support which engages with (is simply supported by) the outer surface of the equipment to be thermally insulated. Each latch-support (Figs. 11 to 13) comprises a body 31 having an axially symmetrical shape about an axis 32 and a spring in the form of an open wire ring 33 which is located on the body 31 with the possibility of changing reversibly its diameter in the installation and dismantling of the TIMs 3 and is configured with end sections which overlap each other within the entire range of change in its diameter. The end face of the body 31 which engages with the surface of the equipment to be thermally insulated has a plane surface or a cylindrical surface with the radius of curvature equal to the radius of the outer surface of the equipment to be thermally insulated. In the body 31 (from the side of the end face opposite to said end face), a seat 34 of a cross-shaped cross section is provided in which seat the first end sections 17 of the respective bundle are received so as to ensure a sliding fit or a running fit between mating surfaces when receiving (accommodating) the first end sections 17 in and when removing them out of the seat 34. In the body 31, from the side of its side surface, a circular groove 35 for the wire ring 33 is provided so as to ensure a partial intersection of peripheral sections of the seat 34 and located at a distance H from the bottom of the seat 34, which distance satisfies the following relation: $(L3 - d/2) \leq H \leq L3$, where d is the cross-sectional dimension of the wire of which the 33 is made, in particular, the diameter of the wire of a round cross section. The groove 35 is configured with a width t which ensures the possibility of changing reversibly by the wire ring 33 of its diameter in the installation/dismantling of the TIMs 3. The minimum inner diameter Dmin of the wire ring 33 is equal to the double distance L5 from the groove 35 bottom to the axis 32 and is determined as follows:

[55] $D_{min} = 2L5 = 2L4 (1 + h1/L4) \cos\{\arctan[(h1 + h2)/L4]\},$

[56] where h1 is the thickness of the metal sheets with which the portion of the frame of the TIMs 3 is lined; and h2 if the width of the lower edge 27 of the tooth 19.

[57] As to the maximum inner diameter Dmax of the wire ring 33, it is determined by the following formula:

[58] $D_{max} = 2L6 (1 + h1/L6) \cos\{\arctan[(h1 + h3)/L6]\},$

[59] where L6 is the distance from the tip 22 of the tooth 19 to the rib 26 of the angle, and h3 is the width of the tip 22 of the tooth 19 (Fig. 6).

[60] The seat 34 has its depth which exceeds H + t by 1 to 3 mm and is provided in the form of a blind axial hole 36 of a radius $R > h + h1/2$, where h is the thickness of the angle of which the corner posts are made 5 in the sectional plane extending across its outer rib 26 and at an angle 45° with the outer surfaces of its flanges 23, and of four identical rectangular radial slots 37 extending from the axial hole 36 and disposed at right angles relative to each other. The seat 34 dimension in the direction of each pair

of the radial slots located opposite to each other is more (preferably, by 0.5 to 1.0 mm) than the maximum outer diameter of the wire ring 33 which is equal to $D_{\max} + 2d$. The width of the radial slots 37 is selected so as to ensure said fit (a sliding fit or a running fit) between the mating surfaces of the seat 34 and the first end sections 17 being inserted into or removed out of the seat 34.

[61] In order to reduce a metal content, the latch-support body (Fig. 14) is configured with four longitudinal ribs 38 extending orthogonally relative to each other each radial slot 37 being located along the rib 38 corresponding thereto and symmetrically about its outer walls. The latch-support body may also be configured of a multiple of parts rigidly connected to each other, for example, of two parts, namely, of a length of a hollow cross-shaped section 39 bent or produced by rolling and a square or round plate-flange 40 rigidly connected (welded) to the end face of the hollow cross-shaped section 39 (Fig. 15). In configuring the end face of the latch-support body 31, which engages with the outer surface of the equipment to be thermally insulated, of a cylindrical shape, the generatrix of this surface should be parallel with one of the pairs of the radial slots 37 located opposite to each other.

[62] The second end sections 18 facing outwards of each bundle are connected detachably to each other by means of a spring 41 made of a tape or wire (Figs. 16 to 18) in the form of a symmetrical closed cross-shaped contour. Each of four identical loop sections of an elongated shape of this contour located orthogonally relative to each other is configured in the form of two straight members 42 parallel with each other. First ends of said straight members 42 are smoothly mated with the straight member 42 which corresponds to each of them of the other two loop sections of the same contour which are adjacent thereto. Second ends of the straight members 42 are mated with each other by means of a member 43 of an arcuate shape, preferably, of a circular arc shape (Figs. 16 to 18). In accordance with a preferred embodiment of the invention, in the spring 41 made of a tape, the members 42 are tapered from the periphery toward the axis of symmetry of the spring 41.

[63] In accordance with another preferred embodiment of the invention, the modular removable thermal insulation is covered with a protective casing (indicated conventionally by a dashed line 44 in Fig. 2) made of thin (about 1 mm thick) stainless steel sheets which, on one side, are supported by the protruding bundles of the second end sections 18 and, on the other (external) side, are secured with the aid of ring clamps tightening said sheets about the circumference similarly to as described in Great Britain Patent Publication GB No.1264760, 1973. The employment of the protective casing ensures the protection of the modular removable thermal insulation in accordance with the present invention against exposure to unfavorable external factors including without limitation seismic factors. Furthermore, thanks to the bundles of the

second end sections 18 protruding outwards, a uniform gap between the modular removable thermal insulation and the protective casing is ensured. Thanks to such gap, heat losses are reduced owing to the existence of one more air gap, on the other hand, and the possibility (under hot climate conditions) of maintaining a protective casing temperature at the recommended level (about 50 C) by pumping a coolant through a ring cross-section channel between the modular removable thermal insulation and the protective casing is ensured, on the other hand.

- [64] The invention may be practiced as follows. In the installation of each TIM 3, all of its four first end sections 17 are first placed into the pair corresponding to each of them of the adjacent radial slots 37 of the seat 34 of the latch-support also corresponding to each of them all of the latches-supports being freely (in other words, using no means to fix their position) placed on the surface of the equipment to be thermally insulated. For this purpose, each first end section 17 of the respective TIM 3 is received (accommodated) in two adjacent radial slots 37 corresponding to it of the seat 34 till the lower edges 27 of both its teeth 19 abut the wire ring 33 which, under compressive force, has initially its minimum diameter which is determined by the diameter of the circular groove 35 bottom. A force is then applied to the TIM 3 being installed which force is directed radially relative to the outer surface of the equipment to be thermally insulated. This force is transmitted, through the first end sections 17 of the respective TIM 3, to the wire ring 33 which corresponds to each first end section 17. When the wire ring 33 engages with the inclined lower sides 20 of two teeth 19 of the respective first end section 17, the diameter of the wire ring 33 increases (under a radially directed force the magnitude whereof depends on an angle α) till it engages with the tips 22 of the teeth 19 of the respective first end sections 17. Thereafter, under an elastic, compressive force, a latching occurs, to say it in other words, an abrupt (towards reduction) change in the diameter of the forcibly expanded wire ring 33 till the achievement of the position determined by the position of the upper edges 24 of the teeth 19 relative to the axis 32; the more the distance W, the more the diameter of the wire ring 33 in its latched position and, therefore, the more the magnitude of the force tightening the first end sections 17 of the respective bundle to each other. Thus, in its latched position, the wire ring 33 of the respective latch-support engages with (is pressed to) the upper edges 24 of the teeth 19 of the first end sections 17 of the respective bundle of the first end sections 17.

- [65] As a result of the installation of each next following TIM 3 onto the surface of the equipment to be thermally insulated, the bundle of four second end sections 18 is also formed which sections are also fastened detachably to each other but, in this case, by means of the spring 41 which is first extended, manually or using a tool, and, in the extended condition, is then put from the top over the second end sections 18 forming

the bundle each loop section of the spring 41 being placed over two flanges 23, which correspond thereto and are opposite to each other, of the angles of two adjacent second end sections 18 of the respective bundle. Once the spring 41 is relieved of tensile load, the spring 41, under a compressive force, acquires (restores) its initial shape; and, in the event of its position lock being in the form of the protrusion 28 or 29, each section of the spring 41 disposed between two straight members 42 of adjacent loop sections is latched to under the protrusion 28 (29) corresponding to it. In accordance with a preferred embodiment of the invention, the width of the tape of which the spring 41 is made is equal to the distance between the protrusion 28 (29) and the front wall 15. If the spring position lock 41 is made in the form of the depression 30, after the spring 41 is relieved of tensile load, each of the arcuate members 43 is latched into the depression 30 corresponding thereto. To facilitate a better fixation of the spring 41, if its spring position locks are in the form of the protrusions 29, the members 42 are tapered from the periphery toward the axis of symmetry of the spring 41.

- [66] The spring-clamping (spring-locking) connection of the TIMs 3 to each other in accordance with the present invention ensures a reduction in mechanical stresses which occur in the radial thermal expansion of the body of the equipment to be thermally insulated since, in the radial thermal expansion of the body of the equipment to be thermally insulated, only a relative movement of the TIMs 3 elastically connected to each other occurs. On the other hand, since the latch-supports are only supported by the outer surface of the equipment to be thermally insulated, in the longitudinal thermal expansion thereof, a slip of the equipment to be thermally insulated relative to the thermal insulation will occur.
- [67] In the dismantling of the TIMs 3, the springs 41 are first removed from all of the four bundles of the second end sections 18 corresponding to the second end sections 18 of the TIM 3 being dismantled. The TIM 3 is then removed using a suitable tool or manually by applying a force thereto directed radially from the surface of the equipment to be thermally insulated. When said force is applied to the TIM 3 being dismantled, such force is transmitted through the first end sections 17 thereof to the wire rings 33 of the latches-supports corresponding to this TIM 3. When each wire ring 33 engages with the teeth 19 second sides 21 corresponding thereto, the wire ring 33 is extended till it engages with the tips 22 of said teeth 19. Thereafter, under an elastic, compressive force, the wire ring 33 contracts and ejects the respective first end section 17.
- [68] The industrial applicability of the present invention is also confirmed by the possibility of its implementation using the prior art process equipment of mechanical engineering enterprises and the prior art materials.

Claims

[Claim 1]

1. A modular removable thermal insulation which comprises circular sections which are located in series longitudinally on an outer surface of an equipment to be thermally insulated and immediately adjacent to each other, each of the circular sections being made of N identical thermal insulation modules butt-jointed to each other with longitudinal sidewalls located at an angle $\varphi(\text{rad}) = 2\pi/N$ relative to each other; each thermal insulation module including a frame made of metal angles, thin facing metal sheets, and a filler of a thermal insulation material, wherein the thermal insulation modules in adjacent sections are located opposite to each other; the frame includes four identical corner posts which are located pairwise at an angle φ relative to each other and connected to each other with upper and lower cross members located parallel with each other, each corner post of the above mentioned corner post pair is connected to the corner post of a second corner post pair located opposite to and in parallel with it with upper and lower cross members located in parallel with each other, the upper cross members and longitudinal members being located at the same level as, and at the same distance from, upper ends of the corner posts which are the nearest thereto, and the lower cross members and longitudinal members are also located at the same level as, and at the same distance from, lower ends of the corner posts which are the nearest thereto; a portion of the frame including the upper and lower, respectively, cross members and longitudinal members as well as the lengths of the corner posts located therebetween is lined all around with said metal sheets which form two identical longitudinal sidewalls located at an angle φ relative to each other, two identical cross sidewalls located parallel with each other as well as a back wall facing the equipment to be thermally insulated and a front wall located opposite thereto and parallel therewith; the ends of the corner posts which protrude beyond the back wall form first end sections of the same length and the ends of the corner posts which protrude beyond the front wall forming second end sections of the same length; each first end section comprises two identical teeth of a triangular shape with a lower face and an upper face of different lengths whose intersection forms a tip of the respective tooth each tooth being provided aside from a flange corresponding thereto of the angle of which the respective corner post is made and the

intersection of the lower side of the tooth with the end of said angle forms a lower edge of the tooth located from the angle rib at a distance which is less than the distance between the upper edge of the tooth and the same rib; each second end section is provided with a spring position lock configured in the form of a symmetrical closed cross-shaped contour with four identical loop sections of an elongated shape which are located orthogonally relative to each other; said thermal insulation modules which abut each other with both longitudinal and cross sidewalls form a thermal insulation enclosure which encompasses the equipment to be thermally insulated with an N-face front surface and an N-face back surface as well as with bundles, which are located regularly along the length of each rib of the back surface, of the first end sections facing the equipment to be thermally insulated, and with bundles, which are located regularly along the length of each rib of the front surface, of the second end sections facing to the opposite direction; four first end sections which are located parallel with each other and form each bundle are connected detachably to each other by means of a suitable latch-support simply supported by the surface of the equipment to be thermally insulated each latch-support comprising an axially symmetrical body in which, from the side of the end face located opposite to its end face which engages with the surface of the equipment to be thermally insulated, a seat of a cross-shaped cross section is provided in which seat the first end sections of the respective bundle are received and a circular groove is provided in the latch-support body from the side of the side surface so as to ensure a partial intersection with peripheral sections of the seat in which groove a spring is located with the possibility of changing reversibly its diameter in the installation and dismantling of the thermal insulation modules the spring being in the form of an open wire ring with end sections which overlap each other within the entire range of change in its diameter; four second end sections which form each bundle and are parallel with each other being also connected detachably to each other with the help of said spring corresponding to each bundle in the form of a symmetric closed cross-shaped contour which spring engages with it position locks provided at the second end sections, the circular groove being located at a distance H from the bottom of the seat which distance satisfies the following relation:

$$(L3 - d/2) \leq H \leq L3,$$

where L3 is the distance between the upper edge of each tooth located at the first end section and the end face of the angle of which the respective corner post is made; d is the cross-sectional dimension of the wire of which the spring located in the groove is made.

[Claim 2] 2. The thermal insulation of claim 1, wherein the seat is provided in the form of a blind axial hole and four identical rectangular radial slots extending from the axial hole and disposed at right angles relative to each other; the seat dimension in the direction of each pair of the radial slots located opposite to each other being more than the maximum outer diameter of the wire ring and a radius R of the axial hole satisfying the following relation:

$$R > h + h_1/2,$$

where h is the thickness of the angle of which the corner posts are made in the plane which extends through an outer rib of the angle and at an angle of 45° with the outer surfaces of the angle flanges; h1 is the thickness of the metal sheets with which the portion of the frame of the thermal insulation modules is lined.

[Claim 3] 3. The thermal insulation of claim 1, wherein the seat is configured so that a sliding fit or a running fit between the mating surfaces of the seat and the first end sections is ensured when inserting the first end sections into and removing the first end sections out of the seat.

[Claim 4] 4. The thermal insulation of claim 1, wherein the spring position lock is configured in the form of a stop located between the flanges of the angle of which the corner post is made.

[Claim 5] 5. The thermal insulation of claim 4, wherein the stop is configured in the form of a projection formed by welding a metal on a surface area located between the angle flanges.

[Claim 6] 6. The thermal insulation of claim 4, wherein the stop is configured in the form of a projection made of a plate of a square shape or a triangular shape welded to the angle flanges from inside them.

[Claim 7] 7. The thermal insulation of claim 1, wherein the spring position lock is configured in the form of a depression located aside from each flange of the angle and at the same distance from its end face.

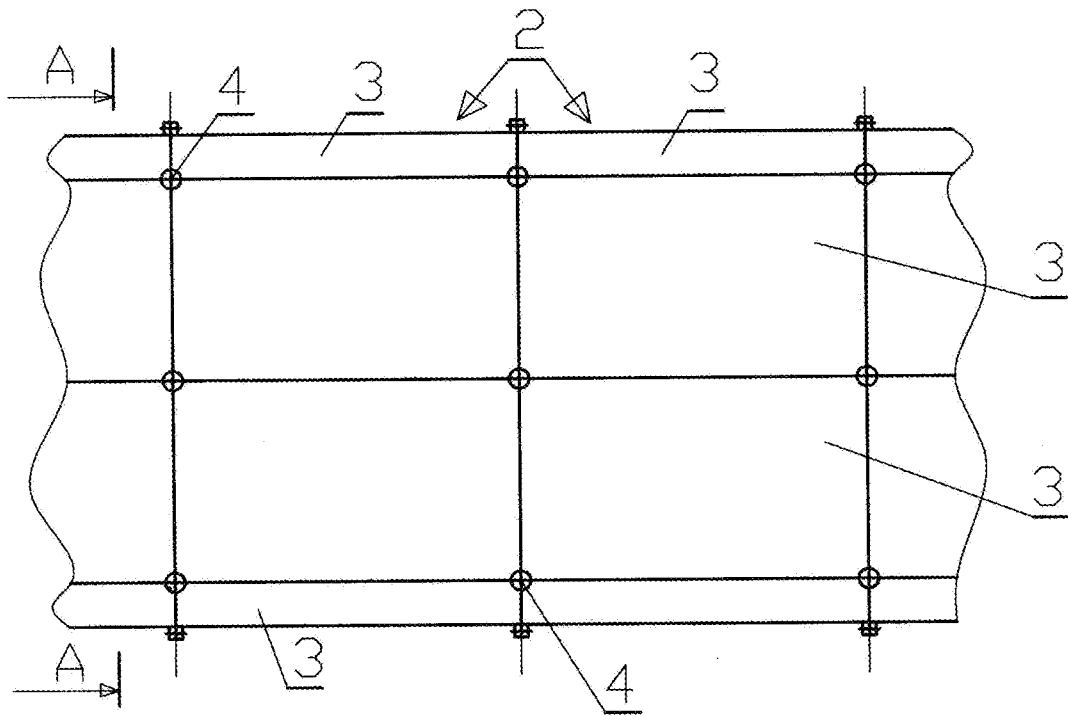


Fig. 1

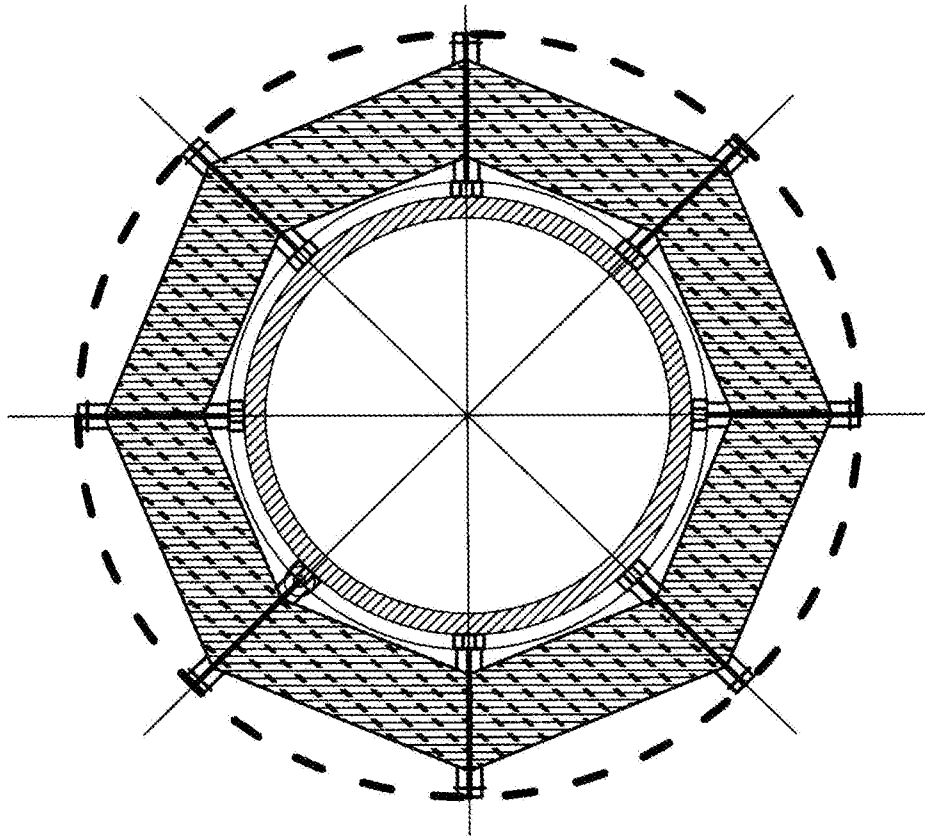


Fig. 2

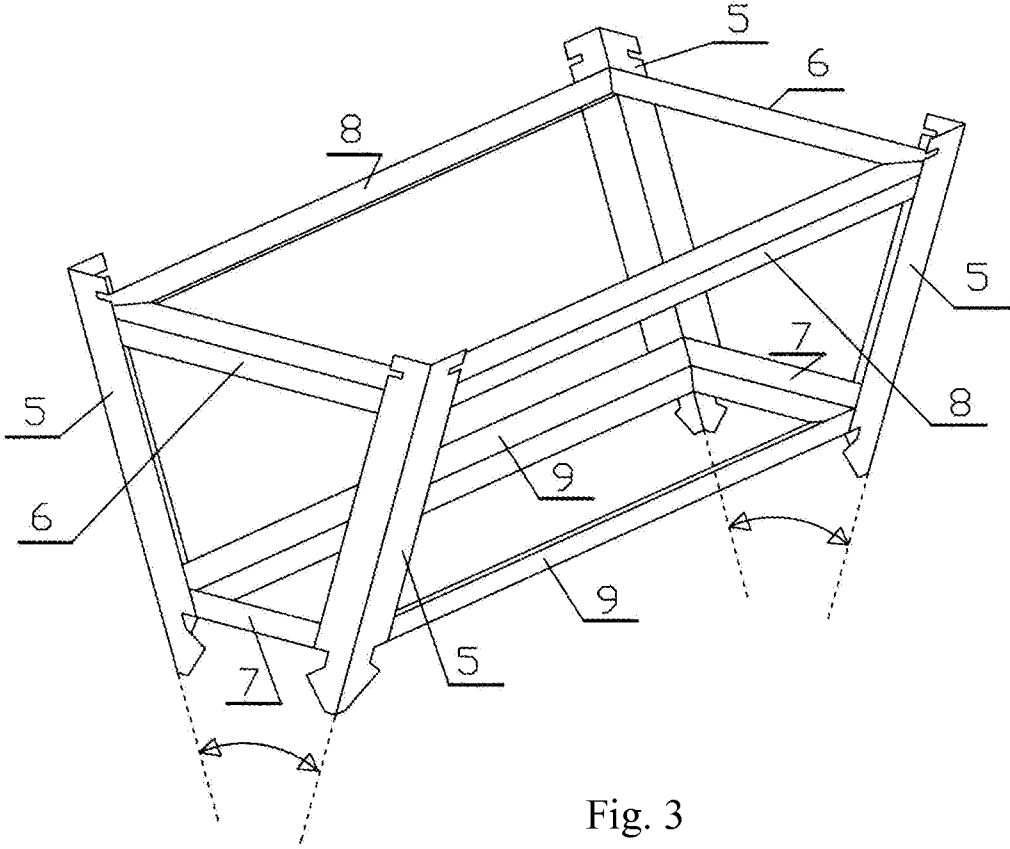


Fig. 3

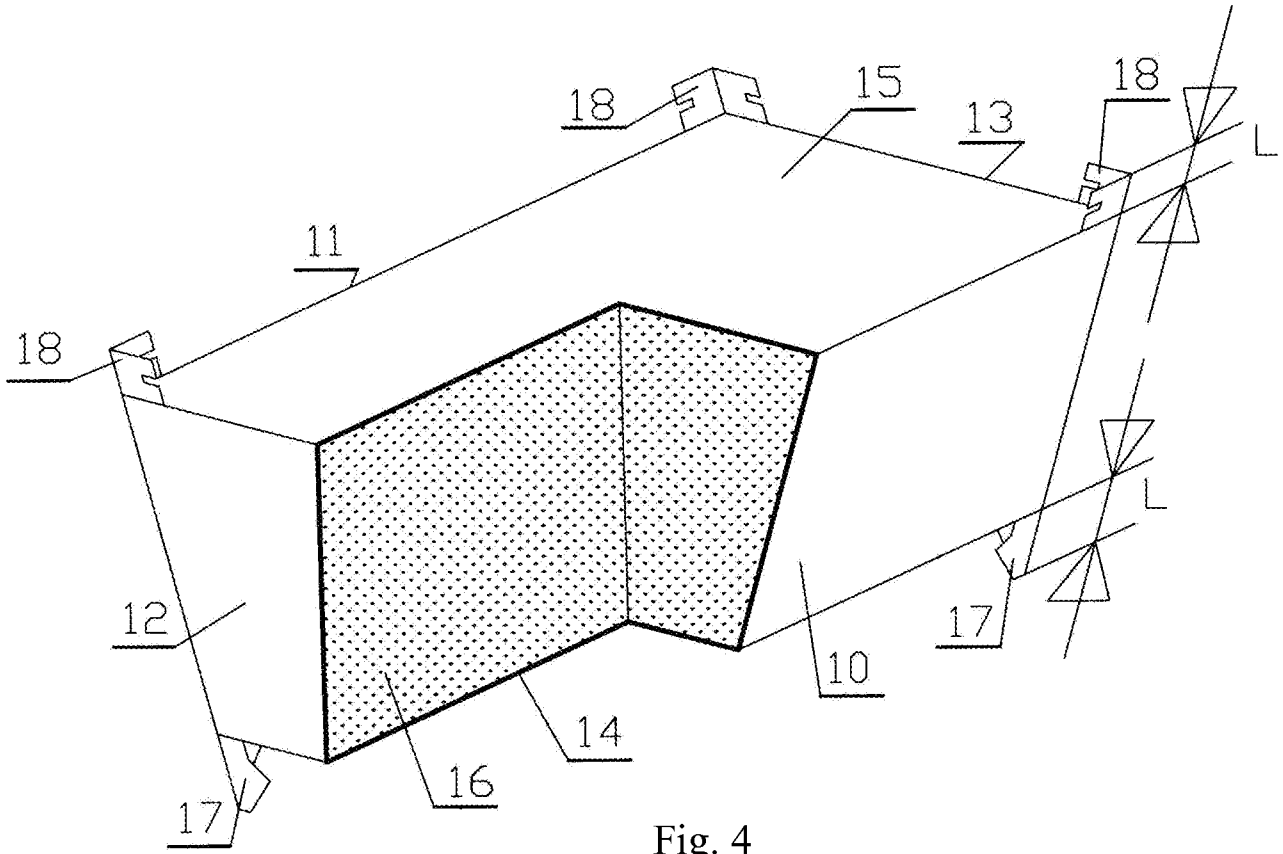


Fig. 4

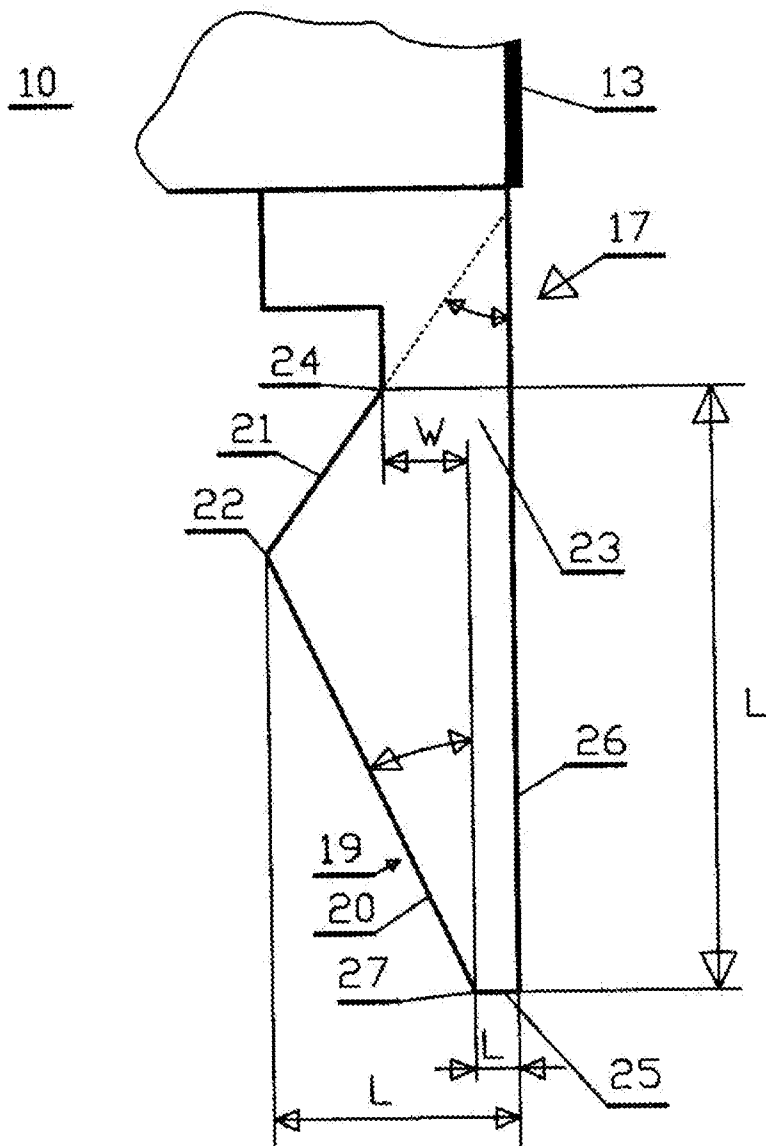


Fig. 5

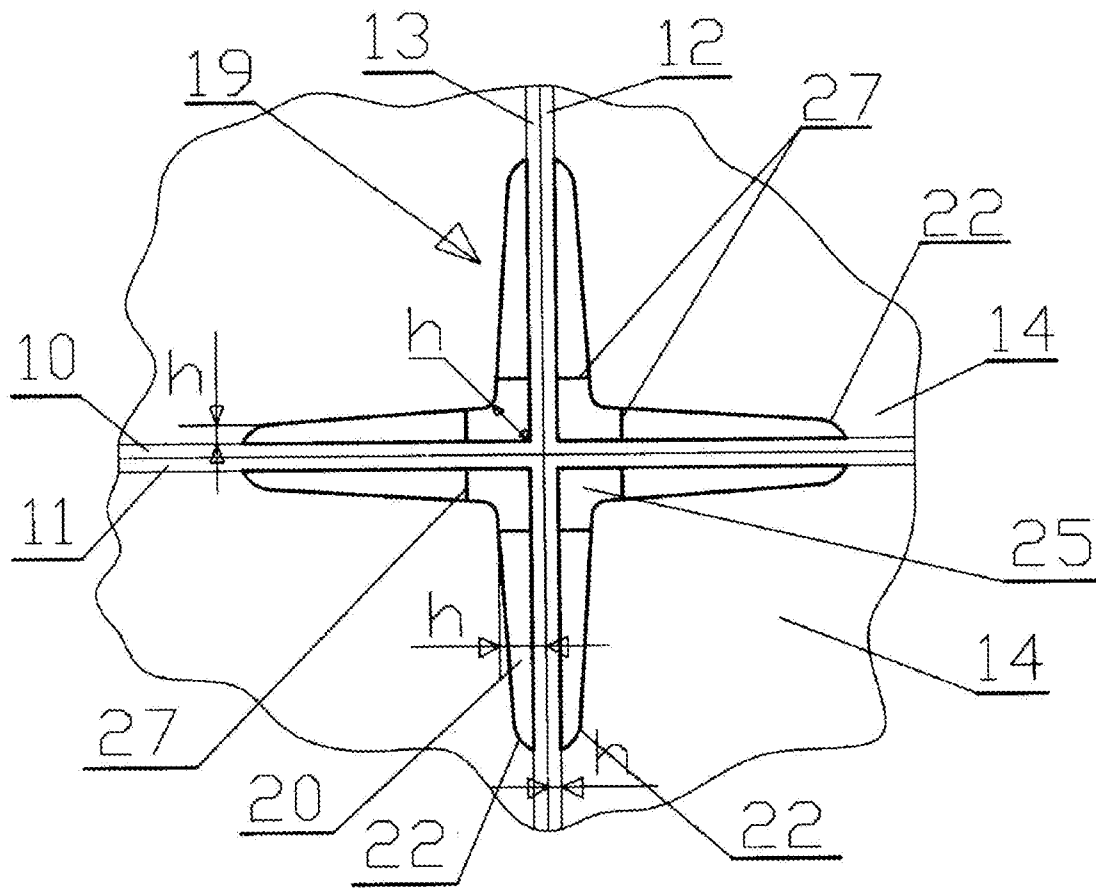


Fig. 6

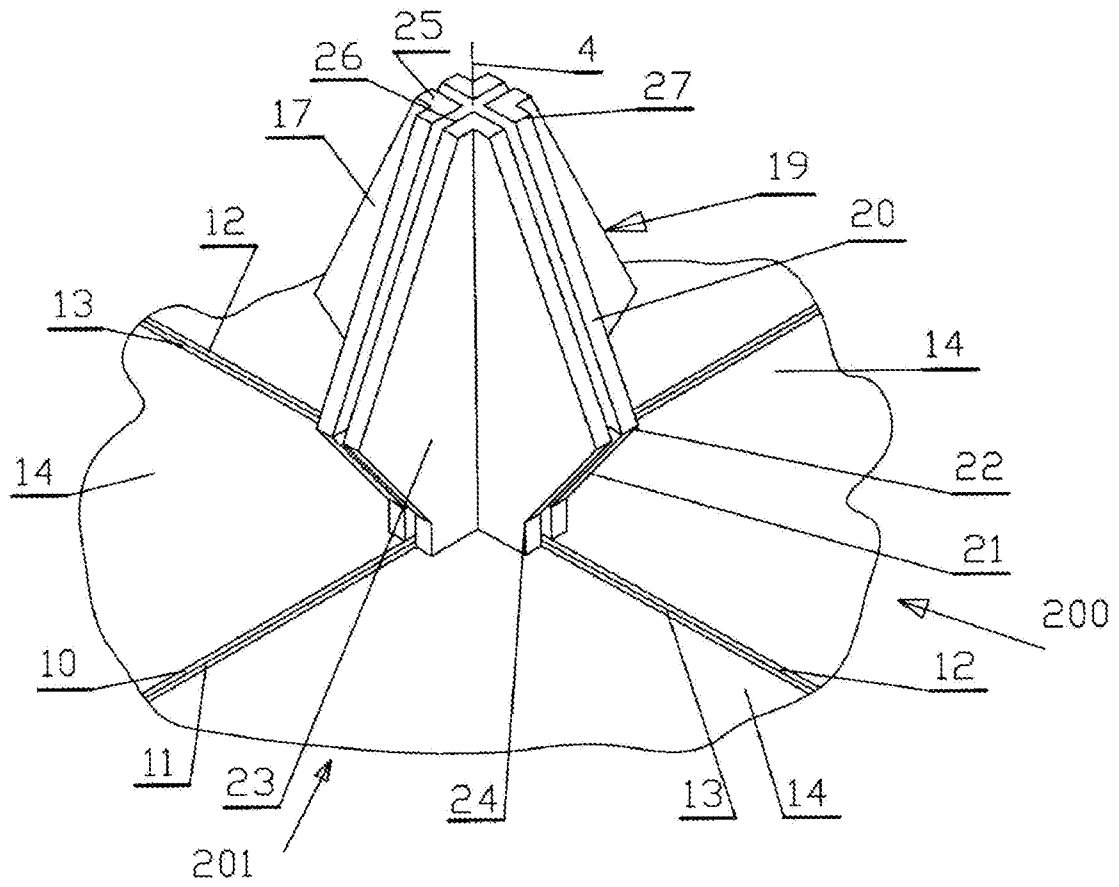


Fig. 7

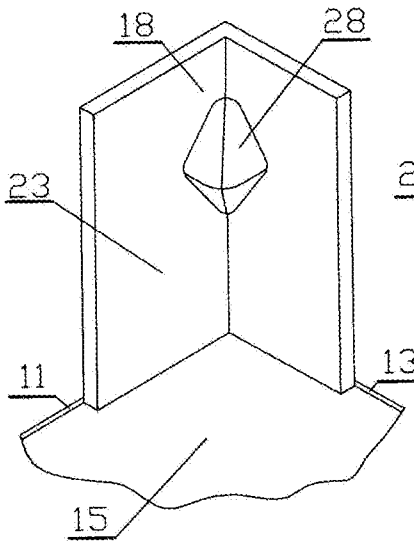


Fig. 8

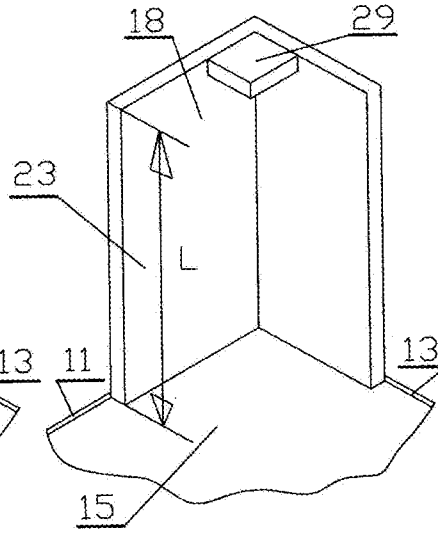


Fig. 9

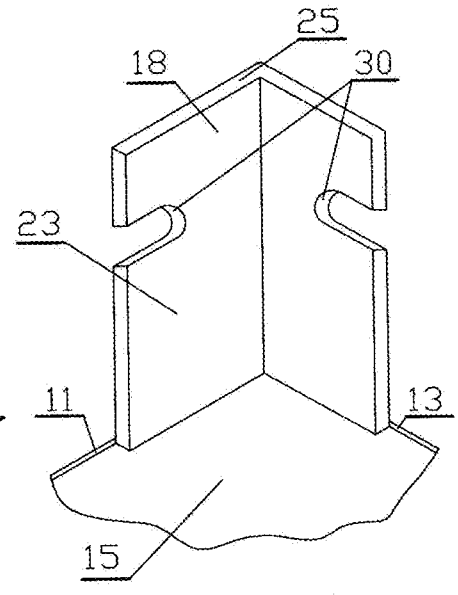


Fig. 10

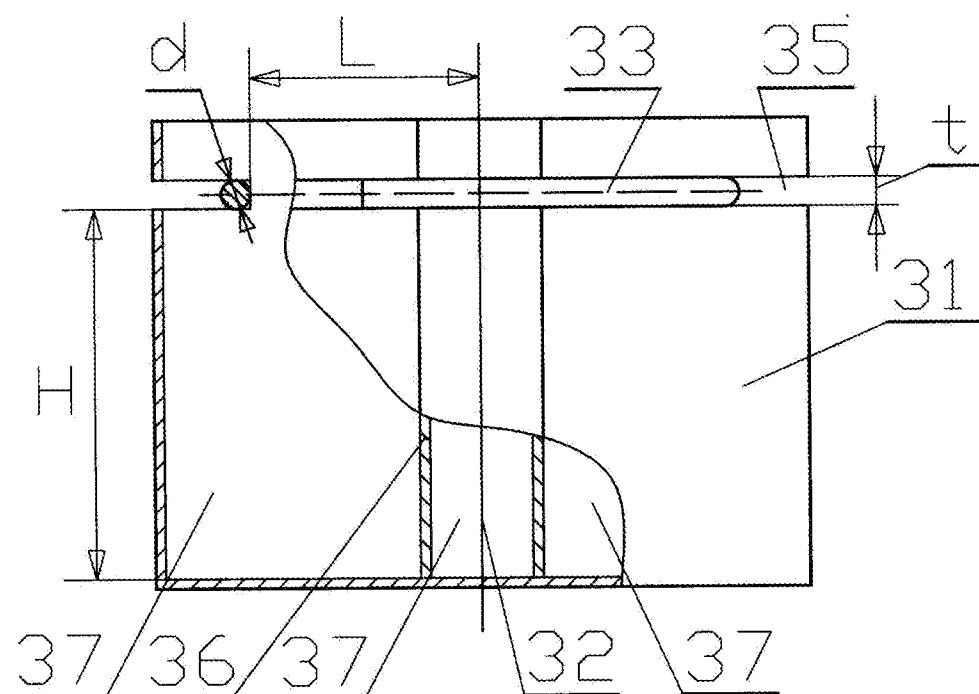


Fig. 11

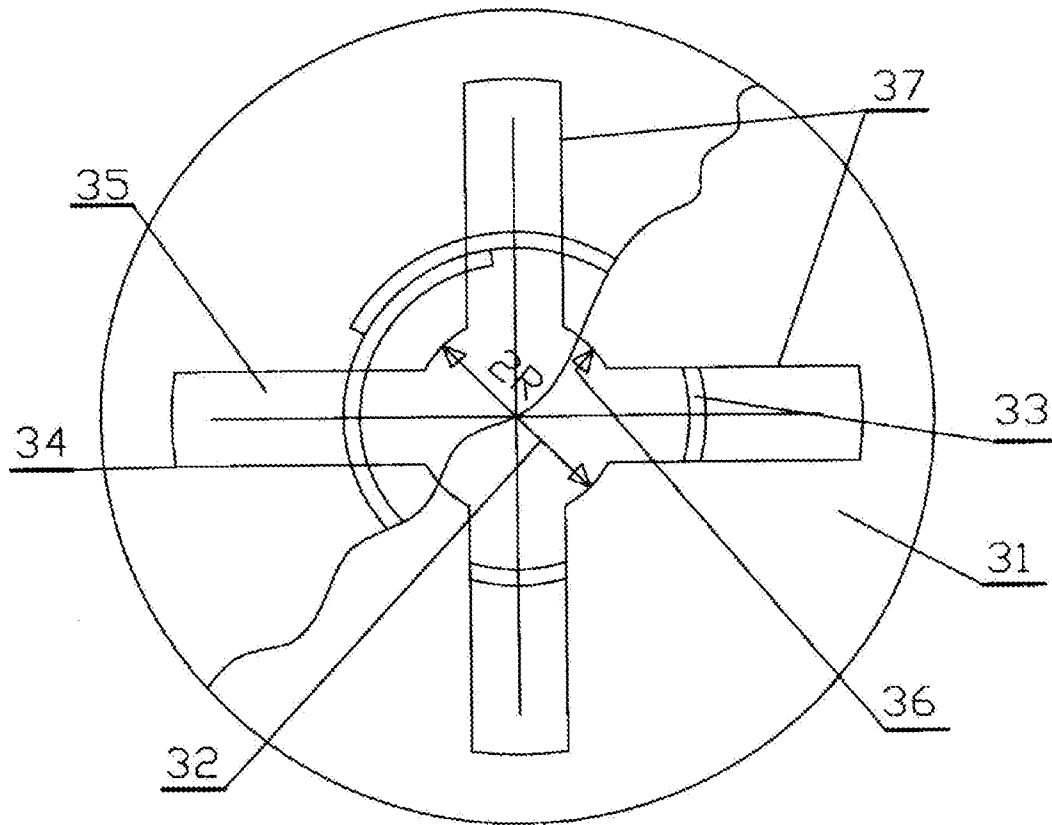


Fig. 12

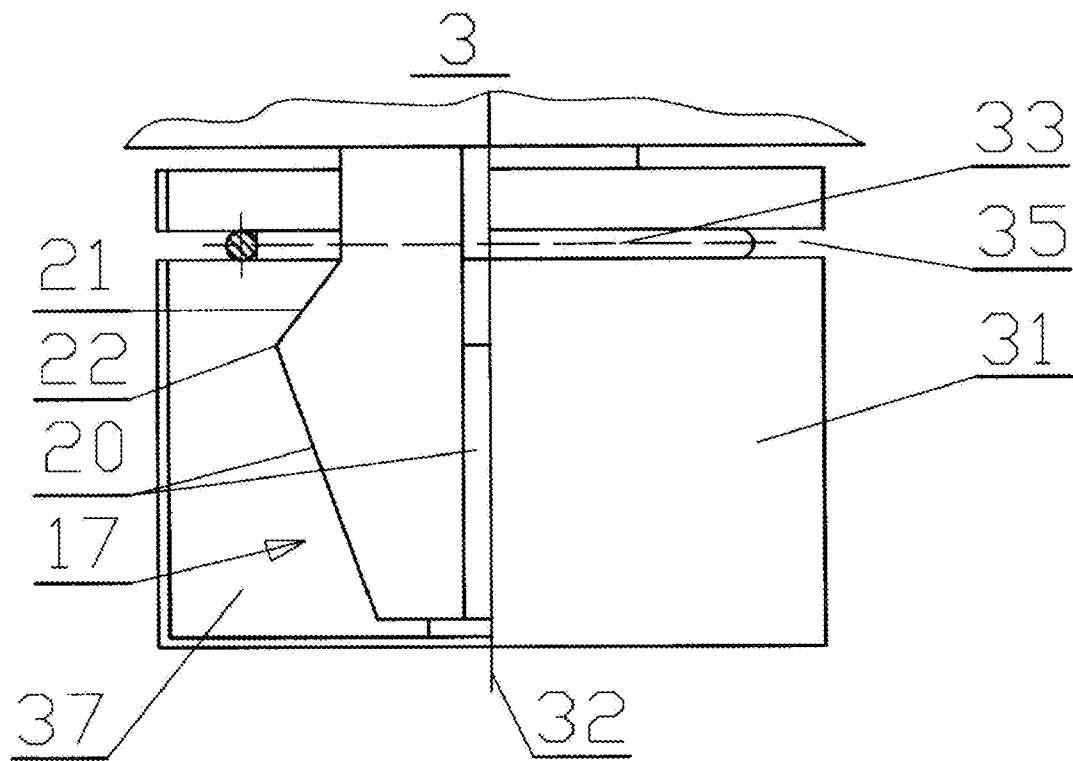


Fig. 13

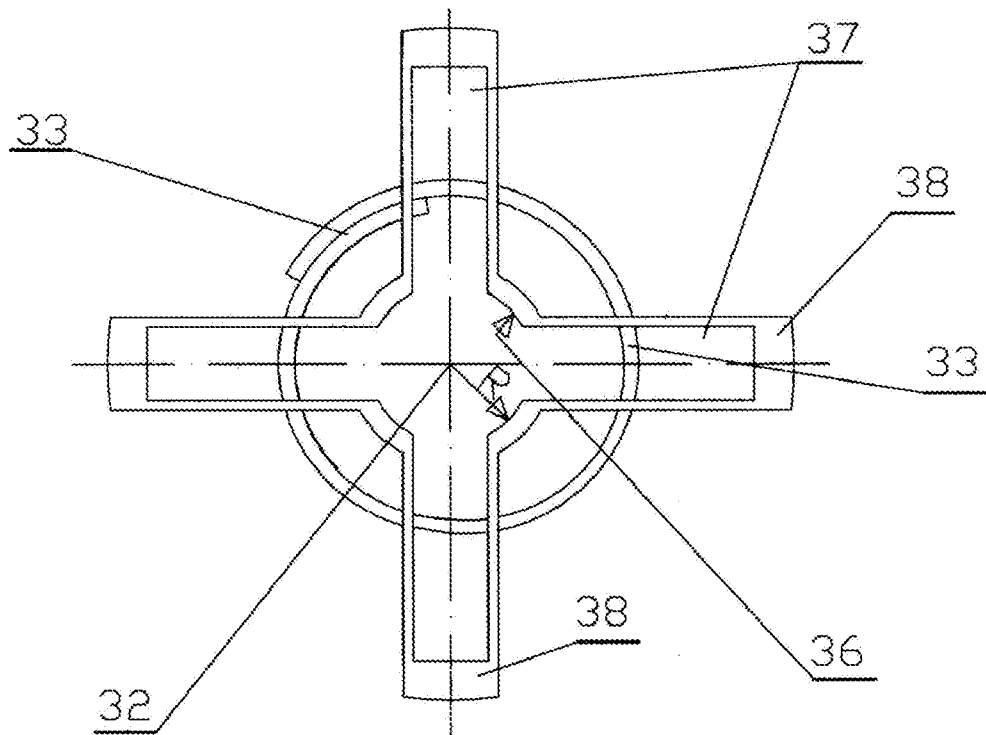


Fig. 14

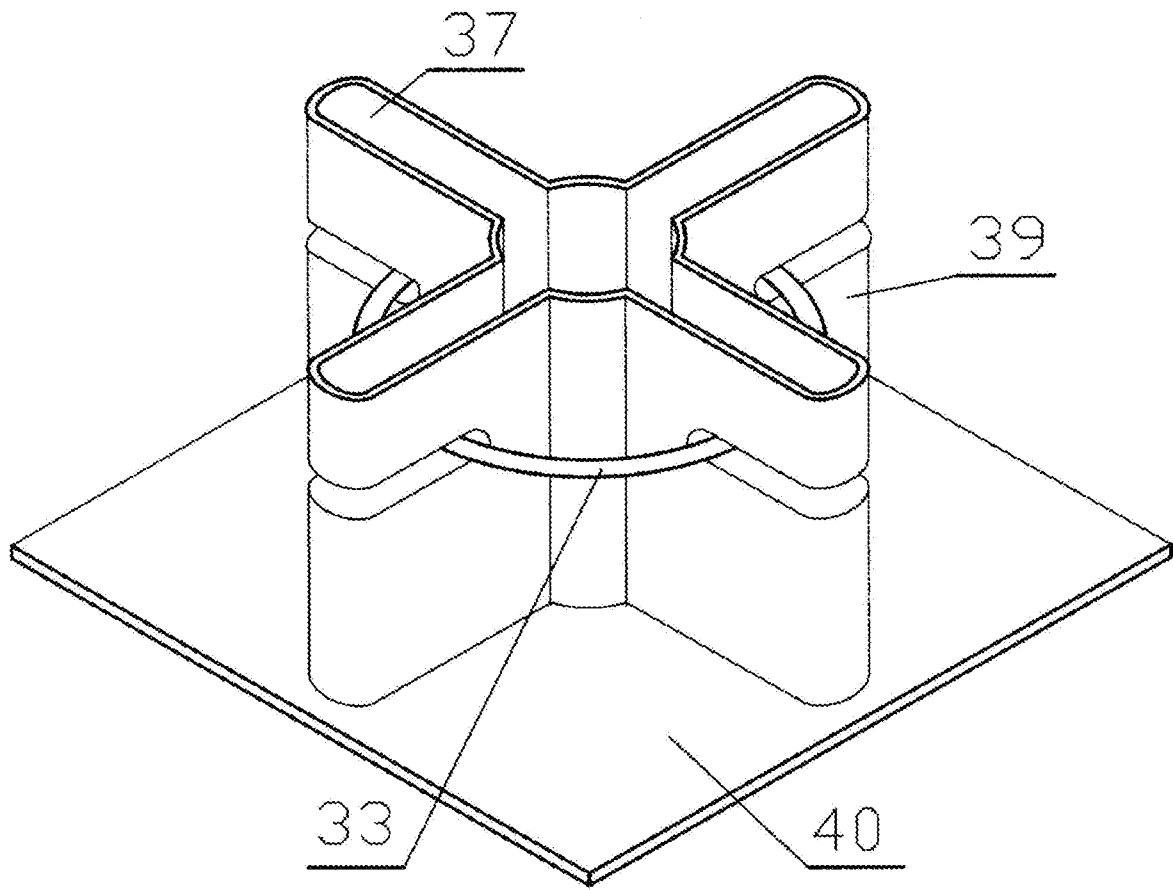


Fig. 15

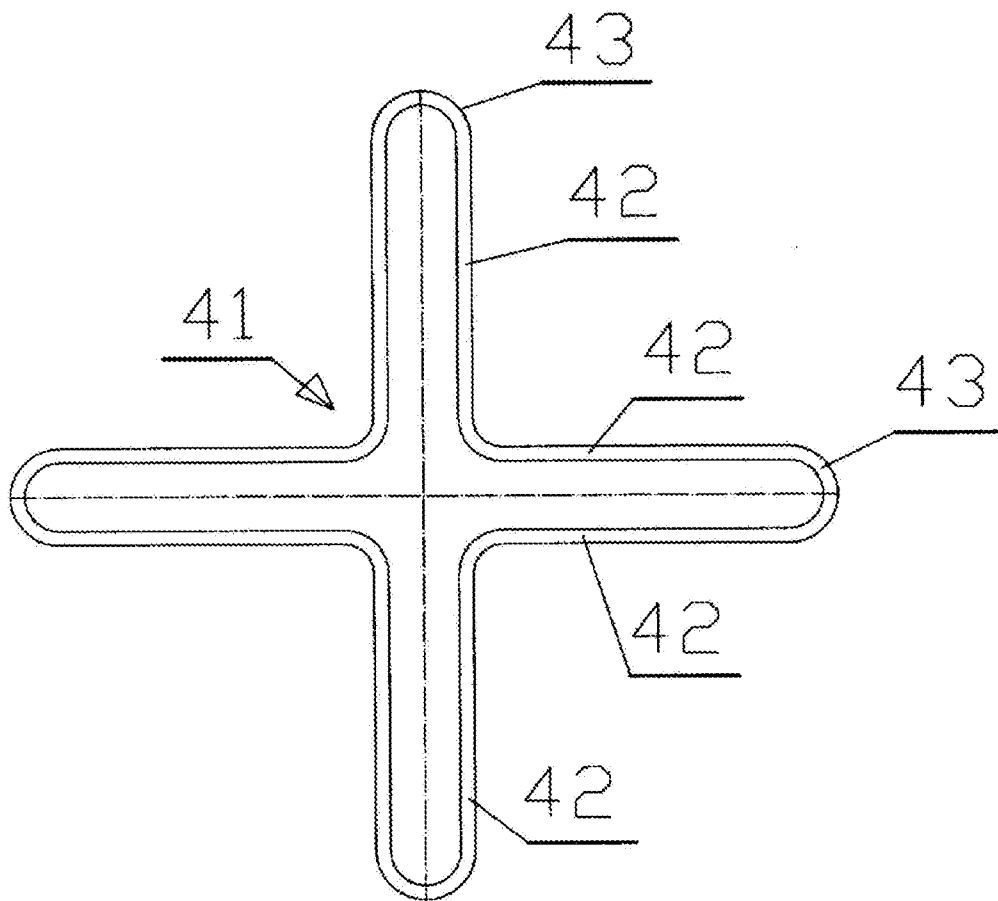


Fig. 16

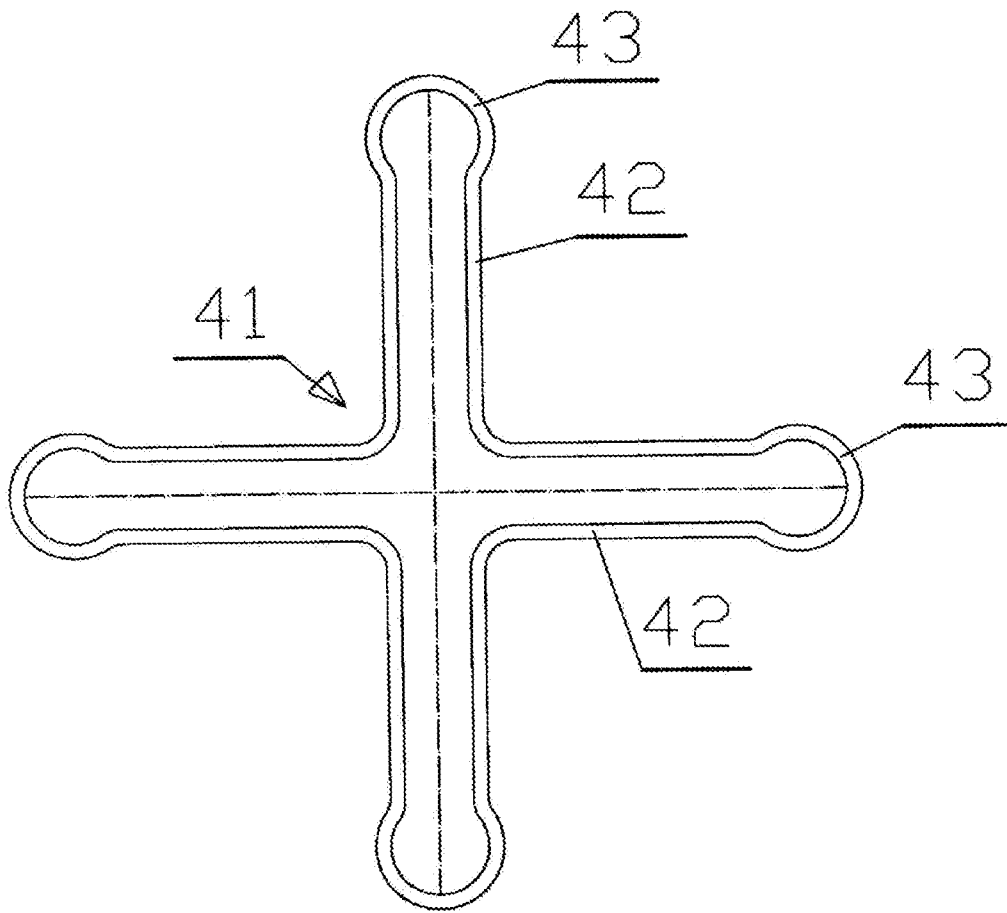


Fig. 17

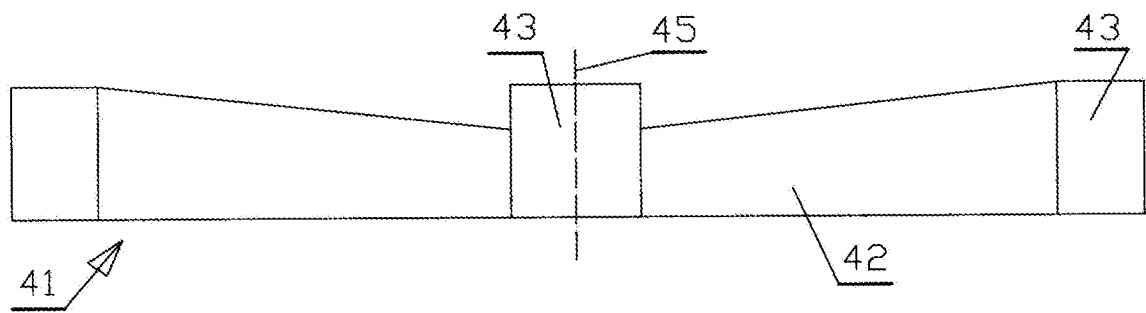


Fig. 18

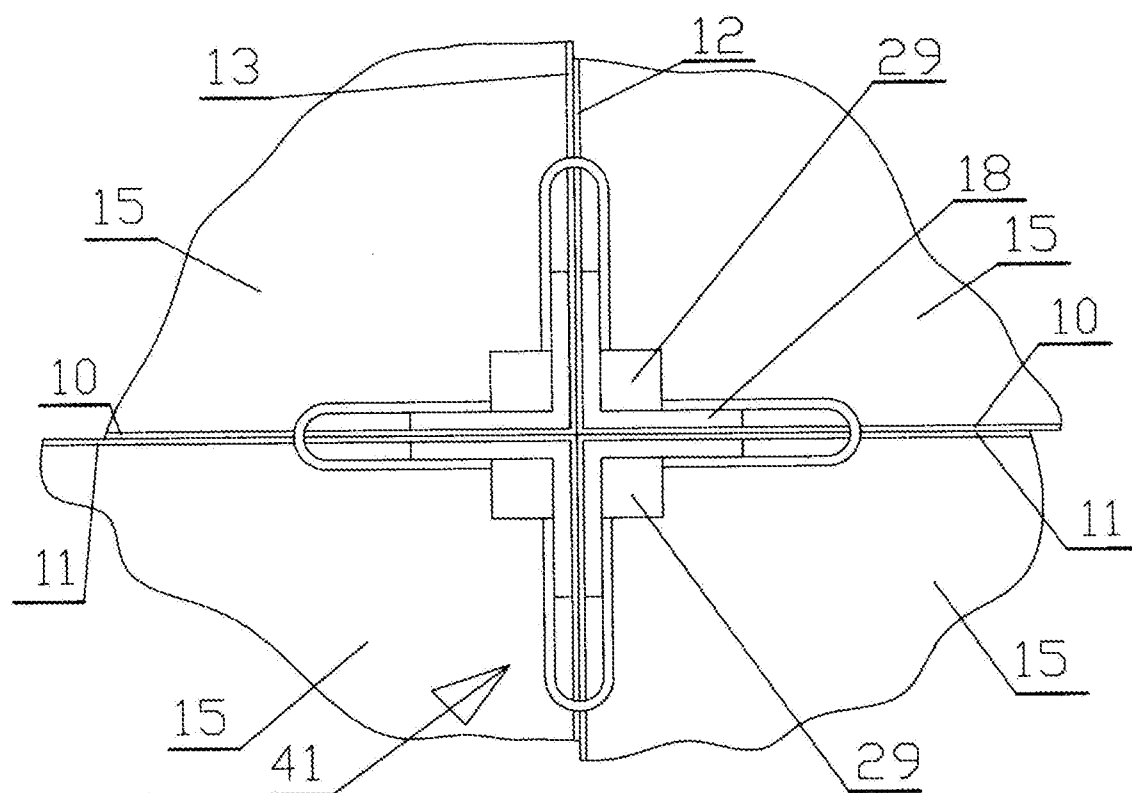


Fig. 19

INTERNATIONAL SEARCH REPORT

International application No.

PCT/IB 2013/050953

A. CLASSIFICATION OF SUBJECT MATTER

*F16L 59/00 (2006.01)**F16L 59/14 (2006.01)*

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

F16L 59/00, 59/10, 59/14, F16L 58/00

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

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

PatSearch (RUPTO internal), USPTO, PAJ, Esp@cenet, Information Retrieval System of FIPS (<http://www.fips.ru>)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	RU 2353849 C1 (KRAINOV BORIS VLADIMIROVICH) 27.04.2009	1-7
A	RU 68645 U1 (FEDERALNOE GOSUDARSTVENNOE UNITARNOE PREDPRIYATIE "INVESTITSIONNO-STROITELNY KONTSEK" "ROSATOMSTROI" (FGUP "ISK "ROSATOMSTROI") 27.11.2007	1-7
A	DE 3421326 A1 (MANNESMANN AG) 05.12.1985	1-7



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

05 April 2013 (05.04.2013)

Date of mailing of the international search report

18 April 2013 (18.04.2013)

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