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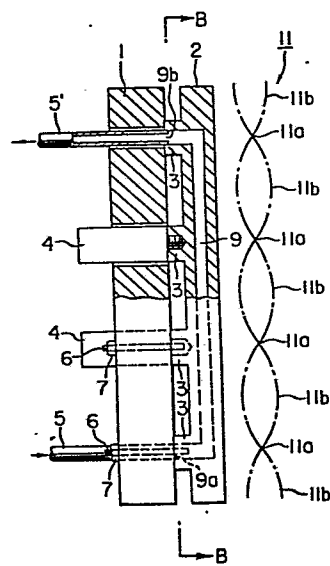
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CONTINUOUS CASTING MOLD.

A problem encountered in a continuous casting operation is that a cast piece seizes to the inside of a casting mold when the cast piece is withdrawn from the mold. It is known therefor to mount a plurality of ultrasonic vibrators at prescribed intervals along at least one straight line in the axial direction to the mold on the outer surfaces of the respective side walls thereof. The vibratory action of the ultrasonic vibrators causes the mold to vibrate in the axial direction so as to prevent the seizure of the cast piece onto the inner surface of the mold. The vibrational efficiency induced by the ultrasonic vibrators is unsatisfactory with the aforementioned conventional mold so that it has not been possible to reliably prevent the seizure of the cast piece onto the inside surface of the mold. The continuous casting mold of the invention eliminates the aforementioned problem and vibrates efficiently, and includes a plurality of ultrasonic vibrators mounted at prescribed intervals along at least one straight line in the axial direction of the mold on the outer surface of the respective side walls of the mold, the respective side walls of the mold being secured to a cast

frame and including therein at least one cooling water passage along the axial direction, the water passage including a cooling water supply opening and a cooling water discharge opening on the outer surfaces of the respective side walls of the mold. The respective side walls of the mold are secured to the mold frame at the positions corresponding to at least two or more nodes of the oscillatory waves produced in the axial direction of the mold by the vibration of the ultrasonic vibrators. The cooling water supply opening and the cooling water exhaust opening are disposed respectively at the positions corresponding to the respective nodes.

FIG. 2



CONTINUOUS CASTING MOLD

FIELD OF THE INVENTION

The present invention relates to a continuous casting mold which is used for a continuous casting machine.

5 DESCRIPTION OF THE PRIOR ART

Continuous casting of steel is generally conducted with the use of a continuous casting machine comprising a tundish, a mold, a group of guide rolls, and a group of pinch rolls. Continuous casting machines are broadly
10 classified into the vertical type continuous casting machine and the horizontal type continuous casting machine. In the case of a vertical type continuous casting machine, molten steel charged into the tundish is poured through an immersion nozzle provided in the bottom wall of the
15 tundish into the mold. The molten steel cooled in the mold forms a solidified shell. The molten steel having thus formed the solidified shell is withdrawn, while being guided by the group of guide rolls sequentially arranged below the mold, through the group of pinch rolls.
20 In the meantime, the solidified shell, cooled by cooling water sprayed from a plurality of nozzles arranged between said rolls, gradually increases the thickness thereof, and forms a continuously cast strand having a prescribed cross-sectional shape.

In the above-mentioned continuous casting operation, there is a problem of the molten steel seizing to the inner surface of the mold at the time of withdrawing the molten steel having formed the solidified shell from the mold. It is therefore the usual practice to vibrate the mold with a certain amplitude in the withdrawing direction of the cast strand with a view to preventing seizure of molten steel to the inner surface of the mold. This vibration of the mold has usually been effected by a mechanical means. However, in order to vibrate a mold by a mechanical means, it was necessary to provide large-scale facilities with huge quantities of energy. In addition, a mechanical means, which is difficult to vibrate the mold at a high frequency, causes wavy vibration marks on the cast strand surface under the effect of mold vibration, which may in turn cause surface cracks of the cast strand and was therefore problematic in terms of the quality of cast strand.

Recently, the horizontal type continuous casting machine forming a cast strand by horizontally withdrawing molten steel having formed a solidified shell from a horizontal mold provided at the lower part of a side wall of the tundish has been industrially applied because of the low installation costs and other advantages. In the case of this horizontal type continuous casting machine,

the horizontal mold is directly connected to the lower part of a side wall of the tundish. It was therefore impossible to vibrate the horizontal mold alone by a mechanical means.

5 As a measure to solve the above-mentioned problems, we have proposed a vibrating apparatus of a continuous casting mold, disclosed in Japanese Patent Provisional Publication No. 86,432/79 dated July 10, 1979 (hereinafter referred to as the "prior art"), which comprises:

10 a plurality of ultrasonic vibrators, fitted to the outer surface of each of the side walls of a continuous casting mold, at prescribed intervals in the axial direction of said mold; said mold being vibrated in the axial direction thereof by the vibration of said plurality of
15 ultrasonic vibrators.

 The above-mentioned prior art is applicable to a vertical type continuous casting machine as well as to a horizontal type continuous casting machine. According to the vibrating apparatus of the above-mentioned prior art,
20 it is possible to vibrate the mold in the axial direction thereof, i.e., in the withdrawing direction of cast strand, at a high frequency, thus permitting prevention of seizure of a cast strand to the inner surface of the mold. Unlike a vibrating apparatus based on a mechanical means, this

does not require huge quantities of energy nor large-scale facilities, without causing wavy vibration marks on the surface of cast strand under the effect of vibration of the mold. In the application thereof to a mold for a
5 horizontal type continuous casting machine, furthermore, the fine vibration at a high frequency imparted to the mold keeps a high degree of seal at the junction between the tundish and the mold, without leakage of molten steel from this junction caused by vibration of the mold.

10 With a view to improving the vibration efficiency of the mold in the above-mentioned prior art, we carried out various studies. As a result, we reached the following conclusion. Each of the side walls of the mold is fixed to the mold frame by such means as bolts. If the
15 fixing position corresponds to a loop of the vibration wave produced in the axial direction of the mold, the above-mentioned vibration wave is inhibited by the mold frame, thus resulting in such problems as a largely decreased vibration efficiency of the mold and loosening or even
20 breakage of the bolts used for fixing each of the side walls of the mold to the mold frame under the effect of vibration. In addition, each of the side walls of the mold has at least one conduit for cooling water in the axial direction of the mold. This conduit has a cooling
25 water supply opening and a cooling water discharge opening

on the outer surface of each of the side walls of the mold, the cooling water supply opening being connected to a cooling water supply pipe with a fixed end, and the cooling water discharge opening being connected to a cooling water discharge pipe with a fixed end. If the positions of the cooling water supply opening and the cooling water discharge opening correspond to loops of the vibration wave, however, the above-mentioned vibration wave is inhibited by the cooling water supply pipe and the cooling water discharge pipe, thus resulting in such problems as a largely decreased vibration efficiency of the mold and breakage of the junctions of the cooling water supply pipe and the cooling water discharge pipe with the cooling water supply opening and the cooling water discharge opening.

SUMMARY OF THE INVENTION

An object of the present invention is therefore to provide, when vibrating the mold in a continuous casting machine in the axial direction of the mold with the use of a plurality of ultrasonic vibrators, a continuous casting mold for vibrating the mold at a high efficiency in the continuous casting machine.

Another object of the present invention is to

provide a continuous casting mold in which bolts for fixing each of the side walls of the mold to the mold frame do not loosen nor break under the effect of vibration of the mold.

5 Further another object of the present invention is to provide a continuous casting mold in which the junctions of the cooling water supply opening and the cooling water discharge opening provided on the outer surface of each of the mold side walls with the cooling water supply
10 pipe and the cooling water discharge pipe do not break under the effect of vibration of the mold.

In accordance with one of the features of the present invention, in a continuous casting mold which comprises:

15 a plurality of ultrasonic vibrators, fitted to the outer surface of each of the side walls of said mold, along at least one straight line in the axial direction of said mold at prescribed intervals; each of said side walls of said mold being fixed to a mold frame;
20 each of said side walls having in the inside thereof at least one conduit for cooling water, and said conduit having a cooling water supply opening and a cooling water discharge opening on the outer surface of each of said side walls;

the improvement characterized in that:

each of said side walls is fixed to said mold frame at positions corresponding to at least two nodes of vibration waves produced in the axial direction of said mold by vibration of said plurality of ultrasonic
5 vibrators; and,

said cooling water supply opening and said cooling water discharge opening are arranged at respective positions corresponding to said nodes.

10 BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a plan view showing the continuous casting mold of the present invention;

Fig. 2 is a partial cutaway descriptive view of the mold of Fig. 1 cut along the line A-A;

15 Fig. 3 is a sectional view of Fig. 2 cut along the line B-B; and,

Fig. 4 is a plan view showing another embodiment of the continuous casting mold of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

20 With a view to solving the above-mentioned problems

involved in the prior art for vibrating a continuous casting mold with the use of ultrasonic vibrators, we carried out intensive studies. As a result, we developed a continuous casting mold as follows:

5 in a continuous casting mold which comprises:

 a plurality of ultrasonic vibrators, fitted to the outer surface of each of the side walls of said mold, along at least one straight line in the axial direction of said mold at prescribed intervals; each of said side
10 walls of said mold being fixed to a mold frame; each of said side walls having in the inside thereof at least one conduit for cooling water, and said conduit having a cooling water supply opening and a cooling water discharge opening on the outer surface of each of said side
15 walls;

 the improvement characterized in that:

 each of said side walls is fixed to said mold frame at positions corresponding to at least two nodes of vibration waves produced in the axial direction of
20 said mold by vibration of said plurality of ultrasonic vibrators; and,

 said cooling water supply opening and said cooling

water discharge opening are arranged at respective positions corresponding to said nodes.

Now, the continuous casting mold of the present invention (hereinafter referred to as the "mold of the present invention") is described below by means of an example with reference to drawings.

Fig. 1 is a plan view of the mold of the present invention; Fig. 2 is a partial cutaway descriptive view of Fig. 1 cut along the line A-A; and, Fig. 3 is a sectional view of Fig. 2 cut along the line B-B. In Figs. 1 to 3, 2 is a mold; the side walls of the mold 2 are divided into individual side walls, to the outer surface of which a plurality of ultrasonic vibrators 4 are fitted, through a mold frame 1 described later, along at least one straight line at prescribed intervals in the axial direction of the mold 2. The plurality of ultrasonic vibrators 4 are individually connected to electric source not shown for generating ultrasonic vibration and generate vibration waves of identical wave lengths in the axial direction of the mold 2.

Therefore, when the plurality of ultrasonic vibrators 4 are vibrated at a frequency of about 20 kHz, for example, the resultant horizontal vibration waves are deviated vertically by 90°, become longitudinal vibration

waves 11 in the axial direction of the mold 2, i.e., in the same direction as the withdrawing direction of cast strand, and vibrate the mold 2 in the axial direction thereof, as shown in Fig. 2.

5 Also in Fig. 2, 11a are nodes of the vibration wave 11, and 11b are loops of the vibration wave 11. Positions at which the plurality of ultrasonic vibrators 4 are fitted to the individual side walls of the mold 2 should be such that a loop 11b of the vibration wave 11
10 may be located at the both end faces of the mold 2 and the distance between two adjacent ones of the ultrasonic vibrators 4 may be a half the wave length of the vibration wave 11, to achieve an efficient vibration of the mold 2. The resultant positions of the ultrasonic vibrators 4
15 correspond respectively to the positions of the nodes 11a of the vibration wave 11.

 The plurality of ultrasonic vibrators 4 are fixed, such means as bolts, to a plurality of projections 3 provided at positions on the outer surface of the side
20 walls of the mold corresponding to the positions of the above-mentioned nodes 11a. In Fig. 3, 10 are fitting bores of the ultrasonic vibrators 4, provided in the above-mentioned projections 3. In the illustrated example, two ultrasonic vibrators 4 are fitted to each of the side

walls of the mold 2. However, depending on the size of the mold 2, an appropriate number of ultrasonic vibrators 4 should be provided to efficiently vibrate the mold 2.

In the drawings, 1 is a mold frame for supporting the mold 2; and each of the side walls of the mold 2 is fixed to the mold frame 1. In the mold of the present invention, the mold frame is fixed to the side walls of the mold 2 at positions corresponding to at least two nodes 11a of the vibration waves 11 produced in the axial direction of the mold 2 under the effect of vibration of the plurality of ultrasonic vibrators 4. Also in the drawings, 6 are a plurality of bolts for fixing the side walls of the mold 2 to the mold frame 1; and 7 are a plurality of nuts. The mold frame 1 is fixed to the side walls of the mold 2 through the plurality of projections provided at positions on the outer surfaces of the side walls of the mold 2 corresponding to the above-mentioned nodes 11a. In Fig. 3, 8 are fitting bores of the bolts 6, provided in the projections 3.

Each of the side walls of the mold 2 has in the inside thereof at least one conduit 9 for cooling water in the axial direction of the mold 2. This conduit 9 has, on the outer surface of the side wall of the mold 2, a cooling water supply opening 9a and a cooling water discharge opening 9b.

A cooling water supply pipe 5 with a fixed end is connected, through the mold frame 1, to the cooling water supply opening 9a, and a cooling water discharge pipe 5' with a fixed end is connected, through the mold frame 1, to the cooling water discharge opening 9b. The above-mentioned cooling water supply pipe 5 is connected through a pipe to a cooling water source not shown. Thus, each side wall of the mold 2 is cooled by cooling water fed from the cooling water supply pipe 5, flowing through the conduit 9 and discharged from the cooling water discharge pipe 5'.

In the mold of the present invention, the cooling water supply opening 9a and the cooling water discharge opening 9b are arranged on the projections 3 at positions corresponding to the nodes 11a of the vibration wave 11 produced in the axial direction of the mold 2. The cooling water supply pipe 5 and the cooling water discharge pipe 5' are thus connected respectively to the cooling water supply opening 9a and the cooling water discharge opening 9b provided on each side wall of the mold 2 at positions corresponding to the nodes 11a of the vibration wave 11.

In the example shown in Figs. 1 to 3, the cooling water discharge opening 9b is arranged at the position on each side wall of the mold 2 corresponding to the upper-

most node of the nodes 11a of the vibration wave 11, and the cooling water supply opening 9a is arranged at the position corresponding to the lowermost node of the nodes 11a. Two ultrasonic vibrators 4 are fitted at the positions
5 corresponding to two intermediate nodes of the nodes 11a. Each side wall of the mold 2 is fixed to the mold frame 1 at the positions corresponding to all the nodes 11a of the vibration wave 11. It is however possible to select appropriate positions from among the positions correspond-
10 ing to the nodes 11a of the vibration wave 11, depending upon the size of the mold 2 and other conditions, as the positions of the cooling water supply opening 9a and the cooling water discharge opening 9b, and as the fixing positions of the side walls of the mold 2 to the mold
15 frame 1. However, each side wall of the mold 2 should be fixed to the mold frame 1 at positions corresponding to at least two nodes 11a of the vibration wave 11.

The positions on each of the side walls of the mold 2 corresponding to the nodes 11a of the vibration
20 wave 11 may be easily detected by a known means or may be determined through calculation.

In the mold of the present invention, as described above, each of the side walls of the mold 2 is fixed to the mold frame 1 at positions corresponding to at least

two nodes 11a of the vibration wave 11 produced in the axial direction of the mold 2 by vibration of the plurality of ultrasonic vibrators 4. Therefore, the vibration wave 11 produced in the mold 2 by the plurality of ultrasonic vibrators 4 is never inhibited by the mold frame 1, and the bolts 6 for fixing each side wall of the mold 2 to the mold frame 1 never loosen nor break under the effect of vibration.

In each of the side walls of the mold 2, the cooling water supply opening 9a to be connected with the cooling water supply pipe 5 and the cooling water discharge opening 9b to be connected with the cooling water discharge pipe 5' are arranged respectively at the positions corresponding to the nodes 11a of the vibration wave 11. Therefore, the vibration wave 11 produced in the mold 2 by the plurality of ultrasonic vibrators 4 is never inhibited by the cooling water supply pipe 5 and the cooling water discharge pipe 5'. In addition, the junction between the cooling water supply pipe 5 and the cooling water supply opening 9a, and the junction between the cooling water discharge pipe 5' and the cooling water discharge opening 9b are never broken. The vibration efficiency imparted to the mold 2 by the ultrasonic vibrators 4 is largely improved, and it is thus possible to vibrate the mold 2 at a high efficiency in the axial direction thereof.

Fig. 4 is a plan view showing another embodiment of the mold of the present invention. This example is the same as that shown in Figs. 1 to 3 except that the side walls of the mold 2' are formed into an integral structure, and each of the side walls of the mold 2' has a plurality of conduits 9' for cooling water provided in the inside of each side wall of the mold 2' in the axial direction of the mold 2'. A cooling water supply opening and a cooling water discharge opening may be provided for each of the plurality of conduits 9' for cooling water on the outer surface of each side wall of the mold 2', or the plurality of conduits 9' may be gathered into one conduit at each end to provide one cooling water supply opening and one cooling water discharge opening for each side wall of the mold 2'.

In the above-mentioned examples, the plurality of ultrasonic vibrators are fitted to the outer surface of each of the side walls of the mold along a straight line at prescribed intervals in the axial direction of the mold. Preferably, by fitting the plurality of ultrasonic vibrators at prescribed intervals along a plurality of straight lines in the axial direction of the mold, these plurality of straight lines being arranged at prescribed intervals, it is possible to further improve the vibration efficiency of the mold in the

axial direction thereof. The mold of the present invention is applicable to a vertical type continuous casting machine as well as to a horizontal type continuous casting machine. In all cases, it is possible to vibrate the
5 mold in the axial direction thereof at a high efficiency.

According to the mold of the present invention, as described above in detail, it is possible to vibrate the mold in the axial direction thereof at a high efficiency with the use of a plurality of ultrasonic vibrators
10 which are fitted to the outer surface of each of the side walls of the mold in the axial direction thereof along at least one straight line at prescribed intervals, thereby permitting prevention of seizure of a cast strand to the inner surface of the mold. Bolts for fixing each of the
15 side walls of the mold to the mold frame never loosen nor break under the effect of vibration of the mold. In addition, the junctions of the cooling water supply opening and the cooling water discharge opening provided on the outer surface of each of the side walls of the
20 mold with the cooling water supply pipe and the cooling water discharge pipe are never broken by vibration of the mold.

In the case where the mold of the present invention is applied to a horizontal type continuous casting machine,

the mold can be vibrated in the axial direction thereof
at a high efficiency in a state where a perfect seal is
maintained at the junction between the tundish and the
mold. According to the mold of the present invention,
5 therefore, many industrially useful effects are provided.

WHAT IS CLAIMED IS:

1. In a continuous casting mold which comprises:

a plurality of ultrasonic vibrators, fitted to the outer surface of each of the side walls of said mold, along at least one straight line in the axial direction of said mold at prescribed intervals; each of said side walls of said mold being fixed to a mold frame; each of said side walls having in the inside thereof at least one conduit for cooling water, and said conduit having a cooling water supply opening and a cooling water discharge opening on the outer surface of each of said side walls;

the improvement characterized in that:

each of said side walls is fixed to said mold frame at positions corresponding to at least two nodes of vibration waves produced in the axial direction of said mold by vibration of said plurality of ultrasonic vibrators; and,

said cooling water supply opening and said cooling water discharge opening are arranged at respective positions corresponding to said nodes.

FIG. 1

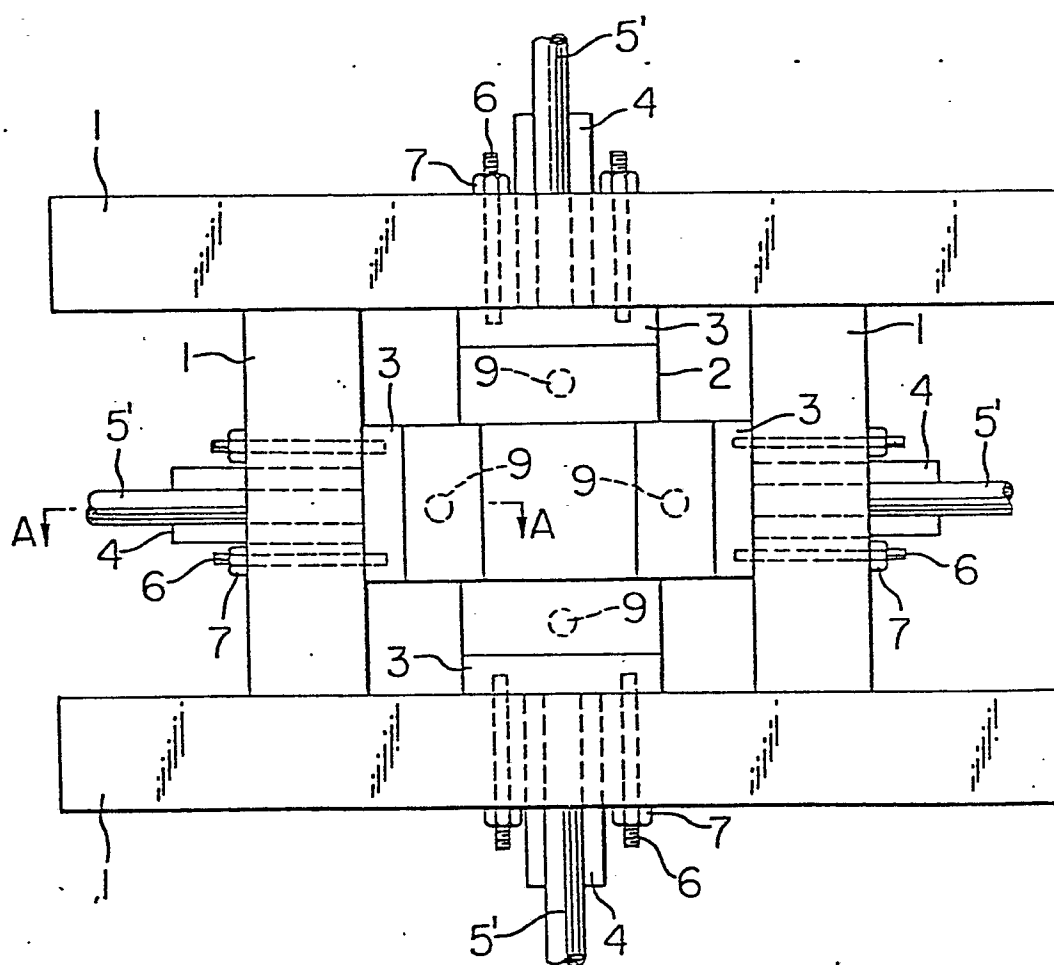


FIG. 2

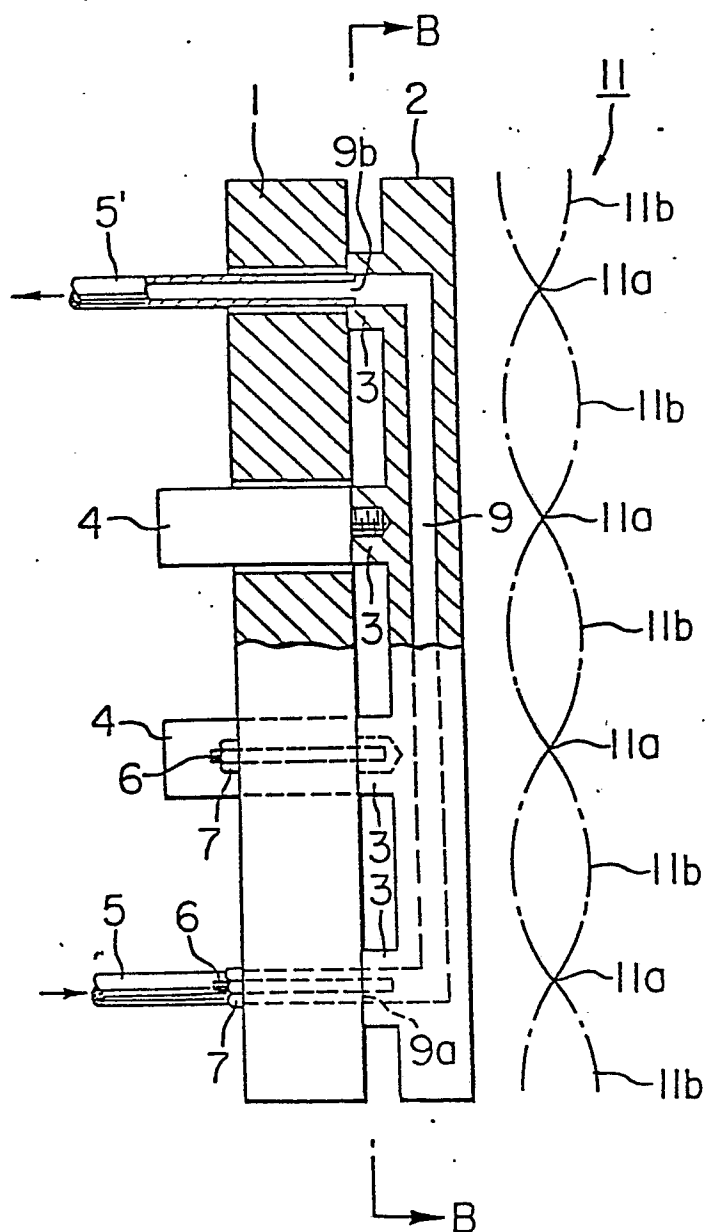


FIG. 3

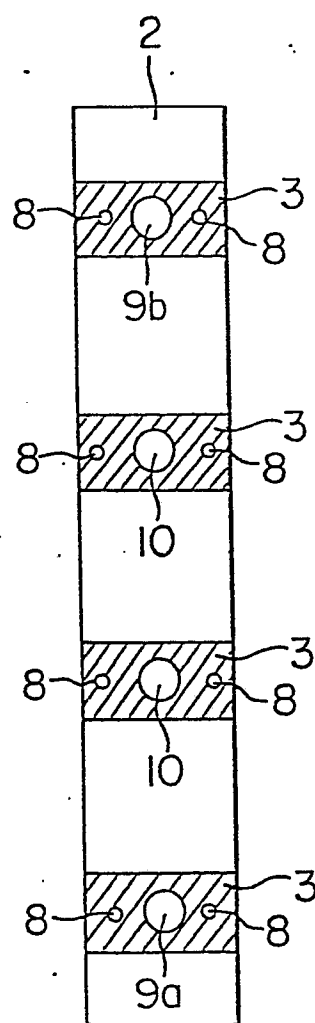
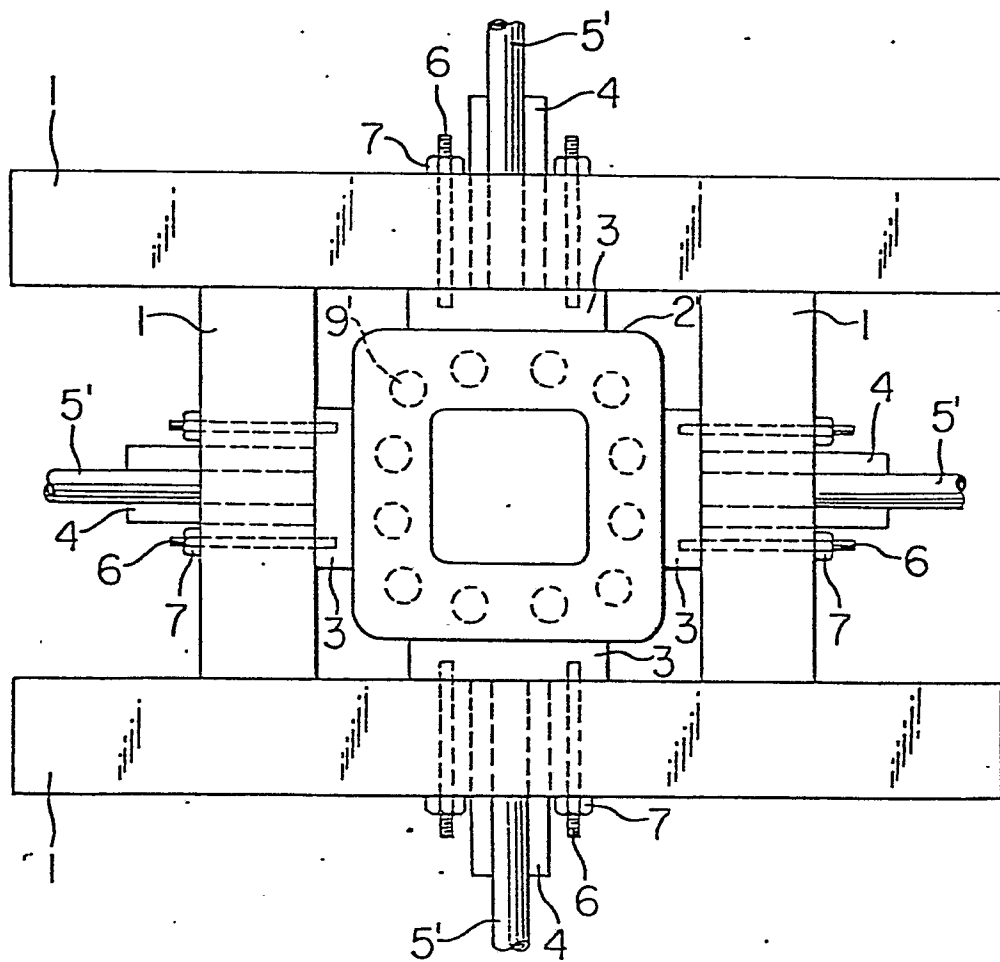


FIG. 4



INTERNATIONAL SEARCH REPORT

0042437

International Application No PCT/JP80/00317

I. CLASSIFICATION OF SUBJECT MATTER (If several classification symbols apply, indicate all) ³		
According to International Patent Classification (IPC) or to both National Classification and IPC		
Int. Cl. ³ B22D 11/07		
II. FIELDS SEARCHED		
Minimum Documentation Searched ⁴		
Classification System	Classification Symbols	
I P C	B22D 11/07, B22D 11/04	
Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched ⁵		
Jitsuyo Shinan Koho 1957 - 1980		
Kokai Jitsuyo Shinan Koho 1971 - 1980		
III. DOCUMENTS CONSIDERED TO BE RELEVANT ¹⁴		
Category ⁶	Citation of Document, ¹⁵ with indication, where appropriate, of the relevant passages ¹⁷	Relevant to Claim No. ¹⁸
X	JP, A, 79-86,432	1
⁶ Special categories of cited documents: ¹⁵ "A" document defining the general state of the art "E" earlier document but published on or after the international filing date "L" document cited for special reason other than those referred to in the other categories "O" document referring to an oral disclosure, use, exhibition or other means "P" document published prior to the international filing date but on or after the priority date claimed "T" later document published on or 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		
IV. CERTIFICATION		
Date of the Actual Completion of the International Search ¹⁹	Date of Mailing of this International Search Report ²⁰	
March 4, 1981 (04.03.81)	March 16, 1981 (16.03.81)	
International Searching Authority ¹	Signature of Authorized Officer ²⁰	
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