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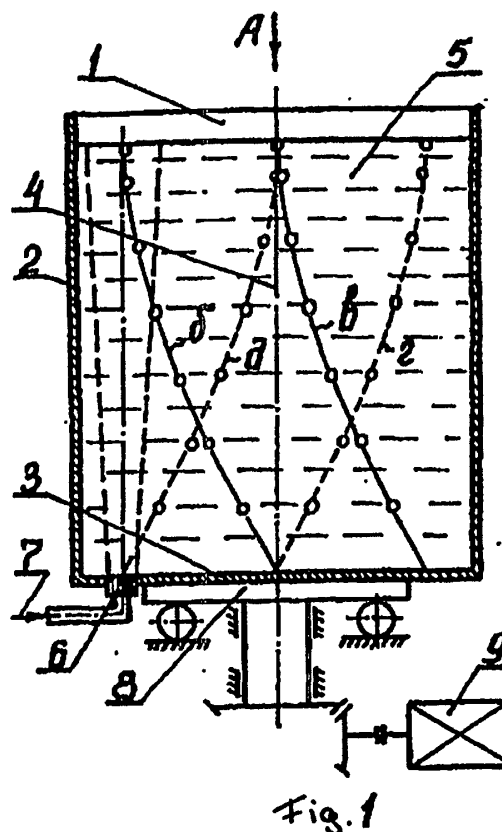
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(54) **METHOD FOR AGITATING STEEL IN A LADLE**

(57) The invention relates to steel processing in a ladle used for ferrous metallurgy. The inventive method for agitating steel in a ladle consists in blowing steel from the bottom with gas or a gas-powder mixture through blowing units. At least one blowing unit is shifted with respect to the vertical axis of the ladle toward the wall thereof. During the blowing, the ladle is rotated around the vertical axis thereof in such a way that the direction of rotation is periodically changed to the opposite direction. When the ladle is turned at an angle of 360° , the blowing is carried out through the blowing units disposed on the radius of the bottom of the ladle. When the ladle is turned at an angle equal to or greater than 180° , the blowing is carried out through the blowing units disposed on the diameter of the bottom of the ladle. When the ladle is turned at an angle equal or less than 90° , the blowing is carried out through the blowing units disposed on the mutually perpendicular diameters of the bottom of the ladle. When the ladle is turned at an angle α equal or greater than 360° , the blowing is carried out through the blowing units disposed in the sector of the ladle having the central angle α .



Description

[0001] The invention relates to ferrous metallurgy and more particularly to treatment of steel in a ladle.

[0002] Ladle metallurgy has spread widely in recent years in steel manufacturing especially where it was comprising continuous teeming. In majority of ladle metallurgy methods stirring of steel in a ladle is performed using inert or indifferent gases or gas-powder mixtures. Gas or gas-powder mixture is supplied through tuyeres or porous plugs in the bottom of ladle and located in its middle or shifted to wall. The number of tuyeres is often set equal to 2. In the same time known are installations where blowing the Argon in is carried out through 16 horizontal tuyeres.

[0003] Stirring of steel, intensification of this process, spanning bigger steel volume in ladle play crucial role in achieving goals of the ladle metallurgy such as homogenization of melt, speeding the deoxidizing processes up, non-metallurgy inclusions removal, as well as unsulphurating and unphosphatizing of steel (the latter by means of injecting gas-powder mixtures into steel).

[0004] Known is a method of stirring steel comprising the step of injection of a soluble gas into steel, said gas evolving under vacuumizing in the form of tiny bubbles rising to the surface of steel (see, for example, Staleplavil'noie proizvodstvo na poroge tret'ego tysyacheletiya, addition 7 to magazine Novosty chernoy metallurgiy za rubezhom - Steelmaking industry on the edge of the third millenium, addition 7 to magazine News of ferrous metallurgy abroad - 2000, p.25). The main drawback of the method is its relatively high expenses, as operation of this method assumes the use of circulation vacuumizing (process NK - PERM of firm "Nippon Kokan").

[0005] Known is a method for stirring steel in a ladle using stirring of steel by electromagnetic forces (see, for example, Injection metallurgy, translation from English, under edition of Sidorenko M.V., Moscow: Metallurgiya, 1986, 90). The main drawback of this method is high cost of the equipment being used, which does not always justify positive effect produced from stirring steel.

[0006] Known is a method for stirring metal in a ladle with gas blowing, comprising the step of supplying gas into metal through the blowing devices in the form of tuyeres with discs plunged into metal. (see, for example, Stal' (Steel), #12, 1999, p. 17-19). The main drawback of this method is that it is impossible to grasp the whole volume of metal in a ladle, which decreases effectiveness of metal stirring.

[0007] Known is a method for stirring steel in a ladle comprising the step of blowing steel from beneath by gas or gas-powder mixture through special blowing devices at least one of which is shifted from the center of ladle (see, for example, mentioned reference "Injection metallurgy", p. 142-143 and fig.12). In operation of this known method gas (or gas-powder mixture) is drawn to the bottom part of the ladle through porous plugs in its bottom or through the plunged tuyere.

[0008] If essential features of this known method for stirring steel in a ladle are taken into account, this method is the closest to the one being claimed herein, consequently it is adopted as the prototype. One of important merits of this method known in the art, in comparison with the methods mentioned above, is its relatively low cost and simplicity. Meanwhile the method has an essential drawback consisting in non-homogeneous stirring of steel in a ladle while blowing gas (gas-powder mixture). Intensive stirring takes place only in steel column (though expanding with height) located just above the gas- or gas-powder-feeding spot. The rest of the whole steel volume in the ladle is stirred in lesser amount, the further from the spot the less the degree of stirring. The bottom parts of steel are almost out of stirring process. All the mentioned factors decrease the effectiveness of stirring steel and prevent achieving goals of ladle metallurgy.

[0009] The method being claimed herein is devoid of the mentioned drawbacks. It provides supply of gas (gas-powder mixture) grasping all the steel volume in a ladle, thus enabling maximal degree of steel stirring in a ladle, which becomes possible when the gas (gas-powder) supply into a ladle is used as a tool for stirring steel. The method comprises the use of inert or indifferent gases, and the compound of powder mixture is defined by technical problem to be solved.

[0010] The above-mentioned technical objects are attained due to the method for stirring steel in a ladle, comprising blowing steel from beneath by a gas or gas-powder mixture through special blowing devices at least one of which is shifted relatively vertical axis of ladle towards its wall; according to the present invention along with blowing a rotation of the ladle relatively its vertical axis is carried out, while direction of rotation is periodically reversed. For rotation through angle α exceeding 360 degrees blowing is performed through blowing devices placed on the radius of ladle's bottom or in the ladle's sector with central angle α . For rotation through angle α exceeding 180 degrees blowing is performed through blowing devices placed on the diameter of ladle's bottom. For rotation through angle α at least being 90 degrees blowing is performed through blowing devices placed on mutually perpendicular diameters of ladle's bottom.

[0011] The offered method for stirring steel in a ladle is illustrated by the following schematic drawings.

[0012] On fig.1 a scheme for operation of the method for stirring steel in a ladle with supply of gas or gas-powder mixture through blowing devices located in the bottom of the ladle is presented.

[0013] On fig.2 the same as on fig.1 scheme is presented for the case of gas or gas-powder supply through the tuyere plunged into steel.

[0014] On fig.3 view A on ladle of fig.1 is shown.

[0015] On fig.4 view B on ladle of fig.2 is shown.

[0016] On fig.5 view A on ladle of fig.1 is shown in case blowing devices located along the radius of ladle's

bottom and their rotation steel relatively through one turn.

[0017] On fig.6 view A on ladle of fig.1 is shown in case blowing devices located along the diameter of ladle's bottom and their rotation steel relatively through half a turn.

[0018] On fig.7 view A on ladle of fig.1 is shown in case blowing devices located on mutually perpendicular diameters of ladle's bottom and their movement steel relatively on a quarter of a turn.

[0019] On fig.8 view A on ladle of fig.1 is shown in case blowing devices located in a sector of central angle α and their movement steel relatively through the angle 360 degrees minus α .

[0020] On fig.9 view analogous to fig.8 but for sector with central angle equal to 90 degrees is presented.

[0021] On fig.10 view A of fig.1 is shown for the case of different location of blowing device in the bottom of ladle and its movement steel relatively for reverse rotation of ladle through the full turn.

[0022] Fig. 11 features locations of blowing devices in the bottom of ladle for the cool model realization of the method being claimed.

[0023] Periodical reversals of ladle rotation is denoted on fig. 3 - 10 by arrows with solid lines in one direction and dashed for reversals.

[0024] Teeming ladle 1 (fig. 1) is executed in the form of body of revolution with walls 2 and bottom 3. Vertical axis of ladle is 4. Liquid steel 5 is in the ladle. Blowing device 6 contacts with steel from below through which inert or indifferent gas or gas-powder mixture 7 is supplied.

[0025] The ladle is mounted on turntable 8 with drive 9. Blowing device may be also executed in the form of plunged into metal thermally isolated tuyere 10 (fig. 2) mounted to the ladle's wall by means of mounting tools 11. Blowing device 6 may be executed in a form of porous fireproof insert or fireproof plug with cavities (on fig. 3, 5 - 10 cavities are denoted as crosses). There may be one (fig. 3) or few (fig. 5 - 10) inserts (plugs). Inserts (plugs) may be located

along the radius of ladle's bottom (fig. 5),

along the diameter of ladle's bottom (fig. 6),

on mutually perpendicular diameters of ladle's bottom (fig. 7),

within the sector of the bottom with central angle α (fig. 8), including $\alpha = 90$ degrees (fig. 9),

randomly, if justified (fig. 10).

[0026] Porous inserts or fireproof plugs may implement hidden or open blowing of steel. Their form is not necessarily to be round. All the mentioned facts change nothing in the essence of the method for stirring steel proposed.

[0027] Dashed line on fig. 3 - 10 shows region in ladle, that experiences action of blowing devices while ladle is stationary, shaded zone - during realization of current method. The action of blowing devices may be intensive, for example, in the beginning of processing steel

in ladle, and not intensive (bubble, soft), for example, at the end of processing. Realization of mentioned regimes of work of blowing devices does not concern the essence of proposed method for stirring steel in ladle.

[0028] The method for stirring steel in ladle is realized in the following way.

[0029] Teeming ladle 1 (fig. 1) after filling with liquid steel 5 is supplied to processing steel, that may include blowing the metal with inert gases, desulphuration and modifying steel by means of blowing steel with gas-powder mixture of appropriate compound. Ladle 1 is set on turntable 8, gas or gas-powder mixture (7) is drawn to blowing devices 6 and processing based on steel stirring effect in ladle takes place while gas is supplied to steel.

[0030] When gas is started to be pushed in steel, rotation of ladle 1 relatively its vertical axis 4 is carried out by drive 9. The angle of ladle rotation depends on execution of blowing devices 6, i.e. on the zone of their influence in the bottom part (3) of ladle 1 while it's stationary.

[0031] While rotating ladle 1 relatively its vertical axis 4 steel 5 due to inertia is almost stationary, while walls 2 and bottom 3 of ladle 1 rotate. Rotation of bottom 3, where blowing devices 6 are located, with stationary steel 5 is equal to rotation of blowing devices 6 in horizontal plane steel relatively. In its turn rotation of blowing devices 6 steel 5 relatively completely changes the stirring pattern in ladle: from local - in the area where blowing device 6 is located to affecting the whole steel volume on the way blowing devices 6 move in horizontal plane steel relatively. The said is the main essence of herein claimed method for stirring steel.

[0032] Realization of present method for stirring steel in ladle removes necessity of high velocities of ladle rotation, and velocities of $3 \dots 15$ rpm are enough ($\omega = 0.3 \dots 1.5 \text{ c}^{-1}$), as steel volume while rotating experiences only forces of liquid friction between layers of steel near the bottom 3 and walls 2, which are known as of no significance.

[0033] For realization of current method there is no need in constant rotation of ladle, as firstly, constant ladle rotation leads to turning steel 5, secondly, requires the solution to the problem of drawing gas or gas-powder supply to blowing devices.

[0034] For realization of current method there is no need in performing ladle turns through angles exceeding 360 degrees, as for one ladle turn blowing device 6, executed in the form of only insert (plug) of fig. 1 and 3, even more in the form of set of inserts (plugs), located along the radius of ladle's bottom (fig. 5), comes to its original (initial) position, influencing the whole steel volume in ladle. The need in reverting blowing devices 6 to their original positions steel relatively, i.e. reversals in ladle rotation is obvious. Refusal of such technical solution (i.e. reversals of ladle rotation) leads to unjustified difficulties in drawing gas (gas-powder) to blowing devices without any increase in steel stirring effect. The said facts are reasons for performing reversals.

[0035] The ladle 1 rotation with reversals may be accomplished through electric-mechanical drive (fig. 1 and 2), hydro-mechanical mechanisms (using hydraulic cylinders and rack and pinion mechanism), crank and other devices. Each of realizations includes as drawbacks so and merits not analyzed here, for drive realization makes no influence on the essence of proposed method for stirring steel in ladle.

[0036] As movement of blowing devices 6 in horizontal plane steel 5 relatively is attained through ladle rotation with reversals vertical axis 4 relatively, in realization of present method at least one blowing device is to be shifted from longitudinal axis 4 of ladle (the solution known from experience in processing of steel in ladle).

[0037] In realization of present method for stirring steel in ladle blowing devices are preferably located in the bottom of ladle (fig. 1). In the same time plunged into steel blowing tuyeres 10 (fig. 2 and 4) may be also used, in which case they are mounted to ladle walls with the help of mounting facilities 11 (fig. 2). Using of blowing tuyeres is less desirable in our case due to following reasons: firstly, they diminish inertia forces preventing steel rotation with turning of ladle, secondly, tuyere mounting to ladle walls is technical problem of some difficulty.

[0038] Figures 1 and 3 present the essence of method for stirring steel in ladle using the example with one blowing device 6 in the form of bottom plug shifted from longitudinal axis 4 of ladle 1, that moves steel 5 relatively. Realizations of figures 5 - 10 introduce no changes into the essence of the method being proposed but indicate ways to intensify stirring of steel in ladle due to different ways of execution of blowing devices.

[0039] When gas (gas-powder mixture) 7 through the blowing device 6 is drawn, it raises up enhancing the zone spanned by its influence (the dashed line on fig. 1 - 10 denotes the zone of stirring steel in ladle if blowing device is stationary). If rotated through one turn blowing device 6 sequentially goes through positions a - d, and in position e comes to initial point a, after which the rotation is reversed and device 6 goes through these positions in reverse order.

[0040] As steel 5 due to inertia forces remains almost still when ladle 1 is rotated, sequential changes in positions of blowing device 6 from a, via b - e alter the pattern the gas (gas-powder mixture) goes through steel, which is presented on figures 1 and 2 in the form of curves b, c, d and e with bubbles, corresponding to positions b, c, d and e of blowing device 6 on figures 3 and 4. When ladle rotation is reversed curves b, c, d and e from fig. 1 deviate to the opposite direction. So, during the cycle of reversed rotation of ladle in our case gas (gas powder) jet 7 acts on the zone of steel 5 dashed on fig. 3 - 10. Simple comparison of dashed zones influenced by direct effect of blowing device 6 in known method and shaded area on fig. 3 - 10 influenced by under realization of current method indicates significant extension of ladle influenced area in our case.

[0041] Locations of blowing devices on fig. 5 - 10 provide

possibilities for stirring steel due to horizontal motions of few blowing devices steel relatively.

[0042] In version on fig. 5 blowing devices located along the radius of ladle bottom feed steel 5 with gas all through the ladle volume while the latter is reversibly rotated through one turn (on fig. 5 the influenced area of steel 5 by gas 7 is shaded).

[0043] In version on fig. 6 blowing devices located along the diameter of ladle bottom feed steel 5 with gas all through the ladle volume while the latter is reversibly rotated through not less than half a turn (on fig. 6 the influenced area of steel 5 by gas 7 is shaded). Realization of version of fig. 6 does not exclude reversible rotation of ladle through one turn or through medium values between half and one turn. The mentioned action enhances additionally stirring of steel by gas, though need in such a stirring is not always justified.

[0044] In version of fig. 7 blowing devices 6 are located along perpendicular diameters of ladle bottom and reversible quarter-turn lets gas to stir the whole ladle volume. As with case on fig. 6 for this version rotation though angles more than quarter-turn but less than one turn is not ruled out.

[0045] In version of fig. 8 blowing devices are located in sector with central angle Alpha and to influence the whole steel volume it needs reversible rotation of ladle through the angle not less than $360^\circ - \text{Alpha}$ (and more, but not exceeding one turn). Central angle Alpha of the sector may be increased or decreased and the ladle turn angle is decreased or increased respectively.

[0046] On figures 9 and 10 other versions of locations of ladle bottom blowing devices along with appropriate rotation angles and areas of steel influenced by gas (gas-powder mixture) are shown.

[0047] Figures 3 - 10 cover not all possible versions for locations of ladle bottom blowing devices, but in any case not less than one of them is located shifted from longitudinal axis of ladle towards its wall, as it is this solution, that provides shifting of blowing devices in horizontal plane steel relatively while rotating the ladle relatively its vertical axis.

Example 1. Cold model of steel-teeming ladle made of transparent acrylic plastic with internal diameter of 550 mm at temperature of 20 degrees Celsius is filled with water up to the height of 450 mm. On top of water there was placed a layer of painted sunflower oil 7 mm thick. The water imitated liquid steel, while oil - slag.

In the bottom of the model on mutually perpendicular diameter there were placed 9 blowing devices one of which was located in the center of the model. In addition, one blowing device was placed in one of sectors formed by mentioned diameters (fig. 11). Each blowing device to which air was supplied is executed in the form of cavity with 13 holes 1.5 mm in diameter and placed every 15 mm. Every blowing device is equipped with separate air supply with op-

tions of complete switching off and intensity regulation. There was performed regimes of blowing water with air at pressures less than 10 kPa.

The ladle model was placed onto the table with rotation drive.

Bubble blowing of water was performed through one blowing device placed in the sector. In the water - its upper part, middle and near the bottom - ink is injected and its dispersion time is measured. Ink is introduced near the ladle wall opposite to the blowing device through which air was supplied at three levels: surface layers (1/4 of slag height), middle part and near the bottom of the bath.

If ladle is stationary, ink was dispersed in 25 seconds in the upper part, about 25 seconds in the middle, and about 40 seconds near the bottom, where stagnation zone was formed as in 40 seconds dispersion was not finished. Water counterflows were observed near the wall where ink was injected, but sunflower oil did not mix with water.

For reversible rotation of ladle through one turn with average angular velocity of 1.25 sec^{-1} dispersion of ink at all levels took about 10 seconds, i.e. by the end of first turn of blowing device to initial position. The stagnation zone wasn't formed. No distinct counterflows were observed. Stirring took place all through water volume. Sunflower oil didn't mix with water.

Thus, motion of blowing device in horizontal plane steel (water) relatively accomplished by reversible rotation of ladle (model) relatively its longitudinal axis intensified significantly the process of stirring, especially in the bottom part of the ladle.

Example 2. Under conditions of example 1 blowing water by air was accomplished through two blowing devices placed along the radius of ladle bottom with central blowing device switched off. Ink was injected only into the bottom part of the bath near the opposite to blowing devices wall of ladle on the same diameter.

When ladle is stationary dispersion of ink took about 60 seconds with formation of bottom stagnation zone, where ink remained after 60 seconds. Water counterflows were observed near the wall where ink was injected. Sunflower oil did not mix with water.

For reversible ladle rotation through one turn with average angular velocity about 1.25 c^{-1} full dispersion of ink took 15 seconds including the bottom part of the model. Stirring took place all through the volume. Sunflower oil did not mix with water.

Example 3. Under conditions of example 1 blowing was performed through 5 blowing devices located along the diameter of ladle bottom. Ink was injected at three levels: into the surfaces layers (1/4 of slag height), in the middle and near the bottom. Ink drops were injected near the opposite part of ladle wall (i.e. at maximal distance from blowing devices).

If ladle is stationary, ink was dispersed in 10 sec-

onds in the upper part, about 10 seconds in the middle, and about 20 seconds near the bottom, with formation of stagnation zone at the bottom. Water counterflows were observed near the wall where ink was injected. Sunflower oil did not mix with water.

For reversible ladle rotation through half a turn with average angular velocity about 0.8 c^{-1} the ink was dispersed in 10 seconds in the upper part, about 10 seconds in the middle, and about 7 seconds near the bottom including bottom itself. Stirring took place all through the volume. Sunflower oil did not mix with water.

Thus, shifting blowing devices in horizontal plane steel (water) relatively accomplished through reversible rotation of ladle (model) relatively its vertical axis in this case intensifies stirring of steel significantly especially in the lower part of ladle.

Example 4. Under conditions of example 1 intensive blowing was performed through one blowing device placed in a sector.

When ladle is stationary water and oil mix notably. In addition, above the blowing device on the surface of bath a zone free of oil is formed. The main part of oil is shifted towards the opposite from blowing device wall of ladle, where caught in big fractions by water counterflows and entrained to the depth of about 2/3 of bath height, and then shifted to upgoing flows of water above the blowing device and rises upwards.

For reversible ladle rotation through one turn with average angular velocity about 1.25 c^{-1} the mentioned oil fraction being concentrated near the opposite from blowing device wall is destroyed. The oil is caught more smoothly by water flows and in smaller fractions goes almost to the bottom, then going upward in places where with ladle rotation rising water flows are formed. Stirring took place all through the volume.

Example 5. Under conditions of example 4 intensive blowing water by air was accomplished through two blowing devices placed along the radius of ladle bottom with central blowing device switched off.

For stationary ladle mixing of water and oil described in example 4 grows notably. For reversible rotation of ladle relatively its longitudinal axis through one turn mixing of water and oil grows all through the bath volume and additionally oil fractions in water become smaller.

Example 6. Under conditions of example 4 intensive blowing water by air was accomplished through six blowing devices placed in the bottom sector with central angle of 90 degrees (the central blowing device, two blowing devices on each of two mutually perpendicular radii and one in between of them were on). Effects described in examples 4 and 5 enhance as when ladle is stationary, so and for the case of rotation, especially through the angle of 270 degrees. In the latter case there takes place full mix-

ing of water and oil in the whole volume with seen dispersion of oil particles. However, switching the air supply off results in quick separation of water and oil in the bath into two fractions: oil above water. Thus, the proposed method for stirring steel in teeming ladle due to shifting blowing devices in horizontal plane stirring in whole volume of steel is realized. Using intensive blowing of steel with gas (gas-powder mixture) needed characteristics of steel are obtained faster. Further non-intensive blowing with inert or indifferent gas (bubble soft blowing) allows all the steel volume to be spanned by soft blowing, which provides high quality clearance of steel from small scale inclusions remained in steel after intensive blowing.

An important feature of the proposed method for stirring steel in ladle is its relatively easy technical realization - moving blowing devices in horizontal plane steel relatively in order to influence the whole steel volume by means of rotating of ladle with steel relatively its vertical axis with periodical reversals in rotation.

Relative simplicity of technical realization of the method for stirring steel in ladle lets it to be considered for use in the process of teeming steel into the intermediate ladle. Additionally, stirring of steel allows metal to be refined due to absorption on boundaries bubbles - metal of non-metal phases as well as additionally degassed from nitrogen and hydrogen. Realization of method proposed for stirring of steel in this case presumes the use of steel teeming ladles with central teeming glass.

degrees, while blowing is performed through blowing devices placed on mutually perpendicular diameters of the ladle bottom.

- 5 5. The method of claim 1, wherein rotation of ladle is accomplished through the angle α being at least 360 degrees, while blowing is performed through blowing devices placed within a sector with central angle α .

Claims

1. Method for agitating steel in a ladle, comprising blowing steel with gas or gas-powder from below through special blowing devices, at least one of which is shifted relatively vertical axis of the ladle towards its wall, said method furthermore comprising simultaneous with blowing rotation of ladle relatively its vertical axis with periodical reversals.
2. The method of claim 1, wherein rotation of the ladle is accomplished through the angle α being at least 360 degrees, while blowing is performed through blowing devices placed on the radius of the ladle bottom.
3. The method of claim 1, wherein rotation of the ladle is accomplished through the angle α being at least 180 degrees, while blowing is performed through blowing devices placed on the diameter of the ladle bottom.
4. The method of claim 1, wherein rotation of ladle is accomplished through the angle α being at least 90

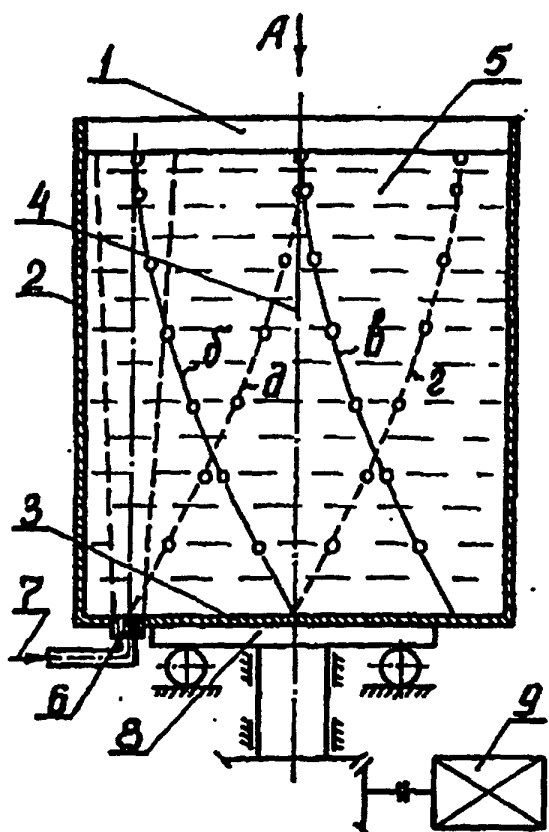


Fig. 1

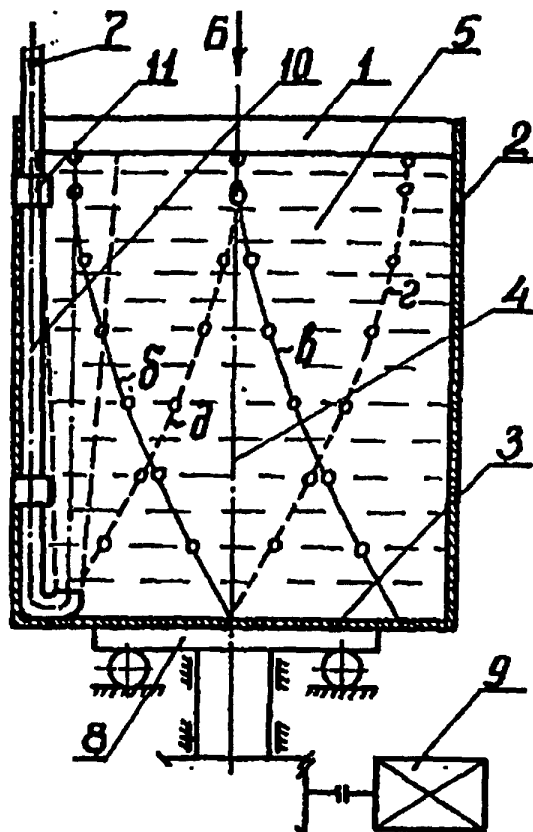


Fig. 2

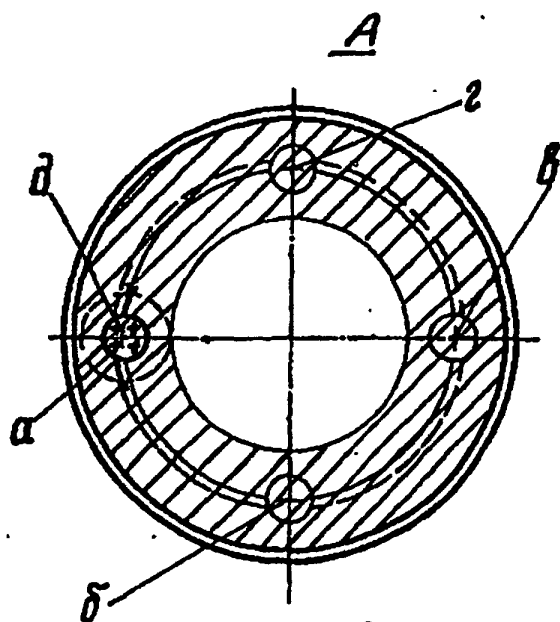


Fig. 3

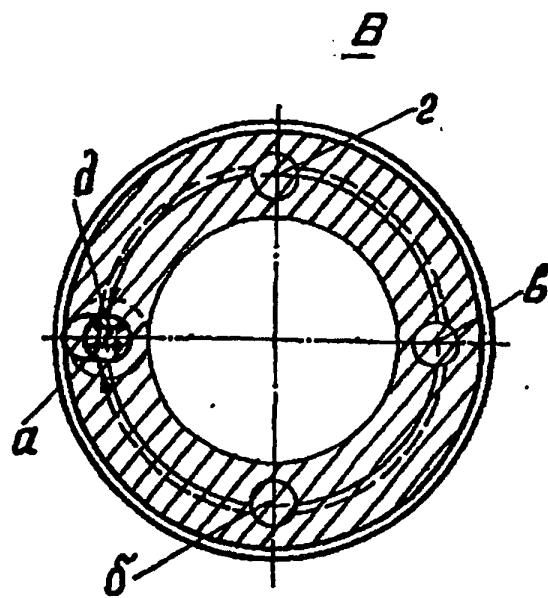


Fig. 4

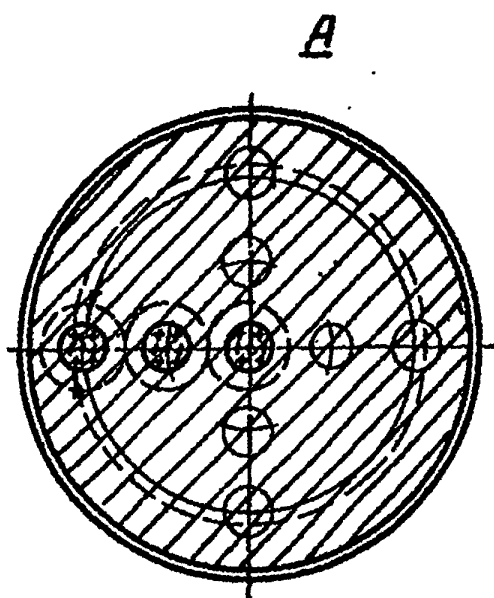


Fig. 5

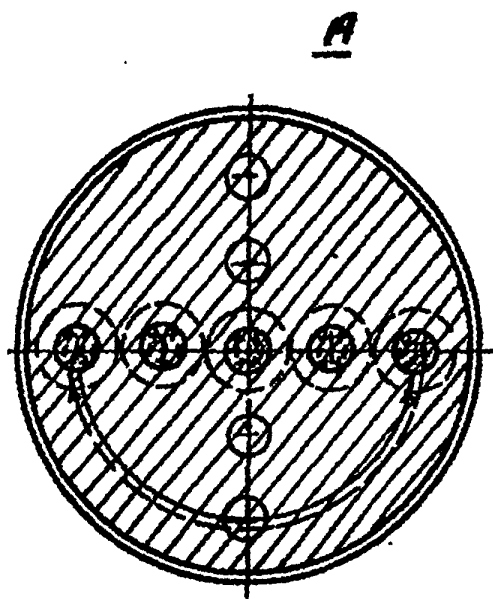


Fig. 6

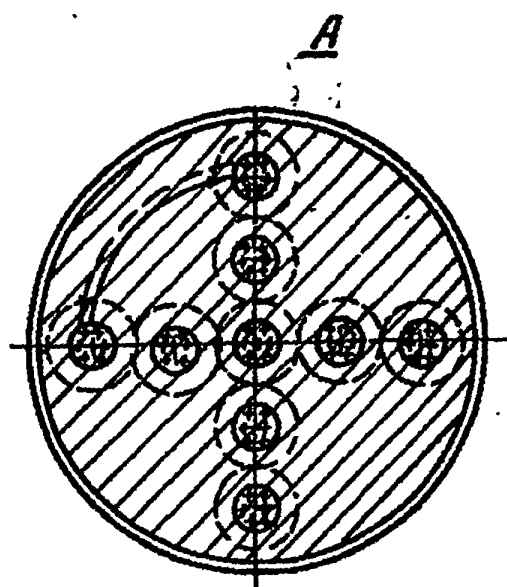


Fig. 7

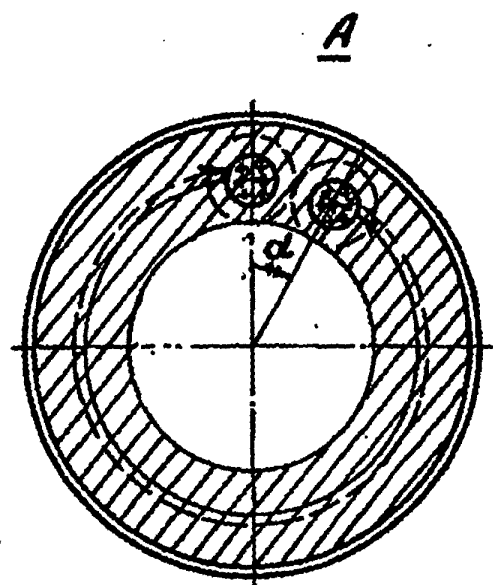


Fig. 8

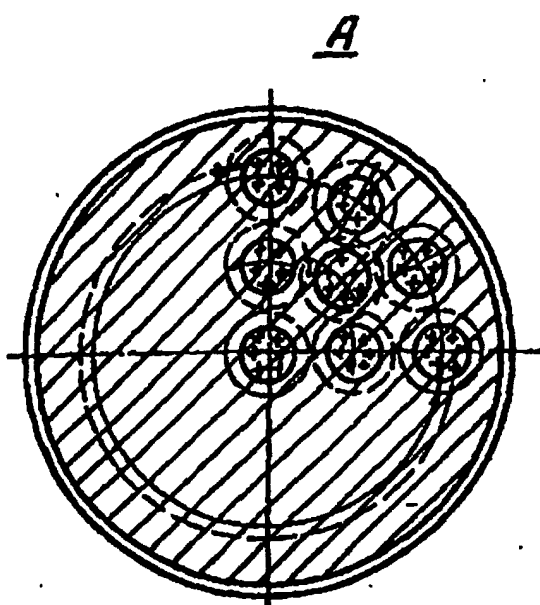


Fig. 9

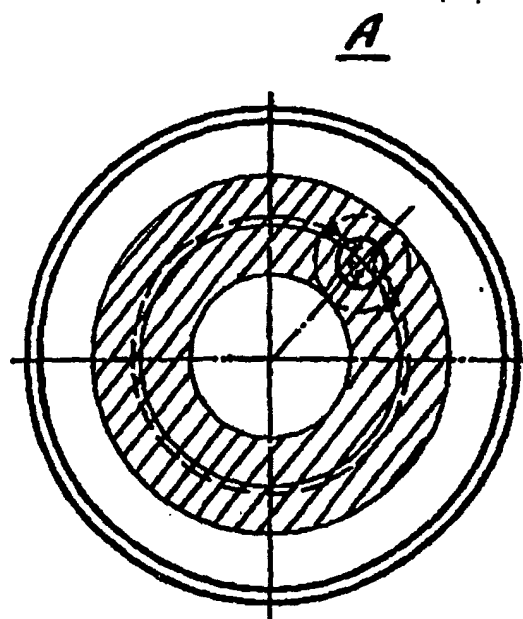


Fig. 10

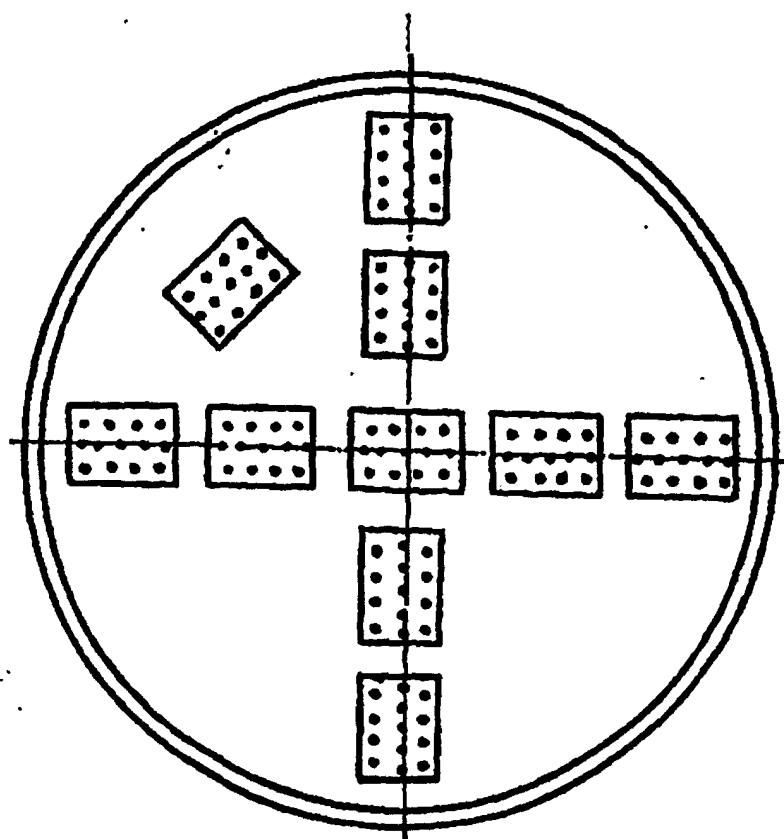


Fig. 11

INTERNATIONAL SEARCH REPORT

International application No.
PCT/RU 02/00180

A. CLASSIFICATION OF SUBJECT MATTER		
C21C 7/072, B22D 1/00		
According to International Patent Classification (IPC) or to both national classification and IPC 7		
B. FIELDS SEARCHED		
Minimum documentation searched (classification system followed by classification symbols) IPC 7 C21C 7/00-7/068, C21C 5/00,5/04, C21C 5/28-5/35,5/52, C22B 11/00,13/00,15/00, C21C 1/00-1/10, B22D 41/00,41/42, B22D 1/00		
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)		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	SU 557867 (UKRAINSKY GOSUDARSTVENNY INSTITUT PO PROEKTIROVANIJU METALLURGICHESKIKH ZAVODOV), 13.06.1977, the claims, the description	1-5
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A	GB 760561 (AIR LIQUIDE) 31.10.1956, the abstract, figure 1	1-5
☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.		
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