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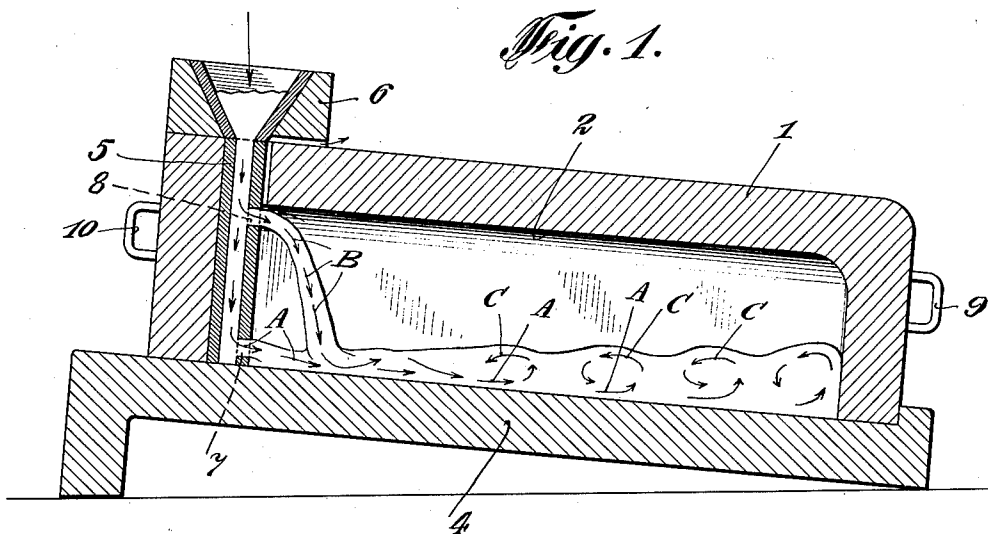
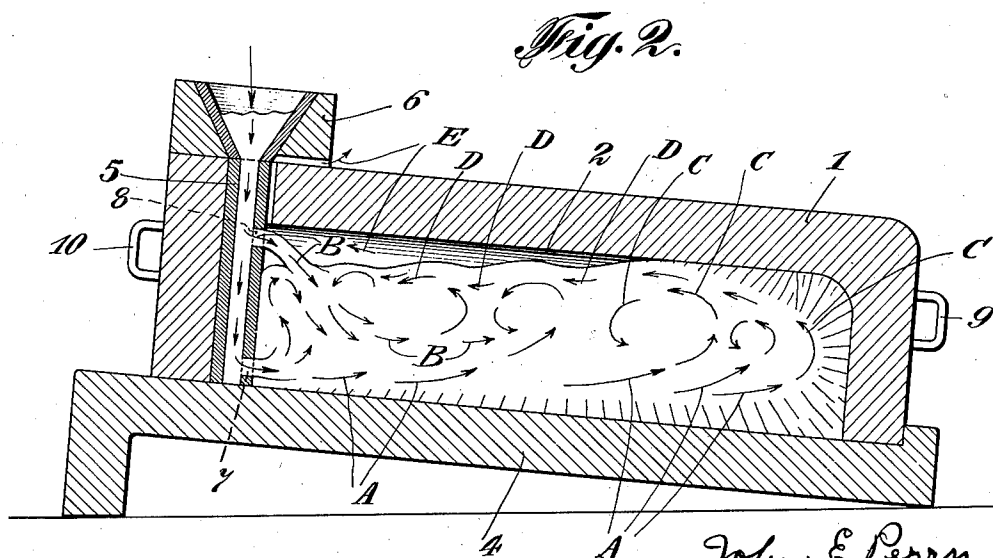
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METHOD OF MAKING INGOTS, AND THE INGOT

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UNITED STATES PATENT OFFICE.

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METHOD OF MAKING INGOTS, AND THE INGOT.

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To all whom it may concern:

Be it known that I, JOHN E. PERRY, a citizen of the United States, and a resident of the city of Sharon, in the county of Mercer, State of Pennsylvania, have invented new and useful Improvements in Methods of Making Ingots, and the Ingot, of which the following is a specification.

The present invention relates broadly to metallurgy and more especially to the method of casting steel ingots and the like and the ingot resulting from the method.

The principal object of this invention is the method of casting a steel ingot by quickly filling a chill mold and preventing segregation during filling and causing the entire ingot to chill over its exterior surface quickly whereby the molten interior is subjected to pressure during the cooling of the ingot.

Another object of the present invention is the method of casting a steel ingot which comprises establishing currents in the molten steel during the pouring, which currents oppose segregation, then quickly chilling all sides of the molten steel and causing the ingot to cool in such manner that the interior thereof is maintained under pressure until the ingot is of uniform temperature throughout.

A further object of the present invention is the method of casting steel ingots in chill molds wherein the method may be carried out by introducing the steel into the mold in such manner that movements in the molten steel are such as to prevent segregation, and then chilling all surfaces of the ingot quickly to cause internal pressure in the central molten mass to permit freeing of occluded gases in the steel.

A further object of the present invention is the method of casting steel ingots in chill molds by introducing the steel into a substantially horizontal pool by means of a plurality of separate streams arranged to cause vertical moving currents in the steel pool to carry the surface portion of the steel downwardly and mingle the lighter products with the heavier to prevent segregation during pouring.

A still further and important object of the present invention is the method of casting steel ingots wherein the pouring produces a substantially horizontal pool of steel and wherein a part of the steel is introduced

beneath the surface of the pool and another part of the steel is introduced above the surface of the pool.

A still further and important object of the present invention is the method of casting steel ingots wherein a runner is provided in one end of the matrix portion of a horizontal chill mold and is arranged with two openings, one in the upper part of the mold matrix and the other one in the lower part of the mold matrix, with both openings unobstructed in such manner that when steel is poured into the runner it issues first in larger volumes in the lower opening beneath the surface of the steel pool, whereas as the mold fills the upper opening eventually contributes the larger amount of fresh steel, and this strikes the surface of the pool and causes a churning and mixing action.

A still further and primary object of the invention is an article of manufacture comprising an ingot of steel having all chill sides with a steel shell of high fusion point steel and with a central mass of steel containing lower fusion point material and wherein segregation is substantially limited throughout the ingot.

Another object of this invention is the article of manufacture comprising a smooth surface steel ingot of substantially solid metal throughout and being ready for the rolling processes when the ingot is stripped from the ingot mold.

A still further object of the present invention is a steel ingot having a substantially pure steel shell, and solid core of metal containing non-segregated metalloids in non-deleterious quantities throughout the core.

Other and further objects will in part be obvious, and will in part be pointed out in the specification hereinafter following by reference to the accompanying drawings forming a part of the application and wherein like characters represent like parts throughout the several figures thereof.

Realizing that this invention may be embodied in different forms and be practiced in different ways without departing from my invention I desire that the specific disclosure herewith shall be regarded as illustrative and not considered in the limiting sense.

Figure 1 is a more or less diagrammatic construction illustrating one type of mold

and showing the steel as it begins to enter the mold.

Figure 2 illustrates the pouring as having progressed further;

5 Figure 3 illustrates the mold completely filled and beginning to chill;

Figure 4 illustrates a longitudinal section through an ingot in accordance with the present invention;

10 Figure 5 illustrates a cross-section through the ingot illustrated in Figure 4.

In the prior art it has been customary to cast steel ingots in horizontal molds by means of runners provided with a single
15 inlet opening near or adjacent the bottom of the mold and by providing gas outlets in the upper part of the mold, usually at the end opposite the runner. In some cases it has been proposed to cast horizontal ingots by a
20 runner which enters the mold through the bottom wall thereof or the stool and wherein the top of the mold is provided with a series of gas outlets arranged along the upper part of the mold. In these constructions of the
25 prior art the metal which is feeding the ingot being formed is forced to rise through the zone which is solidifying or crystallizing, and the movement of the metal has heretofore been in the direction of the move-
30 ment of the gas through the metal as the gas was being set free while the steel solidified. This has a tendency to facilitate the freeing of gas in the molten steel and thereby causing more free gas and thus
35 causing the plastic or partly solidified steel to tend to be full of gas bubbles, and to finally solidify as a honey-comb mass not suitable for rolling. Furthermore, where the steel rises as an undisturbed pool the materials of lowest fusion are forced out
40 from the solidifying steel into the still molten portion of the steel and the materials of lesser fusion point tend to rise to the top of the pool and to remain in that position. Therefore where chill covers are used the
45 part of the material of lowest fusion namely the top of the pool comes into contact with the top cover and forms a thin chill, but since the fusion point of this metal is low this upper part of the ingot tends to remain
50 molten longer than the bottom or side portions of the ingot and the free gases move into this liquid metal consequently there is liability of this upper part of the ingot
55 being spongy or honey-combed and at the same time the ingot in this upper part tends to contain excessive amounts of materials which when in large quantities are considered as detriments to good steel and are
60 referred to in the art as "segregation." Some of the materials which will be found in excess in the top of such an ingot, when poured in the manner known of the prior art, are sulphur, phosphorus, manganese,
65 and other materials which are not detri-

mental when present in small quantities, but which become detrimental when permitted to segregate in the manner specified.

The present invention overcomes the dif-
70 ficulties of the known prior art by providing a method of casting horizontal steel ingots in such manner that segregation is substantially prevented and the formation of gas bubbles in the final ingot is substantially
75 eliminated. This method may be accomplished in various ways and may be carried out by providing a full chill mold wherein the runner extends to the bottom of the mold but is provided with runner openings
80 at both the bottom and the top of the mold matrix and preferably the mold is inclined to the horizontal with the runner end thereof higher than the other end and with provision for escape of gases at the runner end,
85 preferably around the runner itself. In carrying out the method the mold is a horizontally inclined chill mold with all sides and ends having a heat absorbing capacity sufficiently great to very quickly chill all
90 molten steel coming in contact with the walls of the matrix portion of the mold. The pouring should be very rapid so that the mold is very quickly filled with steel which enters through both openings and the larger proportion enters through the lower opening.
95 As the steel is running from the lower opening into the pool, it is also running from the upper opening and this strikes the surface of the pool. The effect of a plurality of streams of steel, one leading into the pool from be-
100 neath the surface, and the other leading into the matrix above the pool surface, is to produce a rolling or undertow condition in the molten steel. The steel flowing from the lower opening strikes the lower end of the
105 mold and tends to run backward toward the runner so that the surface movement is toward the runner end, while the steel from the upper opening dropping upon the surface of the steel pool meets the oncoming
110 surface movement of the steel from the lower opening causing the movement to reverse itself in a downward rolling movement. This movement continues as the mold fills and as the ferro-static pressure increases
115 in the mold the amount of metal flowing from the upper opening proportionately increases so that the fresh molten steel is supplied in gradually increasing volumes to the surface of the pool as the pool rises. In
120 the meantime the rolling or undertow movement continues. This action thoroughly mixes the materials in the mold and prevents any materials of low fusion point collecting as strata or "segregation." As the
125 mold is filled quickly the fresh steel quickly reaches the chill cover and immediately a shell of solid steel at a high fusion point begins to form. The undertow or rolling
130 action has prevented segregation and has

tended to prevent the formation of gas bubbles. The result is that when the entire mold is filled and the chilling action is going on the solid steel shell of a high fusion point steel grows from the mold walls toward the center and gradually encloses the molten steel material of a slightly less fusion point. This pure steel shell of the high fusion point steel freezes and contracts around the central mass of lower fusion point, and from which the heat must escape through the outer shell. This causes the heat gradient to run from the central mass radially to the outer surfaces. The internal pressures depend upon the heat differential between the hottest part and the coolest part of the ingot. Therefore with the outer shell cool and rapidly solidifying, and the inner mass hot and liquid, the central mass is subjected to great pressure. This pressure continues in proportion to the heat differential and therefore continues until the ingot is of uniform temperature. The mixing movement of the steel, and the surface supply of fresh steel prevents segregation during pouring and the quick pouring soon brings the melted steel against the chill cover at which time the enclosing steel shell starts to form and from that time on conditions are not conducive to segregation. Therefore segregation is substantially prevented. All mold gases escape during pouring through the gas outlets provided and when the chilled shell forms pressure builds up so quickly that the occluded gases in the steel are prevented from being freed and this eliminates gas bubbles. The finest steel is on the smooth outside of the ingot and this gives fine rolling surfaces to the ingot. The resulting product therefore comprises a solid steel ingot having a shell of two or three inches in thickness, depending upon the size of the ingot, of the pure high fusion point steel and the interior or core of the ingot is a solid metal throughout wherein the low fusion point materials are distributed in such manner that at no point in this core are these materials present in deleterious quantities, and the whole ingot is ready for rolling into finished product.

Referring now to the drawings the mold for carrying out the present invention may comprise a chilled trough-like body 1 provided with a matrix portion 2 and adapted to be inverted upon a suitable stool 4. The stool is inclined slightly to the horizontal so that the axis of the matrix portion of the mold is slightly inclined. A fountain 6 is adapted to set over a runner tile 5 that extends through an opening in the top of the mold and is set along one end of the mold matrix. The tile is provided with a vertical passageway connected with the funnel of the fountain and is also provided with inlet openings 7 and 8 the axes of which are substantially parallel with the

axis of the mold matrix. These inlet openings may be varied and in fact the invention may be carried out by providing a single inlet opening preferably near the location of the inlet opening 8. A space is left around the tile where it passes through the top of the mold and another space is also provided beneath the fountain in order to provide a gas escape opening. The mold body preferably is also provided with crane staples 9 and 10 whereby the mold may be lifted from the stool.

Referring to Figures 1, 2 and 3, which illustrate the method, it will be noted that the steel issues into the mold body in such manner as to create vertical eddy currents. Where a plurality of openings are used the steel issuing from the opening 7 takes the general direction indicated by the arrows A, while the steel from the opening 8 pours on the surface of the steel pool in the direction indicated by the arrows B. This produces a backward and downward action at the surface as indicated by the arrows C. In Figure 2 with the mold nearly filled the surface action of the pool is more nearly in the direction toward the pouring end as is indicated by the arrows D so that the steel surface tends to carry mold gases toward the gas outlet and these gases have a direction indicated by the arrows E. The space occupied by the gases gradually diminishes and when the mold is filled, as shown in Figure 3, chilling action begins while there is still a slight movement in the body of the steel. This chilling action is indicated in Figures 3, 4, and 5 by the lines F and the action begins at the end farthest from the inlet openings. The result of the chilling is to produce a shell of substantially pure steel which encloses the core G made up of alloy steel containing materials which tend to solidify at a slightly lower temperature than the pure steel. The center or core of the ingot contains more metalloids than does the shell thereof and these metalloids increase in quantity gradually toward the axis of the ingot. These materials, however, are so thoroughly mixed that such materials do not occur at any point in the ingot in such quantities as to be deleterious. The entire ingot therefore is capable of being fabricated into finished product.

Having thus described my invention, what I claim is:

1. The method of casting steel ingots which comprises providing a mass of molten steel by filling the matrix of a mold which matrix has the form of the ingot desired and maintaining the steel constituents homogeneously distributed throughout the entire mass thereof; and freezing the molten steel into a solid mass by quickly absorbing heat from all sides thereof to arrest the molecular movement of the constituents of

the steel before the condition of homogeneity of the mass has substantially changed.

2. The method as claimed in claim 1 and wherein the homogeneous distribution of the constituents of the steel is maintained by agitation of steel in the mold during the filling thereof.

3. The method as claimed in claim 1 wherein the homogeneous distribution of the constituents of the steel is maintained by the production of vertical eddy currents in the steel during the operation of filling the mold.

4. The method as claimed in claim 1 and wherein the molten steel is introduced into the mold cavity in such manner that the inflow of molten steel causes a thorough mixing of the steel during the complete filling operation.

5. The method as claimed in claim 1 and wherein the steel mass is quickly formed by quickly filling a mold cavity, and wherein heat is rapidly absorbed from the steel shell enclosing the molten interior of the ingot to cause the chilled shell to cool with sufficient rapidity to establish internal pressure on the molten mass and to maintain said pressure until the ingot is solidified.

6. The method as claimed in claim 1 and wherein agitation of the molten steel is maintained by streams of steel which enter the mold substantially parallel to the horizontal axis of the mold.

7. The method of casting ingots which comprises pouring the molten metal into a matrix in such manner as to cause vertical eddy currents which continually mix the upper portions of the pool with the lower portion thereof during pouring.

8. The method of casting steel ingots which comprises pouring the steel into a matrix in such manner as to cause vertical eddy currents which continually mix the upper portions of the pool with the lower portion thereof during pouring and then chilling all sides of the molten steel as soon as the pouring is finished.

9. The method of casting steel ingots or the like which comprises establishing vertical eddy currents in the steel pool by means of forces established by the molten steel entering into the mold during pouring.

10. The method of casting steel ingots or the like which comprises establishing vertical eddy currents in the steel pool by means of forces established by the molten steel entering into the mold during pouring and filling the mold matrix quickly before the eddy currents have ceased.

11. The method of casting steel ingots or the like which comprises establishing vertical eddy currents in the steel pool by means of forces established by the molten steel entering into the mold during pouring, filling the mold matrix quickly before the eddy cur-

rents have ceased, and then chilling the steel to form a steel shell as soon as the pouring is finished.

12. The method of casting steel ingots or the like which comprises directing the flow of molten steel into the matrix portion of the mold in such manner as to cause the vertical flowing eddy currents in said mold to rotate so as to carry the surface portions of the molten steel downward and the bottom portions of the steel upward during the pouring operation.

13. The method of casting steel ingots or the like in a full chill mold which comprises directing the flow of molten steel into the matrix portion of the mold in such manner as to cause the vertical flowing eddy currents in said mold to rotate so as to carry the surface portions of the molten steel downward and the bottom portions of the steel upward during the pouring operation and quickly filling the mold to bring the steel against the chill top.

14. The method of casting steel ingots or the like which comprises directing the flow of molten steel horizontally into the matrix portion of the mold by means of a plurality of streams in such manner as to cause the vertical flowing eddy currents in said mold to rotate so as to carry the surface portions of the molten steel downward and the bottom portions of the steel upward during the pouring operation.

15. The method of casting steel ingots or the like which comprises directing the flow of molten steel into the matrix portion of the mold in such manner as to cause vertical flowing eddy currents in said mold to rotate so as to carry the surface portions of the molten steel downward and the bottom portions of the steel upward during the pouring operation, and then quickly chilling the steel when the pouring operation is finished.

16. The method of casting steel ingots or the like in a full chill mold which comprises directing the flow of molten steel horizontally into the matrix portion of the mold by means of a plurality of streams in such manner as to cause the vertical flowing eddy currents in said mold to rotate so as to carry the surface portions of the molten steel downward and the bottom portions of the steel upward during the pouring operation, quickly filling the mold to bring the steel against the chill top, and quickly chilling the steel in the mold.

17. The method of casting steel ingots or the like in a horizontal mold, which comprises introducing molten metal at one end of said mold with the direction of the introduction of the metal being substantially horizontal in such manner as to cause the vertical rotating eddy currents in the steel pool to form in the mold matrix during the pouring.

18. The method of casting steel ingots or the like in a horizontal mold, which comprises introducing molten metal at one end of said mold with the direction of the introduction of the metal being substantially horizontal in such manner as to cause the vertical rotating eddy currents in the steel pool to form in the mold matrix during the pouring, and chilling all surfaces of the steel before the eddy currents have ceased.

19. The method of casting steel ingots or the like which comprises agitating the steel during pouring to prevent segregation, then quickly chilling the entire surface of the steel to form a chilled shell, causing the chilled shell to cool with sufficient rapidity to establish internal pressure on the molten interior thereof and to maintain said pressure until the entire ingot is solidified.

20. The method of casting steel ingots or the like which comprises pouring the steel quickly, agitating the steel during pouring to prevent segregation, then quickly chilling the entire surface of the steel to form a chilled shell, causing the chilled shell to cool with sufficient rapidity to establish internal pressure on the molten interior thereof and to maintain said pressure until the entire ingot is solidified.

21. The method of casting steel ingots or the like which comprises quickly filling a complete chill mold adapted to chill all surfaces of the ingot to be formed, preventing segregation and the formation of gases during pouring, and simultaneously chilling all surfaces of the ingot as soon as the mold is filled and before gases are being freed from the steel in such volumes as to cause bubbles.

22. The method of casting steel ingots or the like which comprises quickly filling a complete chill mold adapted to chill all surfaces of the ingot to be formed, agitating the molten steel during the filling operation to cause vertical eddy currents in the steel, simultaneously chilling the steel on all sides as soon as the mold is filled to form a steel shell enclosing the molten interior of the ingot under pressure, and cooling said shell with sufficient rapidity to maintain the pressure on the molten interior until the ingot is completely solidified.

23. As an article of manufacture an ingot mold provided with a channel adjacent one end of the mold matrix, and a separable runner column in said channel and having a plurality of openings leading into said matrix with one of said openings leading into the lower portion of the matrix and the other of said openings leading into the upper portion of said matrix.

24. As an article of manufacture a horizontal ingot mold having a longitudinally extending matrix therein provided with a channel adjacent one end of the mold matrix, and a separable runner column in said

channel and having a plurality of openings leading into said matrix with one of said openings leading into the lower portion of the matrix and the other of said openings leading into the upper portion of said matrix.

25. As an article of manufacture an ingot mold provided with a channel adjacent one end of the mold matrix, and a separable runner column in said channel and having a plurality of openings with axes parallel to the axis of the matrix and leading into said matrix with one of said openings leading into the lower portion of the matrix and the other of said openings leading into the upper portion of said matrix.

26. As an article of manufacture an ingot of steel comprising a substantially pure steel shell having all surfaces thereof chilled and with a solid steel core enclosed by said shell and with the metal content of the ingot gradually increasing in metalloids toward the axis thereof and with the cross-section of the ingot comprising substantially solid steel throughout.

27. As an article of manufacture an ingot of steel comprising a substantially pure steel shell having all surfaces thereof chilled and with a solid steel core enclosed by said shell and with the metal content of the ingot gradually increasing in metalloids toward the axis thereof and with the cross-section of the ingot comprising substantially solid steel throughout and with gas bubble cavities being negligible whereby the entire ingot may be rolled into finished product.

28. As an article of manufacture an ingot of solid steel comprising a substantially pure steel shell of high fusion materials and having all surfaces thereof smooth and chilled and with a solid steel core enclosed by said shell and with the metal content of the ingot gradually increasing in metalloids toward the axis thereof and with the cross-section of the ingot comprising substantially solid steel throughout.

29. As an article of manufacture an ingot of steel comprising a substantially pure steel shell having all surfaces thereof chilled and with a solid steel core enclosed by said shell and with the metal content of the ingot gradually increasing in metalloids toward the axis thereof with the materials of lowest fusion substantially at the axis of the ingot and with the cross-section of the ingot comprising substantially solid steel throughout.

30. As an article of manufacture an ingot of solid steel comprising a substantially pure steel shell of high fusion materials and having all surfaces thereof smooth and chilled and with a solid steel core enclosed by said shell and with the metal content of the ingot gradually increasing in metalloids toward the axis thereof with the materials of lowest fusion substantially at the

axis and with the cross-section of the ingot comprising substantially solid steel throughout and with gas bubble cavities being negligible whereby the entire ingot may be
5 rolled into finished product.

31. A solid steel ingot comprising a chilled shell with all sides thereof substantially smooth surfaces and with the shell enclosing a solid steel core which has solidified under pressure and with the occluded
10 gases retained in the steel mass.

32. A solid steel ingot comprising a chilled shell of a less metalloid content than the ladle steel and with all sides thereof
15 substantially smooth surfaces and with the shell enclosing a solid steel core which has solidified under pressure and with the occluded gases retained in the steel mass and with the content of the core being slightly
20 greater in metalloids than the ladle steel.

33. An article of manufacture comprising a solid steel chilled ingot having a solid chilled shell enclosing a central core of solid steel containing metalloids in non-deleterious quantities distributed throughout
25 the core.

34. An article of manufacture comprising a solid steel chilled ingot having a solid chilled substantially pure steel shell enclosing
30 a central core of solid steel containing metalloids in non-deleterious quantities distributed throughout the core and substantially without cavities due to the mold gases.

35. The method of casting ingots which comprises pouring the molten metal into a mold while homogeneously distributing its constituents throughout the mass, and then freezing the molten metal by chilling on

all sides before the homogeneity of the mass has substantially changed. 40

36. The method of filling a chill mold which comprises simultaneously directing a plurality of commingling streams of molten metal into the matrix through a plurality of
45 orifices in one end thereof of which the axis of one lies on a different straight line than the axis of another.

37. An ingot mold comprising in combination, a matrix portion having a channel adjacent one end thereof, and a runner
50 column in said channel and having a plurality of vertically spaced openings leading into the matrix.

38. In the method of casting, the step which consists in simultaneously pouring
55 horizontally directed impinging streams of molten metal within a matrix to produce a mixing action throughout the mass during the pouring.

39. In the method of casting, the pouring
60 step which consists in homogeneously distributing the constituents of the molten metal within the matrix by the action of commingling streams and currents.

40. In the method of casting steel ingots,
65 the step which consists in simultaneously pouring impinging streams of molten steel within a matrix to produce a continuous mixing of the mass during the pouring.

41. In the method of casting steel ingots,
70 the pouring step which consists in homogeneously distributing the constituents of the molten steel within a matrix by the action of commingling streams and currents.

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