

June 24, 1930.

E. GATHMANN
INGOT MOLD AND INGOT

1,767,174

Filed Aug. 12, 1929

3 Sheets-Sheet 1

Fig. 1.

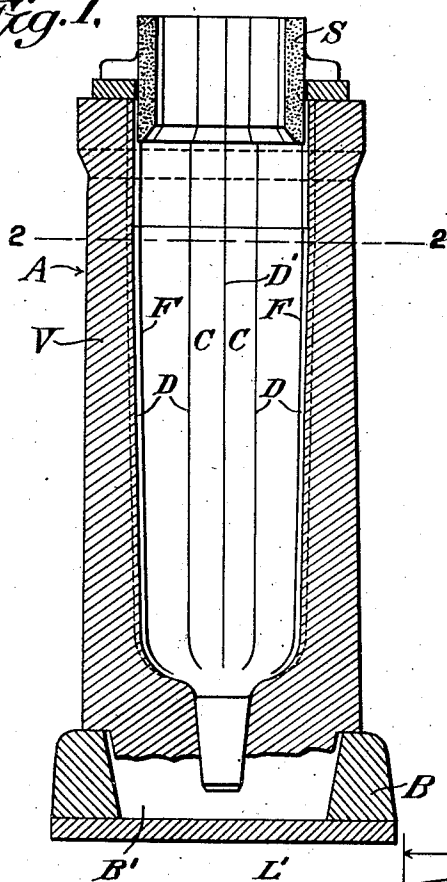


Fig. 3.

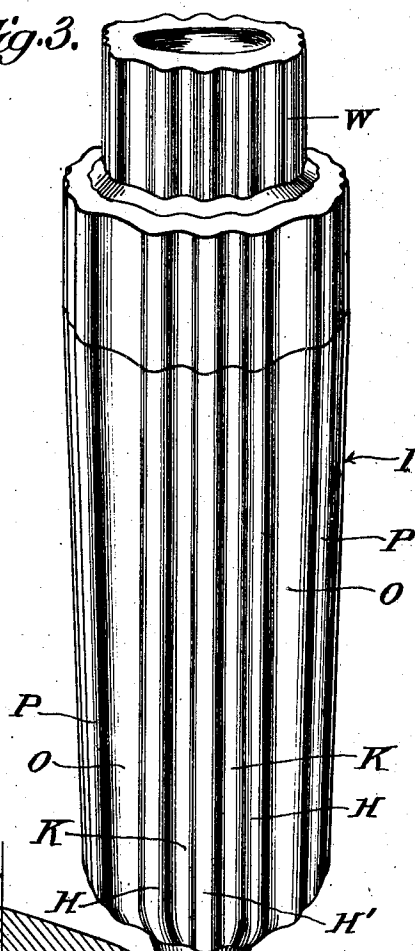
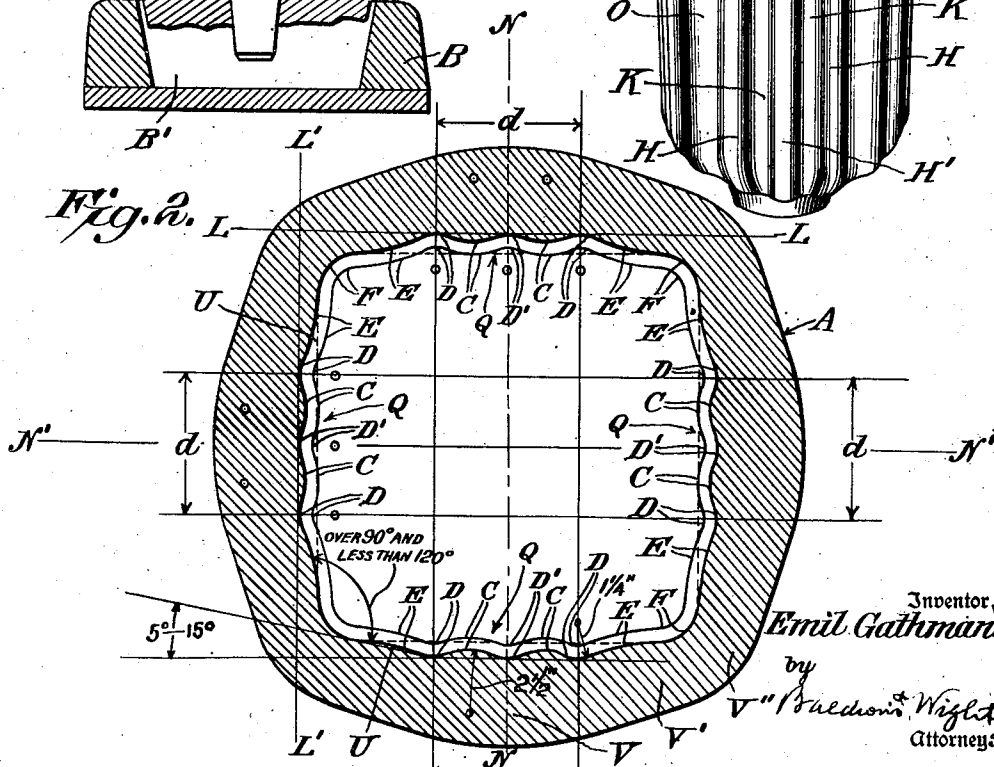


Fig. 2.



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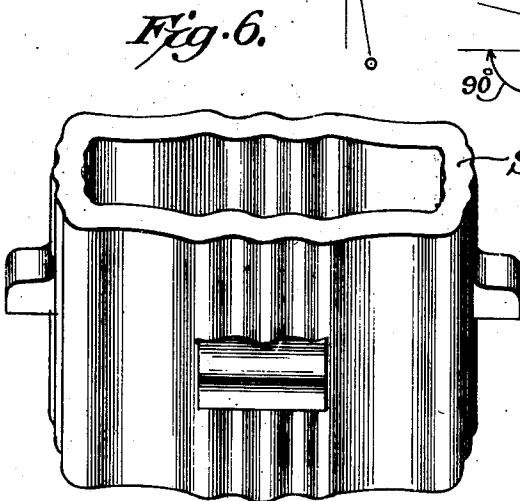
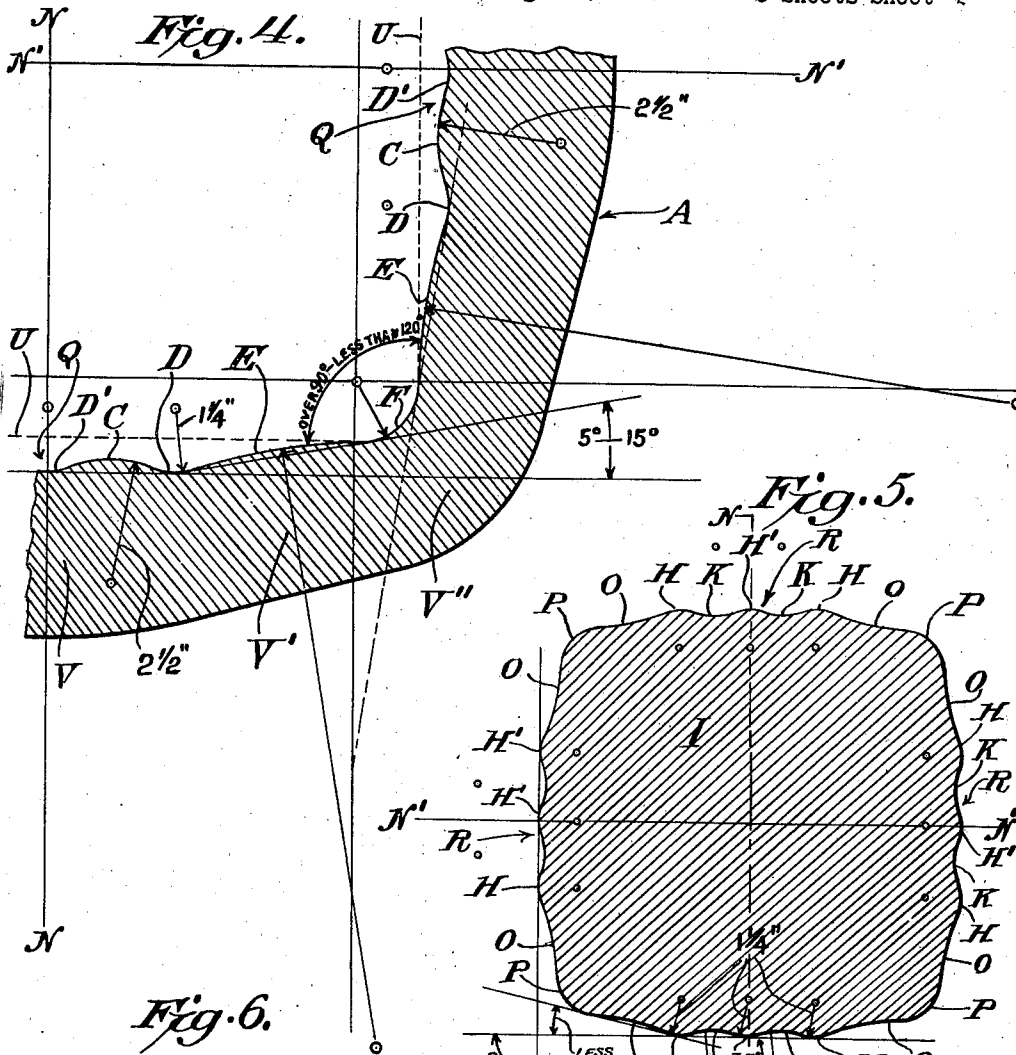
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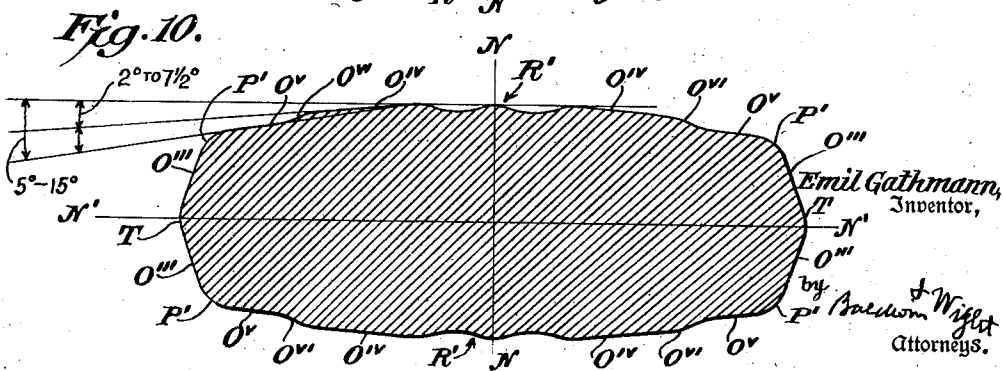
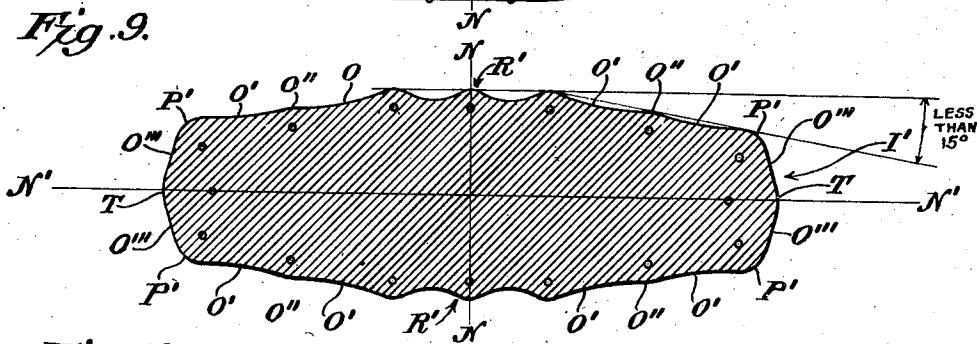
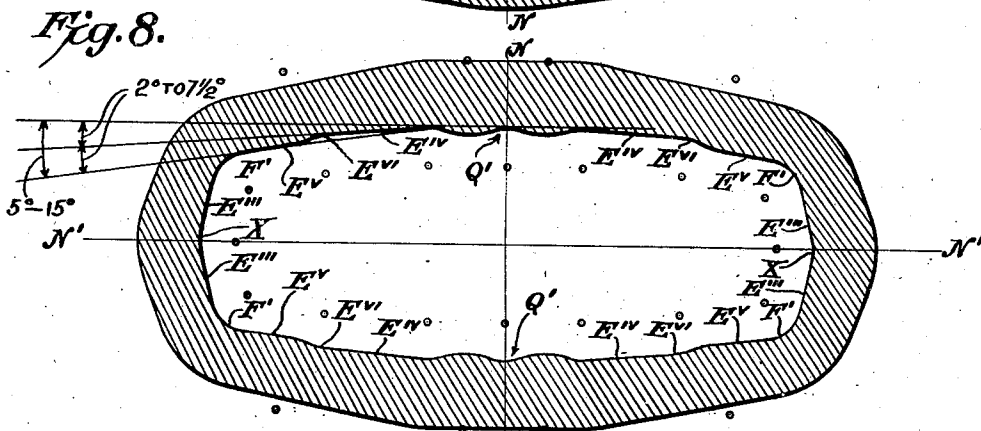
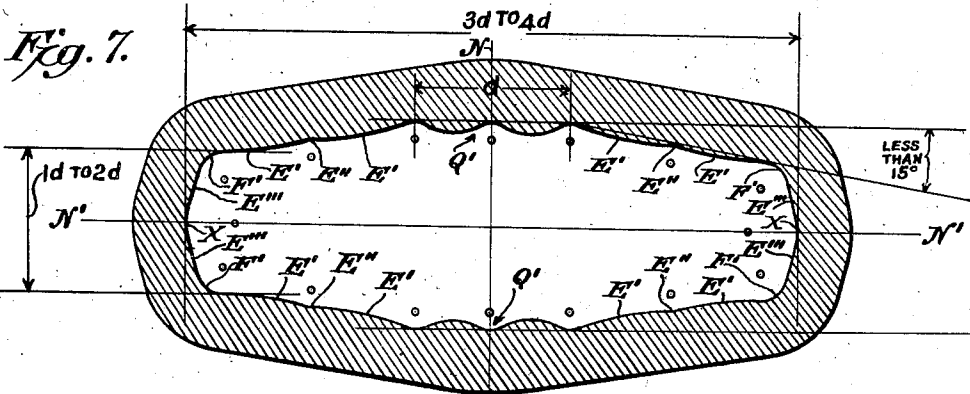
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Filed Aug. 12, 1929

3 Sheets-Sheet 3



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UNITED STATES PATENT OFFICE

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INGOT MOLD AND INGOT

Application filed August 12, 1929. Serial No. 385,343.

This invention relates to certain improvements in metallic ingot molds having substantially vertical ingot-forming chambers; and involves certain novel characteristics in the horizontal contour or cross section of the ingot forming chambers of the molds and of the ingots cast therein.

More especially my invention relates to certain improvements in the cross sectional contour of the matrix of ingot molds and to the contour of the sides of the ingots formed therein of the general kind shown, described, and claimed in my U. S. Patents No. 1,061,467, of May 13, 1913, No. 1,440,535, of January 2, 1923, No. 1,484,940, of February 26, 1924, No. 1,532,741, of April 7, 1925, and No. 1,719,543, of July 2, 1929, 1,745,089 of Jan. 28, 1930 and 1,757,663 of May 6, 1930.

In the patents before referred to, I have shown and described mold contours adapted to produce ingots with fewer surface flaws or defects than are inherent in ingots produced in the usual rectangular molds having straight-sided or plane walls, or even in the symmetrically corrugated or fluted molds of the octagon or dodecagon types of the kind illustrated in U. S. Patent No. 621,646, issued to H. L. Gantt March 21, 1899.

The object of my present invention is to improve the contours of the chambers of molds of the general type shown in my Patent No. 1,719,543, and, according to my invention, I increase in a novel way the number of salients and inwardly bellied portions of the chamber walls, thus lengthening the perimeter of the cross section of the mold chamber for any given cross sectional area of the ingot to be produced. In this way I am enabled to obtain a tougher and more homogeneous skin solidification in the ingot and to thus avoid the formation of tears in the skin while the ingot is being cooled in the mold, and, at the same time, I retain the advantages arising during the initial roll passes in the reduction of the ingot into blooms and other shapes, which advantages are obtainable by the use of the cambered type of mold of generally rectangular cross section of the kind shown in my patent of May 13, 1913.

My improvements may be embodied in any

type of vertical mold, that is, in big-end up molds, in big-end-down molds, and in those having parallel chamber walls. Molds constructed in accordance with my invention may be used for the production of ingots of any grade of steel that may be required and may be used either with or without shrink head portions.

It is a proven fact that increasing the perimeter of the mold matrix for a given cross sectional area increases the rapidity of the extraction of heat from the outer portion of the ingot metal and thus hastens skin formation to such a degree that the initial walls of the ingot will be of sufficient strength to withstand the ferrostatic pressure of the liquid interior of the ingot during the expansion of the mold and prior to any appreciable contraction of the ingot, and this fact has been borne in mind in designing the contour of my improved mold.

The specific contours of the walls defining the matrix of an ingot mold govern the type and rate of initial or skin solidification of an ingot. By properly increasing the cross sectional area of the matrix of a mold for a given volume of ingot, the rate of cooling is expedited, since the rate of solidification is directly proportional to the ratio of the contact area of the walls of the mold chamber to the volume of the ingot metal cast therein.

Broadly speaking, according to my present invention the contour of the walls of the mold matrix is formed by a plurality of salients including a series of smoothly curved connected inwardly bellied or arc-shaped wall portions and a plurality of outwardly bellied arc-shaped wall portions, the arc defining each of said wall portions being described by a radius of substantially greater length than the chord of the arc. The mold chamber includes at least two oppositely disposed primary side walls, and each of these walls preferably includes two inwardly bellied or arched walls and three outwardly bellied or arched walls, although this number may be increased when the mold is of large cross sectional dimension or where it has a slab-like contour of the type

described in my copending application No. 365,455.

In rolling ingots of the contour above described, the relatively narrow primary side walls are swedged outwardly to a large extent parallel with the axis of the rolls rather than flowed longitudinally, as happens in an ingot when the primary side walls are wide and the adjacent corners are in substantially the same plane as the primary side walls. The free, unworked adjacent walls are thus deformed only slightly, if at all, during the initial passing of the ingot through the rolls.

In the accompanying drawings:

Figure 1 shows a vertical sectional view of an ingot mold of the Gathmann big-end-up type provided with a shrink head casing, the matrix of both the mold and casing being constructed in accordance with my invention, the bottom closure plug being shown in elevation and the stool in section.

Figure 2 is a cross sectional view on an enlarged scale taken on the line 2—2 of Figure 1.

Figure 3 is a perspective view of an ingot formed in a mold of the type shown in Figures 1 and 2.

Figure 4 is a view on an enlarged scale and in horizontal section of a quarter portion of the mold shown in Figures 1 and 2.

Figure 5 shows on an enlarged scale a cross section of the ingot shown in Figure 3.

Figure 6 shows on an enlarged scale a perspective view of the shrink head casing shown in Figure 1 for forming the feeder or shrinkage portion of the ingot.

Figure 7 is a view on an enlarged scale and in horizontal section of a modified form of mold chamber.

Figure 8 is a view on an enlarged scale and in horizontal section of another modified form of mold chamber.

Figure 9 is a horizontal sectional view of an ingot cast in a mold of the kind shown in Figure 7, and

Figure 10 is a horizontal sectional view of an ingot cast in a mold of the kind shown in Figure 8.

Figures 1, 2, and 4 illustrate a mold A of generally rectangular cross section and which is constructed of heat absorbing material of suitable character such as cast iron and which rests on a stool B having a recess or trough B' of the kind shown in my U. S. Patent No. 1,039,725, of October 1, 1912. The mold top consists of a casing S made of heat conserving material, preferably fire brick or the like.

The chamber of the mold A includes four primary side walls generally designated Q which are arranged in pairs of oppositely disposed parallel side walls, eight secondary corner walls E, each having one of its ends connected to an adjacent primary side wall

Q, and four outwardly arched corner walls F intervening between and connecting the adjacent secondary corner walls E. The primary side walls Q are arranged in two pairs of oppositely disposed parallel individual walls and the walls of each pair are perpendicular to the walls of the other pair. The mold walls at V adjacent the primary side walls Q of the mold chamber are preferably thicker than the mold walls at V' adjacent the secondary corner walls E of the chamber, and the mold walls at V' are preferably thicker than the mold walls at V'' adjacent the outwardly arched corner walls F of the mold chamber for the purpose specifically set forth in my patent of July 2, 1929. N—N and N'—N' indicate neutral lines of peripheral shrinkage and pass at right angles to each other through the center of the mold and are parallel to dotted lines U which indicate the chamber contour of a rectangular mold of the old type. In other words, the lines N—N and N'—N' pass through those portions of the mold chamber toward which all shrinkage of the ingot cast in the mold converges during solidification.

The inner walls of the mold chamber are shown as vertically fluted or corrugated both on the primary side walls Q and at their corner portions, these flutings or corrugations preferably consisting of a series of smoothly curved concavo-convex portions. As shown in Figures 1, 2, and 4, each of the primary side walls Q includes three spaced outwardly bellied wall portions D—D—D' and two intervening inwardly bellied wall portions C—C. The primary side walls are so arranged that each intermediate outwardly bellied wall portion D' has its apex on or near the neutral line of shrinkage passing through the particular side wall of which the wall portion D' is a part.

The inwardly bellied portions C and the outwardly bellied portions D and D' of each primary side wall Q are preferably each described by a radius greater than the chord of the arc defining the wall, and the depth of the arc defining each wall in a mold of twenty inches diameter, that is, the distance from the apex of the arc to the chord thereof, is preferably between one eighth of an inch to three eighths of an inch. In each primary side wall the three outwardly arched wall portions are so disposed that a line tangent to their apexes will be perpendicular to a line tangent to the apexes of the outwardly arched wall portions of an adjacent primary side wall. Thus a line L—L tangent to the apexes of the outwardly arched wall portions D—D—D' of the primary side wall Q shown in the upper part of Figure 2 is perpendicular to a line L'—L' tangent to the apexes of the outwardly arched portions of the primary side wall shown at

the left in Figure 2. The width d of each primary wall portion is preferably one third or less than one third of the maximum cross sectional dimension of the matrix in a direction parallel to that primary wall, and the width of each inwardly bellied portion C of each primary wall is approximately one sixth of the maximum cross sectional dimension of the mold chamber.

In big-end-up molds the concavo-convex or fluted portions of the primary side walls should extend into the necked-in portion of the mold and merge or disappear therein as shown in Figure 1 of the drawings and as shown and claimed in my U. S. Patent No. 1,532,741, of April 7, 1925.

The eight secondary corner walls E—E are connected together in pairs by the four outwardly arched primary corner walls F, and the secondary corner walls E are in turn connected to the outwardly arched portions D of the primary side walls Q. Each of the secondary corner walls E extends outwardly from the adjacent corner wall F to the adjacent primary wall Q at an angle of less than fifteen degrees to a tangent connecting the apexes of a pair of the outwardly bellied portions D—D at the opposite sides of an adjacent primary side wall Q, as shown in Figure 4. The arc defining the primary corner walls F subtends an angle of more than ninety degrees but less than a hundred and twenty degrees, as shown in Figure 4, and each of the arcs which respectively define the curved portions of the concavo-convex primary wall subtends an angle of less than forty-five degrees.

Figure 7 shows a modified contour of the secondary walls E—E particularly adapted for molds having an oblong or slab-like cross section. According to my invention, molds of this kind may be provided with secondary corner walls having a plurality of inwardly bellied and outwardly bellied faces presenting a concavo-convex contour, the radius of each inwardly concaved portion being greater than the length of the radius of an outwardly bellied portion. In the present instance each of the secondary corner walls is shown as including two inwardly bellied wall portions E' and an intermediate outwardly bellied wall portion E'' disposed between and connecting the adjacent ends of the inwardly bellied portions E', the other ends of which portions are respectively connected to the adjacent outwardly arched corner wall F' and to the adjacent primary side wall Q', each of which has a contour similar to the contour of the side walls Q of the mold shown in Figures 1, 2, and 4. Adjacent outwardly arched corner walls F' are connected together by means of a pair of secondary corner walls E''' each of which has one of its ends connected to one of the corner walls

F, and each of which has its other end connected to the adjacent wall E''' by means of an outwardly curved salient or wall X.

In some types and sizes of molds constructed in accordance with my invention, it is not necessary that the secondary side walls of the mold chamber be of inwardly bellied contour. Thus a large mold used for producing ingots of slablike contour may be constructed as illustrated in Figure 8. The mold illustrated in this figure has a chamber contour similar to that of the mold illustrated in Figure 7 with the exception that each of the secondary corner walls adjacent a primary side wall Q' includes two straight secondary wall portions E^{iv}—E^v and an intermediate inwardly bellied wall portion E^{vi} disposed between and connecting adjacent ends of the straight portions E^{iv} and E^v. Preferably, each of the straight wall portions E^{iv} extends at an angle of from two degrees to seven and a half degrees to a line tangent to the outwardly bellied portions of the adjacent primary side wall Q', and each of the straight wall portions E^v extends at an angle of from five degrees to fifteen degrees to such a tangent.

Employment of the before-mentioned radii and fluted contour of the primary side walls induces a freer and more rapid shrinkage and consequently a more rapid solidification of the outer skin or contacting portion of the solidifying ingot without danger of causing physical binding of the skin portions of the ingot with the chamber walls of the mold.

The ingot produced in such a mold is of a contour that may be reheated without danger of corner burning and the surface of the ingot will be more readily consolidated during the initial passes of the rolling mill operations as the flow of metal in these passes is primarily of a sidewise nature and without any material elongation of the ingot as a whole.

Figures 3 and 5 illustrate an ingot I which has been formed in a mold chamber of the type shown in Figures 1, 2, and 4 and hereinbefore described, and which is provided with a shrink head portion W. The surface of the ingot includes four primary sides R each of which is of a concavo-convex contour and includes three outwardly extending salients H—H—H' and two inwardly extending salients K—K. The primary sides Q' of the ingot are connected to adjacent corners P by means of secondary side or corner portions O, and each of these secondary corner portions extends at an angle of less than fifteen degrees to a tangent connecting the apexes of a pair of the salients H—H at the opposite sides of an adjacent primary side R. The arc defining each of the arched corners P subtends an angle of more than ninety degrees, while the arc defining each

of the concavo-convex portions of the primary sides R subtends an angle of less than forty-five degrees.

Figure 9 shows an ingot I' of slab-like cross section which has been formed in a mold having a chamber contour of the kind illustrated in Figure 7 and hereinbefore described. The surface of this ingot includes two oppositely disposed primary sides R' each having a contour similar to the contour of the primary sides R of the ingot shown in Figures 3 and 5 and hereinbefore described. The primary sides R' of the ingot I' are connected to adjacent outwardly arched corners P' by means of secondary side or corner portions each of which includes two inwardly bellied portions O' and an intermediate outwardly bellied portion O'' disposed between and connecting adjacent ends of the inwardly bellied portions O'. Adjacent corner portions P' are connected by a pair of secondary corner portions O''' and an intervening outwardly arched salient T.

Figure 10 illustrates an ingot I'' of slab-like cross section which has been cast in a mold having a chamber contour such as that shown in Figure 8. The contour of the ingot I'' is similar to that of the ingot I' hereinbefore described in detail with the exception that, instead of being provided with secondary side or corner portions each including a plurality of curved salients, each of the secondary side or corner portions of the ingot I'' includes two straight secondary side or corner portions O^{iv} and O^v and an intermediate inwardly bellied connecting salient O^{vi}. Preferably each of the straight portions O^{iv} extends at an angle of from two degrees to seven and a half degrees to a line tangent to the outwardly curved salients of the adjacent primary side R'; and each of the straight portions O^v extends at an angle of from five degrees to fifteen degrees to such a tangent.

An important advantage resulting from use of my multifluted or corrugated primary mold chamber walls and of the ingot cast therein consists in the production of an ingot having vertically extending concavo-convex salients on the neutral lines of shrinkage of the ingot, these salients serving to hasten solidification in that portion of the ingot where the skin in ingots heretofore known to the art has formerly been thinnest and consequently weakest at all times during the period of solidification.

A further advantage of my improvements arises in the rolling mill, where, because of my concavo-convex primary ingot faces, the central portion of the ingot may be subjected to a greater degree of compression than any other type of corrugated or fluted ingot heretofore known to the art, without danger of the rupturing of the skin of the ingot.

It is to be understood that the action of

rapid cooling and solidification of the ingot through contact with the mold chamber walls is only temporary and ceases after the mold has become heated throughout and has expanded away from the ingot, by which time, however, the solid skin of the ingot has been built up to a sufficient thickness to withstand the ferrostatic pressure of the liquid interior of the ingot mass. Cooling and solidification and consequent formation of the inclosing skin portion of the ingot are greater at the salients or outwardly bellied portions than at the inwardly bellied portions. As heretofore described, outwardly extending salients are provided on the neutral lines of contraction, which greatly enhance the rate of cooling of the primary faces of the ingot.

It is not intended to limit the invention to any specific construction or general shape of cross section of molds except insofar as relates to the novel concavo-convex contour of the primary walls of the mold chamber and of the ingot cast therein as defined in the claims.

It will be observed that each of the oppositely disposed side walls of the mold is relatively thick as compared with the corner walls, and that each of said side walls is provided with a plurality of inwardly bellied curved corrugations or flutes. In this way the rate of cooling of the ingot adjacent the side walls is materially increased. This increased rate of cooling is caused not only by the greater thickness of the side walls of the mold, but by the larger contact surface with the molten metal afforded by the lines of curvature of the corrugations.

I claim:

1. An ingot mold with a chamber of substantially rectangular horizontal cross section having two sets of oppositely arranged relatively narrow primary side walls and four sets of inwardly bellied corner walls which are connected to the primary walls and to each other by outwardly extending salients, each of the oppositely disposed side walls being relatively thick as compared with the corner walls and each of said side walls being provided with a plurality of inwardly bellied curved corrugations or flutes whereby the rate of cooling of the ingot adjacent said side walls is increased.

2. A metallic ingot having two sets of oppositely arranged relatively narrow primary sides and four outwardly arched corners connected to the primary sides by inwardly curved sides, at least two of the oppositely arranged primary sides being provided with a plurality of inwardly bellied corrugations, the chord of the arc of each of which is less than the radius from which said arc is struck.

3. A metallic ingot having two oppositely disposed relatively narrow sides of smoothly

curved concavo-convex contour, each of said sides including a plurality of connected and alternately arranged inwardly bellied portions and outwardly bellied portions.

5 4. A metallic ingot having two oppositely disposed narrow sides, the width of each of which is not greater than one third of the maximum cross sectional dimension of the ingot and each of which is of smoothly
10 curved concavo-convex contour, each of said sides including a plurality of connected and alternately arranged inwardly bellied portions and outwardly bellied portions.

5 5. A metallic ingot having two oppositely
15 disposed relatively narrow sides of smoothly curved concavo-convex contour, each of said sides including a plurality of connected and alternately arranged inwardly bellied portions and outwardly bellied portions, one of
20 the outwardly bellied wall portions of each primary side having its apex located on the neutral line of shrinkage passing through the ingot and perpendicular to said primary side.

25 6. A metallic ingot having two sets of oppositely arranged relatively narrow primary sides and four outwardly arched corners connected to the primary sides by secondary
30 sides, at least two of the oppositely arranged sides being provided with a plurality of alternate smoothly curved inwardly bellied and outwardly bellied corrugations.

7. A metallic ingot having two sets of oppositely arranged relatively narrow primary
35 sides and four outwardly arched corners connected to the primary sides by secondary sides, at least two of the oppositely arranged sides being provided with a plurality of alternate smoothly curved inwardly bellied
40 and outwardly bellied corrugations, the apexes of the outwardly bellied corrugations of each of the primary sides of the ingot lying in substantially the same straight line.

In testimony whereof, I have hereunto
45 subscribed my name.

EMIL GATHMANN.

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