Jan. 2, 1923. 1,440,535.

E. GATHMANN.

INGOT MOLD.

FILED JULY 18, 1922.

3 SHEETS—SHEET 1.

Fig. 1.

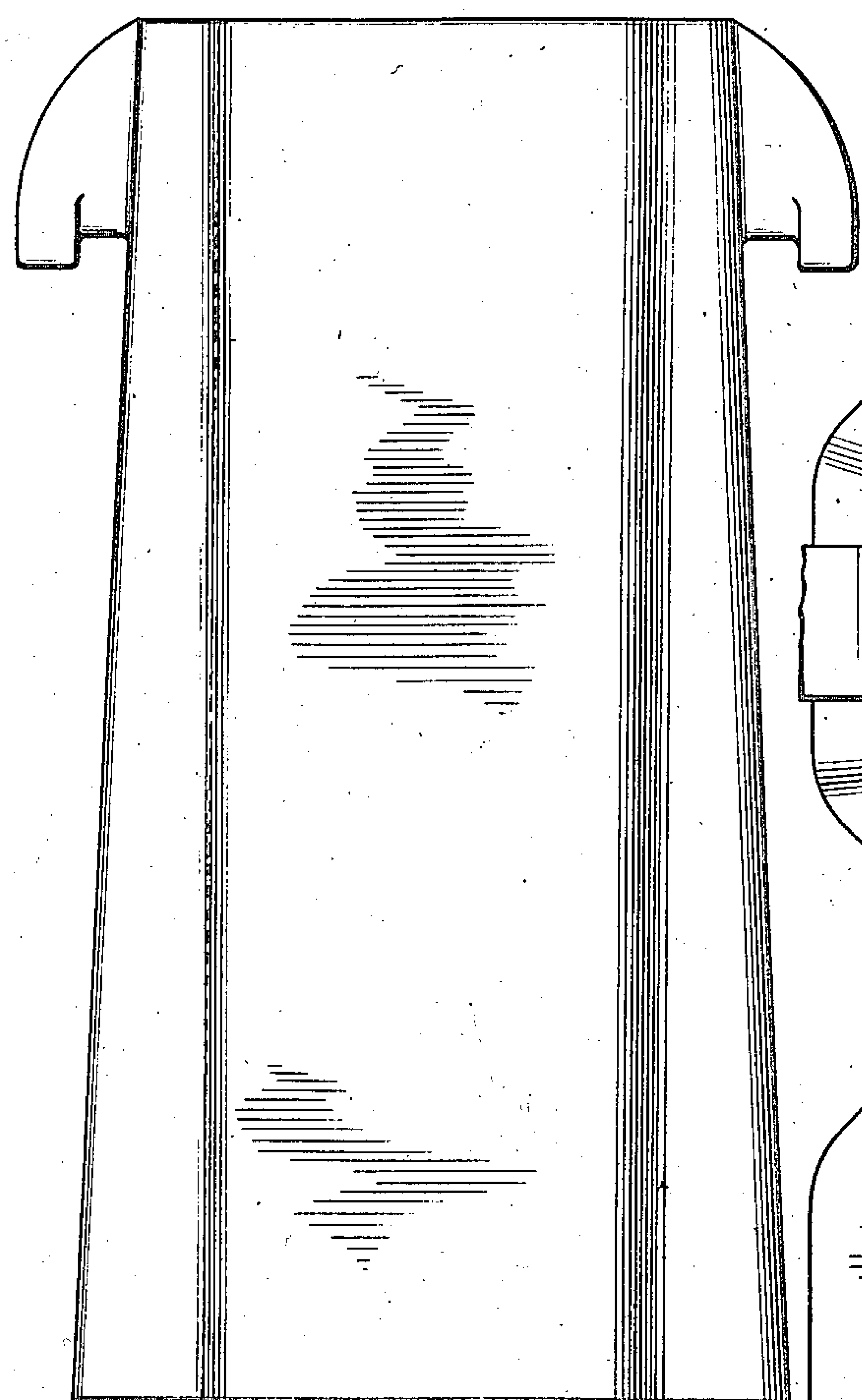
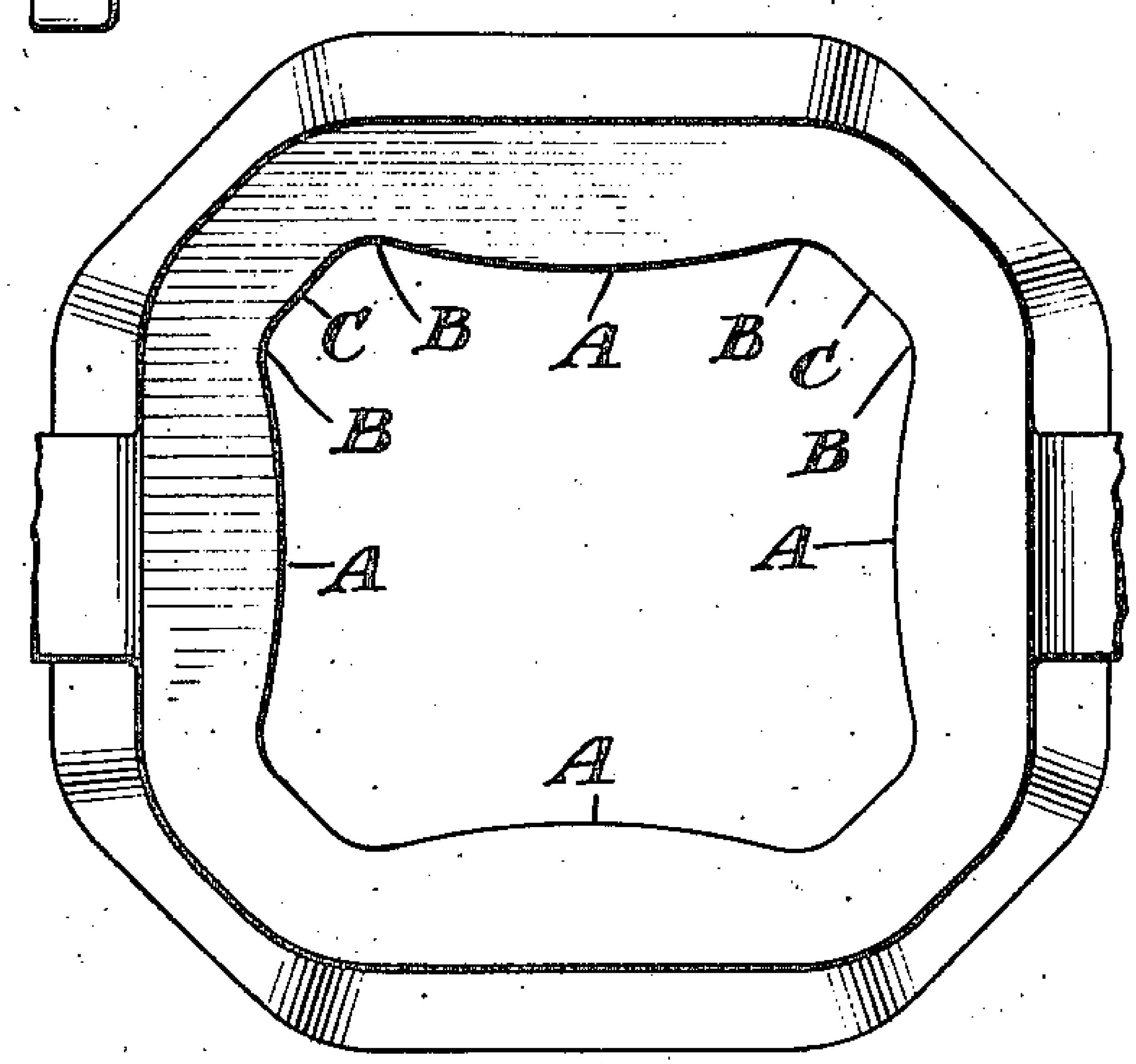


Fig. 2.



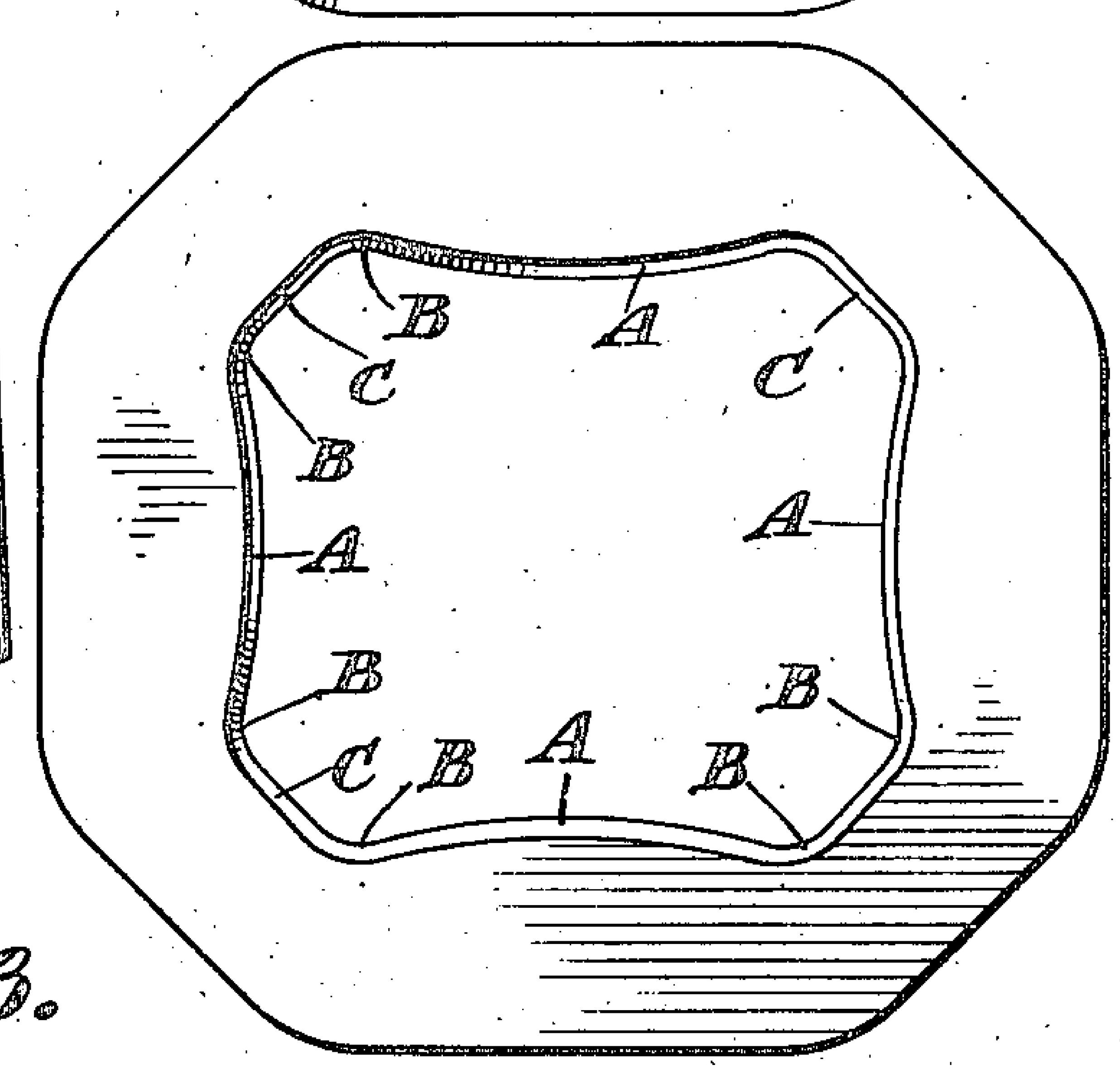


Fig. 3.

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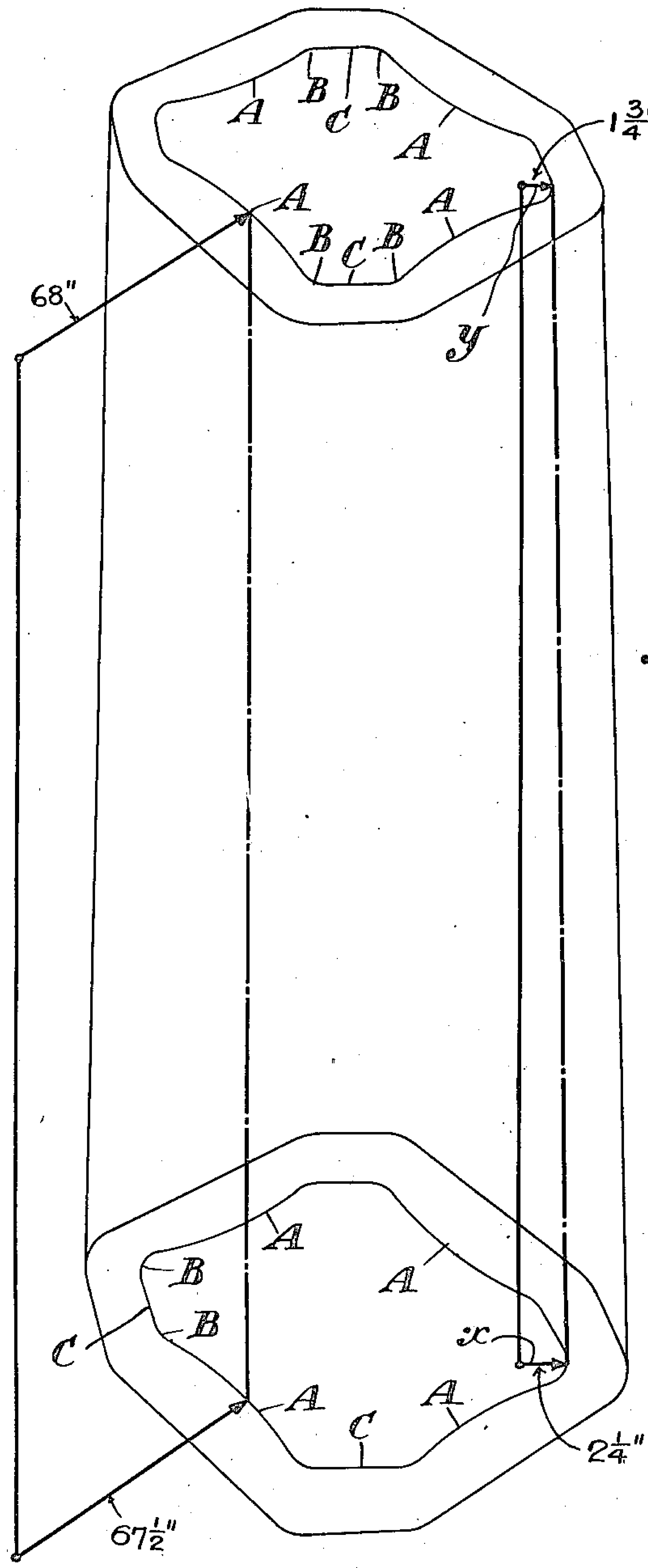

Fig. 4.

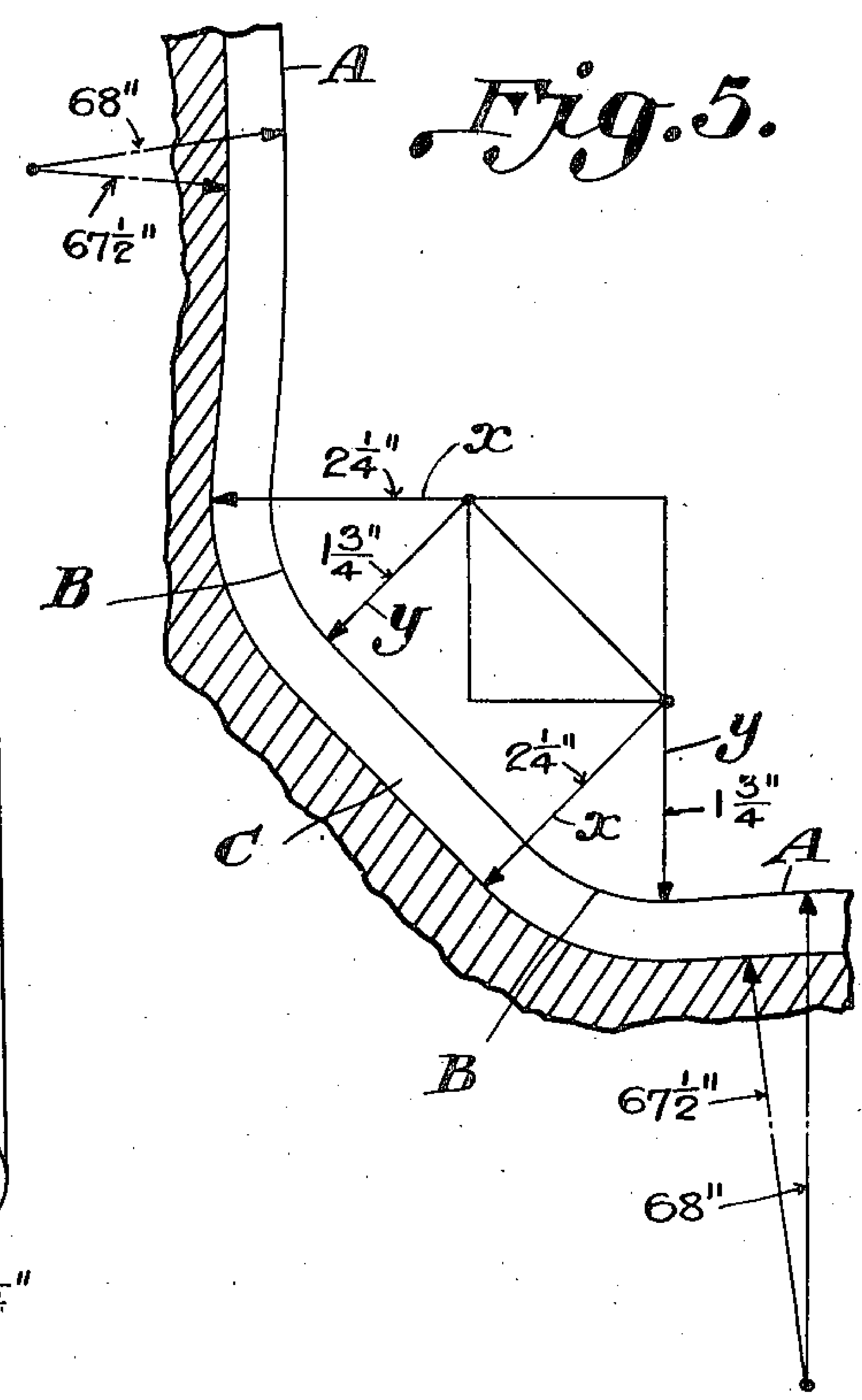

Fig. 5.

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3 SHEETS—SHEET 3.

Fig. 6.

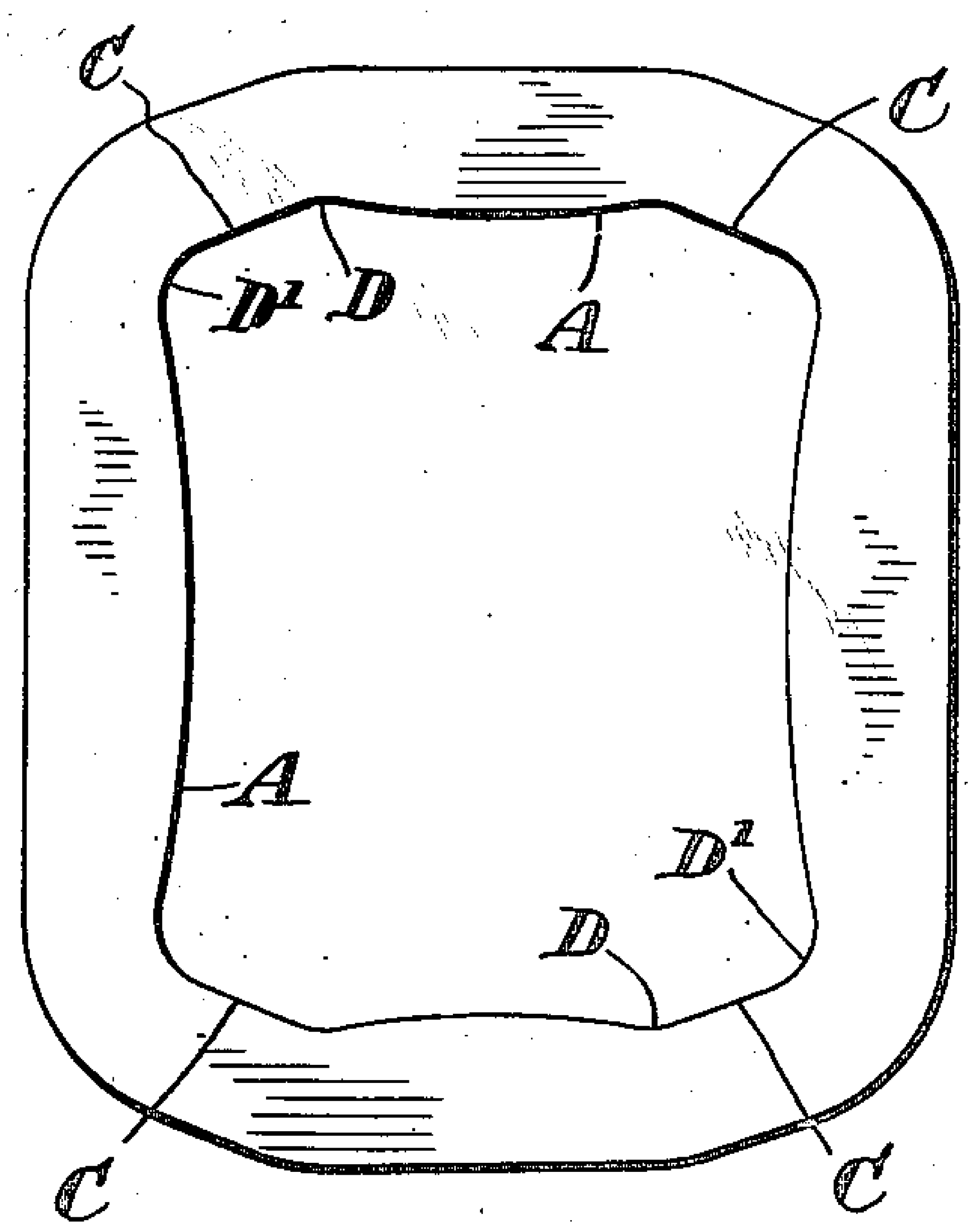


Fig. 7.

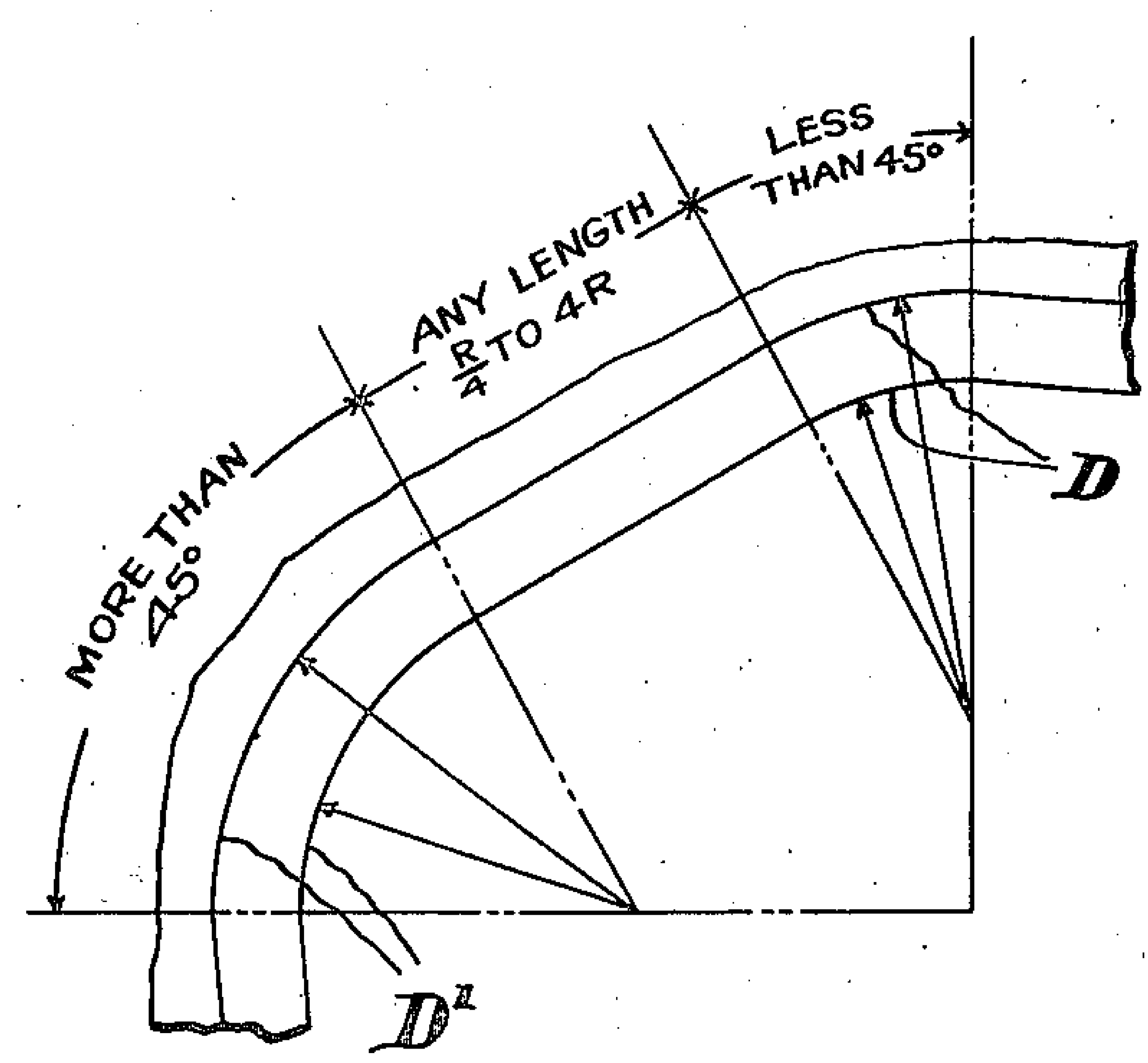


Fig. 8.

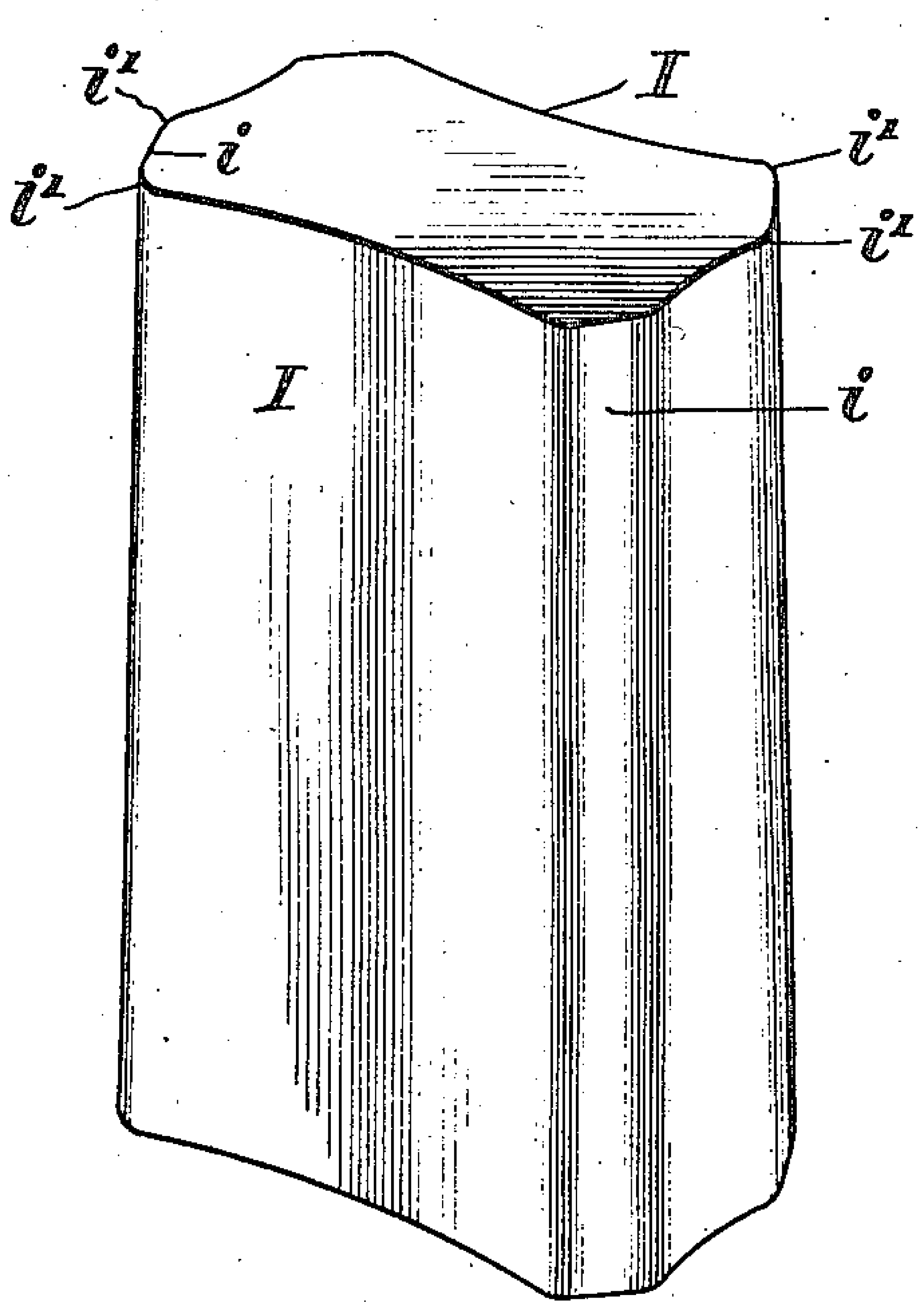
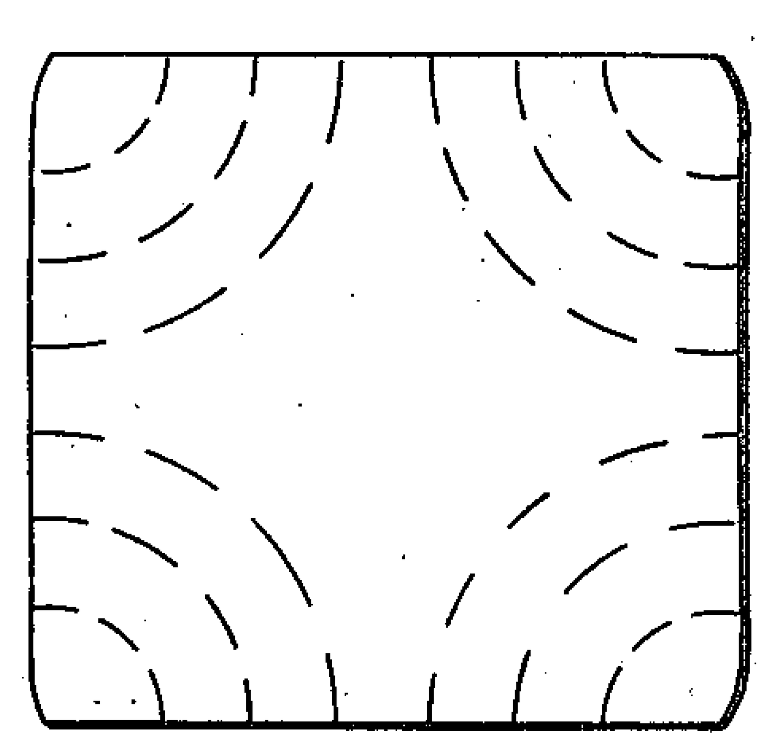


Fig. 9.



Inventor
Emil Gathmann
by his Attorneys
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Patented Jan. 2, 1923. **1,440,535**

UNITED STATES PATENT OFFICE.

EMIL GATHMANN, OF BALTIMORE, MARYLAND.

INGOT MOLD.

Application filed July 18, 1922. Serial No. 575,905.

To all whom it may concern:

Be it known that I, EMIL GATHMANN, a citizen of the United States, residing in Baltimore city, State of Maryland, have invented certain new and useful Improvements in Ingot Molds, of which the following is a specification.

This invention relates especially to ingot molds of the kind used for casting and forming ingots from molten metal.

More specifically my invention relates to metallic ingot molds of the kind constructed to cool or chill the molten mass of metal to a greater extent at the bottom or lower portion of the mold than at the upper part thereof, in the manner shown, described and claimed in my United States Patent No. 921,972 of May 18, 1909 and in subsequent patents granted to me.

In the use of the mold shown in said patent of May 18, 1909, the differential cooling occurred only during a short interval of time, as the ingot decreased in size and the mold cavity increased in size quite rapidly after the ingot was poured, thus forming an annular air film of considerable width, which inasmuch as air is a poor conductor of heat, insulated the contracting semi-fluid ingot from the walls of the mold cavity throughout practically its entire length and thus prevented the full effect of the differential chilling action of the mold walls on the ingot.

The object of my present invention is to construct or shape the mold chamber and to so regulate the thickness of the various portions of the mold walls that the chilling effect of said walls will be transmitted to the ingot for a much longer time than in previous constructions and to so shape the vertical walls of the ingot produced in the mold that it can be rolled or reduced in section with less danger of producing what is termed "reduction laps" cracks or tears on the surface of the ingot.

The accompanying drawings show molds constructed in accordance with my present invention.

Figure 1 is a side elevation of a big end down mold embodying my improvements.

Figure 2 is a top plan view thereof showing the shape of the walls of the mold cavity.

Figure 3 is a bottom plan view looking into the mold cavity and showing the border lines at the bottom and at the top of the mold cavity.

Figure 4 is a diagrammatic view showing the preferred proportional lengths of the radii of the twin salients at the corners of the mold cavity.

Figure 5 is a view illustrating more clearly the manner of constructing the corners of the mold cavity.

Figure 6 is a top plan view of a modification.

Figure 7 is a diagrammatic view illustrating the manner in which each corner of the mold cavity is formed.

Figure 8 is a perspective view of an ingot formed in the mold shown in Figures 6 and 7.

Figure 9 is a diagrammatic section of an ingot indicating its appearance after initial roll passing.

In carrying out my invention I preferably employ mold walls having differential cooling qualities, and preferably construct the mold walls at the upper portion of the mold in such manner that the metal content thereof is equal to approximately between 75% to 100% of the area of the ingot chamber at the upper portion of the mold and construct the lower portion of the mold in such manner that the horizontal area of the mold walls is approximately 1½ times or more of the volume of the area of the mold chamber at the lower portion of the mold. This differential top and bottom arrangement combined—i. e., the bottom differential divided by the top differential of the mold should equal approximately 1½ or more. In this way the lower part of the ingot is chilled or cooled at least 1½ times more rapidly than the upper part.

In order to obtain close contact of the inner chamber of the mold walls with the contained semi-fluid ingot so that it may be cooled or chilled by the mold walls in a differential manner in accordance with the thickness and volume of the mold walls, the matrix cavity of the mold chamber is preferably composed of four major convex surfaces joined at their respective opposite ends by twin salients, the junction of said salients with the major convex surfaces having in a big end down mold a concave contour of a smaller radius at the upper portion of the mold than at the lower portion thereof. The radii at the upper and lower portions of each salient are preferably described from centers in the same vertical line as indicated in Figure 4. This construction of the salients provides a uniform length of chord of the four major convex surfaces at the horizontal planes at the top and bottom of the mold cavity and at any plane between said top and bottom portions. Rolling mill operations or passes of the ingot between blooming mill rolls is thus greatly facilitated as the uniform length of chord of convexity gives the concave sides of the ingot a good passing surface in rolling and the ingot can be readily entered between rolls without danger of angular slip and consequent danger of diamond shaped or cobbled blooms.

The four major surfaces of the ingot will thus be given a horizontal cross section of a concave contour, the concave surface being formed from the convex major surfaces of the mold.

As is well known to those familiar with this art, ingots provided with concave surfaces solidify with less danger of surface or skin cracking and seams, as contraction is less obstructed and the ingot thus formed is more free from these defects. At the same time such ingots as designed by this invention may be as easily rolled as rectangular ingots.

As the mold is heated by the liquid steel poured or teemed into it, and as the outer portions of the liquid ingot become solidified, the convex surfaces of the mold cavity expand initially inward and compensate for the decrease of volume of the solidifying ingot. This inward expansion of the convex mold walls is most pronounced and important at the lower thicker portion of the mold walls and is designed to be progressively lessened towards the thinner upper portion of the mold walls. The outer skin of the ingot which is always initially rather fragile is thus supported by the convex mold walls until ingot walls of substantial thickness and strength are produced by the cooling action of the mold. Heat is absorbed by said walls to a greater extent and volume at the lower portion and bottom of the ingot than at the top thereof, as the top which is thinner will become heated throughout more rapidly and will expand outwardly away from the ingot sooner than the heavier lower portions of the mold walls in direct proportion to the difference in the thickness or relative volume of said top and bottom walls compared to the top and bottom sections of the ingot. After a given time interval both the bottom and top of the mold walls will be heated throughout and expand outwardly while the ingot continues to contract inwardly away from the mold walls. This frees the mold walls from the ingot and allows of stripping or the removal of the mold from the ingot in the usual way. The interval of time between the inward and outward expansion of the mold walls is differential at the top and bottom of the mold or ingot and with my improved construction of mold is much more rapid at the top than at the bottom of the mold cavity but it is of a longer interval than with the ordinary plane square or rectangular mold cavity or matrix at all parts of the ingot.

It has heretofore been the practice to make the cross sectional shape of the mold chamber square or rectangular with rounded corners and with flatened corners which at their junctions with the primary side walls of the mold chamber form salients or angles where the chilling influence of the molds is greatest and hence the solidification of the ingot more rapid. A salient of small radius at each corner of the mold is advantageous in promoting the rapid chilling of the ingot and the formation of strengthening zones in the vertical plane of the ingot, but is disadvantageous in that such salient is apt to be unduly heated or burned in the reheating of the ingot preliminary to the rolling operation.

According to my invention I have combined the advantages of the small salients with the widening of the corners in order to overcome the objections inherent in the usual octagon shaped ingot or mold cavity by providing a new angular arrangement on the corners or salients.

The mold shown in Figures 1 to 5 is a big end down mold, but the invention may be applied to other types of molds. These molds have side walls constructed to promote the cooling of the ingot more rapidly at the lower than at the upper end of the mold in order to reduce piping. As indicated in Figures 2 and 3, the mold cavity is of less cross sectional area at the top than at the bottom of the mold and gradually tapers from bottom to top. This invention as before stated has to do with the particular shape of the mold cavity which has four convex sides A joined at the corners of the mold by twin curved salients B at opposite ends of widened corners C. The widened corners C may be straight or convex. The salients B are concave and the top of each salient at each corner of the mold has a radius the center point of which is in the same vertical line as the center point of the radius of the same salient at the bottom of the mold. This is indicated in Fig. 4. The radius of each said salient gradually shortens from the bottom to the top of the mold in the big end down mold shown. In the mold illustrated the radius x of the twin salients at the bottom of the mold may be for example $2\frac{1}{4}$ inches in length while the radii y at the top of the mold may be $1\frac{3}{4}$ inches in length. The radii of the convex sides of the mold cavity should vary at top and bottom. Thus at the top it may be 68 inches in length and thus at the bottom 67½ inches in length. These proportions are indicated diagrammatically in Figures 4 and 5. The exact lengths of radii need, however, not be followed in different molds, but in all cases the mold cavity is of general rectangular shape in cross section, preferably having at least two convex sides joined by widened corners and twin concave salients between the widened corners and the major sides.

In Figures 6 and 7 I have indicated a construction in which the mold cavity is formed with four inner convex side walls joined by widened corners and salients. In the preferred construction the arc of one twin salient D is greater than 45° and the arc of the other companion salient D′ is less than 45°, the sum of the two forming substantially 90°. The primary sides are indicated at A and the secondary sides at C as before. For instance, where the arc of one twin salient is 60°, the adjoining arc would be 30°, or one arc might be 70° and the adjoining arc 20°.

The advantage in thus constructing the twin salients is primarily that in the initial rolling passes of the ingot or in the so called squaring pass, the slope from one primary side of the ingot to the adjoining primary side should be as flat as practical to prevent formation of laps or seams at the corners in reducing sections of the ingot. I thus prefer to form the initial pass so that the primary faces of the ingot are worked on the more flat sides of the mold chamber or faces. The primary faces of the mold chamber may be flat, convex, or of any other desired contour, but are preferably of convex contour in a mold, such as shown in the drawings. One of the angles should be less and the other more than 45° and the sum of which should be approximately 90°.

The ingot shown in Figure 8 is of superior shape for reduction by rolling. It has four sides I at least two of which are concave and four secondary sides *i*, which are connected with the primary sides by curved salients *i′*, the convex sides of the curves being outward. Such an ingot may be passed through the rolls without danger of producing reduction laps, cracks or tears on the surface of the ingot.

I claim as my invention:

1. A mold having a chamber provided with four primary side walls at least two of which have a convex contour and four widened corners each provided with two curved salients intervening between the widened corners and the adjacent primary side walls of the mold.

2. A mold having a chamber provided with four primary convex side walls and four widened corners each provided with two curved salients intervening between the widened corners and the adjacent primary side walls of the mold.

3. A mold the lower portion of which absorbs heat from the ingot more rapidly than the upper portion and having a chamber provided with four primary side walls at least two of which have a convex contour and four widened corners each provided with two curved salients intervening between the widened corners and the adjacent primary side walls of the mold.

4. A mold having a chamber provided with primary side walls at least two of which have a convex contour and secondary walls or widened corners with curved salients intervening between the secondary and primary walls, the arc of each salient at the top of the mold being struck from a center in approximately the same vertical line as the arc of the companion salient at the bottom of the mold.

5. A mold having a chamber provided with primary side walls at least two of which have a convex contour and secondary walls or widened corners with curved salients intervening between the secondary and primary walls, the arc of each salient at the top of the mold being struck from a center in approximately the same vertical line as the arc of the companion salient at the bottom of the mold, and the radii of the salient from one end of the mold to the other being gradually increased.

6. A mold having a chamber of any desired cross section provided with four primary walls or sides and four secondary walls or sides, the secondary walls being connected to the primary walls by arc shaped portions of the walls of two radii, one describing an arc of less than 45° and the other an arc of more than 45°.

7. An ingot having four primary sides and four secondary sides at the corners which are connected with the adjacent primary walls by two convex salients of relatively small radii, the said secondary sides extending at an angle of considerably more than 45° from one adjacent primary side and at an angle of considerably less than 45° from the other adjacent side, the sum of said angles being substantially 90 degrees.

8. A mold having a chamber provided with four primary side walls and four widened corners each provided with two curved salients intervening between the widened corners and the primary side wall of the mold, one salient describing an arc of less than 20 degrees and the other salient describing an arc of more than 70 degrees.

9. An ingot mold having a chamber provided with four primary side walls at least two of which have an inwardly projecting convex contour and four widened corners each provided with two curved salients in-

tervening between the widened corners and the primary side walls of the mold, one salient describing an arc of less than 45 degrees and the other an arc of more than 45 degrees.

10. An ingot mold having a chamber provided with four primary side walls and four widened corners, each provided with two curved salients intervening between the widened corners and the primary side walls of the mold, one salient describing an arc of approximately 30° and the other salient describing an arc of approximately 60°.

In testimony whereof, I have hereunto subscribed my name.

EMIL GATHMANN.