May 28, 1968 D. H. SORENSON 3,385,678

CORRUGATED INGOT

Filed Nov. 30, 1965 2 Sheets-Sheet 1

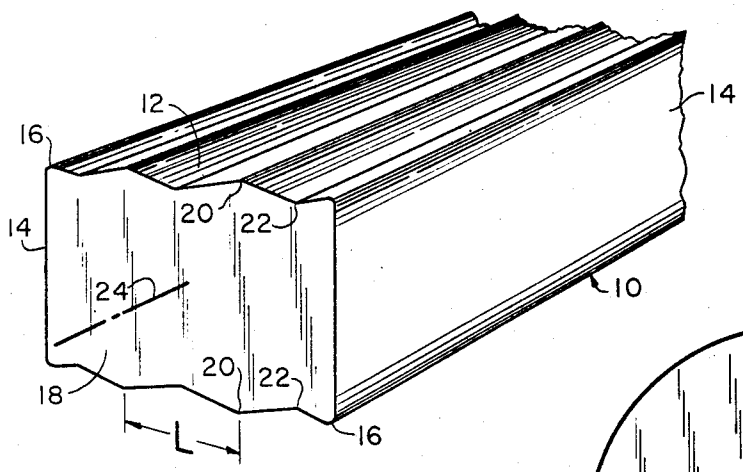

FIG. 1

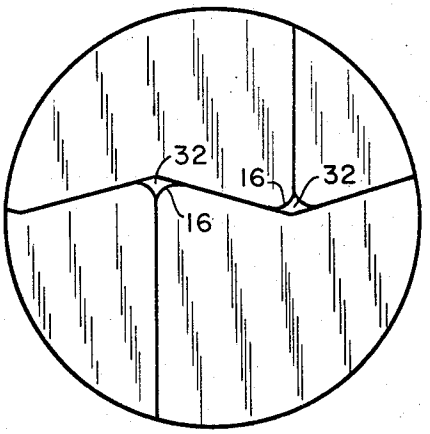

FIG. 4

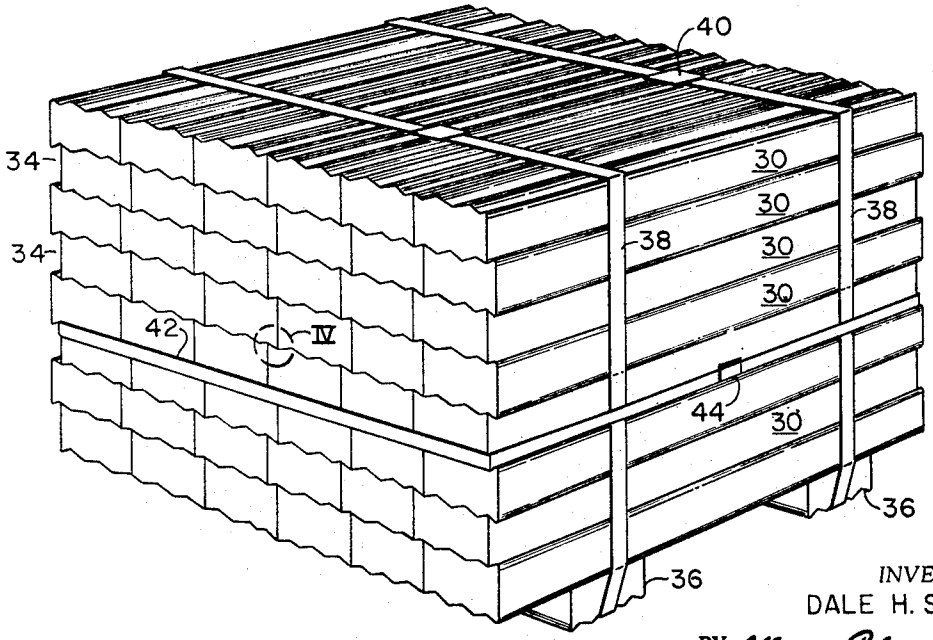

FIG. 2

INVENTOR.
DALE H. SORENSON

BY Kenn, Palmer, Matthews and Lyne
ATTORNEYS

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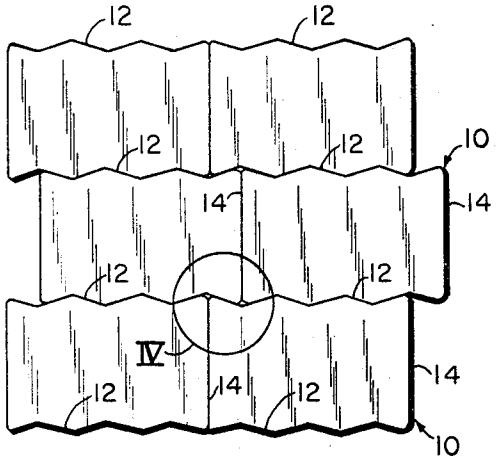

FIG. 3

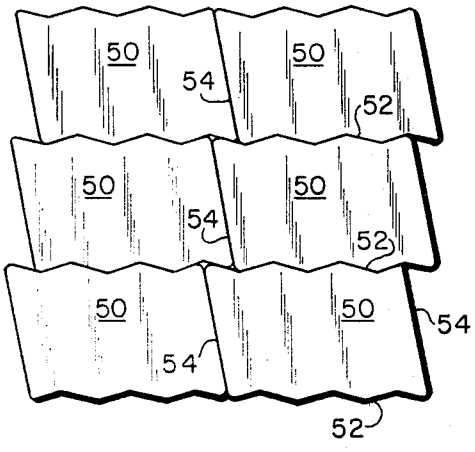

FIG. 5

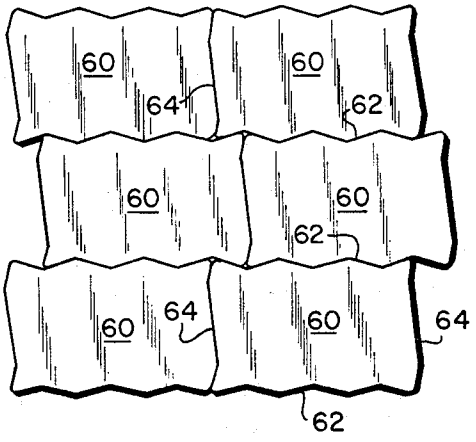

FIG. 6

INVENTOR.
DALE H. SORENSON

BY Glenn, Palmer, Matthews and Lyne
ATTORNEYS

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3,385,678

CORRUGATED INGOT

Dale H. Sorenson, Longview, Wash., assignor to Reynolds Metals Company, Richmond, Va., a corporation of Delaware

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19 Claims. (Cl. 29—187)

This invention relates to cast metal ingots and stacks and packages thereof.

Cast metal ingots according to the invention have a shape such that they can be arranged in an interlocking stack. Such interlocking is achieved by providing corrugations in a specific manner on at least two of the four side faces of each ingot and stacking the ingots so that corrugations of ingots in adjacent layers cooperate to resist relative lateral movement. In addition, the shape of the ingots enables adjacent layers in the stack to be offset so that the weight of an ingot and of the ingots bearing thereon cause the adjacent ingots in the underlying layer to be held together. Moreover, the shape of the ingots minimizes internal and external void spaces in the stack, thereby decreasing the stack's external dimensions for a given weight of metal. The corrugations and the manner of stacking the ingots, by increasing the stability of an ingot stack, enable the formation of a higher stack so as to decrease the floor space required, and substantially lessen the tendency of the stacked ingots to shift with respect to one another, which in turn relaxes the requirements of packaging and of precautions which must be taken during subsequent handling and shipping.

An important feature of the invention is that all ingots in a stack have the same symmetric shape, so that stacking does not require troublesome and time-consuming orientation of the ingots to conform to a predetermined scheme.

By virtue of their shape the ingots according to the invention may be cast continuously and without likelihood of inadequate metal fill.

Terms relating to symmetry are used herein in their geometric sense, so that a surface is considered symmetric about an axis when it intercepts with any straight line drawn perpendicular to the axis are equidistant from the axis, and, similarly, a surface is considered symmetric about a plane when its intercepts with any straight line drawn perpendicular to the plane are equidistant from the plane. In addition, the term "cylinder" is used in its geometric sense to mean the surface traced by a straight line moving parallel to a fixed straight line and intersecting a fixed, closed line. Finally, the term "aluminous metal" is used herein to mean aluminum and alloys containing more than fifty percent aluminum.

For a better understanding of the invention, and of its other details, objects, and advantages, reference is now made to the accompanying drawings, which show, for purposes of illustration only, present preferred embodiments of the invention. In the drawings:

FIGURE 1 is a transverse view of an ingot according to the preferred form of the invention;

FIGURE 2 is a transverse view of a stack of such ingots;

FIGURE 3 is an end view of a group of ingots shown in FIGURE 2;

FIGURE 4 is a detail taken at IV in FIGURES 2 and 3;

FIGURE 5 is an end view of a group of ingots according to an alternate form of the invention; and

FIGURE 6 is an end view of a group of ingots according to another alternate form of the invention.

As shown in FIGURE 1, the ingot **10** according to the preferred form of the invention is of generally rectangular cross-section with three wavelengths (L) of uniform, planar corrugations on each of its two greater side faces **12**. The remaining two side faces **14** are generally planar and generally perpendicular to side faces **12**, joining therewith at rounded edges **16**. This cross-sectional configuration enables the ingot to be continuously cast while ensuring proper metal fill at its extremities. By virtue of such continuous casting, the ingot **10** is of uniform transverse cross-section along its length, i.e., it is cylindrical. End faces **18** desirably are perpendicular to side faces **12** and **14**, and may be formed by cutting the continuous casting into convenient lengths by a saw, shear, plasma arc torch, or other convenient means.

Crests **20** and troughs **22** of the corrugations on respective side faces **12** are opposite each other, so that side faces **12** are symmetric about an imaginary plane equidistant therebetween. In addition, the four side faces **12** and **14** are symmetric about the ingot's longitudinal axis **24**. Therefore the shape of ingot **10** is such that side faces **12** and **14** are similarly disposed even if ingot **10** is (1) rotated 180 degrees about longitudinal axis **24**, and/or (2) rotated 180 degrees about either a horizontal or a vertical axis at its midpoint, or successively about both.

An example of the embodiment of ingot **10** was sawed from a continuous casting of 6063 aluminum alloy to have a weight of about fifty pounds and a length of about 30 inches between its end faces **18**. The distance between side faces **14** was about 5.075 inches, while the distance between side faces **12** was about 3.750 inches between crests **20** and about 3.250 inches between troughs **22**. Thus the wavelength L of the corrugations was 1.670 inches, and the amplitude was about 0.125 inch. The radius of curvature of side edges **16** was about 0.1875 inch, and the radius of curvature of side faces **14** at crests **20** and troughs **22** was about 0.125 inch.

As shown in FIGURES 2, 3, and 4, identical ingots **10** may be arranged in an interlocking stack having a plurality of layers **30**. In the particular embodiment of FIGURE 2, forty-eight of fifty ingots are disposed in eight layers **30** with six ingots in each layer. The ingots in each layer are aligned and laterally offset with respect to the ingots of each adjacent layer. Thus the corrugations of ingots of adjacent layers mate in such a manner as to minimize the internal void space to that shown at **32** in FIGURE 4. The distance of the offset is arranged to be less than one-half the width of a corrugated side face **12** in order to prevent the overhanging ingot **10** of each layer from falling off during stacking, and preferably is only one-half corrugation wavelength L so as to minimize the corresponding external void space **34**, thereby increasing the efficiency and stability of the stack. Since the troughs **22** of the corrugations do not occur at the side edges of the ingots, the interlocking causes abutting ingots within each layer to be held laterally together by the cooperation of their corrugations with those of a single ingot in an adjacent layer.

The remaining two of the fifty ingots act as runners **36** for supporting and giving rigidity of the forty-eight stacked ingots, as is shown in FIGURE 2. Encompassing the ingot stack and each runner ingot are metal straps **38** secured by ties **40** and fitting within the central trough **22** of the corrugated bottom of the runner ingot **36**. Preferably the lengths of the runner ingots **36** are slightly less than the width of a layer **30**, so that straps **38** tend to compress bottom layer **30**. A further, substantially horizontal strap **42** secured by tie **44** may be added when the package will be subjected to unusually rough treatment during shipping or handling, since it minimizes the tendency of the central ingots **10** to "core" or move longitudinally with respect to the remainder of the package. Non-metallic straps may be used in place of straps **38** and

42, so as to produce less contaminant if the package is to be melted as a unit.

Other package embodiments are also possible. In order to improve the rigidity of the package, two additional "runner" ingots may be placed beneath straps 38 on the top of the stack in the same manner as runner ingots 36 are disposed beneath the stack. Conventional packaging, for example, battens, a top covering, shrouding, or a deck, may be provided to further protect the ingots, or wooden runners may be used in place of runner ingots 36.

It should be noted that the corrugations are kept interlocked by the action of vertical forces resulting from the weight of the ingots and the restraint of the straps, thereby preventing lateral movement of the ingots, and that frictional forces tend to restrain the ingots from longitudinal movement. Further, the previously discussed, symmetric, cylindrical shape of the ingots enables each ingot to be stacked in any one of four possible positions, thereby eliminating the need for orienting each ingot for placement in the stack.

In the embodiment of the invention shown in FIGURE 5, ingots 50 have corrugated major side faces 52 and planar minor side faces 54 which are not generally perpendicular thereto, so as to form a rhomboidal cross-section. In another embodiment of the invention shown in FIGURE 6, ingots 60 have corrugations both on major side faces 62 and on minor side faces 64. The ingots of FIGURES 5 and 6 are similar to the ingot of FIGURES 1–4 in that (1) each is symmetric about its longitudinal axis, so that its side faces are similarly disposed even if the ingot is rotated 180 degrees about that axis, and (2) the distance between the minor side faces is substantially constant, so as to provide complete side face contact with substantially no internal void space in the stack.

The inclined side faces 54 of ingot 50 and the corrugated side faces 64 of ingot 60 provide restraint against vertical movement of the stacked ingot which is not provided by the side faces 14 of ingot 10. On the other hand, ingots 50 and 60 can be stacked in only two different positions and cannot be rotated 180 degrees end-for-end and still fit into the stack; they must be stacked in each layer progressively from one side to the other; and they are more easily tipped over when resting on a side face 54 or 64.

Although the particular corrugations described herein are substantially planar, it will be apparent that the invention may employ corrugations of sinusoidal or other desired configuration.

While present preferred embodiments of the invention have been illustrated and described, it will be understood that the invention may be otherwise variously embodied and practiced within the scope of the following claims.

What is claimed is:

1. An ingot having side faces defining a cylinder which is symmetric about the longitudinal axis of the ingot, at least two opposite side faces being corrugated, and the distance between another pair of side faces in a direction generally parallel to said corrugated side faces being substantially constant.

2. A cast metal ingot having four side faces defining a cylinder which is symmetric about the longitudinal axis of the ingot, at least two opposite side faces being corrugated, and the distance between the remaining two side faces in a direction generally parallel to said corrugated side faces being substantially constant.

3. The ingot of claim 2 wherein said remaining two side faces are generally planar.

4. The ingot of claim 2 wherein the distance between the two corrugated side faces is not a minimum between the side edges of said ingot.

5. The ingot of claim 2 wherein the major portions of the surfaces of said corrugations are planar.

6. The ingot of claim 2 wherein said corrugations are of substantially uniform amplitude and wavelength.

7. The ingot of claim 2 wherein said remaining two side faces are also corrugated.

8. The ingot of claim 2 wherein the side edges thereof are rounded.

9. The ingot of claim 2 wherein the distance between the two corrugated side faces is less than the distance between said remaining two side faces.

10. The ingot of claim 2 wherein adjacent side faces are generally perpendicular.

11. The ingot of claim 2 wherein said corrugated side faces are symmetric about a plane.

12. A continously cast aluminous metal ingot having four side faces defining a cylinder which is symmetric about the longitudinal axis of the ingot, two opposite side faces being symmetric about a plane and being provided with corrugations of substantially uniform amplitude and wavelength, the remaining two side faces being planar and parallel, the side edges of said ingot being rounded, the distance between said corrugated side faces being less immediately adjacent said edges than at said edges, the distance between said corrugated side faces being less than the distance between said planar side faces, and adjacent side faces being substantially perpendicular.

13. A stack of ingots of claim 2 disposed with the two corrugated side faces horizontal, wherein the ingots in each of a plurality of layers are offset by a distance of less than one-half said distance between said remaining two side faces with respect to the ingots of an adjacent layer, so that any internal voids in said stack are small in comparison with said corrugations.

14. The stack of claim 13 comprising further a strap encompassing said ingots in a plane perpendicular to said side faces.

15. A stack of ingots of claim 11, disposed with said plane horizontal wherein the ingots of each layer are offset by a distance of less than one-half said distance between said remaining two side faces with respect to the ingots of an adjacent layer so that adjacent ingots in a layer are held together by the cooperation of their corrugations with the corrugations of a single ingot in said adjacent layer, so that any internal voids in said stack are small relative to said corrugations.

16. The stack of claim 15 wherein said distance is one-half the wavelength of the corrugations adjacent the side edges of said ingots.

17. A stack of corrugated cast metal ingots comprising a plurality of horizontal layers each consisting of adjoining ingots having corrugations aligned along a horizontal plane and laterally offset with respect to the ingots of an adjacent layer by a distance of one-half the wavelength of the corrugations so that corrugations of ingots of adjacent layers interlock.

18. A package of corrugated cast metal ingots comprising at least two of said ingots aligned as runners, a stack of said ingots according to claim 17 resting upon the runner ingots, and a securing strap encompassing each runner ingot and the ingots of said stack.

19. The package of claim 18 wherein each said strap lies in a plane perpendicular to the corrugations of the ingots in said stack and fits within a corrugation in its runner ingot.

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HYLAND BIZOT, *Primary Examiner.*