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2,996,792

METHODS FOR PRODUCING HOLLOW METALLIC SHEETS

Filed Oct. 15, 1957

3 Sheets-Sheet 1

Fig. 1.

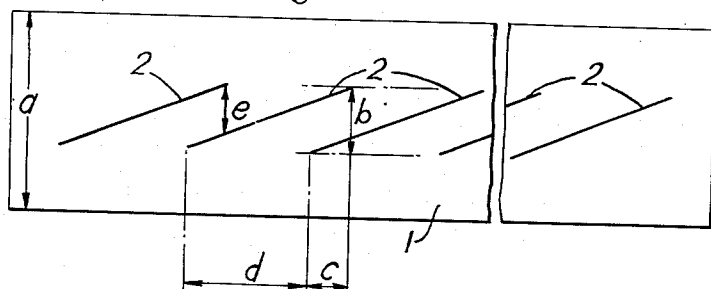


Fig. 2.

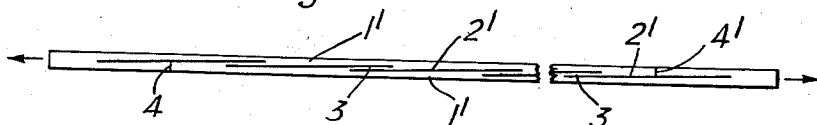
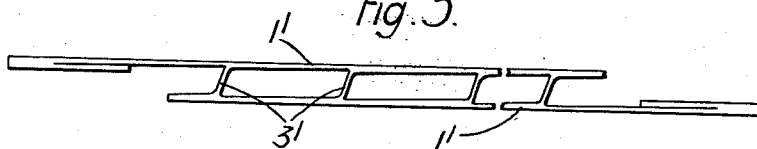


Fig. 3.



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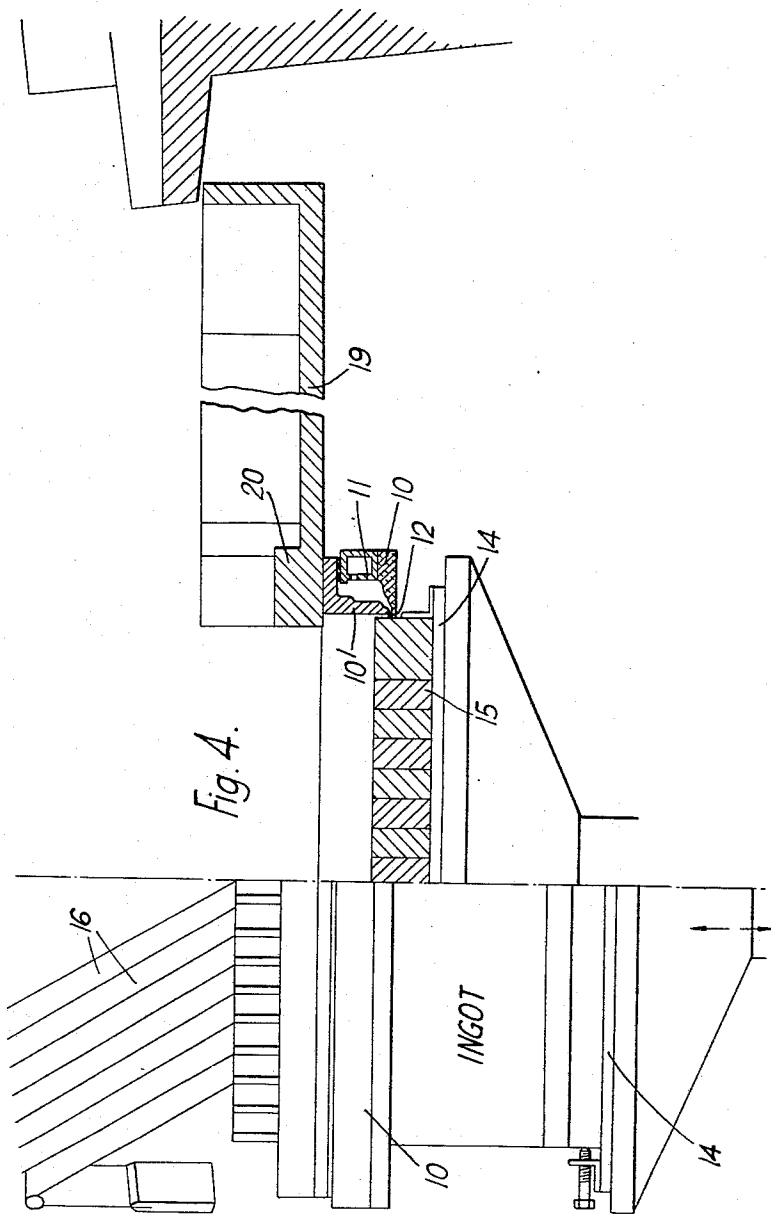
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METHODS FOR PRODUCING HOLLOW METALLIC SHEETS

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3 Sheets-Sheet 2



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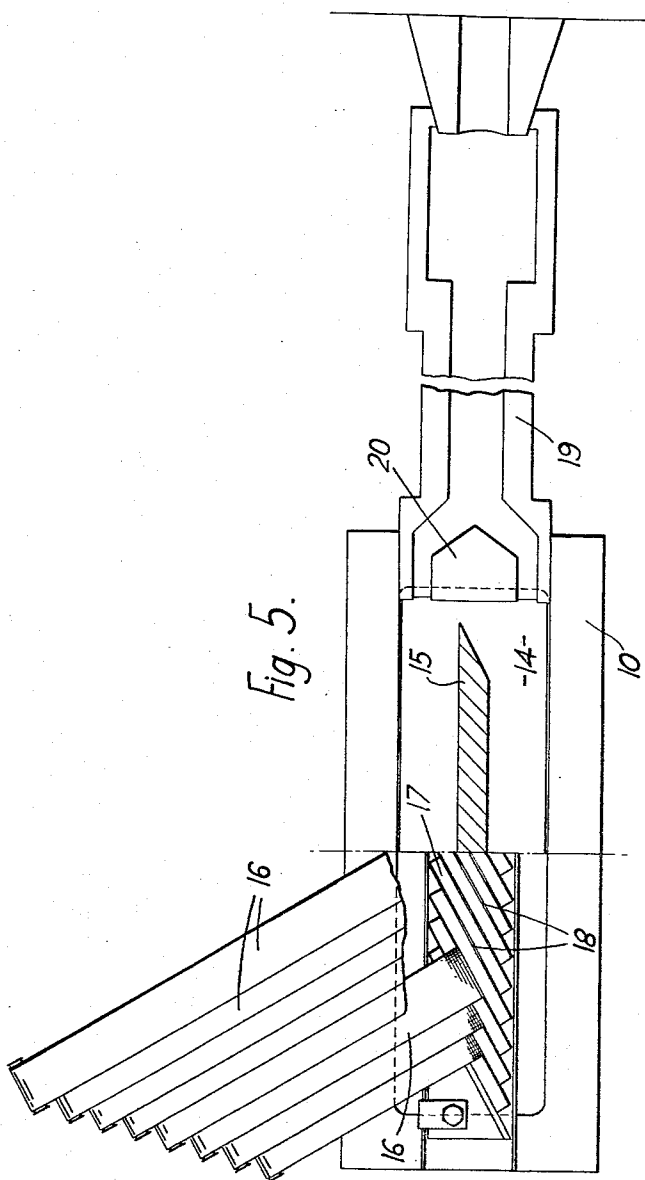
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METHODS FOR PRODUCING HOLLOW METALLIC SHEETS

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3 Sheets-Sheet 3



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METHODS FOR PRODUCING HOLLOW METALLIC SHEETS

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5 Claims. (Cl. 29—157.3)

The present invention relates to hollow metallic sheets and to a method for producing the same, and is particularly, but not exclusively, directed to the production of hollow sheets of aluminium and aluminium alloys.

It is already known to produce hollow aluminum sheets having continuous longitudinal passage-ways formed therein between two surface layers of metal. In the known method the passage-ways are originally defined by printing patterns of stop-weld material on both sides of a central aluminium sheet, which is then united to two other aluminium sheets by hot-rolling except over those areas to which the stop-weld material has been applied, the stop-weld material of course having extended during rolling. The passage-ways are then opened up by forcing fluid under pressure into the paths of the stop-weld material through the composite sheet, which is held between a pair of die plates and the fluid pressure separates the two surfaces of the composite sheet where they have been prevented from uniting by the stop-weld material.

The present invention provides a new method of producing hollow aluminium or other metal sheet and is capable of producing such a sheet having a different internal structure from that produced by the known method referred to above. It is also believed to be possible to produce larger and thicker hollow aluminium sheets of the kind provided by the present invention.

According to the present invention a hollow metallic sheet comprises two flat surface layers of metal held in spaced relation by means of continuous parallel ribs extending between the surface layers, said ribs being integral with the metal of the surface layers.

The hollow sheets of the present invention are primarily intended for use as structural members, since they have good bending and buckling properties, weight for weight, compared with flat sheets. Alternatively, the hollow sheets of the present invention may be employed in such applications as heat exchangers, where the passage-ways defined between the ribs are employed for the passage of fluids.

The method of producing the hollow metallic sheets of the present invention basically comprises forming a flat composite metal body having two metal surface layers and a central layer formed of metallic segments connecting the two surface layers, the said segments being separated from each other by lengths of stop-weld material arranged therein with their side edges overlapping each other (as viewed in plan) and the segments themselves being substantially parallel to the plane of the metal body, and applying a force to the two surface layers to effect relative lateral movement of said surface layers and to deform the regions where the connecting segments and surface layers are joined and simultaneously to rotate said segments to form upstanding ribs for the spaced separation of the surface layers.

The lateral forces on the surface layers are preferably produced by gripping the edges of the composite metal body in a stretching machine and continuing the stretching until the connecting segments have been rotated through an angle of at least about 70°.

As an alternative to lateral stretching, the initial separation of the surface layers for the erection of the ribs can be effected by the application of an outward force

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normal to the surfaces of the body, as by means of outwardly movable suction heads.

One method of producing the flat metal composite body comprises casting a parallel-faced metal ingot so as to have two metal surface layers and a central metal layer containing substantially parallel spaced inclined lengths of stop-weld material, which is in the form of coherent lengths which remain solid at the casting temperature used in forming the metal ingot, the side edges of the lengths of stop-weld material overlapping each other in the ingot, reducing the ingot by rolling at least in a direction substantially along the lengths of the stop-weld material to form a sheet (thus reducing the angle of the lengths of stop-weld material to the surfaces) and splitting the composite sheet thus formed at or near its edges to permit the separation of the two surface layers from each other. Alternatively it may be possible to effect splitting of the metal to define separate surface layers at an earlier stage in the process.

The preferred material for use as stop-weld material in the formation of composite sheets by a casting method is woven glass fibre tape. This is particularly suitable where the stop-weld material is arranged to be in the form of straight strips in cross section to define straight metal connecting segments. Where it is desired that the stop-weld material should be curved or bent or cranked-shaped in cross section, it is preferred to use a more rigid material for this purpose, of which graphite is one example, since it can be formed into rod or strip form of desired cross-sectional shape.

The principal criterion of any stop-weld material for the present purpose is that it shall remain solid at the casting temperature of the ingot and should not disintegrate into separate lengths on subsequent rolling. Woven glass fibre has the particular advantage that it disintegrates during rolling into a fine powder which remains as a continuous thin film inside the sheet and is very readily, almost completely, removed after separation of the surface layers.

The production of hollow sheets in accordance with the present invention is hereinafter described with reference to the accompanying drawings, wherein:

FIGURE 1 is a cross section of an ingot.

FIGURE 2 is a cross section of a rolled sheet produced from the ingot of FIGURE 1.

FIGURE 3 is a cross section of a hollow sheet produced from the rolled sheet of FIGURE 2.

FIGURE 4 is a section of an apparatus for producing an ingot of the shape shown in FIGURE 1.

FIGURE 5 is a plan view of the apparatus of FIGURE 4.

The ingot of which an end view is shown in FIGURE 1 has two surface layers 1 of metal separated by and integral with a central layer incorporating a plurality of woven glass fibre tapes 2, to act as stop-weld material. The tapes 2 are arranged side by side, with their side edges overlapping each other (viewing the ingot in plan). The overall thickness of the ingot is indicated by *a*, whilst the thickness of the layer, in which the tapes 2 lie, is indicated by *b* and the lateral overlap of the strips 2 by *c* and their lateral separation by *d* and their vertical separation by *e*.

As the ingot shown in FIGURE 1 is rolled out to the shape shown in FIGURE 2, the thickness of the surface layers 1' is now much reduced, whilst the angle that the stop-weld strips 2' (now in the form of a film of disintegrated glass particles) makes with the surface is much decreased. It will be seen that the metal between the reduced strips 2' is now in the form of connecting segments or potential ribs 3 between the surface layers 1'. The top and bottom surfaces 1' of the sheet shown in FIGURE 2 are cut at 4 and 4' respectively down to

the stop-weld material and the sheet is then spread apart, for example by a transverse load applied to the edges of the sheet in the direction of the arrows by apparatus such as a stretch mill, or by an outward force applied by means of suction heads or by a combination of these methods. This erects the segments to turn them into the ribs 3' as shown in FIGURE 3.

It will be observed that in the finished sheet the surface layers 1' are not of uniform thickness and it can be seen that each surface layer is slightly tapered laterally between each pair of ribs 3'.

The skin thickness of the surface layers 1', the overall thickness of the hollow sheets, the spacing and thickness of the ribs 3' may all be controlled by variation of the values of *a*, *b*, *c*, *d* and *e*, and the angle of inclination of the strips 2, in the initial ingot and the reduction given to the ingot in subsequent rolling.

There is a relation in thickness between the skin thickness of the surface layers 1' and the thickness of the ribs 3' which cannot be exceeded if a hollow sheet of satisfactory surface appearance is to be produced by transverse stretching alone. It is essential that the maximum stress to which the surface layers are subjected is less than the yield stress of the metal. If this condition is not fulfilled the surface layers yield plastically at their thinnest points to give a hollow sheet having slight corrugations in its surfaces which mar its appearance. In practice it is found that using the stretching method alone the thickness of the surface layers 1' should be at least twice the thickness of the ribs 3'.

In order to produce hollow sheets having superior mechanical properties it may be desirable to make the sheets in such manner that a proportion of the surface layers 1' are of stronger material than the ribs 3'. This can be achieved, for example, by making the ingot of a ductile aluminium alloy which does not harden excessively during rolling and then cladding a work-hardening or heat-treatable alloy onto one or both faces of the ingot by known methods during the rolling stage. This will enable the opening up of the sheet to be carried out without fear of cracking the ribs and will provide the stronger (and more expensive) alloy only in the place where it provides most strength, i.e. in the surface layers.

It is also possible to use the same method to provide a hollow sheet which is clad with a softer material, such as super purity aluminium, for corrosion protection.

An ingot, such as that shown in FIGURE 1, for use in the manufacture of the hollow sheet of the present invention may be made by the semi-continuous casting process using the apparatus shown in FIGURES 4 and 5. The mould 10, which is shown diagrammatically only, is of the water-jacketed, curtain-cooling type, having a working surface 10' made of copper. In this mould the cooling water is fed into the hollow wall through two inlets (not shown) which are separated from the working surface by a perforated plate 11 which serves to direct the water to the outer surface of the working face of the mould. The cooling water discharges through a peripheral slot 12 adjacent to the lower edge of this working face and envelops the ingot as it is withdrawn into the casting pit on the stool 14, which forms the bottom of the mould at the beginning of the casting operation, as shown on the right hand side of FIGURE 4.

For the purpose of producing the ingots required for producing the hollow sheets, the stool 14 is provided with a series of clamp plates 15 which in the present example are arranged at an angle of about 30° to the length of the stool and these are employed to hold the ends of woven glass tapes 16. The tapes 16 are led from storage reels (not shown) down between guide plates 17 which are inclined at the same angle as the clamp plates 15 on the stool 14, so that the tapes at the beginning of the casting operation are stretched from the guide plates 17 to the stool 14 and are arranged parallel to one another and oblique with respect to the sides of the

mould, but in a spatial zone extending parallel to the sides of the mould. The guide plates 17 are relieved centrally at 18, so that the tapes are prevented from wandering laterally, whilst at the same time there is frictional contact between the tapes and the clamp plates, so as to maintain tension on the tapes as the stool 14 is withdrawn downwardly.

It will be appreciated from the description in relation to FIGURES 1, 2 and 3 that the disposition and spacing of the tapes in the ingot must remain as constant as possible and it is in order to achieve this result that the type of mould referred to above is employed, since this gives a rapid rate of chilling so as to ensure that the depth of the sump of molten metal on the top of the ingots, and hence the unsupported lengths of the tape inserts, is kept to a minimum.

In order to minimise disturbance of the position of the tapes by the inflowing molten metal, a special launder 19 is employed, in which there is a central baffle 20 which divides the metal into two streams directed on either side of the array of inserts.

As an example, an ingot was cast by means of this type of apparatus having an initial thickness of 6". The two ends of the ingot were cut off and rejected, whilst the central block which had been machined to remove the uneven surface, that is common to ingots cast by the continuous process, was heated to 520° C. and then hot-rolled to reduce it to a slab ¼" thick. This slab was cut into lengths, the edges of which were then split as shown at 4 and 4' in FIGURE 2, at a distance of about 3" in from the edges by passing them between a pair of rolls, one of which carries a cutting edge and the other is plain.

For certain purposes, such as applications for heat exchangers, it may be desirable to provide a hollow sheet having an intermediate layer from which ribs extend on both sides to surface layers. Such a product can readily be produced from a rolled sheet having two spaced layers in which strips of stop-weld material lie, the strips of stop-weld material in each layer being arranged in relation to each other as before. These layers are separated by a medial zone of metal in which no stop-weld material lies and this provides the central layer from which the ribs extend, after the rolled sheet has been opened up by lateral stretching.

By casting in inserts of stop-weld material of decreasing width, a hollow sheet can be produced in which the length of the ribs decreases from one end of the sheet to the other, so that the hollow sheet is tapered. It will be necessary to employ a stretcher with swivelling grips for stretching the sheet or alternatively suction heads.

I claim:

1. A method of producing hollow metallic sheets comprising casting a metal ingot having arranged therein a plurality of coherent lengths of a stop-weld material, said lengths of stop-weld material lying substantially in, but at an angle to, the central plane of said ingot and substantially parallel with each other with their edges in overlapping relation, but separated from each other by metal, rolling the ingot at least in a direction substantially longitudinal of the lengths of stop-weld material to produce a sheet having longitudinally extending, substantially parallel and overlapping fissures in the central plane thereof between respective surface portions of the sheet, splitting the composite sheet lengthwise near each edge into one of said fissures and applying oppositely directed lateral forces to said surface portions of the sheet to effect relative lateral displacement of said surface portions and to bend up the metal lying between the overlapping fissures so as to cause relative separating movement of said surfaces, whereby passageways are formed, along the regions of the stop-weld material, between the metal parts which are bent up, and the composite sheet is thus converted to a structure in which the aforesaid surface portions are separated by said passageways.

2. A method of producing hollow metallic sheets com-

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prising casting a metal ingot having arranged therein a plurality of coherent lengths of a stop-weld material, said lengths of stop-weld material lying substantially in, but at an angle to, the central plane of said ingot and substantially parallel with each other with their edges in overlapping relation, but separated from each other by metal, rolling the ingot at least in a direction substantially longitudinal of the lengths of stop-weld material to produce a sheet having longitudinally extending, substantially parallel and overlapping fissures in the central plane thereof, splitting the composite sheet lengthwise near one edge from one surface through to a fissure, splitting the composite sheet lengthwise near the opposite edge from the opposite surface through to another fissure and applying lateral tensile forces to the edges of said sheet outwardly of said lengthwise splits to bend up the metal between the overlapping fissure so as to cause relative separating movement of said surfaces, whereby passageways are formed, along the regions of the stop-weld material, between the metal parts which are bent up, and the composite sheet is thus converted to a structure in which the aforesaid surface portions are separated by said passageways.

3. A method of producing hollow metallic articles according to claim 1, in which the stop-weld material is woven glass-fibre tape.

4. A method of producing hollow metallic articles according to claim 2, in which the stop-weld material is woven glass-fibre tape.

5. A method of producing hollow metallic structures comprising forming a flat metal body having two surfaces, said body comprising metallic portions respectively along the surfaces and a central portion between said surface portions, said central portion comprising metallic segmental portions connecting the surface portions, and lengths of stop-weld material overlapping each other along their side edges and separating the segmental portions from each other, each length of stop-weld material which lies between two other lengths of said material being arranged with its opposite side edges respectively overlapping above one and below the other of said other lengths, and said segmental portions wholly separating

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the lengths of stop-weld material from each other and being disposed to extend substantially parallel with the surfaces of the body, said operation of forming the flat metal body including rolling said body from a thicker structure thereof which has the lengths of stop-weld material arranged centrally therein in substantially parallel, edgewise overlapping relation with each length overlapping respectively above and below the lengths adjacent to it, said rolling being effected at least in a direction substantially longitudinal of the lengths of stop-weld material to produce the aforesaid flat metal form of the body, said lengths of stop-weld material defining fissures in the body in its thicker structure and in the aforesaid flat metal form rolled therefrom, and said forming operation including splitting the body lengthwise near each edge into one of said fissures, and applying opposite forces to the two surface portions along paths substantially aligned with the surfaces of the body to effect movement of the entirety of the two surface portions relative to each other and to bend the segmental portions into a disposition at a substantial angle to the surfaces of the body, for mutually separating the surface portions and converting said segmental portions into laterally spaced ribs between the separated surface portions, whereby a hollow metallic structure is formed having passageways, along the regions of the stop-weld material, between the ribs.

References Cited in the file of this patent

UNITED STATES PATENTS

29,276	Holmes	July 24, 1860
866,140	Kahn	Sept. 17, 1907
1,788,145	Bates	Jan. 6, 1931
2,191,788	Collins	Feb. 27, 1940
2,375,334	Valyi et al.	May 8, 1945
2,756,496	Holland	July 31, 1956
2,766,514	Adams	Oct. 16, 1956
2,775,028	Wampler	Dec. 25, 1956

FOREIGN PATENTS

205,695	Australia	Jan. 10, 1957
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