April 29, 1930. B. F. HOPKINS ET AL 1,756,196

METHOD OF MAKING METAL SHEETS

Filed Feb. 23, 1928

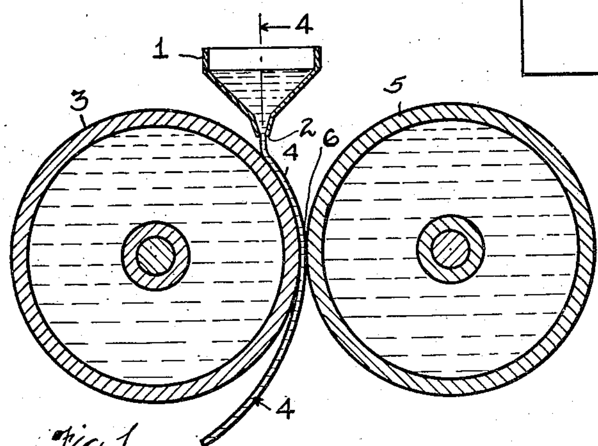

Fig. 1

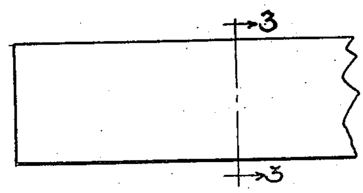

Fig. 2

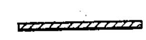

Fig. 3

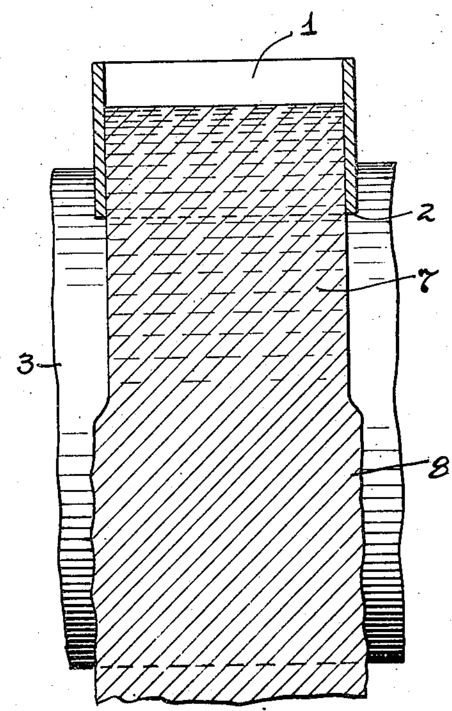

Fig. 4

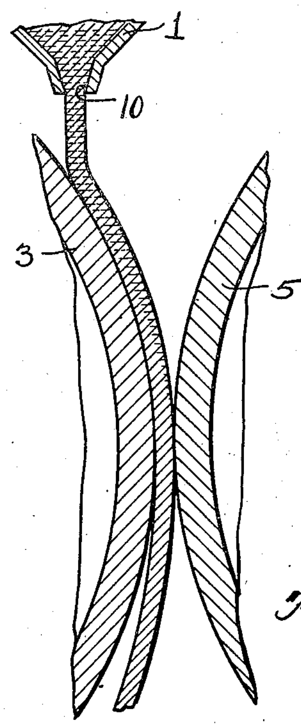

Fig. 5

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UNITED STATES PATENT OFFICE

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METHOD OF MAKING METAL SHEETS

Application filed February 23, 1928. Serial No. 256,226.

The present invention, relating as indicated to a metal sheet and method of making same, is more particularly directed to an improved cast metal sheet and to a method of making same directly from molten metal by casting against a moving element. The particular object of the invention is the provision of a new and extremely economical and simplified method of forming sheets directly from molten metal with the elimination of the intermediate steps, such as the casting of billets and the consequent rolling and rerolling of these billets to the desired thin sectional form.

The present method is also particularly directed and adapted for the forming of solid metal sheets where a considerable number of heat units must be abstracted from the molten metal in a relatively extremely short space of time, either because the metal which is being cast is an alloy having more than one critical temperature, or the sheet being formed is of such a thickness that extremely rapid removal of heat from the molten material is necessary to cause solidification entirely through the sheet which it is desired to form.

To the accomplishment of the foregoing and related ends, said invention, then, consists of the means hereinafter fully described and particularly pointed out in the claim; the annexed drawing and the following description setting forth in detail one method and one product exemplifying our invention, such disclosed procedure and product constituting, however, but one of various applications of the principle of our invention.

In said annexed drawing:—

Fig. 1 is diagrammatic in character and is a transverse sectional view illustrating one form of apparatus for carrying out the present invention; Fig. 2 is a plan elevation of a portion of a sheet produced by our method; Fig. 3 is a section on the line 3—3, Fig. 2; Fig. 4 is a section on the line 4—4, Fig. 1; and Fig. 5 is a view similar to Fig. 1, but showing apparatus for forming a sheet of materially greater thickness than that illustrated in the first-named figure.

We are aware that molten metal has been cast directly into wires or thin strips by pouring molten metal between cooperative rolls which act to suddenly chill the metal, causing it to solidify in the throat which is formed between the two rolls, but such apparatus has been found commercially practicable only in the casting of homogeneous metals of low melting point in which a drop in temperature of a few degrees was sufficient to convert the molten metal into a solid. Our method is designed to cast sheets or other metals, such for example as alloys composed of metals having different melting points which produces two or more critical temperatures in the alloy, some times of considerable difference. In casting such an alloy it is necessary to maintain the molten metal at a temperature in excess of the highest melting point of any of the several metal combinations contained in the alloy, while to produce a homogeneous solid from this molten metal it is necessary to almost instantaneously reduce the temperature to a point below the lowest melting point of any of the metals contained in the alloy. It will be evident that in many alloys the temperature drop required will be several hundred degrees, and apparatus and methods which have been found practical in casting sheets of homogeneous metals are entirely unsuccessful in casting alloys under the conditions named.

Another condition in which it is necessary to suddenly produce a very considerable drop in temperature is where even homogeneous or relatively homogeneous metals are desired to be cast in such thicknesses that there may be a considerable temperature difference between the interior and the exterior of the sheet. In this condition it is necessary to reduce the temperature materially below the point of solidification of the metal in order that the interior of the sheet be brought to the solidifying temperature.

We have found that alloys may be cast directly into sheets, and homogeneous metal into relatively thick sheets, by the method now about to be described. Our method, briefly stated, consists in pouring the molten metal directly onto a moving element of materially lower temperature than that of the molten metal and having a surface speed closely apprxoimating that of the metal which is being poured thereon, and then subjecting the congealed sheet of metal resulting from this operation to pressure from opposite sides while still hot and compressible in order to compress the metal, eliminate any flow of air holes in the sheet and bring the same to the required thickness. One form of apparatus which may be used for carrying out the process is illustrated in Fig. 1, and consists of a reservoir 1 provided with a discharge opening 2 positioned closely adjacent to a moving element in the form of a roll 3. In this apparatus the reservoir 1 should be so formed or controlled that the molten metal 4 issuing from the outlet 2 is under a minimum of pressure or head, while the discharge opening 2 should be positioned as closely as possible to the roll 3 in order to avoid splashing and spreading of the column of molten liquid which is falling thereon. The column of liquid should approximate as closely as possible the dimensions of the sheet which it is desired to produce and the temperature of the moving element 3 should be controlled so that it is materially lower than the temperature of the molten metal, producing a cooling effect on the metal sufficient to congeal the same by the time that the metal has been brought to the point of engagement of it by a second moving element, here shown as also in the form of a roll 5. The position of the reservoir with respect to the central vertical plane between the two rolls should be such that the required cooling effect is secured on the metal between its point of contact with the roll and the point of contact with the metal of the second roll 5.

For any given set of conditions it is of course possible to calculate approximately the distance through which the molten metal should be allowed to contact with the element 3, and for a given maintained temperature of the element 3 a given room temperature and given temperature reduction required to solidify the metal from the molten condition, the point of engagement between molten metal and the moving element can be closely assumed and then set more precisely by slightly varying the position of the reservoir 1 with respect to the center of the roll 3.

It is highly desirable that a minimum of excess metal be allowed to flow onto the roll as this excess metal will cool more slowly than the metal adjacent to the roll, and will build up at a point 6 between the two rolls, or rather between the solidified sheet and the roll 5, and will then be solidified by the roll 5 and rolled into the sheet proper, producing a laminated effect which will detrimentally affect the character of the sheet produced. This condition can be secured by proportioning the outlet passage 2 in the reservoir so that it closely approximates the desired dimensions of the sheet, making allowance of course for the thinning and widening effect of the two rolls upon the sheet, which is illustrated in Fig. 4, by comparison between the upper portion of the sheet 7 and the lower portion 8, which is the same sheet after the passage between the two rolls.

In Fig. 5 there is shown the same two moving elements in the form of rolls 3 and 5 and the same reservoir 1, but provided in this case with an enlarged discharge opening 10 adapted to feed a very much thicker stream or column of liquid against the first moving element 3, and in this case to discharge the molten metal onto the element 3 at a point more adjacently spaced from the horizontal plane passing through the roll centers than was the case in the apparatus of Fig. 1. In casting a thicker sheet of material, such as is shown in Fig. 5, an increased quantity of heat must be abstracted from the material in order to cause complete solidification, and hence the adjustment of the reservoir 1 with respect to the center of the roll 3. It will be understood that for various metals this setting will vary materially, depending upon the conditions already named, which are the temperature of the molten metal, the solidification temperature and the cooling effect of the roll 3, as well as the temperature of the room, and that no absolute rule can be given for various alloys and metals and for various thicknesses of sheet.

We have successfully carried out the method described above and have made sheets of good quality and texture of a cadmium lead babbitt in which the initial temperature of the molten metal was carried at about 750°, while solidification became complete at about 450°, involving a reduction of approximately 300° in the temperature of the metal between its point of issuance from the reservoir and the point of passage across the center line of the two rolls. In casting sheets of this material the molten metal was allowed to fall through not more than two inches onto the surface of the roll and was in contact with the first roll for a distance of approximately three inches before being engaged by the second roll. The lineal speed of the surface of the roll approximated the falling speed of the molten metal and both rolls were water-cooled by a continuous circulation therethrough of water entering at approximately 60° to 70°. In this manner sheets of some six inches in width and about $\frac{1}{32}$ of an inch in thickness were made continuously, and an extremely homogeneous sheet of high quality was produced which was sufficiently strong and flexible to permit of being secured against a roughened steel sheet when the two were homogeneously rolled together under heavy pressure rolls.

Other forms may be employed embodying

the features of our invention instead of the one here explained, change being made in the form or construction, provided the elements stated by the following claim or the equivalent of such stated elements be employed, whether produced by our preferred method or by others embodying steps equivalent to those stated in the following claim.

We therefore particularly point out and distinctly claim as our invention:—

In a method of casting metal strips, the steps which consist in pouring against a horizontal roll at a point materially above the central horizontal plane thereof, molten metal in a column approximating the width and thickness of the desired strip, maintaining the temperature of said roll sufficiently below that of the metal to at least partially solidify the latter between its point of engagement with the roll and the central horizontal plane thereof, and then engaging the partially solidified strip with a second roll while maintaining a relationship between the rolls adapted to compress and size the resulting metal strip.

Signed by us, this 18th day of February, 1928.

JOHN V. O. PALM.
BEN F. HOPKINS.