April 6, 1943. C. D. COXE 2,316,144

FORMATION OF METAL SHAPES

Filed Aug. 30, 1941

Fig. 1

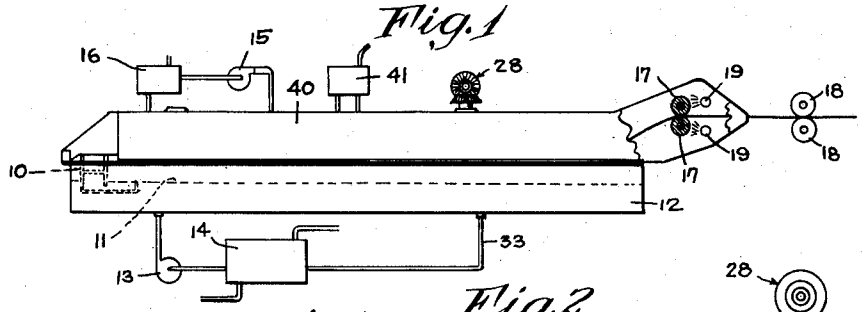


Fig. 2

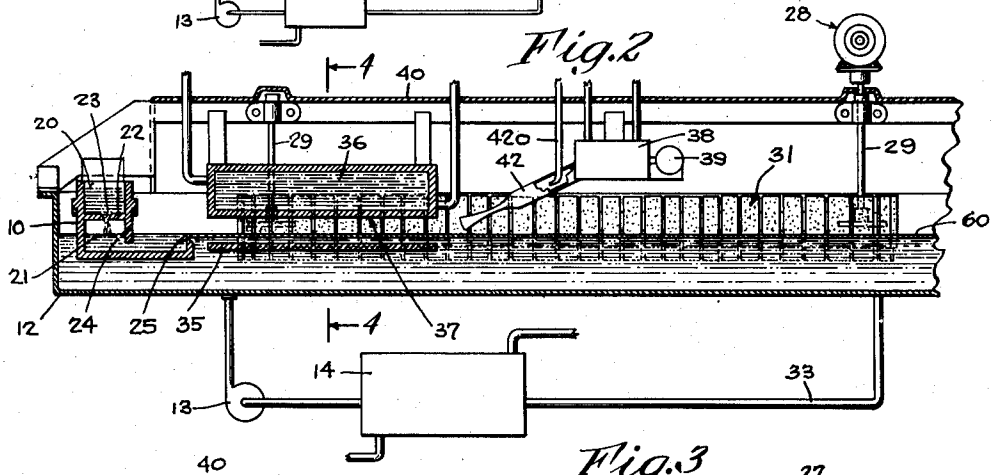


Fig. 3

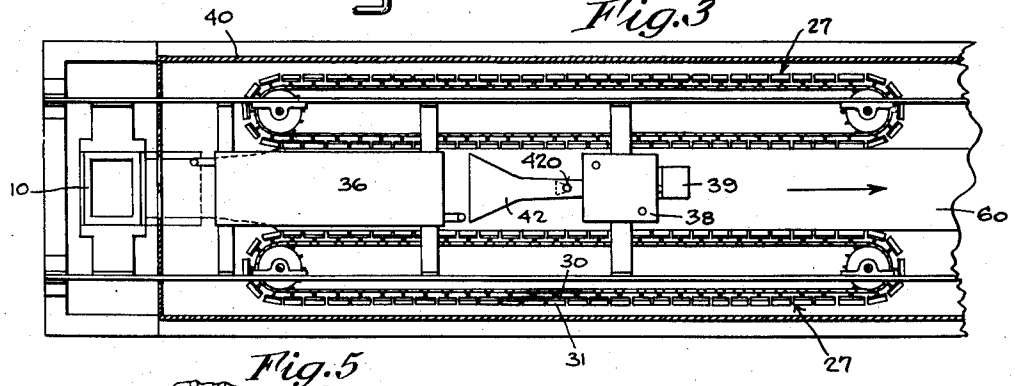


Fig. 5

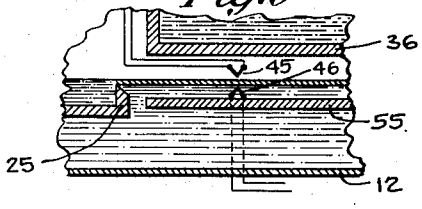
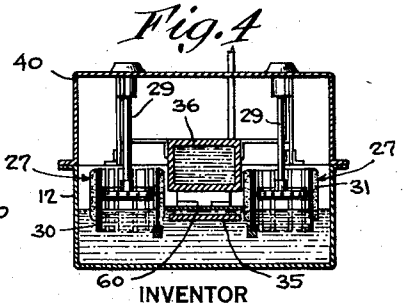


Fig. 4



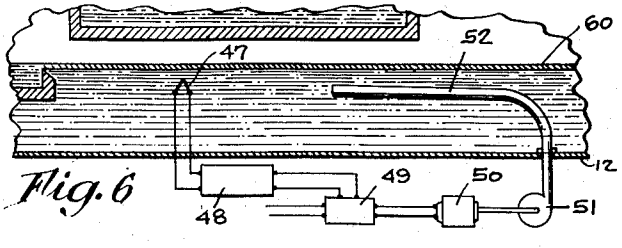


Fig. 6

INVENTOR

Charles D. Coxe

BY Harold L. Gammons

AGENT

Patented Apr. 6, 1943 2,316,144

UNITED STATES PATENT OFFICE

2,316,144

FORMATION OF METAL SHAPES

Charles D. Coxe, Bridgeport, Conn., assignor to Remington Arms Company, Inc., a corporation of Delaware

Application August 30, 1941, Serial No. 408,926

43 Claims. (Cl. 22—57.2)

This invention relates to the method and apparatus for making metallic shapes directly from molten metal by floating the metal on a fluid, and is particularly adapted for the production of metallic sheets. A method and equipment of this character are disclosed in applicant's prior application, Serial No. 334,537, filed May 11, 1940, patented October 13, 1942, Patent No. 2,298,348.

The present invention comprises certain improvements and refinements upon the disclosure of the earlier application, such improvements including a more accurate control of the rate of heat exchange between the body or sheet of metal being formed and contiguous media, accompanied by metallurgical improvement in the body or sheet.

It is an object of this invention to provide elements for improving the surface characteristics of metal sheets being formed upon a fluid bath. More particularly, an object of this invention is to provide improved means to control the rate of heat removal from the surfaces of the metal sheets being formed so as to obviate the formation of undesirable vestigial shrinkage effects. Another object is to correlate rates of heat dissipation from different surfaces of the sheet being formed in such a way as to effect substantially simultaneous solidification thereof, and to insure that no exterior portion solidifies later than the adjacent interior portion. A further object is to provide an improved apparatus for cleaning the bath metal off of the surface of the finished sheet. A still further object is to provide an improved feeding device for uniformly flowing the molten metal to be shaped onto the surface of the molten metal bath.

Other objects, features and advantages of the invention will appear from the following detailed description and drawing, which give several illustrative forms of the invention.

In the drawing:

Fig. 1 is a diagrammatic side elevation of one type of apparatus used in conjunction with the devices of this invention, with a portion cut away showing the heated squeeze rolls.

Fig. 2 is a detailed side elevation partially in section of the apparatus of Fig. 1, not including the squeeze rolls.

Fig. 3 is a plan view of Fig. 2.

Fig. 4 is an end elevation on line 4—4 of Fig. 2, showing details of the endless chain.

Fig. 5 is an enlarged fragmentary section of the apparatus of Fig. 2 adjacent the heat control surfaces, showing the automatic regulating devices.

Fig. 6 is a fragmentary side elevation of the apparatus of Fig. 2 showing modified means for regulating the temperature of the bath.

As disclosed in applicant's prior application, mentioned above, the formation of metal articles directly from molten metal by flowing the molten metal to be shaped onto the surface of a fluid bath necessitates that the bath material be one having a lower melting point and a higher boiling point than the freezing point of the metal which is to be shaped, and the specific gravity of the bath be either greater or less than the specific gravity of the metal to be shaped, depending upon the mode in which the invention is carried out.

In illustrating the improvements of this invention, applicant has arbitararily chosen a bath having a relatively high specific gravity so that it will stay at the bottom of the container while the molten metal which is to be shaped will float on top of the bath. It will be understood, however, that applicant's invention is also applicable when the specific gravities of bath and metal being cast are reversed.

As an example, lead having a melting point of 620° F., a boiling point higher than 2800° F., and a specific gravity of 11.34 may be used as the molten bath; and aluminum having a melting point of about 1220° F. and a specific gravity of 2.7 may be the metal to be shaped.

If the aluminum be maintained at a temperature of about 1274° F., and most of the lead kept at a temperature of about 752° F., aluminum will freeze at the interface of the two metals. The resultant layer of aluminum can be removed, making room at the interface for another portion of the aluminum to freeze; and the frozen aluminum may be removed continuously in the form of an endless strip or a strip of the length desired.

Although lead and aluminum have been cited as suitable metals for molding relatively thin sheets of aluminum directly on the fluid lead, it will be understood that other combinations of metals and non-metals may be used, the requisites being merely that the two be immiscible in the liquid state and show properly related freezing points, boiling points, and specific gravities.

Referring to Fig. 1, the metal to be shaped is poured into an improved pouring box 10, which feeds the metal on to the surface 11 of the fluid bath held in the carrier 12. Although the pouring box 10 is shown located with the pouring lip 25 rearwardly of a point adjacent the entrance to the conveyor chains 27, it will be understood

that, if warranted by improved operation, the pouring box may be located forwardly so that the pouring lip 25 is positioned adjacent the entrance to the conveyor chains. Further, although the pouring box is shown in plan view as being substantially rectangular, it will be understood that the box may be circular or have other geometrical shapes.

A circulating pump 13 and cooler 14 illustrate one example of means to maintain the temperature of the greater portion of the fluid bath uniform. The pump 15 and cooler 16 are adapted, as hereinafter described, to circulate a cooled fluid through suitable heat absorbing means, arranged to cool the upper surface of the metal being cast.

The pair of rolls 17, 17 shown in the cut away portion of Fig. 1 are suitably designed as improved means for removing any bath metal which may be clinging to the surface of the cast metal sheet as it is withdrawn from the apparatus by the pinch rolls 18, 18. The rolls 17, 17 are suitably arranged as squeeze rolls, and are heated, as for instance by burners 19, 19 so that as the metal sheet passes through the heated squeeze rolls the fluid metal of the bath clinging thereto is cleaned or stripped from the metal strip while the bath metal is in a fluid state. The action of the rollers is therefore substantially that of a wringer for wringing off the fluid bath. Although the burners 19, 19, as illustrated, are directed on to the outer surface of the squeeze rolls, it will be understood that other arrangements for heating the rolls may be made, as, for example, locating the burners on the inside of the rolls.

An alternative means for removing the fluid bath material comparable to that of the heated squeeze rolls is the use of a blast of hot gas which may be directed on to the surface of the frozen sheet from a blower similar to that shown at 38 in Fig. 2, but located in substantially the position of the squeeze rolls.

The metering or pouring box 10 illustrates suitable means adapted to uniformly feed the metal to be shaped on to the surface of the fluid bath. To this end, the pouring box 10 is divided into upper and lower sections 20 and 21 respectively by an apertured partition 22. By maintaining a substantially constant level of molten metal in the upper section 20, the aperture 23 of the partition 22 feeds the molten metal at a substantially uniform rate into the lower section 21 of the pouring box and from thence the metal flows under a skimming dam 24 to a pouring lip 25. The dam 24 is one example of suitable means for smoothing out such turbulence or ripples in the molten metal as may be caused by the flow of the metal from the upper section of the box into the lower section and for holding back the dross. The lip 25 is shown immersed in the metal of the bath and is effective for directing a uniformly smooth flow of molten metal on to the surface of the bath.

As the molten metal flows over the pouring lip 25 and contacts the surface 11 of the fluid bath, freezing tends to occur sooner at the interface or points of impingement of the metals than at that portion of the cast metal away from the interface, i. e. the upper surface, depending upon the thickness of the cast metal and the relative differences of temperature between the bath and other media in contact with the surfaces of the metal.

It is desirable, therefore, to provide means for controlling the dissipation of heat from the respective surfaces of the cast metal so that the freezing, and in particular the initial freezing, at the interface is retarded and maintained at a rate which permits freezing of the upper surface prior to complete freezing upwardly through the cast metal from the interface. It is also desirable that the freezing continue uniformly from the advanced portion of the cast sheet rearwardly to the pouring lip so as to preclude the formation of intermediate frozen portions or frozen "islands" in the sheet which would give rise to shrinkage defects in the surface of the sheet. In these respects it may be emphasized that the regulation of the dissipation of heat from the surfaces of the cast metal need not necessarily be continued throughout the entire time required for complete solidification of the strip for it has been found that once the outer surfaces of the metal have frozen, the subsequent solidification inwardly may proceed at its own pace without the occurrence of shrinkage cavities or other defects on the outer surfaces. Hence, as hereinafter described, the heat dissipation controlling means are located substantially adjacent the initial point of impingement of the cast metal on the fluid bath, but it will be clear that these means may extend over a substantial length of the bath if desirable.

One example of the means employed to retard the cooling of the edges of the cast sheet and simultaneously to displace the metal sheet as it is formed comprises the endless chains 27 shown in Figs. 2 and 4, which are suitably driven through gears 28 and shafts 29 from some suitable source of power (not shown). The chain comprises a plurality of independently mounted substantially vertical metal plates 30 (see Fig. 4), which are advanced in the direction shown by the arrow in Fig. 3, each plate being faced with a suitable plate or block 31 composed of a substance having low heat conductivity and comprising engaging means for engaging and limiting the margins of the cast metal. The latter flows from the lip 25 of the pouring box into engagement with the heat insulating blocks 31 of the endless chain which displace the strip of metal over the surface of the bath, the metal gradually solidifying substantially throughout its thickness. The use of the facing blocks of low heat conductivity greatly retards the dissipation of heat from the edges of the cast metal sheet and contributes toward a more uniformly controlled cooling of the surfaces of the metal sheet.

Because the sheet being formed is of necessity at a higher temperature than the temperature of the bath, it is evident that the molten bath will absorb heat from the cast metal and therefore the bath must be cooled or so designed that the proper temperature differential will be maintained. This may be done in any one of several ways, as, for example, the fluid bath material may be drawn into the pipe 33 (see Fig. 2) and passed through a suitable cooler 14. A pump 13 may be employed to return the bath fluid toward the container 12 at a temperature such that the metal sheet will properly freeze on the surface of the bath.

One means of controlling the initial freezing or rate of heat exchange at the interface of the lower surface of the cast metal and the fluid bath is to provide a baffle plate 35 immersed in the bath and adjacent the pouring lip 25 of the pouring box. Insofar as the baffle restricts the circulation of the bath metal in this localized area, the

cooling caused by circulation is counteracted and hence that restricted area of the bath metal adjacent the point of impingement of the metal and the bath is maintained at a substantially higher temperature than the temperature of the remaining portion of the bath. The length of the baffle relative to the length of the metal is substantially in the proportions shown and is such as to provide a localized area of relatively high temperature sufficient to retard the initial freezing of the lower surface of the cast metal as it is fed on to the fluid bath so that the dissipation of heat from the lower surface and upper surface may be held at substantially the same rate. Although the baffle shown comprises a steel plate, it will be clear that the baffle may take other forms and may be made of other suitable materials. It may be observed too that, in addition to its function as means for localizing the heat of the bath, the baffle also dampens and smooths out the surface ripples of the bath.

Suitable means are also provided for controlling the dissipation of heat from the upper surface of the cast metal. Referring to Fig. 2, **36** is a suitable heat absorber comprising a hollow block adapted to be continuously cooled by water which may be circulated through the block and the cooler **16** by a pump **15** and suitable pipe connections. The block **36** may be supported between the endless chains **27** as shown in Fig. 3 in the localized area of the baffle **35** with its lower surface **27** immediately above the surface of the bath. As the cast metal flows on to the bath from the pouring lip **25** and is moved forwardly by the endless engaging means **31**, the upper surface of the cast metal passes immediately beneath the relatively cool surface **37** whereby the removal or dissipation of heat from the upper surface of the cast metal is accelerated. By regulating the cooling effect of the heat absorber **36**, the initial rate of cooling of the upper surface of the cast metal may thus be accelerated to approach the initial rate of cooling of the lower surface.

The heat absorber or water jacket **36**, shown in Fig. 2, is a hollow block, but it will be clear that the absorber may comprise spaced lengths of tubing or have other conventional radiator constructions, and that any suitable fluid may be circulated instead of water.

It is also possible to control the dissipation of heat from the upper surface of the cast metal by sweeping the upper surface with a flow of relatively cool air or gas. To this end a blower **38** having suitable drive means **39**, diagrammatically illustrated in Fig. 2, is suitably supported in a casing **40**, which comprises a substantially hermetically sealed hood arranged to maintain an atmosphere of air or other suitable gas in contact with the surface of the metal bath and cast metal sheet. Suitable cooling means **41** may be used to cool the recirculated gas and a duct **42** is provided for directing the recirculated gas over the upper surface of the cast sheet. The location of the duct **42** is consistent with the use of a heat absorber of the type shown, but it will be clear that by using a radiator type absorber, a vertical down draft of air may be directed through the tubes of the radiator on to the upper surface of the cast sheet. An additional cooling means augmenting the cooling effect of the draft of cool air or gas may be the use of a suitable spray nozzle **420** located in the mouth of the duct **42** and supplied with a cooled fluid, such as water, which is adapted to be atomized by the draft of air to form a cool mist over the surface of the cast metal sheet. With this construction, the cooling effect of the water jacketed surface **37** and the cool draft of gas or mist may supplement each other or may be used independently of each other.

Suitable means for automatically regulating the cooling effect of the heat absorber and cooling draft and the heating effect of the baffle relative to the respective upper and lower surfaces of the cast metal, whereby the initial dissipation of heat from these surfaces may be maintained substantially equivalent, may comprise any well-known type of heat responsive device such as the pyrometers shown at **45** and **46** (see Fig. 5) suitably located adjacent the upper and lower surfaces respectively of the cast metal sheet. The pyrometers may be connected in any conventional manner to a suitable power controlling device for automatically regulating the speed of operation of the pumps of the respective circulated cooling media.

In Fig. 6 is shown an alternative form of metal bath cooling means which may be used instead of that shown in Fig. 2. This modification comprises a temperature control system embodying the use of a suitable heat responsive device such as a thermo-couple **47** suitably immersed in a fluid bath adjacent the pouring lip **35**. The thermo-couple is arranged to control means such as a pyrometer control at **48**, a power control **49**, and a motor **50**, diagrammatically shown in Fig. 6, which automatically regulate the speed of operation of the bath circulating pump **51**. The latter is shown provided with a duct **52** immersed in the bath for delivering the cooled fluid metal adjacent the upper surface of the bath. Thus, as the temperature of the bath adjacent the thermo-couple drops, due to too rapid circulation, the thermo-couple automatically reduces the speed of operation of the pump, which in turn reduces the rate of circulation or cooling of the bath. Similarly, if the temperature of the bath tends to rise too high for ideal operating conditions, the thermo-couple automatically reduces the cooling of the bath. In this modified apparatus, the thermo-couple **47** may also act in conjunction with the pyrometer **45** of Fig. 5, to automatically maintain substantially equivalent rates of cooling of the upper and lower surfaces of the metal bath.

By the invention disclosed herein, metal sheets cast upon a fluid bath may be produced having substantially smooth surfaces and edges free from shrinkage cavities or dendritic-like structure, thus greatly enhancing the value of the product. As this is the first time that a satisfactory method and apparatus have been developed for such purpose, the invention is not limited to the details disclosed but is to be construed as broadly covering all equivalent devices and processes falling within the scope of the appended claims.

What is claimed is:

1. Apparatus for the casting of metal by floating said metal upon a fluid immiscible with said metal comprising a substantially stationary fluid bath container to form a planar surface fluid bath, a fluid in said container, means for regulating the exchange of heat between said metal and the media in contact therewith, said means comprising devices for sustaining the heat at a localized area of said fluid, and means for cooling the atmosphere above and adjacent said metal.

2. Apparatus for the casting of metal by float-

ing said metal upon a fluid immiscible with said metal comprising a substantially stationary fluid bath container to form a planar surface fluid bath, a fluid in said container, means for regulating the exchange of heat between said metal and the media in contact therewith, said means comprising a heat exchange retarding device for sustaining the heat at a localized area of said fluid, and heat exchange accelerating means for cooling the atmosphere above and adjacent said metal.

3. Apparatus for the casting of metal by floating the metal upon a fluid substantially immiscible with said metal comprising means immersed in said fluid adapted to retard the rate of heat exchange between said metal and said fluid.

4. Apparatus for the casting of metal by floating the metal upon a fluid substantially immiscible with said metal comprising means immersed in said fluid adapted to control the rate of heat exchange between said metal and said fluid.

5. Apparatus for the casting of metal by floating the metal upon a fluid immiscible with said metal comprising means immersed in said fluid adapted to provide a localized area of higher temperature than other portions of the fluid, thereby retarding the rate of heat exchange between said metal and said fluid.

6. Apparatus for the casting of metal by floating the metal upon a fluid immiscible with said metal comprising means immersed in said fluid adapted to obstruct the circulation of said fluid thereby retarding the rate of heat exchange between said metal and said fluid.

7. Apparatus for the casting of metal by floating the metal upon a fluid substantially immiscible with said metal comprising means immersed in said fluid adapted to retard the rate of heat exchange between said metal and said fluid, and means to accelerate the dissipation of heat from the upper surface of said metal.

8. Apparatus for the casting of metal by floating the metal upon a fluid substantially immiscible with said metal comprising means immersed in said fluid adapted to control the rate of heat exchange between said metal and said fluid, and means to control the dissipation of heat from the upper surface of said metal.

9. Apparatus for the casting of metal by floating said metal upon a fluid substantially immiscible with said metal, comprising a cooled surface supported above said metal for cooling the atmosphere, thereby accelerating the dissipation of heat from the upper surface of said metal.

10. Apparatus for the casting of metal by floating said metal upon a fluid substantially immiscible with said metal, comprising the combination of a cooled surface supported above said metal, and blower means for moving air across said cooled surface, thereby accelerating the dissipation of heat from the upper surface of said metal.

11. Apparatus for the casting of metal for floating said metal upon a fluid substantially immiscible with said metal, comprising means immersed in said fluid adapted to provide a localized area of higher temperature than other portions of the fluid, thereby retarding the rate of heat exchange between said metal and said fluid; and means supported above said metal for cooling the atmosphere, thereby accelerating the dissipation of heat from the upper surface of said metal.

12. Apparatus for the casting of metal by floating said metal upon a fluid immiscible with said metal including means for displacing the metal, comprising elements of low heat conductivity contacting the margins of said metal.

13. Apparatus for the casting of metal by floating said metal upon a fluid immiscible with said metal including means for moving the metal over the surface of said fluid, comprising elements of low heat conductivity contacting the edges of said metal and simultaneously limiting the width thereof.

14. Apparatus for the casting of metal by floating said metal upon a metal bath immiscible with the metal to be cast, comprising means for displacing the cast metal and means to remove the bath metal from the displaced metal while said bath metal is in a fluid condition.

15. Apparatus for the casting of metal by floating said metal upon a metal bath immiscible with the metal to be cast, comprising means for moving the cast metal over the surface of said bath, and squeezing means to remove the bath metal from the moving cast metal while said bath metal is in a fluid condition.

16. Apparatus for the casting of metal by floating said metal upon a metal bath immiscible with the metal to be cast, comprising means for moving the cast metal over the surface of said bath, and heated means to remove the bath metal from the moving cast metal while said bath metal is in a fluid condition.

17. Apparatus for the casting of metal by floating said metal upon a metal bath immiscible with the metal to be cast, comprising means for moving the cast metal over the surface of said bath, and heated squeeze rolls to remove the bath metal from the moving cast metal while said bath metal is in a fluid condition.

18. Apparatus for the casting of metal by floating said metal upon a fluid substantially immiscible with said metal, comprising means adapted to feed the metal on to the surface of said fluid, said means comprising a pouring box having a pouring lip immersed in said fluid to uniformly feed the metal on to the surface of the fluid.

19. In an apparatus for casting metal sheets directly from molten metal, the combination comprising: a substantially stationary molten metal bath container to form a planar surface molten metal bath, a molten metal in said container, the metal of the bath being substantially immiscible with and having a lower melting point than the molten metal; means to feed the molten metal into contact with the metal bath so that the freezing will occur at the interface of the two metals; and means to retard the rate of heat exchange between the lower surface of the molten metal and the upper surface of the bath.

20. In an apparatus for casting metal sheets directly from molten metal, the combination comprising: a metal bath, the metal of the bath being substantially immiscible with and having a lower melting point than the molten metal; a pouring box to uniformly feed the molten metal into contact with the metal bath so that the freezing will occur at the interface of the two metals; means immersed in said metal bath adjacent said box to retard the rate of heat exchange between the lower surface of the molten metal and the metal bath; and means to displace the at least partially frozen sheet of molten metal.

21. In an apparatus for casting metal sheets directly from molten metal, the combination comprising: a stationary metal bath, the metal of the bath being substantially immiscible with and having a lower melting point than the molten

metal; a pouring box having a lip to feed the molten metal into contact with the molten metal bath so that the freezing will occur uniformly at the interface of the two metals; means to circulate the metal of said bath; a baffle immersed in said metal bath adjacent said lip and relatively close to the underside of the molten metal to restrict the circulation of the bath metal and thereby to retard the rate of heat exchange between the lower surface of the molten metal and the metal bath; means to displace the at least partially frozen sheet of molten metal; and means to remove fluid bath metal from said sheet.

22. In an apparatus for casting metal sheets directly from molten metal, the combination comprising: a metal bath, the molten metal of the bath being substantially immiscible with and having a lower melting point than the molten metal; a pouring box having a lip to feed the molten metal into contact with the metal bath so that the freezing will occur uniformly at the interface of the two metals; means to circulate the metal of said bath; heat responsive means immersed in said metal bath adjacent said pouring lip; means responsive to said heat responsive means to control the operation of said circulating means and thereby to retard the rate of heat exchange between the lower surface of the molten metal and the metal bath; means to displace the at least partially frozen sheet of molten metal; and heated means to squeeze fluid bath metal from said sheet.

23. In an apparatus for casting metal sheets directly from molten metal, the combination comprising: a metal bath, the metal of the bath being substantially immiscible with and having a lower melting point than the molten metal; means immersed in said bath to feed the molten metal into contact with the metal bath so that the freezing will occur at the interface of the two metals; and means to control the dissipation of heat from the upper surface of the molten metal.

24. In an apparatus for casting metal sheets directly from molten metal, the combination comprising: a metal bath, the metal of the bath being substantially immiscible with and having a lower melting point than the molten metal; means immersed in said bath to feed the molten metal into contact with the metal bath so that the freezing will occur at the interface of the two metals; cooling means to accelerate the dissipation of heat from the upper surface of the molten metal; and means to displace the at least partially frozen sheet of molten metal.

25. In an apparatus for casting metal sheets directly from molten metal, the combination comprising: a metal bath, the metal of the bath being substantially immiscible with and having a lower melting point than the molten metal; means to feed the molten metal into contact with the metal bath so that the freezing will occur at the interface of the two metals; cooling means comprising a fluid cooled surface supported above the upper surface of the molten metal to accelerate the dissipation of heat from the upper surface of said metal; and means to displace the at least partially frozen sheet of molten metal.

26. In an apparatus for casting metal sheets directly from molten metal, the combination comprising: a metal bath, the metal of the bath being substantially immiscible with and having a lower melting point than the molten metal; means to feed the molten metal into contact with the metal bath so that the freezing will occur at the interface of the two metals; means to maintain a cooled atmosphere over the upper surface of the molten metal to accelerate the dissipation of heat from the upper surface of said metal; means to displace the at least partially frozen sheet of molten metal; and means to remove fluid bath metal from said sheet.

27. In an apparatus for casting metal sheets directly from molten metal, the combination comprising: a metal bath, the metal of the bath being substantially immiscible with and having a lower melting point than the molten metal; a pouring box having a lip immersed in said bath to feed the molten metal into contact with the metal bath so that the freezing will occur uniformly at the interface of the two metals; means to maintain a cooling gas over the upper surface of the molten metal; a blower for moving the gas over said surface; gas cooling means comprising a fluid cooled surface supported above the upper surface of the molten metal to accelerate the cooling of the upper surface of said metal; means to displace the at least partially frozen sheet; and heated means to squeeze fluid bath metal from said sheet.

28. In an apparatus for casting metal sheets directly from molten metal, the combination comprising: a metal bath, the metal of the bath being substantially immiscible with and having a lower melting point than the molten metal; means to feed the molten metal into contact with the metal bath so that the freezing will occur at the interface of the two metals; and means for displacing the partially frozen molten metal comprising elements of low heat conductivity contacting the margins of said molten metal.

29. In an apparatus for casting metal sheets directly from molten metal, the combination comprising: a metal bath, the metal of the bath being substantially immiscible with and having a lower melting point than the molten metal; means to feed the molten metal into contact with the metal bath so that the freezing will occur at the interface of the two metals; means for moving the partially frozen molten metal over the surface of said bath comprising elements of low heat conductivity contacting the edges of the partially frozen metal to retard the dissipation of heat from the edges of said metal; and means to remove fluid bath metal from the at least partially frozen sheet.

30. In an apparatus for casting metal sheets directly from molten metal, the combination comprising: a metal bath, the molten metal of the bath being substantially immiscible with and having a lower melting point than the molten metal; a pouring box having a pouring lip immersed in said bath to feed the molten metal into contact with the metal bath so that the freezing will occur at the interface of the two metals; means including two endless chains having engaging means for moving the partially frozen sheet of molten metal along the surface of the metal bath, said engaging means comprising heat insulating blocks contacting the opposite edges of the sheet being formed to retard the cooling of the edges of said sheet; and heated means to squeeze fluid bath metal from the at least partially frozen sheet.

31. In an apparatus for casting metal sheets directly from molten metal, the combination comprising: a substantially stationary molten metal bath container to form a planar surface molten metal bath, a molten metal in said container, the metal of the bath being substantially im-

miscible with and having a lower melting point than the molten metal; means to feed the molten metal into contact with the metal bath so that the freezing will occur at the interface of the two metals; means to control the rate of heat exchange between the lower surface of the molten metal and the metal bath; means to control the dissipation of heat from the upper surface of the molten metal being shaped; and means to displace the at least partially frozen sheet.

32. In an apparatus for casting metal sheets directly from molten metal, the combination comprising: a metal bath, the metal of the bath being substantially immiscible with and having a lower melting point than the molten metal; a pouring box having a pouring lip immersed in said bath to uniformly feed the molten metal into contact with the metal bath so that the freezing will occur at the interface of the two metals; a baffle immersed in said metal bath adjacent said lip to retard the rate of heat exchange between the lower surface of the molten metal and the metal bath; cooling means comprising a fluid cooled surface supported above the upper surface of the molten metal to cool the atmosphere in contact therewith, thereby accelerating the dissipation of heat from said surface; means to displace the partially frozen metal sheet comprising elements of low heat conductivity engaging the edges of the sheet; and means comprising heated rolls to squeeze fluid bath metal from the partially frozen sheet.

33. In the manufacture of metal articles directly from molten metal, the process comprising the steps of providing a bath of metal substantially immiscible with the molten metal to be formed, feeding the molten metal into contact with the metal bath, and maintaining the rates of heat exchange which exist between the surfaces of the molten metal and the media in contact therewith substantially equal.

34. In the manufacture of metal articles directly from molten metal, the process comprising the steps of providing a bath of metal substantially immiscible with the molten metal to be formed, feeding the molten metal uniformly into contact with the metal bath, retarding the cooling of the lower surface of the molten metal by sustaining the heat at a localized area of said metal bath so that said lower surface cools off at substantially the same rate as the upper surface of said molten metal, and then continuously displacing the partially frozen molten metal from the bath.

35. In the manufacture of metal articles directly from molten metal, the process comprising the steps of providing a bath of metal substantially immiscible with the molten metal to be formed, feeding the molten metal uniformly into contact with the metal bath, accelerating the cooling of the upper surface of the molten metal so that said upper surface cools off at substantially the same rate as the lower surface, and then continuously displacing the partially frozen molten metal from the bath.

36. In the manufacture of metal articles directly from molten metal, the process comprising the steps of providing a bath of metal substantially immiscible with the molten metal to be formed, uniformly feeding the molten metal into contact with the metal bath, circulating the bath metal, retarding the circulation of the metal bath locally so that the lower surface of the molten metal cools off at substantially the same rate as the upper surface of said molten metal, and then continuously removing the partially frozen molten metal from contact with the bath.

37. In the manufacture of metal articles directly from molten metal, the process comprising the steps of providing a bath of metal substantially immiscible with the molten metal to be formed, uniformly feeding the molten metal into contact with the metal bath, maintaining a draft of relatively cool gas over the upper surface of the molten metal so that the upper surface of said metal cools off at substantially the same rate as the lower surface of said metal, and then continuously removing the partially frozen metal from contact with the bath.

38. In the manufacture of metal sheets directly from molten metal, the process comprising the steps of providing a bath of metal substantially immiscible with and having a lower melting point than the metal to be formed into sheets, uniformly feeding the molten metal into contact with the metal bath, accelerating the cooling of the upper surface of the partially frozen molten metal by flowing a relatively cool fluid over said surface, circulating the bath metal, retarding the cooling of the lower surface of said partially frozen sheet by locally restricting the circulation of the metal bath whereby the respective upper and lower surfaces cool off at substantially the same rate, and then continuously squeezing fluid bath metal from the partially frozen metal.

39. Apparatus for the casting of metal by floating said metal upon a fluid immiscible with said metal, comprising means for maintaining substantially uniform rates of heat exchange between the surfaces of said metal and the media in contact therewith.

40. Apparatus for the casting of metal by floating said metal upon a fluid immiscible with said metal, comprising means adjacent the surfaces of said metal for maintaining the rates of heat dissipation from the surfaces of said metal substantially equivalent.

41. Apparatus for the casting of metal by floating said metal upon a fluid immiscible with said metal, comprising heat responsive devices adjacent the upper and lower surfaces of said metal, and means responsive to said devices for automatically maintaining the rates of heat dissipation from said surfaces substantially equivalent.

42. In an apparatus for casting metal sheets directly from molten metal, the combination comprising: a metal bath, the metal of the bath being substantially immiscible with and having a lower melting point than the molten metal; means to direct the two metals into contact with each other; and means for maintaining substantially uniform rates of heat exchange between the surfaces of said molten metal and the media in contact therewith.

43. In an apparatus for casting metal sheets directly from molten metal, the combination comprising: a metal bath, the metal of the bath being substantially immiscible with and having a lower melting point than the molten metal; means to direct the two metals into contact with each other; heat responsive devices adjacent the upper and lower surfaces of said molten metal; and means responsive to said heat responsive devices for automatically maintaining the rates of heat dissipation from said surfaces substantially equivalent.

CHARLES D. COXE.