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Battiston et al.

[11] **3,858,642**

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[54] **APPARATUS FOR DELIVERING METAL TO A ROTATING CONTINUOUS CASTING DRUM**

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[73] Assignee: **Cominco Ltd.,** British Columbia, Canada

[22] Filed: **June 5, 1973**

[21] Appl. No.: **367,143**

[30] **Foreign Application Priority Data**

Oct. 31, 1972 Canada 155736

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[51] **Int. Cl.** **B22d 11/06**

[58] **Field of Search** 164/87, 276; 425/224; 264/212, 216; 137/563, 573, 574, 577

[56] **References Cited**

UNITED STATES PATENTS

993,904	5/1911	Strange	164/276
1,082,287	12/1913	Schaffer et al.	137/563

FOREIGN PATENTS OR APPLICATIONS

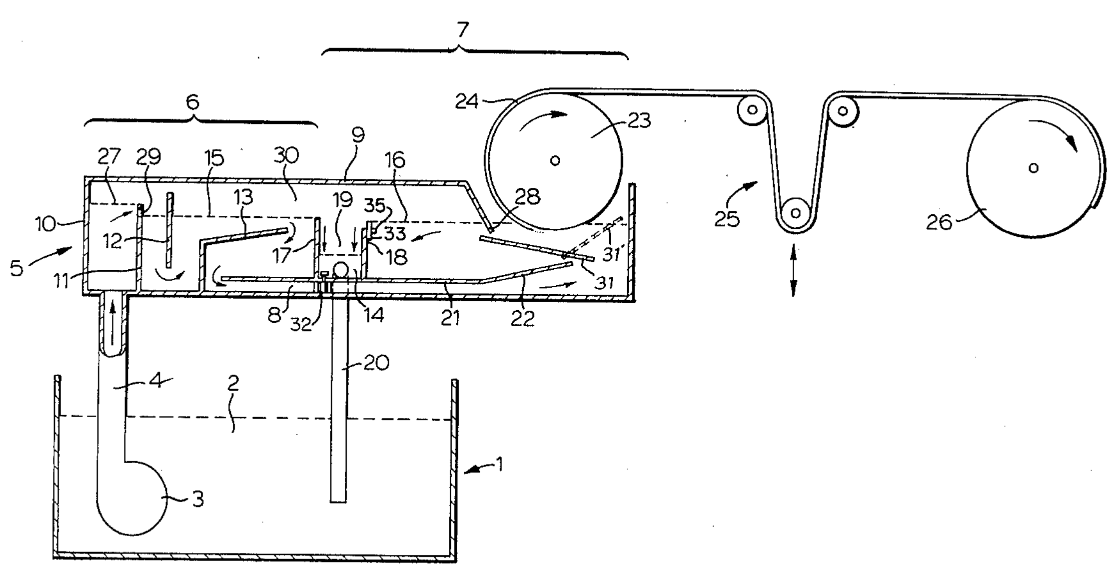
674,691	4/1939	Germany	164/276
711,133	9/1941	Germany	164/276

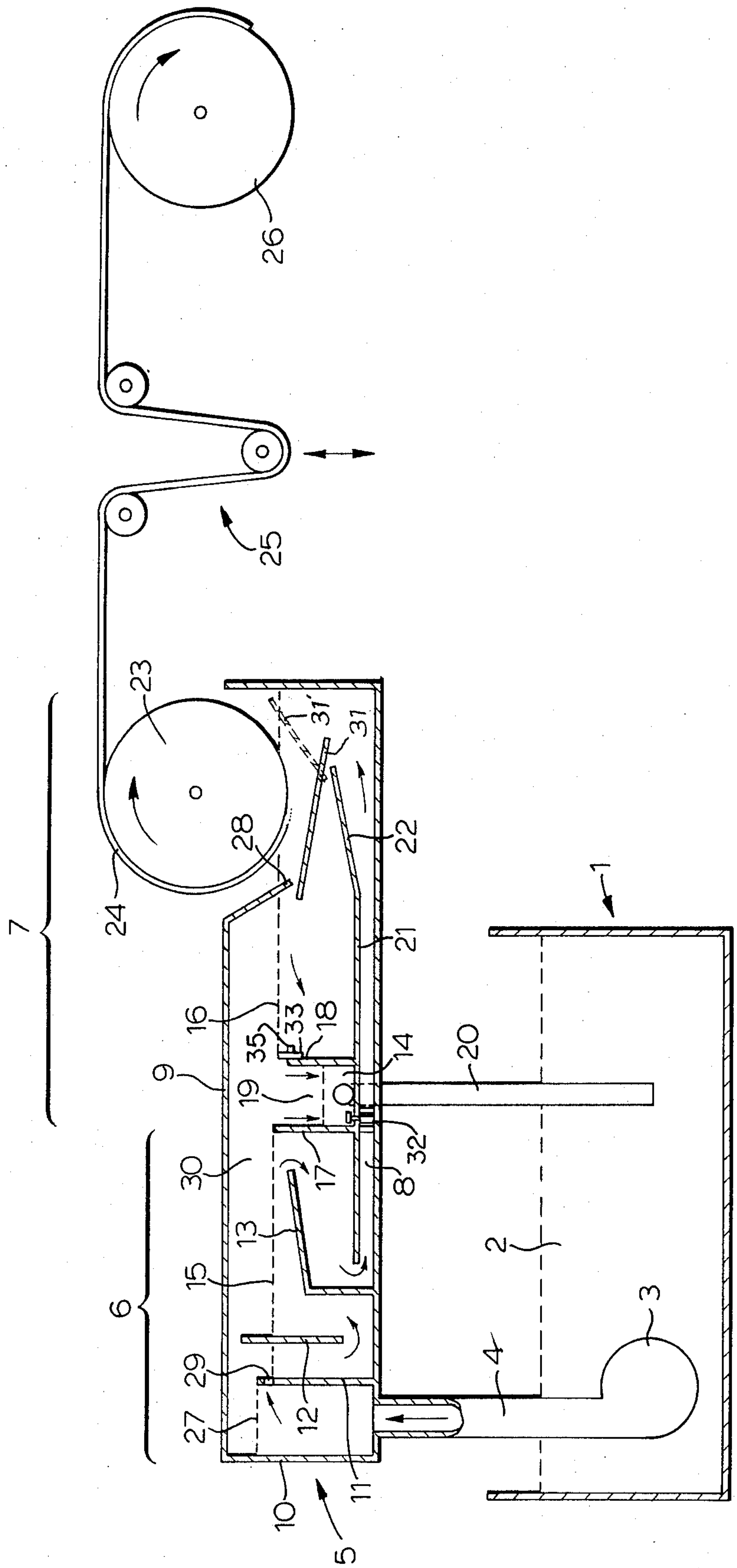
Primary Examiner—Andrew R. Juhasz
Assistant Examiner—John E. Roethel

[57] **ABSTRACT**

A method and apparatus for drum casting metal strips from a molten metal such as lead containing reactive alloying additives. The apparatus comprises a feed trough having a system of holding and casting sections, weirs, baffles, and conduits for providing a controlled flow of molten metal of uniform temperature to a quiescent bath of said molten metal, free of entrained gas bubbles, in a drum casting zone.

8 Claims, 1 Drawing Figure

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APPARATUS FOR DELIVERING METAL TO A ROTATING CONTINUOUS CASTING DRUM

BACKGROUND OF THE INVENTION

This invention relates to a method and apparatus for casting metal strips from a molten metal and more particularly relates to a method and apparatus for the continuous casting of metal strips from a reactive molten metal alloy.

Conventional casting drum equipment used as a component in the method and apparatus of the present invention is described in Canadian Patent No. 396,499. This equipment has long been used for the continuous casting of sheet from relatively inert molten lead which does not require protection against drossing as compared to the casting of lead alloys which may contain reactive metal additives. Reactive alloys, such as lead-calcium and lead-lithium alloys, are becoming increasingly significant in the manufacture of lead storage battery grids and, because of the exceptional reactivity of additives such as calcium and lithium with oxygen to form dross, considerable care must be taken to keep the molten alloys from being exposed to oxygen. Formation of this dross is undesirable in that the dross tends to become entrapped in the metal that forms the grids and subsequently adversely affects the physical and electro-chemical properties of the grids. Also, dross formation is undesirable in that it causes depletion of the reactive metal additive in solidified alloy.

It has been found that lead-calcium alloy cannot be handled satisfactorily in a conventional book-mold type grid casting machine because of drossing due to its reactivity, of its lack of fluidity during casting and of its lack of tensile strength immediately after casting. Although lead-calcium alloy becomes stronger through aging, the grids are very difficult to handle immediately after casting, and poor castability and weak strength characteristics dictate the production of thick grids and the use of an inert atmosphere. Such alloy can be handled more readily by known continuous casting procedures.

Continuous drum casting of battery grids is disclosed in U.S. Pat. No. 3,455,371. Excess molten metal is fed to a throat region adjacent to the descending periphery of a rotating drum where a portion of the metal is wiped into cavities formed between a shaped surface on the drum and a continuous belt to form a continuous strip of battery grids. Excess metal flows to the edges of the throat region to be returned through funnels and a conduit to a melting pot. In the handling of reactive lead alloy, formation and entrapment of dross would occur in the throat region.

U.S. Pat. No. 2,074,812 discloses a process in which a drum rotates in a bath of molten metal in a covered chamber, dross being excluded from the metal within the chamber by a submerged partition. Bath level control is not provided for or disclosed in this patent.

U.S. Pat. No. 3,228,072 discloses a method of casting between moving belts in which numerous grooves leading from a pouring box provide non-turbulent flow of molten metal with uniform distribution across the width of the lower belt. Metal flows under a lateral baffle in front of the grooves into a pool at the entrance of a casting region defined by the converging belts. The distribution method maintains a layer of cooler metal on the lower belt, thereby preventing warping. In order to pass through the numerous grooves, the molten metal must be sufficiently above melting temperature to prevent freezing. The temperature differential in the casting region would cause irregularities in drum cast sheet.

SUMMARY OF THE INVENTION

I have discovered a method and apparatus which will substantially obviate the foregoing disadvantages of existing casting equipment by re-cycling reactive molten metal alloy under substantially inert conditions to provide a controlled and uniform bath temperature, and by supplying the molten metal to a casting drum as a low-dross constant-level quiescent bath. In accordance with a preferred embodiment of my invention, I provide an apparatus for delivery of molten metal to and maintenance of a quiescent pool of said molten metal at the peripheral surface of a rotating drum dipping in said pool for casting of said metal on the drum, said apparatus comprising a substantially rectangular trough, inlet means for introducing molten metal from a reservoir and outlet means for return of excess molten metal to said reservoir, said trough having a holding section and a casting section, first and second opposed spaced-apart weirs mounted on adjacent internal walls of said holding and casting sections, said first weir adapted to discharge molten metal from the holding section and said second weir adapted to discharge molten metal from the casting section, means for adjusting the heights of said weirs relative to each other, a channel beneath said internal walls communicating said holding section with said casting section, baffle means disposed within said holding section to evenly distribute incoming molten metal across the holding section, a plate defining the upper face of said channel and extending into said casting section, the part of said plate that extends into said casting section being sloped upwardly, and an immersed baffle between said drum and said second weir. Surges in the flow of incoming metal passing through said holding section are dampened by discharge of waves over the first weir. Molten metal flows at a uniform rate through the channel to rise under the upwardly sloping part of the plate into the quiescent pool. Excess metal that is not removed by the drum passes under the immersed baffle to flow over the second weir. The weirs, internal walls, channel, baffle means, plate and immersed baffle extend transversely across the width of the trough. The weirs, internal walls, baffle means and plate are thermally conductive to promote temperature stabilization of the molten metal as it moves through the trough.

It is a principal object of the present invention therefore to provide, by controlled uniform flow, a constant-level, quiescent bath of low-dross molten metal for drum casting of metal strip and sheet.

It is also a principal object of the invention to maintain the molten metal in the casting zone at a uniform temperature.

It is another object of the present invention to make improved cast strip or sheet of lead alloyed with a reactive metal such as calcium or lithium.

It is a further object of the invention to provide an improved molten metal feeding trough apparatus for the production of cast metal sheet having improved uniformity of composition, texture and thickness.

And, it is a further object of the invention to provide a feeding trough within which there is essential inert atmosphere protection of reactive molten metal alloy without restricting access to the casting drum.

BRIEF DESCRIPTION OF THE DRAWING

These and other objects of the invention, and the manner in which they are attained, will become evident from the following description of the method and apparatus illustrated in the drawing, in which:

The FIGURE shows schematically the method and apparatus of the invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

A lead-base alloy is prepared for casting in a suitable heated reservoir **1** by melting 99.99+percent pure lead into which is alloyed the prescribed amount of an additive such as elemental calcium or lead-calcium master alloy. Although the description of the method and apparatus of the present invention will proceed with reference to the casting of a lead-calcium alloy, it will be understood lead-calcium alloy is illustrative only of the reactive alloys that can be cast into strip or sheet by the present invention and the specification and claims are not to be construed as limited thereto. Molten metal alloy **2** in heated reservoir **1** is protected from oxidation by an inert gas cover such as nitrogen or by a floating reductant (not shown). The molten alloy is conveyed through a closed system comprising pump **3** and conduit **4** to feeding trough **5** which comprises a holding section **6** and a casting section **7.** The holding section and part of the casting section are enclosed throughout the casting of reactive metal alloy to form a chamber **30** within which the flow and levels of the molten metal are controlled under an inert gas cover. In the remaining part of casting section **7** the molten metal surface is exposed to air during start-up of operations.

In holding section **6,** a combination of baffles and a weir is used to control the rate and pattern of metal flow through adjustable channel **8** into casting section **7.** Holding section **6** comprises feed gallery **10** with inner wall **11,** partially submerged baffle **12,** and inclined baffle **13.** Levels of molten alloy in the holding and casting sections, shown by broken lines **15** and **16** respectively, are controlled by the relative heights of opposed spaced-apart overflow weirs **17** and **18** that are mounted on adjacent internal walls of the holding and casting sections. Flowing metal in excess of that which is removed by casting passes under immersed baffle **28** and over weir **18** into overflow compartment **19** between weirs **17** and **18** and returns to reservoir **1** through conduit **20.** Plate **21** defines the upper face of channel **8** and has a sloping portion **22** extending into casting section **7.** Weirs **17** and **18,** overflow compartment **19,** conduit **20** and plate **21** are shown as parts of a unit **14** which may be adjusted vertically, such as by spacers and threaded mounting bolts designated by numeral **32.** Also, weirs **17** and **18** preferably are mounted for adjustment relative to each other, for example, by means of a vertically adjustable lip **33,** shown attached to weir **17** by threaded mounting bolts **35** to control the relative heights of levels **15** and **16** for reasons which will become apparent as the description proceeds. Rotating casting drum **23,** which is internally water-cooled, is immersed in molten metal in the casting section to a depth that is sufficient to permit adhesion on its peripheral face of a layer of solidified metal sheet **24.** On separating from the drum, sheet **24** advances to tensioning device **25** and take-up roll **26.** Holding section **6** and a part of casting section **7** that is adjacent overflow weir **18** are enclosed by cover **9,** thereby forming control chamber **30.**

As indicated by the arrows, molten metal flows into feed gallery **10,** through laterally spaced holes near the top of wall **11** and under submerged baffle **12** to rise over inclined baffle **13.** Volumetric surges together with a regular portion of the molten metal flow over weir **17,** to return to heated reservoir **1,** to permit the main stream of the metal to flow at a uniform rate to the casting section. This metal flows downward, through channel **8,** and rises at decreased linear velocity as the sectional area increases below sloping extension **22** to fill casting section **7** to a level determined by the height of overflow weir **18.** Part of the molten metal entering casting section **7** is removed by rotating drum **23,** the balance flowing over weir **18** and returning to heated reservoir **1.**

A flow of inert gas through the space below cover **9** and above the molten bath provides protection against oxidation of the molten metal within holding section **6.** During start-up of the operation, the exposed portion of molten metal surface **16** in the zone immediately adjacent drum **23** is not protected against oxidation. This arrangement permits convenient access to the drum for necessary handling of sheet **24** as it begins to form. After continuous operation is established, a protective cover (not shown) may be placed over the casting section.

Since the cross section of feed gallery **10** is much greater than that of conduit **4,** velocity and turbulence of the flowing metal are decreased as the metal arises. The height of wall **11** permits the metal in feed gallery **10** to rise to a level **27** which is higher than level **15.** Further absorption of flow fluctuations due, for example, to pumping, occurs as the molten metal flows through horizontally disposed holes in the upper part of wall **11** between bath heights **15** and **27,** as designated by numeral **29.** These holes may provide an equal distribution of metal flow across the width of the trough, or spacing between these holes may be adjusted to provide a lateral differential in the flow that compensates for heat loss through the side walls of the trough. Relatively rapid descent and rise of the flowing metal through a somewhat narrowed channel surrounding submerged baffle **12** promotes the separation of dross that may be present in the molten metal in reservoir **1.** This dross rises readily to the surface as the flowing metal approaches weir **17.** If surges in metal delivery develop, waves will be set up on the part of molten surface **15** that is immediately in front of weir **17.** Inclined baffle **13** directs any such waves and accumulated dross over weir **17,** leaving the lead flowing through the remainder of the system substantially free of dross and unaffected by the surges. In order that metal may flow through to casting section **7,** the height of weir **17** cannot be lower than that of weir **18.** Preferably, weir **17** is slightly higher than weir **18,** thereby directing a greater proportion of the flow to the casting section.

The internal structures of the trough help to maintain uniform temperature and uniform flow of the molten metal. Stabilization of the temperature of the flowing metal is promoted in the relatively large portion of holding section **6** that is below inclined baffle **13.** Extension of plate **21** into this part of section **6** provides an indirect flow path that helps temperature stabilization.

Coarse adjustments of metal flow to the casting section are made by vertical movement of the plate **21** to vary the height of channel **8.** Molten metal from channel **8** moves horizontally across the bottom of the expanded zone beneath inclined portion **22** and rises in a uniform flow, providing steady, non-turbulent entry and passage through casting section **7.** Direct flow of surface metal to overflow weir **18** is prevented by immersed baffle **28,** an extension of cover **9.** Molten metal surrounding immersed baffle **28** provides a seal between the atmosphere on the drum side and the inert-gas-filled chamber **30** in which control of levels and flows is maintained. The quiescent upward movement of the whole cross section of molten metal towards the surface causes only minimal disturbance of the portion of surface **16** that is near drum **23.** Avoidance of turbulence-promoted oxidation of reactive elements in the molten metal alloy permits start-up and short term operation without excessive inclusion of dross or depletion of elemental reactive metal in the cast metal sheet. The movement of the molten metal around sloping portion **22** results in the flowing metal achieving substantial temperature homogenization by the time it reaches the drum. Inner wall **11** of the feed gallery, baffles **12** and **13,** and plate **21** are thermally conductive, thereby promoting temperature stabilization of surrounding molten metal.

Inclined baffle **31** extending across the width of the trough preferably is disposed within the molten metal under drum **23** with its upper end extending under immersed baffle **28** and its lower end extending slightly beyond the upper edge of the sloping portion **22** of plate **21.** Baffle **31** is effective in diverting gas bubbles, such as hydrogen gas bubbles rising from the underside of sloping portion **22** of plate **21,** to baffle **28** for collection in chamber **30** and thereby avoiding inclusion of the gas bubbles in the metal solidifying on the drum without adversely affecting or disturbing the flow pattern of molten metal about the passage between the edge of sloping portion **22** and the outer wall of the trough. Alternatively, the baffle could be disposed as shown by the broken lines designated **31′** to divert the bubbles towards the outer end wall of casting section **7.**

The rate of flow of inert gas, such as argon, through the upper part of holding section **6** is kept low so as to prevent pressurizing the system and thus affecting the metal level in the casting section.

In practice, most effective operation of the feeding trough was obtained when a low continuous flow of metal over weir **18** is maintained. With channel **8** set so as not to be restrictive, convenient flow control is obtained by setting weir **17** at about one-sixteenth inch above weir **18** and by varying the speed of pump **3.** Handling of lead-calcium, lead-lithium and lead-calcium-tin alloys in the foregoing feed trough, with no protective atmosphere in the drum zone of the casting section during start-up, did not produce excessive dross.

What we claim as new and desire protect by Letters patent of the United States is:

1. Apparatus for delivery of a molten metal to and maintenance of a quiescent pool of said molten metal at the peripheral surface of a rotating drum dipping into said pool for casting of said metal onto the drum comprising a substantially rectangular trough, inlet means for introducing molten metal from a reservoir and outlet means for return of excess molten metal to said reservoir; said trough having a holding section and a casting section, first and second opposed, spaced-apart weirs mounted on adjacent internal walls of said holding and casting sections, and first weir adapted to discharge molten metal from the holding section and said second weir adapted to discharge molten metal from the casting section, means for adjusting the heights of said weirs relative to each other, a channel beneath said internal walls communicating with holding section with said casting section, baffle means disposed within said holding section to evenly distribute incoming molten metal across the holding section, a plate defining the upper face of said channel and extending into said casting section, the part of said plate that extends into said casting section being sloped upwardly, and an immersed baffle between said drum and said second weir, said weirs, internal walls, channel, baffle means, plate and immersed baffle extending transversely across the width of said trough.

2. A trough as claimed in claim **1,** said weirs, internal walls, baffle means and plate being thermally conductive to promote temperature stabilization of the molten metal as it moves through said trough.

3. A trough as claimed in claim **1,** said holding section comprising a feed gallery having an inner wall with horizontally disposed holes across its upper end, a submerged baffle and a baffle with an upper portion inclined towards said first weir, whereby molten metal that is introduced into said feed gallery disperses across said trough through said horizontally disposed holes, passes under said submerged baffle and passes over said included upper portion, and thence flows downward into said channel, and whereby dross and surges of molten metal are directed over said first weir.

4. A trough as claimed in claim **1,** said upper plate of said channel being extended into said holding section.

5. A trough as claimed in claim **1,** said immersed baffle in said casting section being an extension of a cover that spans said holding section, thereby closing said holding section and part of said casting section to provide for an inert gas cover.

6. A trough as claimed in claim **1,** an inclined immersed baffle extending across the width of the trough and disposed within the casting section below the drum, whereby gas bubbles rising from the upwardly sloping part of the plate are diverted, thereby avoiding inclusion of the gas bubbles in metal solidifying on the drum.

7. A trough as claimed in claim **1,** the adjacent internal walls and the plate that defines the upper face of said channel being parts of vertically adjustable unit that can be moved to provide adjustments in the rate of metal flow to the casting section.

8. A trough as claimed in claim **1,** the heights and spacing of said walls and baffles providing for the retention of relatively large masses of molten metal in both holding and casting sections thereby achieving substantial temperature homogenization of the molten metal by the time it reaches the drum.

* * * * *

UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,858,642 Dated January 7, 1975

Inventor(s) Louis Battiston et al.

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Title page: the forth named inventor "Thorpe E. Watson" should read -- Thorpe W. Watson --. Column 6, line 14, "communicating with" should read -- communicating said --; line 37, "included" should read -- inclined --; line 56, before "vertically" insert -- a --.

Signed and sealed this 1st day of July 1975.

(SEAL)
Attest:

RUTH C. MASON
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents
and Trademarks