Oct. 28, 1969 R. W. HAZELETT ET AL 3,474,853

APPARATUS FOR COOLING AND SUPPORTING THE CASTING BELT IN A CONTINUOUS METAL CASTING MACHINE OF THE DRUM AND BELT TYPE

Original Filed April 14, 1966 3 Sheets-Sheet 1

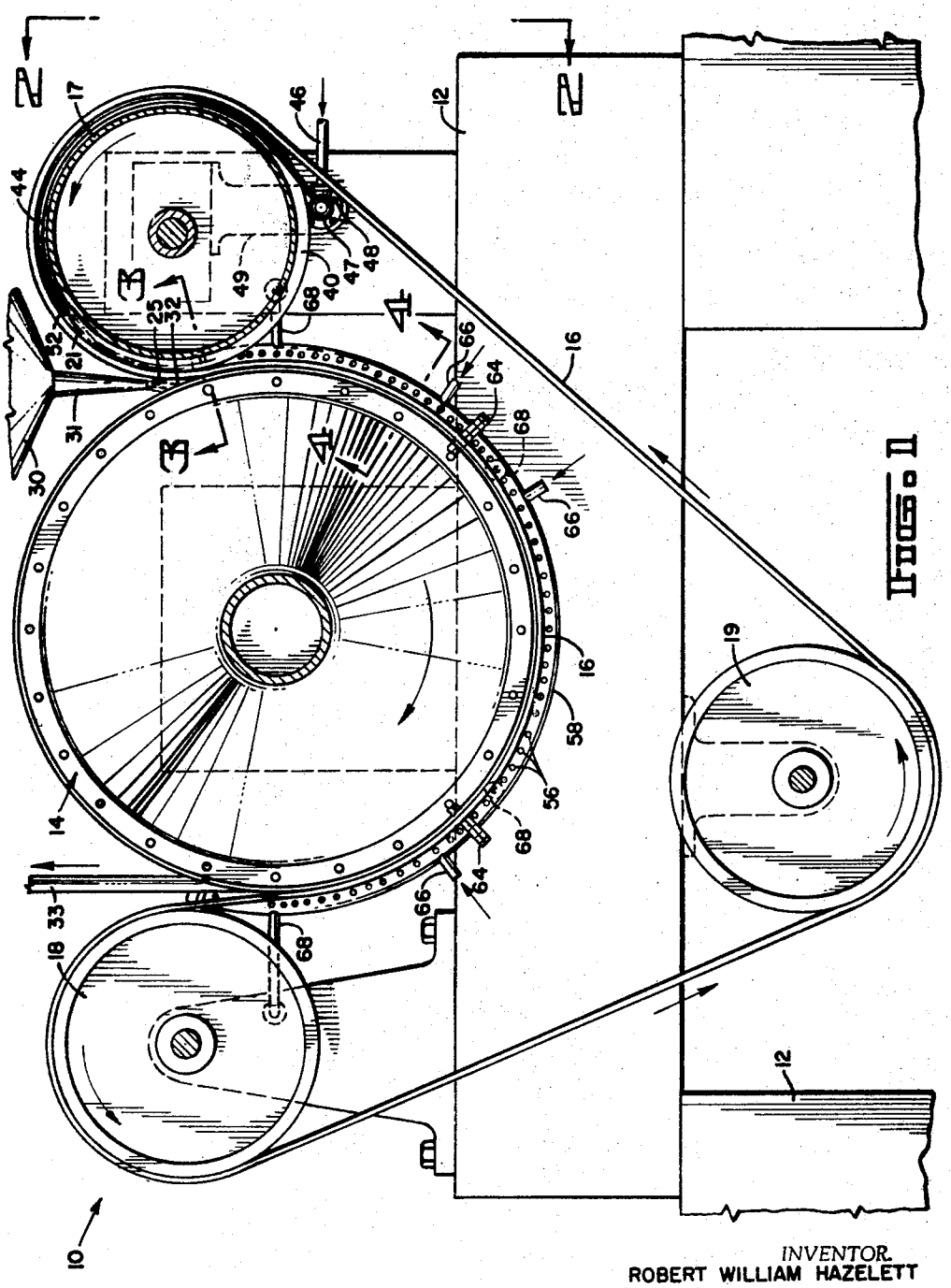


FIG. 1

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Original Filed April 14, 1966 3 Sheets-Sheet 2

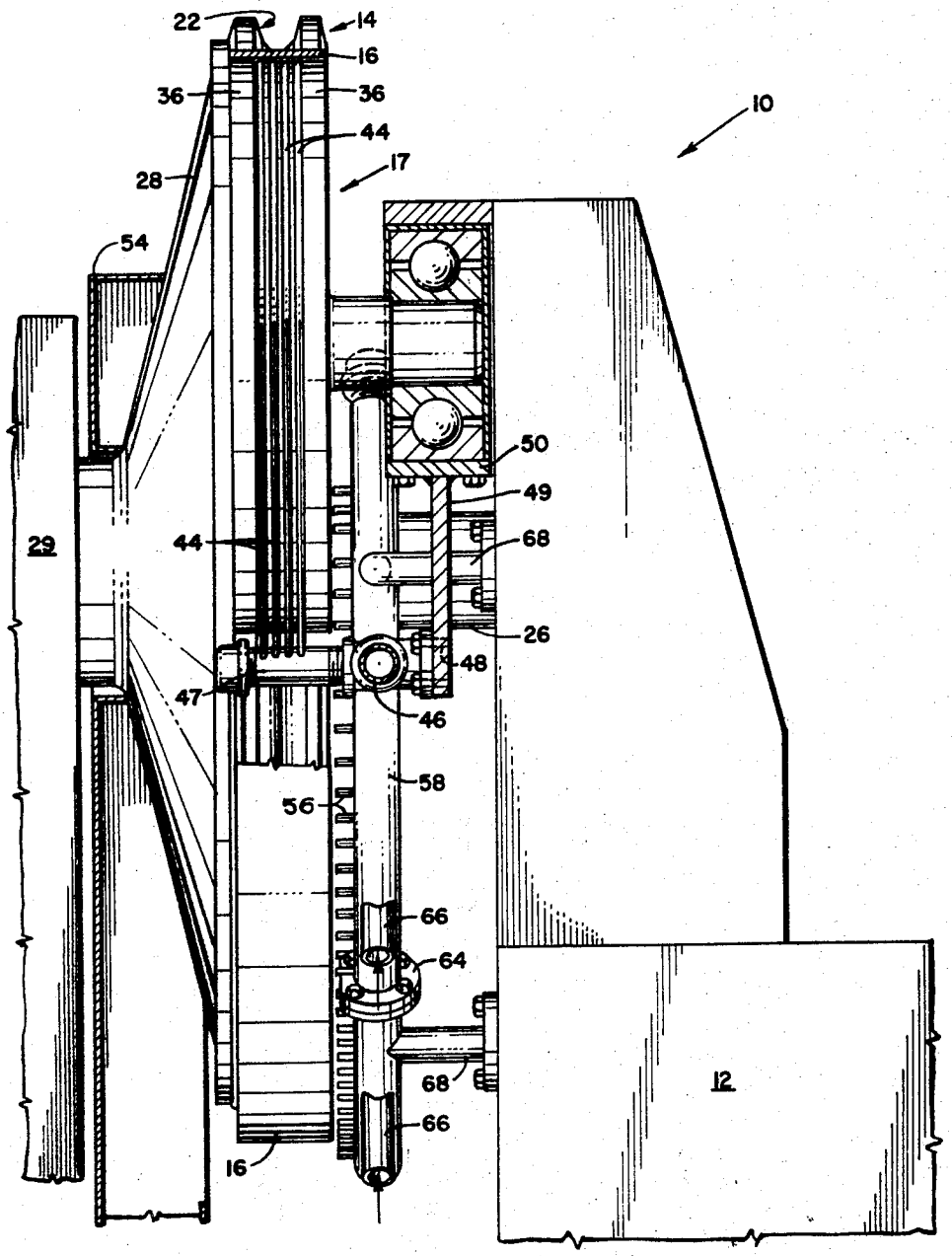


FIG. 2

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Original Filed April 14, 1966 3 Sheets-Sheet 3

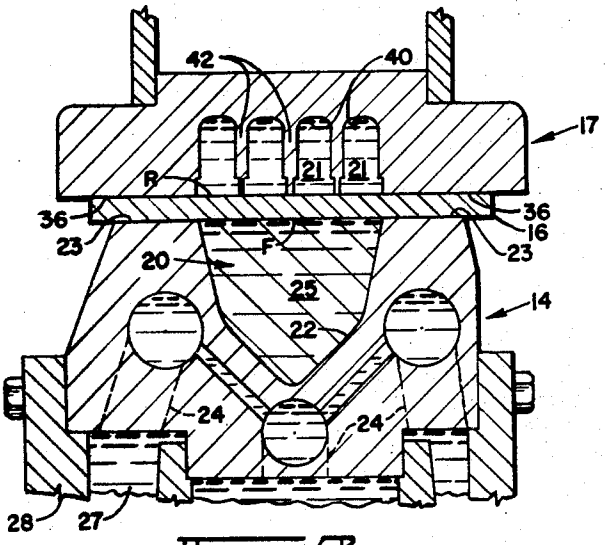


FIG. 3

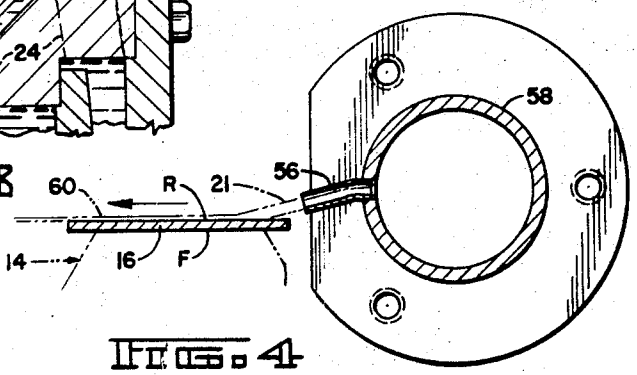


FIG. 4

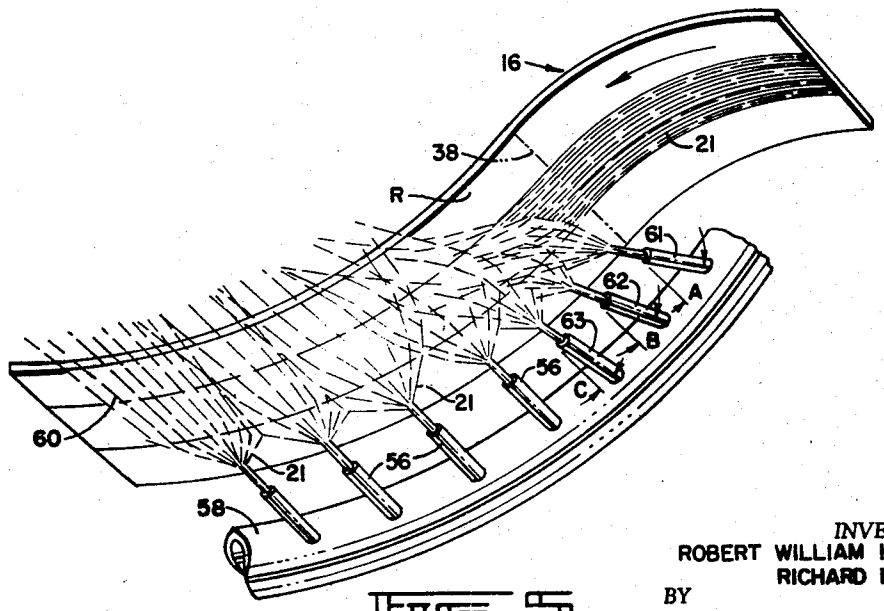


FIG. 5

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APPARATUS FOR COOLING AND SUPPORTING THE CASTING BELT IN A CONTINUOUS METAL CASTING MACHINE OF THE DRUM AND BELT TYPE

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Original application Apr. 14, 1966, Ser. No. 542,566. Divided and this application Mar. 19, 1968, Ser. No. 734,507

Int. Cl. B22d *11/06, 11/12*

U.S. Cl. 164—278 11 Claims

ABSTRACT OF THE DISCLOSURE

A continuous metal casting machine of the drum and belt type with apparatus for cooling the casting belt as it approaches the drum, as it comes in contact with and as it revolves with the drum to prevent buckling or warping of the belt and to confine the molten metal in the moving mold space without leakage, enabling use of a thinner casting belt which passes along reverse curves including concave and convex portions. A first pulley runs the belt partially around it guiding the front face of the belt toward the revolving drum to define the entrance for molten metal, a second pulley guiding the belt partially around the drum confining the molten metal, with the rear surface of the belt describing a concave curve moving toward the drum and a convex curve as it passes around the drum, deep circumferential grooves in the first pulley and curving coolant feed tubes nesting within the grooves direct coolant toward the concave rear surface of the belt flowing the coolant longitudinally along the rear surface toward the convex region. A pair of support surfaces on the first pulley press the belt against the spaced lands on the drum to seal the entrance to the mold space with the deep grooves and thin fins located between said support surfaces. The convex portion of the belt is cooled with coolant applied in a different direction, and diagonal nozzle means are shown providing a transition in the direction of application of the coolant.

This application is a division of application Ser. No. 542,566, filed Apr. 14, 1966, which issued as United States Patent No. 3,429,363 on Feb. 25, 1969.

The present invention relates to apparatus for cooling the belt in a metal casting machine of the drum and belt type. In this type of machine a continuously moving mold space is defined between the periphery of a revolving drum and a belt which runs partially around the drum as the drum revolves. This invention relates to apparatus for cooling the casting belt as it approaches the drum and as it comes into contact with and as it revolves with the drum to prevent buckling or warping of the belt and to confine the molten material in the moving mold space without leakage.

In the prior art, for example as shown in United States Patent No. 2,865,067, issued to Properzi, are disclosed arrangements for cooling the drum by flowing liquid coolant through a network of interconnected passages within the drum. However, great difficulty has been experienced for many years in attempts to cool the casting belt. The prior art arrangements tended to cool the drum more efficiently than the belt. This often set up temperature differentials across the material being cast, producing uneven cooling which adversely affected the cast product. In addition, the

flexible casting belt was unevenly cooled, which set up localized stresses in the belt, caused its rapid deterioration and created localized defects in the outer surface of the product being cast. Moreover, there were problems in holding the belt firmly against the drum without buckling and without warping or allowing the belt to separate from the drum, which would allow leakage of the molten material being cast.

In the Properzi machine the belt runs in an oblong path which completely encircles the drum. This requires that the cast product be bent sideways to clear the belt as the product is led out of the machine. In the improved type of machine as shown in FIGURE 1 herein the belt is bent into reverse curves so that it does not encircle the machine and the cast product **33** can be led directly out of the machine without bending sideways.

These problems of cooling the belt are particularly severe in the drum and belt machines of this type as shown in FIGURE 1 for casting molten metal in which the front face of the belt is curved in one direction as it approaches the drum and then passes through a transition region and curves in the opposite direction as it runs adjacent to the drum for confining the molten metal against the front face of the belt. That is, the belt follows a path including concave and convex curving portions with an intermediate transition region. The molten metal is introduced into the moving mold space between the drum and the front face of the belt near the transition region, and this is the region of greatest temperature which requires very intense cooling of the rear face of the casting belt. At the same time this is the region where the belt is changing its curvature and requires accurate firm guidance and support to prevent buckling or warping and to prevent the belt from separating from the drum.

These problems have remained unsolved for many years and have limited the usage of this type of drum and belt machine to the casting of lower melting temperature metals.

Among the advantages provided by the present invention are those resulting from the fact that it enables intense, uniform cooling of the rear face of the casting belt along near the moving mold space, including the input region where the belt follows a reverse curve. The more effective cooling provided by this invention allows the use of a thinner casting belt which does not deteriorate through distortion due to temperature differential between the fron and rear face of the casting belt and therefore the operating life of the cooling belt is greatly extended.

In accordance with the cooling apparatus of the present invention in one of its aspects the liquid coolant is impinged against the rear face of the belt near one edge where the rear face follows a convex path around the drum, and the coolant travels transversely across the convex rear face of the belt toward the other edge.

The cooling apparatus of this invention in another of its aspects includes the steps of flowing the coolant longitudinaly along a concave portion of the rear face of the belt as it approaches the drum and flowing the coolant transversely of the rear face along the convex portion of the rear space near the drum, and of making a transition from longitudinal flow to transverse flow.

It is the object of this invention to provide apparatus for cooling the casting belt in a drum and belt machine radically improving the performance and reliability of these machines to the end that their utilization and fields of application may become greatly widespread for continuous casting of metal.

In this specification and in the accompanying drawings are described and shown apparatus embodying the invention for cooling the casting belt in a drum and belt machine for casting metal, and it is to be understood that these are given for purposes of illustrating the best mode currently contemplated for carrying out the invention in order that others skilled in the art may fully understand the invention and the manner of carrying out the invention in practical use and so that they will understand how to utilize equivalents of this apparatus as may be best suited to the conditions of various particular continuous casting installations.

The various features, aspects, and advantages of the present invention will become more fully understood from a consideration of the following specification in conjunction with the accompanying drawings, in which:

FIGURE 1 is a side elevational view of a casting machine of the drum and belt type for practising the cooling method of the invention and embodying apparatus of the invention;

FIGURE 2 is an end elevational view of the machine of FIGURE 1 as seen from the direction 2—2 in FIGURE 1 and drawn on enlarged scale with the belt shown broken away to disclose underlying structure;

FIGURE 3 is a cross sectional view taken along the line 3—3 of FIGURE 1 in the input region where the molten material is introduced into the moving mold space. In this specification the molten material is shown as metal and the apparatus herein is the best mode currently contemplated for carrying out the invention in continuously casting metal.

FIGURE 4 is a cross section taken along the line 4—4 in FIGURE 1 illustrating the cooling apparatus; and

FIGURE 5 is a perspective view illustrating the cooling of concave and convex portions of the rear surface of the belt and also for cooling the intermediate transition or inflection region.

As shown in FIGURES 1 and 2, the continuous casting machine **10** includes a frame base **12** having a drum **14** rotatably mounted on this base. A flexible casting belt **16** runs in an arcuate path around a portion of the revolving drum and is guided and supported by three pulley wheels **17**, **18** and **19**. Between the periphery of the revolving drum and the belt is defined a moving mold space **20** (FIGURE 3). This mold space **20** is formed by a peripheral casting groove **22** in the drum **14** with the belt **16** pressing firmly against a pair of lands or rim portions **23** of equal diameter which straddle this groove **22**.

As shown in FIGURE 3, the casting belt **16** spans across between the lands **23**, and its front face F is toward the mold space, while its rear face R is cooled by fast-travelling liquid coolant **21**, for example such as water which is used in this machine. In order to contain the molten material **25** within the mold space **20** and to cast a product of high quality, it is important that the casting belt **16** be held firmly against the lands **23** and that its front face F continue in a smooth curvature adjacent to them, without any warping or localized distortion.

For cooling the drum **14** there is a network of interconnected pasages **24** (FIG. 3) to which liquid coolant is supplied under pressure through a hollow drum shaft **26** (FIG. 2). The coolant returning from the passages **24** is received in a chamber **27** provided by a conical end plate **28** and then flows into a return duct **29** to circulate back to a suitable reservoir for holding the coolant.

As shown in FIGURE 1 the molten material **25**, is supplied from an insulated pouring container or tundish **30** and feeds down through a spout **31** into the input region or entrance **32** to the mold space **20**. This machine is particularly adapted for continuously casting molten metal, such as aluminium, copper or steel. The cast product **33** is led out of the machine at a point which is generally on the opposite side from the entrance **32**.

Near the entrance to the mold space, the casting belt **16** runs around the pulley **17**, as seen in FIGURE 1. In order to press the belt firmly against the lands **23**, the entrance pulley **17** has a pair of support surfaces **36** of equal diameter, each of which is directly opposite one of the lands **23**. Thus, the belt **16** and drum **14** are held together about the entrance **32** to prevent leakage of the molten metal. The sectional view of FIGURE 3 is taken directly at the entrance plane where the support surfaces **36** are pressing the respective edge areas of the belt **16** tightly against the lands **23**. Also, the belt **16** is maintained under tension pulling it tightly against the drum **14** as it runs therearound.

In following the path described by the belt **16** near the entrance **32** it is seen that the rear face R describes a concave curve as it runs around the pulley **17**; then the belt flexes through a reverse curve or line of inflection along a transverse line, which is indicated by dashes at **38** (FIG. 5); and then the belt describes a convex curve as it runs around the drum **14**.

For providing an intense cooling of the casting belt **16** adjacent to the input region **32** where the molten metal **25** is at its highest temperature, the entrance pulley **17** has a plurality of deep narrow grooves **40**, seen most clearly in FIGURE 3. Between these grooves **40** the pulley **17** has thin knife-like fins **42** which provide support for the middle portion of the belt **16** as it runs around the pulley **17** over the grooves **40** to resist the tension force under which it operates. A plurality of long, coolant-feed nozzles **44** curve approximately half way around the pulley **17**, and one of these nozzle tubes **44** nests within each groove **40** beneath the concave rear belt surface R, as shown in FIGURES 1 and 2. The liquid coolant is fed under high pressure through a line **46** into a manifold **47** to which the base end of each of the nozzle tubes **44** is connected. As shown in FIGURE 2, the manifold **47** is adjustably mounted by bolts **48** secured to a bracket **49**, which is attached to the bearing support **50** for the shaft of the pulley **17**. This adjustment enables the nozzle tubes **44** to be aligned with the grooves **40** when the machine **10** is set up for operation. High velocity jets of the coolant **21** issue from the tips **52** of the nozzle tubes **44** and impinge against the concave rear surface R to produce a film of the coolant travelling longitudinally along the belt **16**. This coolant **21** travels at high speed through the grooves **40** until the line of inflection **38**. As the coolant rushes along the concave surface R centrifugal force produces an intimate contact between coolant and belt to provide a highly effective heat transfer so that the belt is intensely cooled.

In order to cool the belt as it runs around the drum, the coolant **21** is impinged against the rear face R near one edge, as shown in FIGURES 4 and 5 so that the coolant travels at high speed across the convex belt surface and flies off from the opposite edge to be caught in a shield **54**.

A large number of nozzles **56** are connected to a header pipe **58** extending in an arc concentric with the axis of the drum **14** and located near one edge of the belt **16**. In this machine there are approximately sixty of the nozzles **56** and they are uniformly spaced along the length of the header **58**. Each nozzle is directed toward the face R to impinge near the edge of the belt. The axis of each nozzle **56** is aimed at a small angle to the surface R, for example this angle is in the range from 6° to 20°, so that the coolant impinges to spread out and form a fast travelling film **60** (FIG. 5) moving transversely across the face R.

In order to remove the longitudinally travelling coolant beyond the line **38** of the reverse curvature, there is an initial sequence of nozzles **61**, **62** and **63** which are aimed in the direction of travel at progressively decreasing angles A, B, and C. Their jets effectively drive beneath the longitudinally travelling coolant so as to raise the longitudinal coolant from the face R while deflecting it and sweeping

it aside. Thus, a film of high speed coolant is maintained against the face R and a transition is made from longitudinal to transverse flow. This transition is made at the beginning of the convex curvature of the face R.

The header **58** is made in three sections joined by flanges **64**, and coolant is supplied under pressure to the header **58** through a plurality of lines **66**. By supplying coolant at a plurality of connections **66** a substantially uniform high pressure is provided throughout the length of the header **58**, that is, internal pressure drop is minimized. Thus, the transversely flowing coolant layer **60** has substantially uniform velocity at all points along the belt. This provides a high rate of heat transfer and uniformity in cooling the solidifying metal being cast. The arcuate header **58** is mounted on the frame **12** by a plurality of supports **68**.

In order to obtain the most effective cooling action the flexible metal casting belt **16** is made of metal of high tensile strength relatively thin and having good heat conductivity. For example, in the machine as shown this belt **16** is made of mild steel and is less than .060 of an inch thick. Thus, the intense cooling action along the rear face R produces a substantially uniform temperature at all points of the front face F adjacent to the molten metal **25**.

The terms and expressions which I have employed are used in a descriptive and not in a limiting sense, and I have no intention of excluding such equivalents of the invention described as fall within the scope of the claims.

What is claimed is:

1. Apparatus for supporting and cooling the casting belt in a continuous casting machine of the revolving drum and belt type comprising a first pulley having the belt running partially therearound with the rear surface of the belt describing a concave curve as it travels around said pulley, said pulley pressing the front face of the belt against the revolving drum to define an entrance for molten material to be cast between drum and belt, a second pulley guiding the belt to run partially around the periphery of the drum with the rear surface of the belt describing a convex curve, said first pulley having a plurality of circumferential grooves therein beneath the concave rear surface of the belt, a plurality of curving coolant feed tubes nesting within said grooves and having nozzles directed toward the concave rear surface of the belt flowing coolant longitudinally therealong toward the region of the entrance, a source of liquid coolant under pressure connected to said coolant feed tubes, a plurality of nozzles directed toward the convex rear surface of the belt near one edge providing a layer of coolant travelling transversely across the belt for cooling the belt as it runs around the drum.

2. Apparatus for supporting and cooling the casting belt as claimed in claim **1** including at least one nozzle directing coolant diagonally across the rear surface of the belt near the beginning of the convex curve for deflecting and sweeping aside the longitudinally flowing coolant issuing from said grooves.

3. Apparatus for the continuous casting of molten metal wherein the moten metal is confined in a continuously moving mold space defined between the periphery of a revolving drum and the front face of an endless flexible belt which curves partially around the revolving drum comprising a first entrance pulley having the belt running partially therearound with the rear surface of the belt describing a concave curve as it travels around said pulley, said pulley guiding the front face of the belt toward the revolving drum to define an entrance for the molten metal to be cast between said drum and belt, a second pulley guiding the belt to run partially around the periphery of the drum for confining the molten metal with the rear surface of the belt describing a convex curve around said drum, said first pulley having a plurality of deep circumferential grooves therein beneath the concave rear surface of the belt, a plurality of curving coolant feed tubes nesting within said grooves and having nozzles directed toward the concave rear surface of the belt flowing coolant longitudinally along the rear surface in a direction toward the convex region of the rear surface, and a source of liquid coolant under pressure connected to said coolant feed tubes.

4. Apparatus for the continuous casting of molten metal as claimed in claim **3** in which the drum has a pair of peripheral lands which are spaced apart to define the mold space therebetween, said entrance pulley having a pair of support surfaces of equal diameter, each of said support surfaces being directly opposite a respective one of said spaced lands pressing the belt against said lands to seal the entrance to the mold space, said deep circumferential grooves being located between said support surfaces, and a plurality of thin fins located between the respective grooves, said fins supporting the rear surface of the belt opposite to the entrance to said mold space.

5. Apparatus for the continuous casting of molten metal wherein the molten metal is confined in a continuously moving mold space defined between the periphery of a revolving drum and the front face of an endless flexible belt which curves partially around the revolving drum comprising a first entrance pulley having the belt running partially therearound with the rear surface of the belt describing a concave curve as it travels around said pulley, said pulley guiding the front face of the belt toward the revolving drum to define an entrance for the molten metal to be cast between said drum and belt, a second pulley guiding the belt to run partially around the periphery of said drum for confining the molten metal as it solidifies with the rear surface of the belt describing a convex curve around said drum, said first pulley having a plurality of deep circumferential grooves therein beneath the concave rear surface of the belt, a plurality of curving coolant feed tubes nesting within said grooves and having nozzles directed toward the concave rear surface of the belt flowing coolant longitudinally along the rear surface in a direction toward the convex region of the rear surface, a source of liquid coolant under pressure connected to said coolant feed tubes, and nozzle means applying coolant to said convex portion of the rear surface of the belt in a direction different from said longitudinal flow.

6. Apparatus for continuously casting molten metal as claimed in claim **5** in which diagonal nozzle means apply coolant diagonally at high speed across the rear face of the belt to provide a transition between the longitudinally flowing coolant on the concave portion of the rear face and the coolant which is applied in a different direction to the convex portion of the rear face.

7. Apparatus for continuously casting molten metal as claimed in claim **6**, in which said diagonal nozzle means include a plurality of nozzles to apply the coolant diagonally at angles progresively more transverse to the length of the belt.

8. Apparatus for continuously casting molten metal as claimed in claim **6**, in which said diagonal nozzle means impinge the coolant against the rear face of the casting belt so as to drive beneath the longitudinally flowing coolant while deflecting the longitudinally flowing coolant laterally toward one edge.

9. Apparatus for continuously casting molten metal as claimed in claim **6**, in which said diagonal nozzle means is located near the beginning of the convex curving portion of the rear face.

10. Apparatus for continuously casting molten metal as claimed in claim **5** in which nozzle means connected to a source of coolant under high pressure impinges liquid coolant against the convex rear surface near one edge of the belt creating a coolant film travelling across the belt toward the other edge.

11. Apparatus for continuously casting molten metal as claimed in claim **10**, in which the coolant film is travelling transversely across the convex rear surface of the belt toward the other edge at such a high velocity that

the coolant continues its travel by flying freely off from said other edge, and shield means to catch the flying coolant.

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164—283