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SYSTEMS AND METHODS FOR TWO INGOT ROLLING OPERATIONS IN A HOT REVERSING MILL

Roberto Armbrust de Freitas Quintal

Spencer Krass

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SYSTEMS AND METHODS FOR TWO INGOT ROLLING OPERATIONS IN A HOT REVERSING MILL

Traditionally, hot mill operations are a bottleneck in a plant and for a metalworking process. For example, hot mill operations may include a hot reversing mill that transforms an ingot to a slab by rolling the metal material back and forth in multiple passes through the hot reversing mill. The number of passes through the hot reversing mill may vary depending on the product that is being processed. During such rolling operations, delamination may occur at a head and/or tail of the metal slab in which one or both ends becomes flared (sometimes referred to as an "alligator" defect). To continue processing the metal slab to a thickness required for a next metalworking operation (e.g., a hot finishing mill), the head and/or the tail must be cropped. Traditionally, the hot reversing mill stays idle during a cropping operation, which in turn negatively affects the mill cycle time.

In view of these issues, described herein are improved systems and methods for rolling metal ingots. While the systems and methods described herein can be used with any metal material, they may be especially useful with aluminum or aluminum alloys. The systems and methods provided herein may roll two ingots in parallel. As an example, the systems and methods described herein may at least partially roll a first ingot with a hot reversing mill, and while the first ingot is performing a last pass through the hot reversing mill before it is transferred to an intermediate processing operation (e.g., intermediate cropping), a new (second) ingot is advanced to the entry of the hot reversing mill. When the first ingot is transferred to the intermediate processing operation and during intermediate processing of the first ingot, the second ingot may be at least partially rolled with the hot reversing mill (e.g., during the time that the hot reversing mill is traditionally idle). When the first ingot finishes its intermediate processing, the second ingot may be stored or held while the first ingot returns to the hot reversing mill to finish the hot reversing mill operation. Using such techniques, when the second ingot resumes its rolling operation with the hot reversing mill (e.g., when the rolled product formed by the first ingot is advanced to a hot finishing mill), the second ingot will already be partially rolled, and its processing cycle will be shorter. The process of rolling ingots in parallel

may be continued for consecutive ingots as desired, which may reduce the cycle time at a hot rolling mill and thereby allow for increased production and processing of metal ingots.

FIG. 1 illustrates a rolling system 100 for rolling two ingots 101A-B in parallel according to various embodiments. The rolling system 100 includes a hot reversing mill 102 and an intermediate processing system 104 downstream from the hot reversing mill 102. The intermediate processing system 104 includes one or more cropping devices 110 (e.g., a heavy shear, a light shear, etc.) for selectively cropping a metal slab being processed by the rolling system 100. A hot finishing mill 106 is downstream from the hot reversing mill 102, and an entry table region 108 of the rolling system 100 is upstream from the hot reversing mill 102 for initially receiving an ingot and/or holding a partially rolled ingot as discussed in detail below. A controller 112 may be included for at least partially controlling the rolling operation of the rolling system 100.

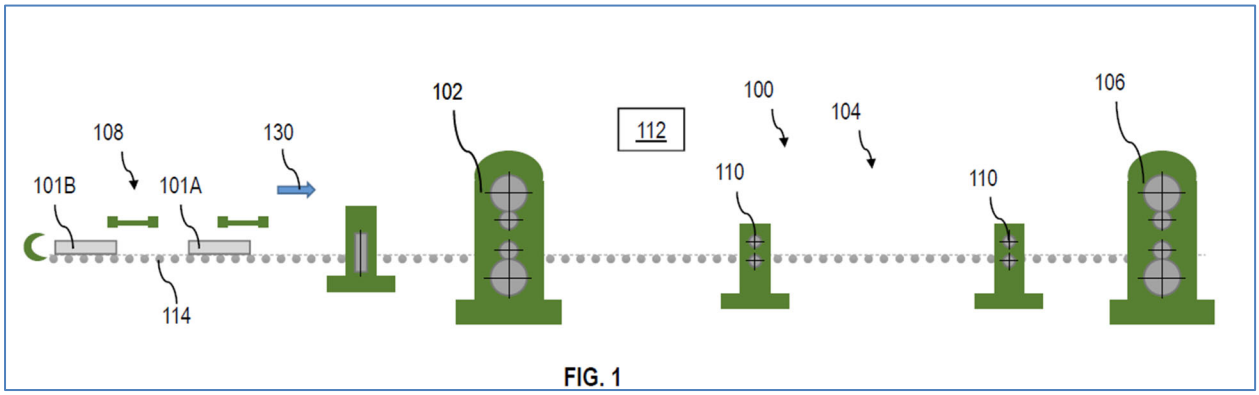

FIG. 1

FIG. 2 illustrates the rolling system 100 during a first rolling phase.

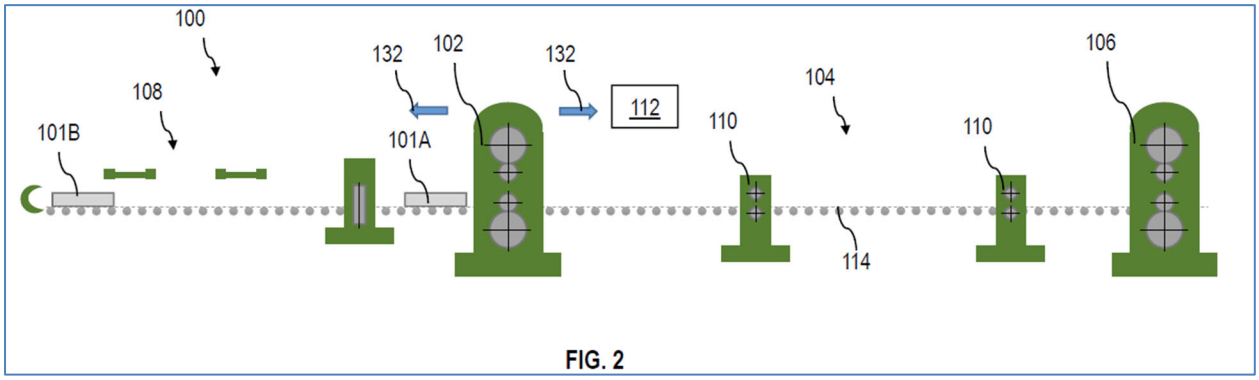

FIG. 2

FIG. 3 illustrates the rolling system 100 during a second rolling phase.

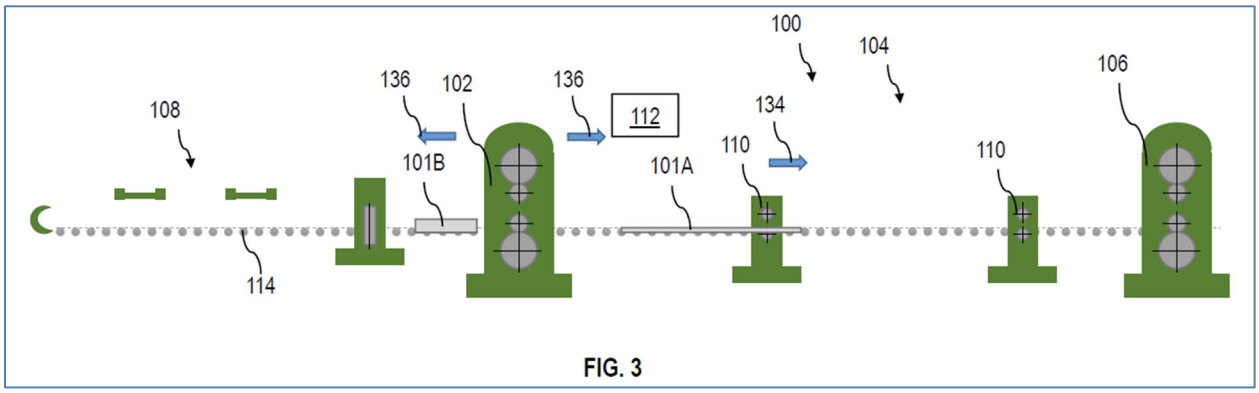

FIG. 3

FIG. 4 illustrates the rolling system 100 during a third rolling phase.

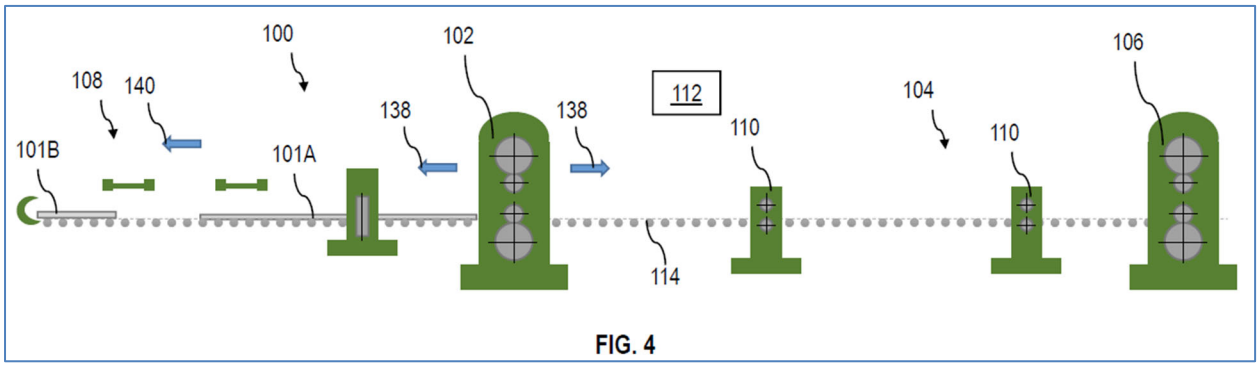

FIG. 4

FIG. 5 illustrates the rolling system 100 during a fourth rolling phase.

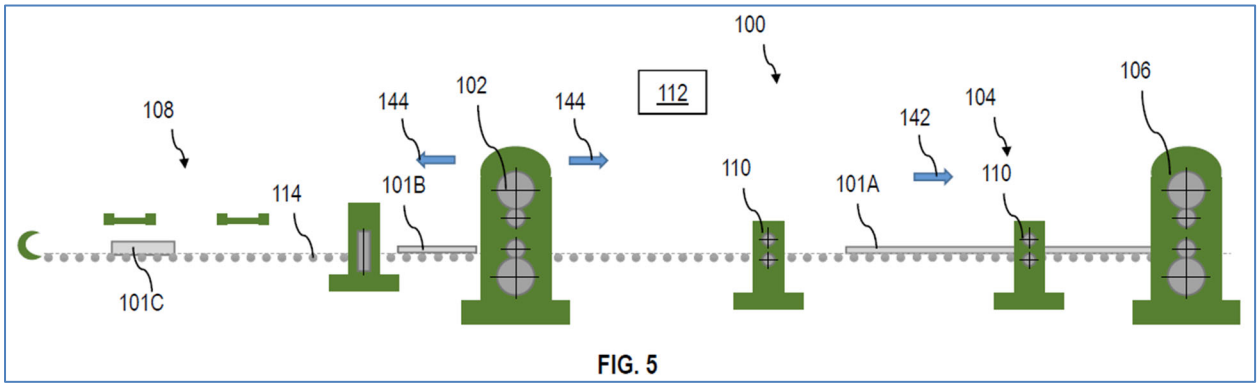

FIG. 5

FIG. 6 illustrates a method 600 of rolling ingots with a rolling system according to various embodiments. FIG. 1 illustrates an optional initial stage of the method 600 before a rolling operation with the rolling system 100. In the initial stage of FIG. 1, the ingots 101A-B are provided in the entry table region 108 such that a first ingot 101A is upstream from a second ingot 101B. However, both ingots 101A-B need not be provided during the initial stage of the

rolling operation, and only the first ingot 101A may be provided at the entry table region 108 and/or otherwise upstream from the hot reversing mill 102.

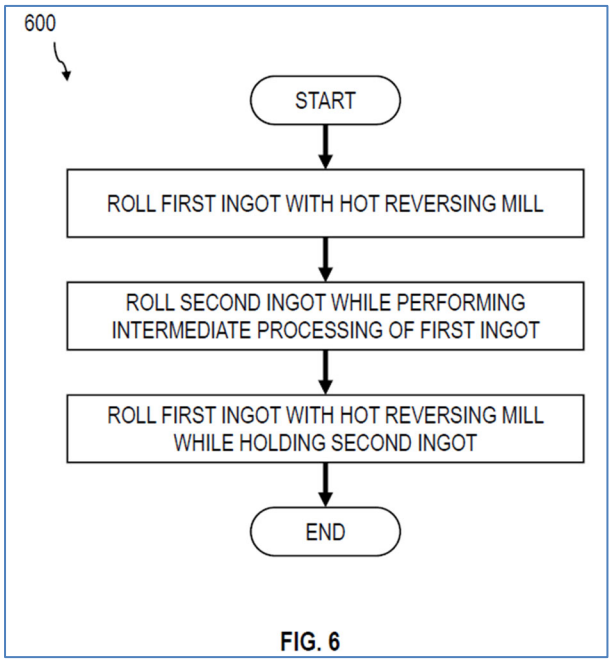

FIG. 6

In a block 602, and referring to FIG. 2, during the first rolling phase, the method 600 includes rolling the first ingot 101A with the hot reversing mill 102. In such embodiments, block 602 includes advancing the first ingot 101A to an entry of the hot reversing mill 102 (represented by arrow 130 in FIG. 1) and subsequently rolling the first ingot 101A with the hot reversing mill 102 (represented by arrows 132 in FIG. 2) such that the first ingot 101A is at least partially rolled. As the first ingot 101A is rolled by the hot reversing mill 102, the thickness of the first ingot 101A is progressively reduced and a length of the first ingot 101A is progressively increased. Block 602 includes rolling the first ingot 101A for a first plurality of passes through the hot reversing mill 102. Block 602 may include advancing the second ingot 101B to the entry of the hot reversing mill 102 during or following a last pass of the first ingot 101A through the hot reversing mill 102 before intermediate processing of the first ingot 101A.

In a block 604, and referring to FIG. 3, during the second rolling phase after the first rolling phase, the method 600 includes moving the partially rolled first ingot 101A downstream to the intermediate processing system 104 (represented by arrow 134 in FIG. 3) and performing intermediate processing on the partially rolled first ingot 101A. In the embodiment of FIG. 3, as

previously mentioned, the intermediate processing system 104 includes one or more cropping devices 110, and performing intermediate processing on the partially rolled first ingot 101A may include cropping at least one of a head or a tail of the first ingot 101A.

Block 604 includes rolling the second ingot 101B with the hot reversing mill 102 (represented by arrows 136 in FIG. 3) while performing intermediate processing of the partially rolled first ingot 101A such that the second ingot 101B is partially rolled. Rolling the second ingot 101B during the second rolling phase includes rolling the second ingot 101B for a second plurality of passes through the hot reversing mill 102. As the second ingot 101B is rolled by the hot reversing mill 102, the thickness of the second ingot 101B is progressively reduced and a length of the second ingot 101B is progressively increased. The second plurality of passes may be less than, the same as, or greater than the first plurality of passes. In certain techniques, the second plurality of passes includes at least two passes through the hot reversing mill 102 such that the second ingot 101B is at least partially rolled.

In a block 606, and referring to FIG. 4, during the third rolling phase after the second rolling phase, the method 600 includes returning the partially rolled first ingot 101A to the hot reversing mill 102 after performing the intermediate processing and then performing subsequent rolling of the first ingot 101A (represented by arrows 138 in FIG. 4) and storing the partially rolled second ingot 101B (represented by arrow 140 in FIG. 4). Storing the partially rolled second ingot 101B includes storing or holding the partially rolled second ingot 101B at the entry table region 108 upstream from the hot reversing mill 102. Rolling the first ingot 101A during the third rolling phase includes rolling the first ingot 101A to a rolled first product (e.g., a slab, sheet, etc.). In certain cases, rolling the first ingot 101A during the third rolling phase includes rolling the first ingot 101A for a third plurality of passes through the hot reversing mill 102, and the third plurality of passes is greater than, equal to, or less than the first plurality of passes. Optionally, block 606 includes advancing the partially rolled second ingot 101B to the entry of the hot reversing mill 102 during or following a last pass of the first ingot 101A through the hot reversing mill 102 to form the rolled first product 101A.

Optionally, and referring to FIG. 5, during the fourth rolling phase after the third rolling phase, the method 600 includes advancing the rolled first product 101A to the hot finishing mill 106 (represented by arrow 142 in FIG. 5). The fourth rolling phase includes rolling the partially

rolled second ingot 101B with the hot reversing mill 102 (represented by arrows 144) until the partially rolled second ingot 101B is ready for intermediate processing by the intermediate processing system 104 (e.g., block 604). Because the second ingot 101B is already partially rolled, the number of passes of the second ingot 101B through the hot reversing mill 102 before intermediate processing may be reduced, thereby reducing the cycle time of the second ingot 101B. The fourth rolling phase optionally includes holding a third ingot 101C at the entry table region 108. During the fourth rolling phase, once the partially rolled second ingot 101B is ready for intermediate processing, the method 600 outlined in blocks 604, 606, and 608 may be repeated.

The overall method 600 may be repeated for each subsequent ingot to be rolled by the rolling system 100.

During any stage of the method 600, the method 600 optionally includes maintaining at least a minimum distance between the ingots 101A-B being rolled in parallel by the rolling system 100.

FIG. 7 illustrates a rolling system 700 substantially similar to the rolling system 100 except that the rolling system 700 further includes an insulated chamber 716. When included, the insulated chamber 716 may maintain and/or heat a partially rolled ingot during a rolling operation. As an example, the insulated chamber 716 may heat and/or keep the second ingot 101B warm or heated during the third rolling phase (block 606 of the method 600), which may facilitate subsequent rolling of the second ingot 101B with the hot reversing mill 102 during the fourth rolling phase.

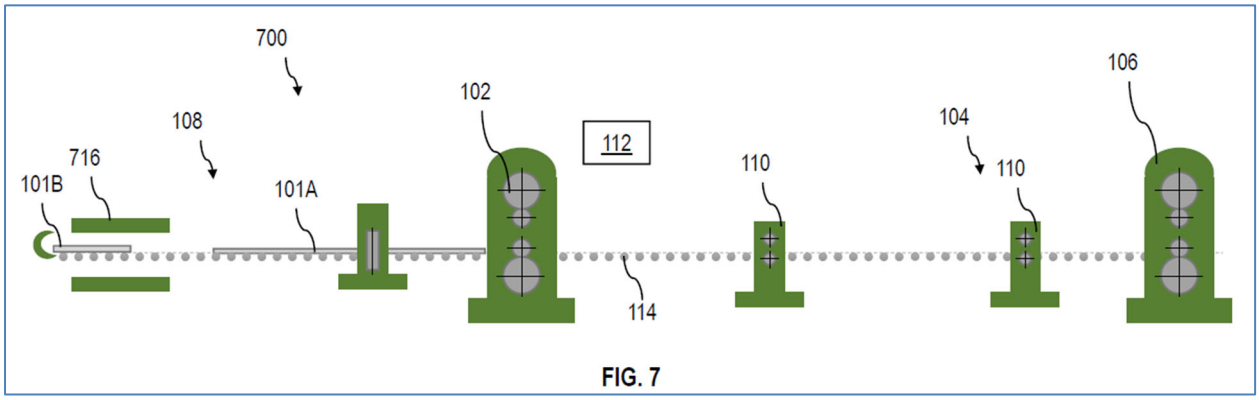

FIG. 7

Referring to FIGS. 8-11, in some embodiments, a method of rolling two ingots 101A-B includes rolling the ingots 101A-B in series rather than in parallel as illustrated in FIGS. 1-6.

Referring to FIGS. 8 and 9, which illustrate a rolling system 800 substantially similar to the rolling system 100, rolling the ingots 101A-B may include rolling the ingots 101A-B in series (i.e., each pass through the hot reversing mill 102 includes rolling the ingot 101A then the ingot 101B or vice versa). As an example, the arrows 818 in FIG. 8 represent a first pass through the hot reversing mill 102 by both ingots 101A-B, and the arrows 920 in FIG. 9 represent a reversing pass through the hot reversing mill 102 by both ingots 101A-B.

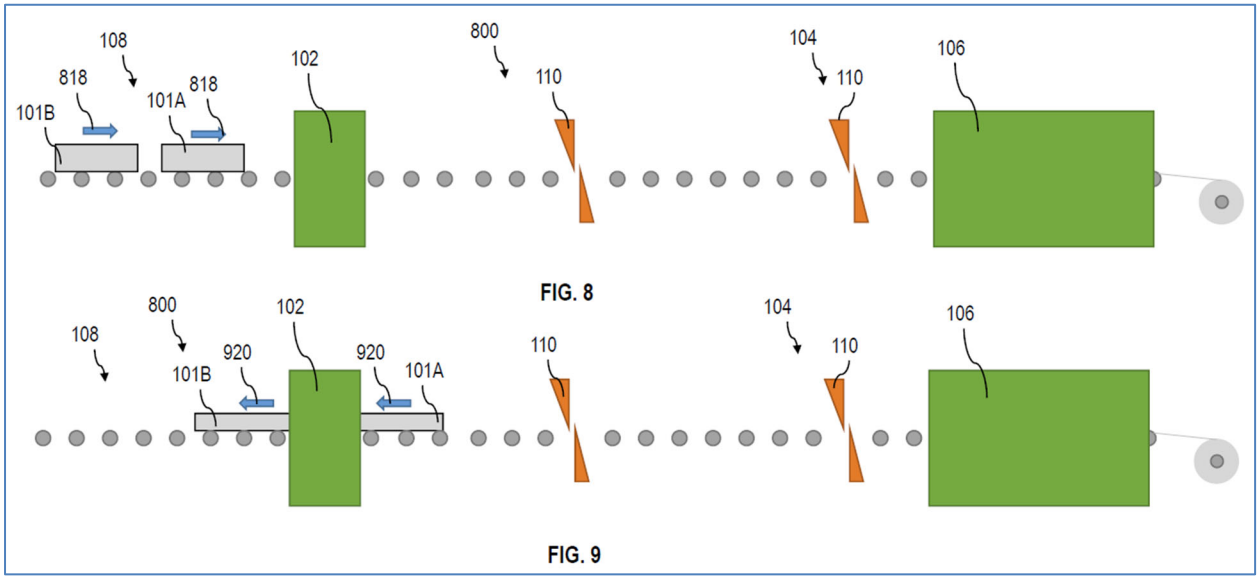

FIG. 8

FIG. 9

After a number of rolling passes of the ingots 101A-B in series such that both the first ingot 101A and the second ingot 101B are partially rolled, the method may include holding the partially rolled second ingot 101B upstream from the hot reversing mill 102 and continuing to process the partially rolled first ingot 101A by intermediate processing (FIG. 10) and subsequent rolling until the first ingot 101A is formed into the first rolled product 101A. Referring to FIG. 11, after the first rolled product 101A is formed, the first rolled product 101A may be advanced to the hot finishing mill 106 (represented by arrow 1122), and the partially rolled second ingot 101B is processed by intermediate processing and subsequent rolling (represented by arrows 1124).

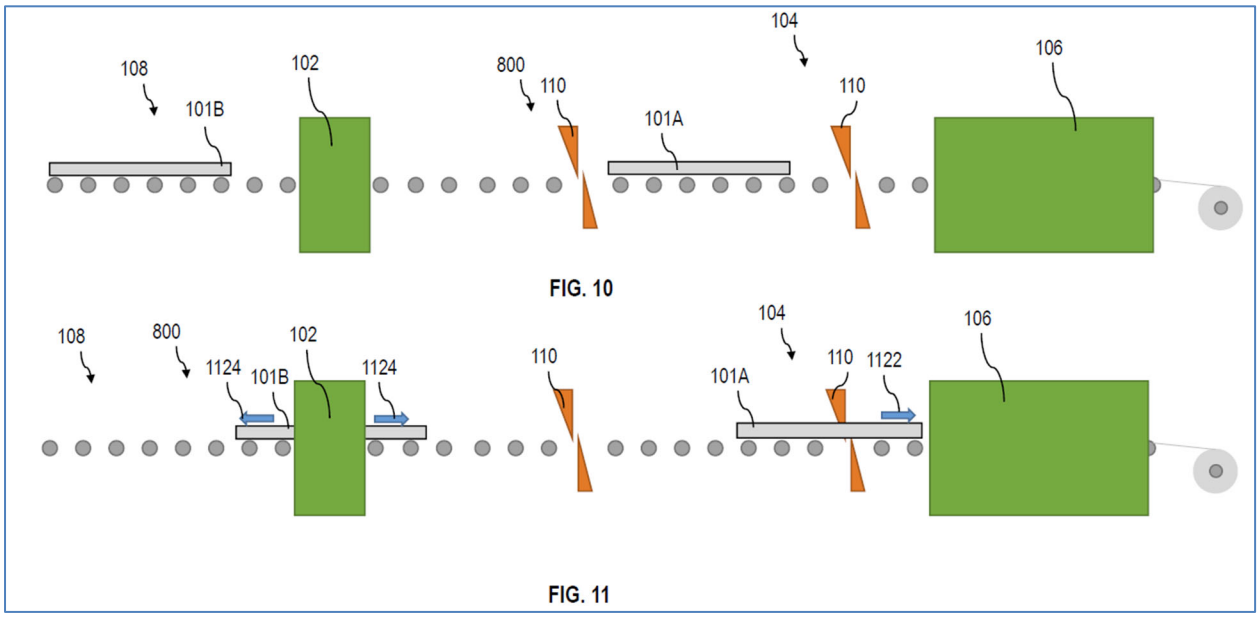

FIG. 10

FIG. 11

Rolling the ingots 101A-B in parallel (FIGS. 1-5) may reduce or eliminate delays during a rolling operation caused by intermediate processing. Rolling the ingots 101A-B in series may reduce or eliminate delays during a rolling operation caused by reversing time, or the time needed for the hot reversing mill 102 to reverse its speed to bring the ingots back to the hot reversing mill 102 for the next rolling operation. As such, rolling operations described herein may reduce cycle time during rolling operations compared to traditional rolling operations, thereby increasing productivity of the rolling systems.