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(54) Intermediate thickness and multiple furnace process line with slab storage and slab sequencing

(57) A method and apparatus of making coiled plate, sheet in coiled form or discrete plate. The apparatus includes a continuous strip caster forming a strand of intermediate thickness; a shear for cutting the strand into a plurality of slabs of desired lengths; a slab sequencing and storing device; one or two reheat furnaces for selectively reheating the slabs; a feed and run back table at the exit of one reheat furnace; a single or twin stand hot reversing mill for reducing the slab to a coiling thickness in a number of flat passes; and a pair of coiler furnaces located on opposite sides of the hot reversing mill.

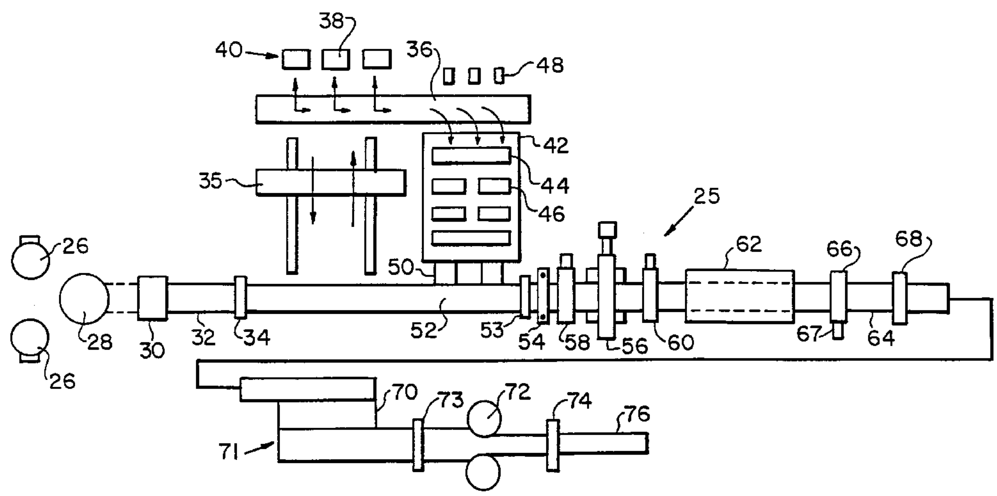

FIG. 1A

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Description

FIELD OF THE INVENTION

This invention relates to the continuous casting and rolling of slabs and, more particularly, to an integrated intermediate thickness caster and a hot reversing mill with flexibility in slab sourcing, sequencing and storage with the ability to roll thin gauge products.

BACKGROUND OF THE INVENTION

Since the advent of the continuous casting of slabs in the steel industry, companies have been trying to combine the hot strip mill with the continuous caster through an inline arrangement so as to maximize production capability and minimize the equipment and capital investment required. The initial efforts in this regard consisted of integrating continuous casters producing slabs on the order of 6 to 10 inches (152.4 to 254 millimeters) with existing continuous or semicontinuous hot strip mills. These existing hot strip mills included a reheat furnace, a roughing train (or a reversing rougher) and a six or seven stand finishing mill with a capacity of 1.5 to 5 million tons (1.4 to 4.5 million metric tons) per year. This arrangement is the present day design of large steel company hot mills, and it is unlikely that new hot strip mills of this design would ever be built due to the high capital cost. The quest for low cost integrated caster hot strip mills is not solved by current designs. Further, such prior art integrated mills were extremely inflexible as to product mix and thus current market requirements.

These difficulties gave rise to the development of the so-called thin slab continuous hot strip mill which typically produces 1,000,000 tons (907,185 metric tons) of steel per year as standard products. These mills have been integrated with thin slab casters on the order of two inches (50.8 mm) or less. Such integrated thin slab casters are enjoying increased popularity but are not without serious drawbacks of their own. Significant drawbacks include the quality and quantity limitations associated with the thin slab casters. Specifically, the trumpet-type mold necessary to provide the metal for the thin slab can cause high frictional forces and stresses along the surface of the thin wall slab which leads to poor surface quality in the finished product. Further, the two-inch (50.8 mm) strip casters are limited to a single tundish life of approximately seven heats because of the limited metal capacity of the mold.

Most importantly, the thin casters, by necessity, have to cast at high speeds to prevent the metal from freezing in the current ladle arrangements. This, in turn, requires the tunnel furnace which is just downstream of the slab caster to be extremely long, often on the order of 500 feet (152.4 meters), in order to accommodate the speed of the slab and still be able to provide the heat input to a thin slab (two inches) (50.8 mm) which loses heat at a very high rate. Since the slab also leaves the furnace at a high speed, one needs the multistand continuous hot strip mill to accommodate the rapidly moving strip and roll it to sheet and strip thicknesses. However, such a system is still unbalanced at normal widths since the caster has a capacity of about 800,000 tons (about 725,750 metric tons) per year and the continuous mill has a capacity as great as 5 million tons (4.54 million metric tons) per year. The capital cost of such a system then approaches that of the earlier prior art systems which the system was intended to replace.

In addition, the scale loss as a percentage of slab thickness is substantial for the two inch (50.8 mm) thin cast slab. Because of the extremely long furnace, one must provide a long roller hearth which becomes very maintenance intensive because of the exposed rotating rollers.

It has been suggested that light gauge hot band on the order of 0.040 inch (1.016 mm) be rolled from these two inch (50.8 mm) slabs. However, in the case of low carbon steels, the thermal decay is too great on a multistand continuous mill making it impossible to achieve the necessary finishing temperatures; and in the case of low alloy high-strength steels, it has been reported that the two inch thick slab does not produce the reduction required for high-strength low alloy steel which then causes a coarse microstructure which must then be refined through special temperature treatments which are greater than for the cold charging of the same microalloyed steel grade, "Optimisation of hot rolling schedule for direct charging of thin slabs of Nb-V microalloyed steel", N. Zentara and R. Kaspar, Materials Science and Technology, May 1994.

The typical multistand hot strip mill, likewise, requires a substantive amount of work in a short time which must be provided for by larger horsepower rolling stands which, in some cases, can exceed the energy capabilities of a given area, particularly in the case of emerging countries. Thin slab casters, likewise, are limited as to product width because of the difficulty in using vertical edgers on a two inch (50.8 mm) slab. Further problems associated with the thin strip casters include the problems associated with keeping the various inclusions formed during steel-making away from the surface of the thin slab where such inclusions can lead to surface defects if exposed. Furthermore, existing systems are limited in scale removal because thin slabs lose heat rapidly and are thus adversely affected by the high-pressure water normally used to break up the scale.

In addition, this thin strip process can only operate in a continuous manner, which means that a breakdown anywhere in the process stops the entire line, often causing scrapping of the entire product then being processed.

The integration of a slab caster with any hot rolling mill requires a synchronizing of the casting and rolling of slabs. Without the ability to decouple the casting and rolling of slabs in such an integrated system, a breakdown anywhere in the process stops the entire line, possibly resulting in the scrapping of the entire product then being processed. The casting and rolling of slabs can be effectively decoupled by providing the ability to transfer a cast slab to a slab storage area. However, this solution is inefficient. The slab is transferred to an external slab storage area such that when the mill is brought back on-line, a substantial amount of energy is required to bring the slabs back to an appropriate rolling temperature. Several other approaches have been attempted to address this particular problem. These include retaining or storing hot slabs in a heating furnace or in a thermal insulating chamber. However, these solutions have also had certain drawbacks, including the space required and the capital expense involved.

It is an object of our invention to integrate an intermediate thickness slab caster with a hot reversing mill. It is a further object to adopt a system which balances the rate of the caster to the rate of the rolling mill and provides for decoupling of the caster from the mill, as needed. It is also an object of our invention to adopt a system using less thermal and electrical energy. It is still a further object to adopt an automated system with small capital investment, reasonable floor space requirements, reasonably powered rolling equipment and low operating costs. It is a further object to provide flexibility in slab sourcing, sequencing and storage, and to economically accommodate increased demand for light gauge wide strip.

SUMMARY OF THE INVENTION

Our invention provides for a versatile, integrated caster and minimill capable of producing at least 650,000 and preferably in excess of 1 million finished tons (at least 589,670 and preferably in excess of 987,185 finished metric tons) a year with a divergent product mix. Such a facility can produce product 24 to 120 inches (610 to 3,048 mm) wide and can routinely produce a product of 800 PIW with 1,200 PIW being possible. This is accomplished using a casting facility having a fixed and adjustable width mold with a straight, rectangular cross section without the trumpet-type mold. The caster has a mold which contains enough liquid volume to provide sufficient time to make flying tundish changes, thereby not limiting the caster run to a single tundish life. Our invention provides a slab approximately two to three times as thick as the thin cast slab, thereby losing much less heat and requiring a lesser input of BTU's of energy. Our invention provides a slab having a lesser scale loss due to reduced surface area per volume and permits the use of one or two reheat or equalizing furnaces with minimal maintenance required. Further, our invention provides a caster which can operate at conventional caster speeds and conventional descaling techniques. Our invention provides for the selection of the optimum thickness cast slab to be used in conjunction with a twin stand, tandem hot reversing mill providing a balanced production capability. Our invention has the ability to separate the casting from the rolling if there is a delay in either end. Our invention provides for hot slab storage if the delay is in the rolling. Our invention provides for the easy removal of transitional slabs formed when molten metal chemistry changes or width changes are made in the caster. Furthermore, our invention provides for easily bringing cold slabs into the processing line. Such slabs may be outsourced (i.e., slabs not formed by the caster) and may be thicker than those which may be cast by the caster. This versatility will allow the processing line to be operated at the respective capacity of the individual components and allows for various portions of the line to be independently operated. This outsourcing of slabs also permits the product mix to include steel grades beyond the capability of the steel-making facility which forms a part of any given integrated process.

All of the above advantages are realized while maintaining the advantages of a thin caster which include low ferrostatic head, low weight of slab, straight molds, shorter length molds, smaller required mold radii, low cooling requirements, low burning costs or shear capacity and simplified machine constructions.

Our invention provides an intermediate thickness slab caster integrated with a hot strip and plate line which includes at least one reheat or equalizing furnace capable of receiving slabs directly from the caster, from a slab collection and storage area positioned adjacent a slab conveyor table exiting the continuous caster or from another area. One embodiment of the present invention includes a slab container capable of receiving slabs from the caster. A feed and run back table is positioned at the exit end of one of the reheat furnaces and inline with a twin stand hot reversing mill having a coiler furnace positioned on either side thereof. In one embodiment of the present invention the feed and run back table is in alignment with the coiler such that the reheat furnace may be selectively bypassed. The mill can reduce a cast slab to a thickness of about one inch (25.4 mm) or less in a minimum number of flat passes, about three or four flat passes. The combination coil, coiled plate, sheet in coil form or discrete plate finishing line extends inline and downstream of the hot reversing mill and the coiler furnaces. The finishing facilities may include a cooling station, a downcoiler, a plate table, a shear, a cooling bed crossover, a plate side and end shear and a piler.

To achieve the necessary balance between the hot reversing mill and the caster, it is preferable to cast slabs having a thickness of about 3 to about 6 inches (about 76 to about 152 mm) and preferably between about 3.5 to about 5.5 inches (about 88.9 to about 139.7 mm). As used herein, the term intermediate thickness is generally intended to define such slabs, although in certain specialty steels such as stainless steel intermediate thickness slabs may extend up to about 8 inches (about 203 mm). The cast slabs are reduced to a thickness capable of being coiled and normally about one inch (about 25.4 mm) or less in four flat passes on the hot reversing mill before starting the coiling of the intermediate product between the coiler furnaces as it is further reduced to the desired finished product thickness. In order to provide the capability of making coiled plate, discrete plate and sheet in coil form up to 1,000 PIW and higher, slab width may vary from 24 to 120 inches (610 to 3,048 mm).

One processing line of the present invention includes an intermediate thickness continuous strip caster with an inline shear downstream of the caster for cutting a cast strand into an intermediate thickness slab of the desired length. A slab conveyor table is provided inline with the shear and a slab loading and unloading mechanism positioned adjacent the conveyor for supplying slabs thereto. A slab collection and storage area is adjacent the slab loading and unloading mechanism for receiving and supplying slabs thereto. At least one reheat furnace is provided having an entry end inline with the slab conveyor table for receiving slabs therefrom and supplying reheated slabs to a feed and run back table positioned at the exit end of the reheat furnace. A hot reversing mill is provided inline with the feed and run back table for reducing a slab on the feed and run back table to an intermediate product having a thickness sufficient for coiling in a number of flat passes. Two spaced coiler furnaces are positioned inline with the feed and run back table, with one located upstream of the hot reversing mill and the other located downstream thereof. The coiler furnaces are capable of receiving and paying out the intermediate product as it is passed between the coiler furnaces and through the hot reversing mill so as to be reduced to an end product. A finishing line is provided downstream and inline with the coiler furnaces and the hot reversing mill.

In the above-described apparatus, the hot reversing mill includes a pair of four-high rolling mill stands adapted to be operated in tandem with an adjustable vertical edger positioned between the pair of rolling mill stands. Additionally, the slab loading and unloading means includes a first slab transfer device adjacent the slab conveyor table and operable transverse to the slab conveyor table, wherein the feed and run back table is positioned adjacent an end of the first slab transfer device. A second slab transfer device is adjacent the feed and run back table, wherein the slab collection and storage area is adapted to receive slabs from and supply slabs to the second slab transfer device. Additionally, this embodiment of the present invention may include a second reheat furnace having an entry end inline with a feed and run back table and an exit end inline with the slab conveyor table.

The method of operation of processing coil plate, sheet in coil form or discrete plate according to the present invention includes providing an intermediate thickness continuous caster and inline shear for casting an intermediate thickness strand and shearing the strand into a slab of predetermined length. Additionally, a slab loading and unloading device adjacent the slab collection and storage area for moving slabs between a position inline with the intermediate thickness caster and the slab collection and storage area is provided.

As discussed above, one embodiment of the present invention may include a slab container which includes a vertically movable carriage adapted to engage a lowermost slab and a stack of the slabs, wherein the slabs in the stack are directly contacting each other. Insulation may be provided to surround at least the sides and top of the stack. In one embodiment of the invention, the carriage may be mounted on a track within an insulated slab holding pit with a cover adapted to enclose the slab holding pit. In a second embodiment, the carriage may include one or two pairs of slab engaging arms adapted to engage and support a lowermost slab in the stack of slabs. The slab engaging arms are preferably movable to accommodate varying slab widths and include insulating side and top members attached to each slab engaging arm. The top members of the insulation on respective slab engaging arms are configured to overlap each other, allowing for movement of the slab engaging arms to accommodate the varying widths of the slabs.

A slab originating from either the intermediate thickness caster, the slab container (if provided) or the slab collection and storage area is fed to an inline heating furnace. The slab to be reduced is extracted from the inline heating furnace onto a continuous processing line which includes a hot reversing mill having a coiler furnace on each of the upstream and downstream sides thereof. The slab to be worked is passed back and forth through the reversing mill to form an intermediate product of a thickness capable of being coiled. The intermediate product is coiled in one of the coiler furnaces. The coiled intermediate product is passed back and forth through the mill to reduce the coiled intermediate product to an end product of desired thickness, the intermediate product being collected in and fed out of each of the coiler furnaces on each pass through the hot reversing mill. The end product may be finished into one of either coiled plate, discrete plate or sheet in coil form.

The method according to the present invention also provides that some of the coil slabs may bypass the heating furnace if the temperature of the slab is sufficient for rolling; additionally, some of the slabs supplied to the heating furnace may be outsourced (i.e., slabs which were not cast in the intermediate thickness caster). These outsourced slabs may have a thickness greater than slabs cast by the intermediate thickness caster and/or a chemistry different from that which can be produced on the melting/refining furnace(s) associated with the caster. The hot reversing mills of the present invention include a pair of rolling mill stands adapted for operation in tandem further including an adjustable vertical edger positioned between the pair of rolling mill stands. The method of the present invention may include a second heating furnace adjacent the inline heating furnace to provide for a wide versatility in slab sourcing, sequencing and processing, as will be described in detail herein.

BRIEF DESCRIPTION OF THE DRAWINGS

Figs. 1A and 1B are schematics illustrating an intermediate thickness strip caster and inline hot reversing mill and coiler furnace arrangement according to a first embodiment of the present invention;

Fig. 2 is a schematic illustrating an intermediate thickness strip caster and inline hot reversing mill and coiler furnace arrangement with multiple reheat and equalizing furnaces according to a second embodiment of the present invention;

Figs. 3A and 3B are schematic illustrations of a third embodiment for the intermediate thickness strip caster and inline hot reversing mill and coiler furnace arrangement according to the present invention;

Fig. 4 is a sectional view of one embodiment of a slab storage container shown schematically in Figs. 3A and 3B;

Fig. 5 is a side view of another embodiment of a slab storage container shown schematically in Figs. 3A and 3B; and

Fig. 6 is a front view of the slab storage container shown in Fig. 5.

DESCRIPTION OF THE PREFERRED EMBODIMENT

The intermediate thickness slab caster and inline hot strip and plate line of a first embodiment of the present invention is illustrated in Fig. 1A. This embodiment is well suited for slab sequencing as will be discussed hereinafter. One or more electric melting furnaces 26 provide the molten metal at the entry end of our combination caster and strip and plate line 25. The molten metal is fed into a ladle furnace 28 prior to being fed into the caster 30. The caster 30 feeds into a mold (curved or straight) 32 of rectangular cross section.

A torch cutoff (or shear) 34 is positioned at the exit end of the mold 32 to cut the strand of now solidified metal into an intermediate thickness slab, about 3.0 to 6 inches (about 76 to about 152 mm) thick, of the desired length which also has a width of 24 to 120 inches (610 to 3048 mm).

The slab then feeds on a feed and run back table 52 to a slab takeoff area where it may be removed from the feed and run back table 52 by a movable slab transfer table 35 operating transverse to the feed and run back table 52. The slabs are moved by the slab transfer table 35 to a table conveyor 36 to be charged into a furnace 42 or removed from the inline processing and stored in a slab collection and storage area 40 which normally will house slab conditioning facilities of one type or another. The provision of the easily accessible slab collection and storage area allows for a decoupling of the caster and the downstream processing. For example, if the mill goes off-line during a casting, the remaining casts may be forwarded to the slab collection and storage area. Additionally, if the caster were off-line, then the downstream processing can be continued with outsourced slabs. The slab collection and storage area 40 allows individual slabs to be collected for individual surface processing to address defects in individual slabs. The preferred furnace is of the walking beam type although a walking hearth furnace could also be utilized in certain applications. Full-size slabs 44 and discrete length slabs 46 for certain plate products are shown within walking beam furnace 42. Slabs 38, which are located in the slab collection and storage area 40, may also be fed into the furnace 42 by means of slab pushers 48 or charging arm devices located for indirect charging of walking beam furnace 42 with slabs 38. It is also possible to charge slabs from other slab yards or storage areas. Where slabs are introduced from the slab collection and storage area 40 or from the off-line locations, the furnace 42 must have the capacity to add Btu's to bring the slabs up to rolling temperatures.

Because the intermediate thickness slabs retain heat to a much greater extent than the thin slabs, temperature equalization is all that is required in many modes of operation. Additionally, for certain cast slabs, the internal temperature throughout the slab as it is received on the feed and run back table 52 may be sufficient for rolling directly. In this situation, the slab may be fed directly to downstream processing, bypassing the furnace 42. It is also anticipated that a second furnace may be positioned upstream of the first furnace 42 to increase the flexibility and the control of the current system.

The various slabs are fed through the furnace 42 in a conventional manner and are removed by slab extractors 50 and placed on the feed and run back table 52. Descaler 53 and/or a vertical edger 54 can be utilized on the intermediate thickness slabs. A vertical edger normally could not be used with a slab of only 2 inches (50.8 mm) or less.

Downstream of feed and run back table 52 and vertical edger 54 is a single stand hot reversing mill 56 having an upstream and a downstream coiler furnace 58 and 60, respectively. Run out table 61 and cooling station 62 are downstream of coiler furnace 60. Downstream of cooling station 62 is a coiler 66 operated in conjunction with a coil car 67 followed by a plate table 64 operated in conjunction with a shear 68. The final product is either coiled on coiler 66 and removed by coil car 67 as sheet in strip or coil plate form or is sheared into plate form for further processing inline. A plate product is transferred by transfer table 70 which includes a cooling bed onto a final processing line 71. The final processing line 71 includes a plate side shear 72, plate end shear 74 and plate piler 76. Of course, the plate product facility is omitted where only coil or coil and sheet product are desired.

The advantages of the subject invention come about as the result of the operating parameters employed and the sequencing flexibility available with the current design. The cast strand should have an intermediate thickness, generally between about 3.0 inches to about 6 inches (about 76 to about 152 mm) , preferably between 3.5 inches to 5.5 inches (about 88.9 to about 139.7 mm). The width can generally vary between 24 inches and 100 inches (610 mm and 2,540 mm) to produce a product up to 1,000 PIW and higher.

The slab is flat passed back and forth through hot reversing mill 56 in a minimum number of flat passes achieving a slab thickness of about 1 inch (25.4 mm) or less. The intermediate product is then coiled in the appropriate coiler furnace, which in the case of three flat passes would be downstream coiler furnace 60. Thereafter, the intermediate product is passed back and forth through hot reversing mill 56 and between the coiler furnaces to achieve the desired thickness for the sheet in coil form, the coil plate or the plate product. The number of passes to achieve the final product thickness may vary but normally may be done in nine passes which include the initial flat passes. On the final pass, which normally originates from upstream coiler furnace 58, the strip of the desired thickness is rolled in the hot reversing mill and continues through the cooling station 62 where it is appropriately cooled for coiling on a coiler 66 or for entry onto a plate table 64. If the product is to be sheet or plate in coil form, it is coiled on coiler 66 and removed by coil car 67. If it is to go directly into plate form, it enters plate table 64 where it is sheared by shear 68 to the appropriate length. The plate thereafter enters a transfer table 70 which acts as a cooling bed so that the plate may be finished on final processing line 71 which includes descaler 73, side shear 72, end shear 74 and piler 76.

The intermediate thickness continuous caster and hot strip and plate line provide many of the advantages of the thin strip caster without the disadvantages. The basic design of the facility can be predicated on rolling 150 tons (136 metric tons) per hour on the rolling mill. The market demand will obviously dictate the product mix, but for purposes of calculating the required caster speeds to achieve 150 tons (136 metric tons) per hour of rolling, one can assume the bulk of the product mix will be between 36 inches (914 mm) and 72 inches (1829 mm). A 72 inch (1829 mm) slab rolled at 150 tons (136 metric tons) per hour would require a casting speed of 61 inches (1549 mm) per minute. At 60 inches (1524 mm) of width, the casting speed increases to 73.2 inches (1859 mm) per minute; at 48 inches (1219 mm), the casting speed increases to 91.5 inches (2324 mm) per minute; and at 36 inches (914 mm) of width, the casting speed increases to 122 inches (3099 mm) per minute. All of these speeds are within acceptable casting speeds.

The annual design tonnage can be based on 50 weeks of operation per year at 8 hours a turn and 15 turns per week for 6,000 hours per year of available operating time assuming that 75% of the available operating time is utilized and assuming a 96% yield through the operating facility, the annual design tonnage will be approximately 650,000 finished tons (589,670 metric tons).

The intermediate thickness slab caster and inline hot strip and plate line according to a modified version of the first embodiment of the present invention is illustrated in Fig. 1B. The combination caster and strip and plate line 25 is identical to the line 25 described in connection with Fig. 1A except that a twin stand hot reversing mill 56' replaces the single stand hot reversing mill. The provision of the twin stand increases the rolling capacity of the mill. Additionally, the twin stand mill 56' allows for processing of outsourced slabs which are thicker than the intermediate thickness slabs which could be produced by the caster 30. With the twin stand mill 56', four flat reducing passes on the feed and run back table 52 (with two passes occurring with each passage of the slab along the feed and run back table 52) are normally required to arrive at a thickness capable of being coiled.

An intermediate thickness slab caster and inline hot strip and plate line including multiple furnaces and/or a multiple stand hot reversing mill according to a second embodiment of the present invention is illustrated in Fig. 2. The process line in Fig. 2 is similar in many respects to the line illustrated in the embodiment shown in Fig. 1. One or more electrical melting furnaces 126 will provide the molten metal at the entry end of the combination intermediate thickness caster and strip and plate processing line. The molten metal is fed into a ladle furnace 128 prior to being fed into the intermediate thickness caster 130. The caster 130 feeds into a curved or straight mold 132 of rectangular cross section. A torch cutoff or shear 134 is positioned at the exit end of the mold 132 to cut the strand of solidified metal into an intermediate thickness slab of desired length which may also have a width of 24 to 120 inches (610 to 3,048 mm). The intermediate thickness slab then feeds onto a slab conveyor table 136. A hot scarfer 137 may be positioned above the slab conveyor table 136 for processing the surface of the slabs. The slab may be removed from the inline processing and stored in a slab collection and storage area 140 or it may be directly charged from the slab conveyor table 136 into an entry side of an equalizing or reheat furnace 142. The preferred furnace 142 is of a walking beam type, although a roller hearth furnace could be utilized in certain applications. The various slabs are fed through the furnace 142 and removed in a conventional manner and placed on a feed and run back table 152 positioned at the exit of the furnace 142. The feed and run back table 152 is inline with the caster 130 in the processing sense but is not physically aligned with the caster as in the first embodiment.

When slabs are transferred to the slab collection and storage area 140, they can be removed from slab conveyor table 136 by a slab transfer table 138 operating transverse to the processing line. The slab transfer table 138 will transfer a slab from the slab conveyor table 136 to the feed and run back table 152. A second slab transfer table 144 is positioned adjacent the feed and run back table 152 to transfer slabs from the feed and run back table 152 to the slab collection and storage area 140. An alternative arrangement would combine the first and second slab transfer tables 138 and 144 into a single transfer table extending from the slab conveyor table to the slab collection and storage area

140 with the feed and run back table 152 extending from and receiving slabs from an intermediate portion of the combined slab transfer table.

A furnace 146 is positioned between the slab conveyor table 136 and the feed and run back table 152 and positioned adjacent the furnace 142. The furnace 146 may have an entrance side on the feed and run back table 152 and an exit end on the slab conveyor table 136. The slab storage area additionally includes a slab conditioning section 148 wherein further surface processing on the slabs can be performed, as needed.

The disclosed dual furnace and slab loading and unloading arrangement provides for great versatility in slab sourcing and processing. As discussed above, a slab cast from the intermediate thickness caster 130 can be fed directly through furnace 142 onto the feed and run back table 152 and into the processing line. Because the intermediate thickness slabs retain heat to a much greater extent than the thin slabs, the temperature equalization is generally all that will be required in many modes of operation.

The present arrangement additionally provides for transferring a slab from a position inline on the slab conveyor table 136 to the slab collection and storage area 140 through slab transfer tables 138 and 144. Such storage may be required to allow continuous casting to continue when a breakdown downstream in the processing line has occurred or, alternatively, allows for removing individual slabs for further processing in the slab conditioning section 148 such as due to any undesirable surface defects. The present arrangement provides for great versatility in bringing slabs from the slab collection and storage area 140 back in the processing line.

In short delays, the slab may be passed directly onto the feed and run back table 152 by the slab transfer table 144 for subsequent processing. A second alternative would be to transfer a slab onto the slab conveyor table 136 through both slab transfer tables 138 and 144. The slab can then continue down through furnace 142 and to the feed and run back table 152 for processing. Where cold slabs are being re-introduced into the processing line, the present arrangement allows for the slab to be transferred to the slab conveyor table 136 through the reheat furnace 146 which will have a capacity to add BTU's to bring the slab up to the appropriate temperature for subsequent processing. The present arrangement additionally provides for introducing outsourced slabs into the processing line. Outsourced slabs refer to slabs which were not cast on the intermediate thickness caster 130. Such outsourced slabs may have any thickness, including a thickness greater than that cast on the intermediate thickness caster 130 and/or a chemistry different than what can be produced or achieved in electric melting furnaces 126 and ladle furnace 128. The additional ability of incorporating outsourced slabs into the processing line provides additional options for a more complete matching of the speed of the intermediate thickness caster 130 and the supply of outsourced slabs to the downstream processing.

An alternative embodiment of the present invention is contemplated wherein furnace 146 has an entrance side on the slab conveyor table 136 and an exit side on the feed and run back table 152. In such an arrangement, the slabs from the slab collection and storage area 140 would generally be supplied to the slab conveyor table 136 and then through an appropriate one of the furnaces 142 or 146. In this alternative arrangement, both furnaces would generally be operated in the same manner. In the embodiment disclosed in Fig. 2, furnace 146 can be utilized and operated as a reheat furnace whereas furnace 142 can be generally operated as an equalizing-type furnace.

The present arrangement additionally provides for directly transferring an appropriate slab from the slab conveyor table 136 to the feed and run back table 152 for subsequent processing without going through either of the furnaces 142 or 146 as in the first embodiment. Such procedure would only be possible if the cast slab already contains an appropriate rolling temperature throughout. This alternative further illustrates the inherent flexibility of the present design.

The slabs positioned on the feed and run back table 152 for subsequent working are passed through a conventional descaler 153. As discussed above, such a descaler process could be detrimental to 2 inch thin cast slabs.

Downstream of feed and run back table 152 and aligned therewith is a hot reversing mill which includes a pair of four-high rolling mill stands 156 configured to operate in tandem. Positioned between the pair of rolling mill stands 156 is an adjustable vertical edger 154. Vertical edger 154 is intended to be used conventionally or to taper the leading and trailing ends, respectively, of the slab on the first pass through the mill so as to compensate for the flaring out of the extreme ends which occurs during subsequent rolling. Such tapering can be controlled by the AGC, and the vertical edger can be passively driven by the twin stands of the mill. The effectiveness of the tapered ends can be monitored by a width gauge at the exit end of the downstream hot reversing stand wherein a fingerprint of the width is taken and adjustments are made through a feedback loop to the vertical edger, where necessary.

Upstream and downstream coiler furnaces 158 and 160, respectively, are positioned on either side of the pair of rolling mill stands 156 of the hot reversing mill. A run out table 161 extends downstream from the coiler furnace 160. A cooling station 162, such as laminar flow cooling, is downstream of the downstream coiler furnace 160 and extends along the run out table 161. Downstream of the cooling station 162 is an upcoiler 166 which can be operated in conjunction with a coil car 167. A subsequent finishing line may be provided substantially the same as described above in Fig. 1 which includes shear 68, transfer table 70, final processing line 71, plate side shear 72, plate end shear 74 and plate piler 76.

The provision of tandem operated twin reversing stands 156 in the hot reversing mill of the present invention includes increased processing tonnages as well as the ability to achieve lighter gauges such as 0.040 inch, which are of increasing importance in many industries such as the building industry where light gauge hot mill product is formed into studs and the like to replace lumber. The additional expense of incorporating a twin stand reversing mill rather than a single stand reversing mill is justified by the increased productivity and versatility and the incorporation of outsourced slabs from the slab collection and storage area 140, as discussed above. As noted, such outsourced slabs may have a thickness greater than those cast in the caster 130 and can provide for an even greater variety of product mix. The following Examples illustrate such a product mix.

EXAMPLE I

A 48.99 inch (1244 mm) wide x 0.040 inch (1.016 mm) thick sheet in coil form is produced from a 5 1/2 inch (139.7 mm) cast slab in accordance with the following rolling schedule:

EXAMPLE I (TANDEM REVERSING MILL)

24.495 TONS (22.22 METRIC TONS) 1000. PIW
ROLLING SCHEDULE HSM - 48.99(1244 mm) - 5.5000 (139.7 mm)/ .0400 (1.0 mm)

PASS NO.	MILL STAND NAME	GAUGE IN.	GAUGE MM.	% RED	DRAFT IN.	DRAFT MM.	BITE ANGLE DEG.	LENGTH FT.	LENGTH MM.	ELAPSED TIME SEC.
0	FCE:	5.5000	139.700	.0	.000	0.00	.00	53.5	16.3	.00
1	TF1:	3.9350	99.949	28.5	1.565	39.75	17.99	74.8	22.8	9.09
2	TF2:	2.4300	61.722	38.2	1.505	38.23	17.64	121.2	36.9	14.86
3	TF2:	1.3700	34.798	43.6	1.060	26.92	14.79	214.9	65.5	50.47
4	TF1:	.6400	16.256	53.3	.730	18.54	12.26	460.1	140.2	55.39
5	TF1:	.3250	8.255	49.2	.315	8.00	8.05	906.1	276.2	132.76
6	TF2:	.1788	4.542	45.0	.146	3.71	5.48	1646.9	502.0	136.85
7	TF2:	.1073	2.725	40.0	.072	1.83	3.83	2744.4	836.5	264.82
8	TF1:	.0697	1.770	35.0	.038	0.97	2.78	4224.8	1287.7	268.43
9	TF1:	.0470	1.194	32.6	.023	0.58	2.16	6265.3	1909.7	466.76
10	TF2:	.0400	1.016	14.9	.007	0.18	1.20	7361.8	2243.9	466.76

continued

EXAMPLE I (TANDEM REVERSING MILL) --continued

24.495 TONS (22.22 METRIC TONS) 1000. PIW
ROLLING SCHEDULE HSM - 48.99 (1244 mm) - 5.5000 (139.7 mm)/ .0400 (1.0 mm)

PASS NO.	MILL STAND NAME	GAUGE IN.	GAUGE MM.	ENTRY TEMP. DEG. F	ENTRY TEMP. DEG. C	EXIT TEMP. DEG. F	EXIT TEMP. DEG. C
0	FCE:	5.5000	139.700	2250.00	1232.22	2250.00	1232.22
1	TF1:	3.9350	99.949	2207.52	1208.62	2200.11	1204.51
2	TF2:	2.4300	61.722	2197.20	1202.89	2204.63	1207.02
3	TF2:	1.3700	34.798	2143.36	1172.98	2121.95	1161.08
4	TF1:	.6400	16.256	2107.87	1153.26	2127.08	1163.93
5	TF1:	.3250	8.255	2068.29	1131.27	2014.94	1101.63
6	TF2:	.1788	4.542	2000.37	1093.54	2014.71	1101.51
7	TF2:	.1073	2.725	1928.23	1053.46	1934.41	1056.89
8	TF1:	.0697	1.770	1847.25	1008.47	1855.03	1012.79
9	TF1:	.0470	1.194	1752.82	956.01	1752.20	955.67
10	TF2:	.0400	1.016	1725.05	940.58	1702.53	928.07

continued

EXAMPLE I (TANDEM REVERSING MILL) --continued

24.495 TONS (22.22 METRIC TONS) 1000. PIW
ROLLING SCHEDULE HSM - 48.99 (1244 mm) - 5.5000 (139.7 mm)/ .0400 (1.0 mm)

PASS NO.	MILL STAND NAME	GAUGE IN.	GAUGE MM.	ROLL FORCE LB x 10**6	ROLL FORCE N x 10**6	TORQUE LB-FT x 10**6	TORQUE J x 10**6	HORSE POWER	HORSE POWER kW	LOAD RATIO	RMS TIME SEC.
0	FCE:	5.5000	139.700	0.0000	0.0000	0.0000	0.0000	0.	0.00	.0000	.00
1	TF1:	3.9350	99.949	2.7560	12.2587	1.1437	1.5506	12842.	9576.00	1.9441	34.35
2	TF2:	2.4300	61.722	3.2310	14.3715	1.3135	1.7808	23883.	17810.00	2.2326	45.30
3	TF2:	1.3700	34.798	3.6420	16.1996	1.2393	1.6802	13158.	9812.00	2.1064	157.96
4	TF1:	.6400	16.256	4.0939	18.2097	1.1498	1.5588	26134.	19488.00	1.9544	129.33
5	TF1:	.3250	8.255	4.0374	17.9584	.7352	0.9967	13789.	10282.00	1.2496	120.82
6	TF2:	.1788	4.542	3.5497	15.7891	.4304	0.5835	14673.	10942.00	1.0481	82.76
7	TF2:	.1073	2.725	3.5588	15.8295	.2906	0.3940	9652.	7197.00	.6895	60.83
8	TF1:	.0697	1.770	3.7157	16.5274	.2076	0.2815	10617.	7917.00	.7583	72.42
9	TF1:	.0470	1.194	4.9793	22.1479	.1901	0.2577	8272.	6168.00	.5909	69.25
10	TF2:	.0400	1.016	3.0653	13.6345	.0556	0.0754	2846.	2122.00	.2033	8.11

Distance/Length Ratio: .5000
Reversing Tandem Mill Peak Production: 1888.92TPH
Coiling Begins at Pass Number: 4 * TF1 *
Tandem Passes Begin at Pass Number: 1 * TF1 *
Distance Between Cfce #1 and Mill: 35.00 ft. (10.7m)

Distance Between Mill and Cfce #2: 35.00 ft. (10.7m)
Coiling Furnace Diameter: 54.00 in. (1371.6mm)
Coiling Furnace Temperature: 1650.00 Deg. F (898.89 Deg. C)
Acceleration/Deceleration Rate: 250.00 FPM/sec. (76.2 MPM/s)
Final Body Temperature at TS: 1702.53 Deg. F (928.07 Deg. C)

Example I illustrates one of a wide variety of product types which can be rolled with the present system. As illustrated in this Example, the present mill can economically hot roll down to 0.040 inch (1.0 mm) thick. The provision of the twin stands allows for accurately rolling down to these light gauges for which there is an increased market demand.

EXAMPLE II

A 55 inch (1397 mm) wide x 0.060 inch (1.52 mm) thick sheet in coiled form is produced from a 5 1/2 inch (139.7 mm) cast slab in accordance with the following rolling schedule:

EXAMPLE II (TANDEM REVERSING MILL)

27.5 TONS (24.9 METRIC TONS) 1000. PIW
ROLLING SCHEDULE HSM - 55.00 (1397 mm) - 5.5000 (139.7 mm) / 0.0600 (1.52 mm)

PASS NO.	MILL STAND NAME	GAUGE IN.	GAUGE MM.	% RED	DRAFT IN.	DRAFT MM.	BITE ANGLE DEG.	LENGTH FT.	LENGTH M.	ELAPSED TIME SEC
0	FCE:	5.5000	139.700	.0	.000	0.00	.00	53.5	16.3	.00
1	TF1:	3.9480	100.279	28.4	1.560	39.62	17.97	74.7	22.8	8.59
2	TF2:	2.5700	65.278	34.8	1.370	34.80	16.83	114.6	34.9	14.22
3	TF2:	1.6000	40.640	37.7	.970	24.64	14.14	184.0	56.1	42.79
4	TF1:	.8500	21.590	46.9	.750	19.05	12.43	346.4	105.6	47.49
5	TF1:	.4750	12.065	44.1	.375	9.53	8.78	619.9	188.9	106.78
6	TF2:	.2470	6.274	48.0	.228	5.79	6.84	1192.2	363.4	110.94
7	TF2:	.1480	3.759	40.1	.099	2.51	4.51	1989.7	606.5	218.88
8	TF1:	.0941	2.390	36.4	.054	1.37	3.33	3129.3	953.8	222.59
9	TF1:	.0706	1.793	25.0	.023	0.58	2.20	4171.0	1271.3	371.84
10	TF2:	.0600	1.524	15.0	.011	0.28	1.47	4907.8	1495.9	371.84

continued

EXAMPLE II (TANDEM REVERSING MILL) --continued

27.5 TONS (24.9 METRIC TONS) 1000. PIW
ROLLING SCHEDULE HSM - 55.00 (1397 mm) - 5.5000 (139.7mm)/ 0.0600 (1.52mm)

PASS NO.	MILL STAND NAME	GAUGE IN.	GAUGE MM	ENTRY TEMP. DEG. F	ENTRY TEMP. DEG. C	EXIT TEMP. DEG. F	EXIT TEMP. DEG. C
0	FCE:	5.5000	139.700	2250.00	1232.22	2250.00	1232.22
1	TF1:	3.9480	100.279	2208.27	1209.04	2201.51	1205.28
2	TF2:	2.5700	65.278	2198.78	1203.77	2204.63	1207.02
3	TF2:	1.6000	40.640	2154.98	1179.43	2138.02	1170.01
4	TF1:	.8500	21.590	2127.11	1163.95	2140.93	1171.63
5	TF1:	.4750	12.065	2096.08	1146.71	2104.49	1151.38
6	TF2:	.2470	6.274	2092.28	1144.60	2107.45	1153.03
7	TF2:	.1480	3.759	2024.39	1106.88	2027.03	1108.35
8	TF1:	.0941	2.390	1958.84	1070.47	1955.66	1068.70
9	TF1:	.0706	1.793	1854.68	1012.60	1842.76	1005.98
10	TF2:	.0600	1.524	1818.74	992.63	1795.94	979.97

continued

EXAMPLE II (TANDEM REVERSING MILL)--continued

27.5 TONS (24.9 METRIC TONS) 1000. PIW

ROLLING SCHEDULE HSM - 55.00 (1397mm) - 5.500 (139.7mm) / 0.0600 (1.52mm)

PASS NO.	MILL STAND NAME	GAUGE IN.	ROLL FORCE LB X 10**6	ROLL FORCE N x 10**6	TORQUE LB-FT X 10**6	TORQUE J x 10**6	HORSE POWER	HORSE POWER kW	LOAD RATIO	RMS TIME SEC.
0	FCE:	5.5000	0.0000	0.0000	0.0000	0.0000	0.	0.	.0000	.00
1	TF1:	3.9480	3.0812	13.7052	1.2766	1.7307	15141.	11291.	2.1699	40.46
2	TF2:	2.5700	3.3368	14.8421	1.2942	1.7546	23531.	17547.	2.1997	41.58
3	TF2:	1.6000	3.5295	15.6992	1.1492	1.5580	13876.	10347.	1.9534	109.02
4	TF1:	.8500	4.0143	17.8556	1.1449	1.5522	26023.	19405.	1.9461	102.40
5	TF1:	.4750	3.6429	16.2036	.7284	0.9875	12912.	9628.	1.2380	90.89
6	TF2:	.2470	3.0257	13.4583	.5876	0.7966	20038.	14942.	1.4313	117.09
7	TF2:	.1480	3.4411	15.3060	.3386	0.4591	9785.	7297.	.6990	52.74
8	TF1:	.0941	3.5483	15.7828	.2473	0.3353	11241.	8382.	.8029	68.31
9	TF1:	.0706	3.0025	13.3551	.1305	0.1769	5041.	3759.	.3601	19.35
10	TF2:	.0600	2.1214	9.4360	.0579	0.0785	2634.	1964.	.1882	5.21

Reversing Tandem Mill Peak Production:	266.20 TPH
Coiling Begins at Pass Number:	4 *TF1*
Tandem Passes Begin at Pass Number:	1 *TF1*
Distance Between CFce #1 and Mill:	35.00 ft. (10.7m)
Distance Between Mill and CFce #2:	35.00 ft. (10.7m)
Coiling Furnace Diameter:	54.00 in. (1371.6 mm)
Coiling Furnace Temperature:	1650.00°F (898.89°C)
Acceleration/Deceleration Rate:	250.00 FPM/sec. (76.2 MPM/sec.)
Final Body Temperature at TS:	1795.94°F (979.97°C)

Example II, like Example I, illustrates the versatility of the present system in hot rolling thin gauges. These hot rolled narrow gauge products, such as about 0.040 inch (1.0 mm) and about 0.060 inch (1.5 mm) thick, are able to be utilized as final end products in situations in which the final end product is generally not exposed and does not require any surface finishing. Metal construction studs, for example 0.040 inch (1.0 mm) galvanized studs, represent one final end product that can be hot rolled by the present invention. This is a distinct advantage over the known prior art which would generally hot roll somewhere above 0.080 inch (2.0 mm) thick then pickle and finish the product on a cold mill with a subsequent anneal and temper rolling.

EXAMPLE III

A 62 inch (1574.8 mm) wide x 0.090 inch (2.3 mm) thick sheet in coil form is produced from a 10 inch (254 mm) outsourced slab in accordance to the following schedule:

EXAMPLE III (TANDEM REVERSING MILL)

31 TONS (28 METRIC TONS) 1000. PIW

ROLLING SCHEDULE HSM - 62.00 (1574.8 mm)- 10.00 (254 mm)/ 0.0900 (2.3 mm)

PASS NO.	MILL STAND NAME	GAUGE IN.	GAUGE MM	% RED	DRAFT IN.	DRAFT MM	BITE ANGLE DEG.	LENGTH FT.	LENGTH M	ELAPSED TIME SEC.
0	FCE:	10.0000	254.000	.0	.000	0.00	0.00	29.5	9.0	.00
1	TF1:	8.5500	217.170	14.5	1.450	36.83	17.32	34.4	10.5	3.11
2	TF2:	7.1000	180.340	17.0	1.450	36.83	17.32	41.5	12.6	8.18
3	TF2:	5.6500	143.510	20.4	1.450	36.83	17.32	52.1	15.9	12.38
4	TF1:	4.2000	106.680	25.7	1.450	36.83	17.32	70.1	21.4	17.69
5	TF1:	2.9300	74.422	30.2	1.270	32.26	16.20	100.5	30.6	26.69
6	TF2:	1.8700	47.498	36.2	1.060	26.92	14.79	157.5	48.0	32.37
7	TF2:	1.1200	28.448	40.1	.750	19.05	12.43	262.9	80.1	62.21
8	TF1:	.6600	16.764	41.1	.460	11.68	9.73	446.2	136.0	66.30
9	TF1:	.3878	9.850	41.2	.272	6.91	7.48	759.4	231.5	119.01
10	TF2:	.2521	6.403	35.0	.136	3.45	5.28	1168.2	356.1	122.80
11	TF2:	.1765	4.483	30.0	.076	1.93	3.94	1668.6	356.2	192.43
12	TF1:	.1324	3.363	25.0	.044	1.12	3.01	2224.3	678.0	195.91
13	TF1:	.1059	2.690	20.0	.027	0.69	2.33	2780.9	847.6	276.46
14	TF2:	.0900	2.286	15.0	.016	0.41	1.81	3272.2	997.4	276.46

continued

EXAMPLE III (TANDEM REVERSING MILL)--continued

31 TONS (28 METRIC TONS) 1000. PIW
ROLLING SCHEDULE HWM - 62.00 (1574.8 mm) - 10.00 (254 mm)/ 0.0900 (2.3mm)

PASS NO.	MILL STAND NAME	GAUGE IN.	GAUGE MM	ENTRY TEMP. DEG. F	ENTRY TEMP. DEG. C	EXIT TEMP. DEG. F	EXIT TEMP. DEG. C
0	FCE:	10.0000	254.000	2250.00	1232.22	2250.00	1232.22
1	TF1:	8.5500	217.170	2227.38	1219.66	2225.39	1218.55
2	TF2:	7.1000	180.340	2224.30	1217.94	2226.34	1219.08
3	TF2:	5.6500	143.510	2220.03	1215.57	2217.71	1214.28
4	TF1:	4.2000	106.680	2215.05	1212.81	2218.71	1214.84
5	TF1:	2.9300	74.422	2194.47	1201.37	2198.55	1203.64
6	TF2:	1.8700	47.498	2195.76	1202.09	2193.42	1200.79
7	TF2:	1.1200	28.448	2125.80	1163.22	2135.32	1168.51
8	TF1:	.6600	16.764	2121.51	1160.84	2113.87	1156.59
9	TF1:	.3878	9.850	2076.96	1136.09	2087.73	1142.07
10	TF2:	.2521	6.403	2077.75	1136.53	2084.45	1140.25
11	TF2:	.1765	4.483	2030.67	1110.37	2032.36	1111.31
12	TF1:	.1324	3.363	1976.73	1080.41	1976.45	1080.25
13	TF1:	.1059	2.690	1916.07	1046.71	1907.90	1042.17
14	TF2:	.0900	2.286	1893.44	1034.13	1880.60	1027.00

continued

EXAMPLE III (TANDEM REVERSING MILL)--continued

31 TONS (28 METRIC TONS) 1000. PIW
ROLLING SCHEDULE HSM - 62.00 (1574.8mm) - 10.00 (254mm)/ 0.0900 (2.3mm)

PASS NO.	MILL STAND NAME	GAUGE IN.	GAUGE MM	ROLL FORCE LB x 10**6	ROLL FORCE N x 10**6	TORQUE LB-FT x 10**6	TORQUE J x 10**6
0	FCE:	10.0000	254.000	0.0000	0.0000	.0000	0.0000
1	TF1:	8.5500	217.170	3.2570	14.4871	1.3008	1.7636
2	TF2:	7.1000	180.340	3.2540	14.4738	1.2996	1.7619
3	TF2:	5.6500	143.510	3.2821	14.5988	1.3108	1.7771
4	TF1:	4.2000	106.680	3.2788	14.5841	1.3095	1.7754
5	TF1:	2.9300	74.422	3.5122	15.6223	1.3115	1.7781
6	TF2:	1.8700	47.498	3.8134	16.9620	1.2987	1.7607
7	TF2:	1.1200	28.448	4.1445	18.4347	1.1833	1.6043
8	TF1:	.6600	16.764	4.0563	18.0424	.9016	1.2223
9	TF1:	.3878	9.850	3.9993	17.7889	.6770	0.9178
10	TF2:	.2521	6.403	3.2680	14.5361	.3843	0.5210
11	TF2:	.1765	4.483	2.9640	13.1839	.2547	0.3453
12	TF1:	.1324	3.363	2.6926	11.9767	.1722	0.2335
13	TF1:	.1059	2.690	2.4442	10.8718	.1177	0.1596
14	TF2:	.0900	2.286	1.9862	8.8346	.0718	0.0973

continued

EXAMPLE III (TANDEM REVERSING MILL)--continued

31 TONS (28 METRIC TONS) 1000. PIW

ROLLING SCHEDULE HSM - 62.00 (1574.8mm) - 10.00 (254mm)/ 0.0900 (2.33mm)

PASS NO.	MILL STAND NAME	GAUGE IN.	GAUGE MM.	HORSE POWER	HORSE POWER kW	LOAD RATIO	RMS TIME SEC.
0	FCE:	10.0000	254.000	0.	0	.0000	.00
1	TF1:	8.5500	217.170	19641.	14646	2.2110	15.21
2	TF2:	7.1000	180.340	23630.	17621	2.2090	15.18
3	TF2:	5.6500	143.510	22147.	16515	2.2281	20.89
4	TF1:	4.2000	106.680	29763.	22194	2.2258	20.84
5	TF1:	2.9300	74.422	19976.	14896	2.2292	44.72
6	TF2:	1.8700	47.498	30993.	23111	2.2138	44.10
7	TF2:	1.1200	28.448	22189.	16546	2.0114	120.70
8	TF1:	.6600	16.764	28689.	21393	2.0492	117.66
9	TF1:	.3878	9.850	17504.	13053	1.2503	82.40
10	TF2:	.2521	6.403	15284.	11397	1.0917	60.62
11	TF2:	.1765	4.483	10858.	8097	.7755	41.88
12	TF1:	.1324	3.363	9786.	7297	.6990	33.14
13	TF1:	.1059	2.690	5683.	4238	.4059	13.27
14	TF2:	.0900	2.286	4081.	3043	.2915	6.67

Reversing Tandem Mill Peak Production: 403.72 TPH
Coiling Begins at Pass Number: 8 * TF1 *
Tandem Passes Begin at Pass Number: 1 * TF1 *
Distance Between CFce #1 and Mill: 35.00 ft.(10.7m)
Distance Between Mill and CFce #2: 35.00 ft.(10.7m)
Coiling Furnace Diameter: 54.00 in. (1371.6mm)
Coiling Furnace Temperature: 1650.00°F (898.89°C)
Acceleration/Deceleration Rate: 250.00 FPM/sec. (76.2 MPM/sec.)
Final Body Temperature at TS: 1880.60°F (1027.00°C)

Example III illustrates the flexibility of the present system which can receive outsourced slabs for further processing. Such outsourced slabs may be, as here, slabs which are too thick to be cast in the intermediate thickness caster or slabs which have a specialized composition limiting where they may be produced or simply additional slabs to supplement the caster product. The rolling of outsourced slabs and the ability to store cast slabs allows the casting and rolling to be decoupled and operated independently of each other.

EXAMPLE IV

A 48 inch (1219.2mm) wide x 0.125 inch (3.175mm) thick sheet of high carbon steel (0.51-0.95 carbon) in coil form is produced from a 5 ½ inch (139.7mm) thick cast slab in accordance to the following rolling schedule:

EXAMPLE IV (TANDEM REVERSING MILL)

24.000 TONS (21.772 METRIC TONS) 1000. PIW
ROLLING SCHEDULE HSM - 48.00 (1219.2mm) - 5.5000 (139.7mm) / .1250 (3.175mm)

PASS NO.	MILL STAND NAME	GAUGE IN.	GAUGE MM.	% RED	DRAFT IN.	DRAFT MM.	BITE ANGLE DEG.	LENGTH FT.	LENGTH M.	ELAPSED TIME SEC.
0	FCE:	5.5000	139.700	.0	.000	0.00	.00	53.5	16.3	.00
1	TF1:	3.9350	99.949	28.5	1.565	39.75	17.99	74.8	22.8	8.76
2	TF2:	2.5200	64.008	36.0	1.415	35.94	17.10	116.9	35.6	14.98
3	TF2:	1.6500	41.910	34.5	.870	22.10	13.39	178.5	54.4	39.52
4	TF1:	.9850	25.019	40.3	.665	16.89	11.70	299.0	91.1	44.03
5	TF1:	.5600	14.224	43.1	.425	10.80	9.35	525.8	160.3	87.35
6	TF2:	.3500	8.890	37.5	.210	5.33	6.57	841.3	256.4	91.40
7	TF2:	.2450	6.223	30.0	.105	2.67	4.64	1201.9	366.3	153.78
8	TF1:	.1830	4.648	25.3	.062	1.57	3.57	1609.1	490.5	157.51
9	TF1:	.1470	3.734	19.7	.036	0.91	2.72	2003.2	610.6	230.60
10	TF2:	.1250	3.175	15.0	.022	0.56	2.12	2355.8	718.0	230.60

continued

EXAMPLE IV (TANDEM REVERSING MILL)--*continued*

PASS NO.	MILL STAND NAME	GAUGE IN.	GAUGE MM.	ENTRY TEMP. DEG. F			ENTRY TEMP. DEG. C		
				Front	*Tail*	*Diff.*	*Front*	*Tail*	*Diff.*
0	FCE:	5.5000	139.700	2250.0	2250.0	.0	1232.2	1232.2	0.0
1	TF1:	3.9350	99.949	2225.0	2214.4	10.7	1218.3	1212.4	5.9
2	TF2:	2.5200	64.008	2208.4	2206.1	2.3	1209.1	1207.8	1.3
3	TF2:	1.6500	41.910	2131.5	2208.1	76.6	1166.4	1208.9	42.6
4	TF1:	.9850	25.019	2120.1	2161.8	41.7	1160.1	1183.2	23.1
5	TF1:	.5600	14.224	2119.4	2025.2	94.2	1159.7	1107.3	52.3
6	TF2:	.3500	8.890	2093.5	2036.7	56.9	1145.3	1113.7	31.6
7	TF2:	.2450	6.223	1879.0	2014.6	135.6	1026.1	1101.4	75.3
8	TF1:	.1830	4.648	1882.3	1954.2	71.9	1027.9	1067.9	39.9
9	TF1:	.1470	3.734	1835.9	1776.8	59.1	1002.2	969.3	32.8
10	TF2:	.1250	3.175	1762.7	1767.6	4.9	961.5	964.2	2.7

PASS NO.	MILL STAND NAME	GAUGE IN.	GAUGE MM.	EXIT TEMP. DEG. F			EXIT TEMP. DEG. C		
				Front	*Tail*	*Diff.*	*Front*	*Tail*	*Diff.*
0	FCE:	5.5000	139.700	2250.0	2250.0	.0	1232.2	1232.2	0.0
1	TF1:	3.9350	99.949	2225.0	2214.4	10.7	1212.0	1209.7	2.3
2	TF2:	2.5200	64.008	2208.4	2206.1	2.3	1213.6	1213.1	0.4
3	TF2:	1.6500	41.910	2131.5	2208.1	76.6	1162.8	1189.9	27.1
4	TF1:	.9850	25.019	2120.1	2161.8	41.7	1168.7	1188.3	19.7
5	TF1:	.5600	14.224	2119.4	2025.2	94.2	1162.0	1118.6	43.4
6	TF2:	.3500	8.890	2093.5	2036.7	56.9	1145.9	1123.1	22.8
7	TF2:	.2450	6.223	1879.0	2014.6	135.6	1033.8	1093.7	59.9
8	TF1:	.1830	4.648	1882.3	1954.2	71.9	1033.1	1059.1	26.0
9	TF1:	.1470	3.734	1835.9	1776.8	59.1	988.7	971.2	17.4
10	TF2:	.1250	3.175	1762.7	1767.6	4.9	947.1	962.8	15.6

continued

EXAMPLE IV (TANDEM REVERSING MILL)--continued

PASS NO.	MILL STAND NAME	GAUGE IN.	GAUGE MM.	ROLL FORCE LB X 10**6		ROLL FORCE N X 10**6	
				Front	*Tail*	*Front*	Tail
0	FCE:	5.5000	139.700	.0000	.0000	0.0000	0.0000
1	TF1:	3.9350	99.949	3.3819	3.3961	15.0427	15.1059
2	TF2:	2.5200	64.008	3.7790	3.7821	16.8090	16.8228
3	TF2:	1.6500	41.910	3.6795	3.4730	16.3664	15.4479
4	TF1:	.9850	25.019	3.9123	3.7526	17.4019	16.6916
5	TF1:	.5600	14.224	3.9918	4.4220	17.7555	19.6691
6	TF2:	.3500	8.890	3.4093	3.6004	15.1646	16.0146
7	TF2:	.2450	6.223	3.5301	3.0166	15.7019	13.4178
8	TF1:	.1830	4.648	2.9834	2.7839	13.2702	12.3828
9	TF1:	.1470	3.734	2.6765	2.8334	11.9051	12.6030
10	TF2:	.1250	3.175	2.4248	2.2978	10.7855	10.2206

continued

EXAMPLE IV (TANDEM REVERSING MILL)--continued

PASS NO.	MILL STAND NAME	GAUGE IN.	GAUGE MM.	TORQUE LB-FT X 10**6		TORQUE J X 10**6	
				Front	*Tail*	*Front*	Tail
0	FCE:	5.5000	139.700	0.0000	.0000	0.0000	0.0000
1	TF1:	3.9350	99.949	1.4016	1.4076	1.9002	1.9084
2	TF2:	2.5200	64.008	1.4872	1.4884	2.0163	2.0179
3	TF2:	1.6500	41.910	1.1318	1.0683	1.5344	1.4483
4	TF1:	.9850	25.019	1.0476	1.0048	1.4203	1.3623
5	TF1:	.5600	14.224	.8474	.9387	1.1489	1.2726
6	TF2:	.3500	8.890	.5011	.5292	0.6794	0.7175
7	TF2:	.2450	6.223	.3596	.30736	0.4875	0.4166
8	TF1:	.1830	4.648	.2282	.2129	0.3094	0.2886
9	TF1:	.1470	3.734	.1515	.1595	0.2054	0.2162
10	TF2:	.1250	3.175	.1027	.0980	0.1392	0.1329

continued

EXAMPLE IV (TANDEM REVERSING MILL)--*continued*

PASS NO.	MILL STAND NAME	GAUGE IN.	GAUGE MM.	HORSEPOWER		HORSEPOWER kW	
				Front	*Tail*	*Front*	*Tail*
0	FCE:	5.5000	139.700	0.	0.	0.0000	0.0000
1	TF1:	3.9350	99.949	16321.	16390.	12171.	12222.
2	TF2:	2.5200	64.008	27040.	27062.	20164.	20180.
3	TF2:	1.6500	41.910	18428.	17393.	13742.	12970.
4	TF1:	.9850	25.019	28572.	27405.	21306.	20435.
5	TF1:	.5600	14.224	19680.	21801.	14675.	16257.
6	TF2:	.3500	8.890	18623.	19667.	13887.	14666.
7	TF2:	.2450	6.223	12209.	10433.	9104.	7780.
8	TF1:	.1830	4.648	10373.	9679.	7735.	7218.
9	TF1:	.1470	3.734	5855.	6164.	4366.	4596.
10	TF2:	.1250	3.175	4669.	4454.	3482.	3321.

continued

EXAMPLE IV (TANDEM REVERSING MILL) --continued

PASS NO.	MILL STAND NAME	GAUGE IN.	GAUGE MM.	LOAD RATIO		RMS TIME SEC.
				Front	*Tail*	
0	FCE:	5.5000	139.700	.0000	.0000	.00
1	TF1:	3.9350	99.949	2.3824	2.3925	49.95
2	TF2:	2.5200	64.008	2.5278	2.5299	56.05
3	TF2:	1.6500	41.910	1.9238	1.8158	85.81
4	TF1:	.9850	25.019	2.0408	1.9575	90.35
5	TF1:	.5600	14.224	1.4403	1.5955	99.81
6	TF2:	.3500	8.890	1.3302	1.4048	76.83
7	TF2:	.2450	6.223	.8721	.7452	40.79
8	TF1:	.1830	4.648	.7409	.6914	30.95
9	TF1:	.1470	3.734	.4182	.4403	13.47
10	TF2:	.1250	3.175	.3335	.3181	7.50

Reversing Tandem Mill Peak Production: 374.68 TPH
Coiling Begins at Pass Number: 4 * TF1 *
Tandem Passes Begin at Pass Number: 1 * TF1 *
Distance Between Cfce #1 and Mill: 35.00 ft.(10.7m)
Distance Between Mill and Cfce #2: 35.00 ft.(10.7m)
Coiling Furnace Diameter: 54.00 in.(1371.6mm)
Coiling Furnace Temperature: 1650.00°F (898.89°C)
Acceleration/Deceleration Rate: 250.00 FPM/sec. (76.2 MPM/sec.)
Final Front Temperature at TS: 1736.86°F (947.14°C)
Final Tail Temperature at TS: 1765.03°F (962.79°C)

EXAMPLE V

A 60 inch (1524mm) wide x 0.100 inch (2.54mm) thick sheet in coil form is produced from a 5 inch (127mm) cast slab of low carbon steel according to the following rolling schedule:

EXAMPLE V (TANDEM REVERSING MILL)

30.000 TONS (27.216 METRIC TON) 1000. PIW
ROLLING SCHEDULE HSM - 60.00 (1524mm) - 5.0000 (127mm) / .1000 (2.54mm)

PASS NO.	MILL STAND NAME	GAUGE IN.	GAUGE MM.	% RED	DRAFT IN.	DRAFT MM.	BITE ANGLE DEG.	LENGTH FT.	LENGTH M.	ELAPSED TIME SEC.
0	FCE:	5.0000	127.000	.0	.000	0.00	.00	58.9	18.0	.00
1	TF1:	3.7000	93.980	26.0	1.300	33.02	17.37	79.6	24.3	9.20
2	TF2:	2.4000	60.960	35.1	1.300	33.02	17.37	122.7	37.4	15.29
3	TF2:	1.3750	34.925	42.7	1.025	26.04	15.41	214.1	65.3	40.09
4	TF1:	.8250	20.955	40.0	.550	13.97	11.28	356.9	108.8	44.52
5	TF1:	.4580	11.633	44.5	.367	9.32	9.21	642.9	196.0	87.66
6	TF2:	.2920	7.417	36.2	.166	4.22	6.19	1008.4	307.4	92.02
7	TF2:	.2085	5.296	28.6	.083	2.11	4.39	1412.2	430.4	154.38
8	TF1:	.1500	3.810	28.1	.058	1.47	3.67	1963.0	598.3	158.35
9	TF1:	.1176	2.987	21.6	.032	0.81	2.73	2503.8	763.2	230.99
10	TF2:	.1000	2.540	15.0	.018	0.46	2.01	2944.5	897.5	230.99

PASS NO.	MILL STAND NAME	GAUGE IN.	GAUGE MM.	ENTRY TEMP. DEG. F	ENTRY TEMP. DEG. C	EXIT TEMP. DEG. F	EXIT TEMP. DEG. C
0	FCE:	5.0000	127.000	2300.00	1260.00	2300.00	1260.00
1	TF1:	3.7000	93.980	2257.40	1236.33	2245.50	1229.72
2	TF2:	2.4000	60.960	2240.90	1227.17	2244.50	1229.17
3	TF2:	1.3750	34.925	2150.30	1176.83	2149.90	1176.61
4	TF1:	.8250	20.955	2146.10	1174.50	2156.40	1180.22
5	TF1:	.4580	11.633	2133.40	1167.44	2040.00	1115.56
6	TF2:	.2920	7.417	2014.20	1101.22	2008.40	1098.00
7	TF2:	.2085	5.296	1857.00	1013.89	1844.40	1006.89
8	TF1:	.1500	3.810	1856.80	1013.78	1845.10	1007.28
9	TF1:	.1176	2.987	1790.80	977.11	1757.90	958.83
10	TF2:	.1000	2.540	1712.50	933.61	1677.20	914.00

continued

EXAMPLE V (TANDEM REVERSING MILL)--continued

30.000 TONS (27.216 METRIC TON) 1000. PIW

ROLLING SCHEDULE HSM - 60.00 (1524mm) - 5.0000 (122mm) / .1000 (2.54mm)

PASS NO.	MILL STAND NAME	GAUGE IN.	GAUGE MM.	ROLL FORCE LB x 10**6	ROLL FORCE N x 10**6	TORQUE LB-FT x 10**6	TORQUE J x 10**6
0	FCE:	5.0000	127.000	.0000	0.0000	.0000	0.0000
1	TF1:	3.7000	93.980	2.6914	11.9713	.9614	1.3034
2	TF2:	2.4000	60.960	3.1851	14.1673	1.1359	1.5400
3	TF2:	1.3750	34.925	3.8551	17.1475	1.2119	1.6430
4	TF1:	.8250	20.955	3.2415	14.4182	.7469	1.0126
5	TF1:	.4580	11.633	3.9262	17.4637	.7340	0.9951
6	TF2:	.2920	7.417	3.1308	13.9258	.3886	0.5268
7	TF2:	.2085	5.296	2.9526	13.1332	.2559	0.3469
8	TF1:	.1500	3.810	2.8790	12.8058	.2052	0.2782
9	TF1:	.1176	2.987	2.6673	11.8642	.1368	0.1855
10	TF2:	.1000	2.540	2.2102	9.8310	.0801	0.1086

continued

EXAMPLE V (TANDEM REVERSING MILL)--continued

30.000 TONS (27.216 METRIC TON) 1000. PIW

ROLLING SCHEDULE HSM - 60.00 (1524mm) - 5.0000 (122mm) / .1000 (2.54mm)

PASS NO.	MILL STAND NAME	GAUGE IN.	GAUGE MM.	HORSE POWER	HORSE POWER kW	LOAD RATIO	RMS TIME SEC.
0	FCE:	5.0000	127.000	0.	0.00	.0000	.00
1	TF1:	3.7000	93.980	12731.	9494.	1.4293	16.91
2	TF2:	2.4000	60.960	23190.	17293.	1.6888	26.32
3	TF2:	1.3750	34.925	27833.	20755.1	1.8817	76.11
4	TF1:	.8250	20.955	28591.	21320.1	1.2744	35.96
5	TF1:	.4580	11.633	23884.	17810.1	1.0912	50.88
6	TF2:	.2920	7.417	19835.	14791.	.8855	30.50
7	TF2:	.2085	5.296	11744.	8757.	.5243	14.69
8	TF1:	.1500	3.810	13091.	9762.	.5814	19.46
9	TF1:	.1176	2.987	7420.	5533.	.3313	7.43
10	TF2:	.1000	2.540	5110.	3811.	.2281	3.12

Reversing Tandem Mill Peak Production: 467.52 TPH
Coiling Begins at Pass Number: 4 * TF1 *
Distance Between Cfce #1 and Mill: 27.00 ft.(8.2m)
Distance Between Mill and Cfce #2: 27.00 ft.(8.2m)
Coiling Furnace Diameter: 54.00 in. (1371.6mm)
Coiling Furnace Temperature: 1750.00°F (954.44°C)
Acceleration/Deceleration Rate: 250.00 FPM/sec.(76.2MPM/sec.)
Final Temperature at TS: 1677.17°F (913.98°C)

Examples IV and V show the range of grades producible on the present invention providing the broad product mix needed for a competitive mill.

The intermediate thickness slab caster and inline hot strip and plate line of a third embodiment of the present invention is illustrated in Figs. 3A and 3B. The third embodiment is similar to the first two embodiments including electric melting furnaces 226 provided at the entry end of the strip and plate line 225, ladle furnace 228, caster 230, mold 232 and cutoff 234 positioned at the exit end of the mold 232 to cut the strand of now solidified metal into a 3.5 to 6 inch thick slab (intermediate thickness) of the desired length which also has a width of 24 to 120 inches.

The slab then feeds on a table conveyor 236 to a slab takeoff area where it is directly charged into a furnace 242 or is stored in slab storage container 280 or alternatively is removed from the inline processing and stored in a slab collection area 240. If the cast slab is needed to be stored prior to rolling, such as due to maintenance on the rolling mill, it is preferred that the slabs be stored in the slab storage container 280. The slab collection area 240 will generally be utilized where additional processing of a slab is required, such as surfacing of the slab by hand scarfing. Full-size slabs 244 and discrete length slabs 246 for certain plate products are shown within walking beam furnace 242. Slabs 238 which are located in the slab collection area 240 may also be fed into the furnace 242 by means of slab pushers 248 or charging arm devices located for indirect charging of walking beam furnace 242 with slabs 238. It is also possible to charge slabs into furnace 242 from the slab storage container 280 which feed onto the table conveyor 236. As discussed above, where slabs are introduced from off-line locations, the furnace must have the capacity to add Btu's to bring the slabs up to rolling temperatures. The slab storage container 280 will minimize the need for such off-line slab loading.

The various slabs are fed through the following furnace 242. The third embodiment operates substantially identical to the two embodiments discussed above. The third embodiment includes slab extractors 250, feed and run back table 252, descaler 253, vertical edger 254, and hot reversing mill 256 downstream of feed and run back table 252, upstream and downstream coiler furnace 258 and 260, cooling station 262, coiler 266 downstream of cooling station 262, coil car 267, a plate table 264, a shear 268, a transfer table 270, and a final processing line 271 which includes a plate side shear 272, plate end shear 274 and plate piler 276.

Fig. 3B illustrates a modified version of the embodiment of the caster and inline mill illustrated in Fig. 3A. Fig. 3B is identical to Fig. 3A except that a plurality of slab storage containers 280 and 280' is provided adjacent the table conveyor 236. A second slab storage container 280' obviously provides additional capacity for storing cast slabs in the event of a delay downstream. However, the addition of a second or more slab storage container 280' also provides slab sequencing possibilities. This allows for a certain prioritization and changing of the order of slabs by directing them to appropriate slab storage containers 280, 280' from which the slabs can be selectively withdrawn.

Fig. 4 illustrates a first embodiment of the slab storage container 280. The slab storage container 280 includes a carriage 282 mounted by rollers 284 onto a track 286 located within a slab holding pit 288. The walls 290 of the slab holding pit 288 are appropriately insulated as is the top surface 292 of the carriage 282 which engages and supports the lowermost slab of a stack of slabs. An insulated movable cover 294 is provided for covering the slab holding pit 288 and the stack of slabs, as shown in phantom in Fig. 4. Slab pushers 296 are provided for moving slabs into and out of the stack in the slab storage container 280. The slab storage container 280 operates as follows. The lowermost slab of the stack of slabs is pushed onto the top surface 292 of the carriage 282 by slab pushers 296. Carriage 282 is then indexed down a distance substantially equal to the thickness of the slab whereby a second slab can be pushed by slab pusher 296 directly on top of the initial slab. When the stack of slabs has been placed into the slab storage container 280, the cover 294 can be positioned on top of the slab holding pit 288 to maintain the heat within the slabs.

The configuration of the slab storage container 280 provides a simple and effective means for storing a stack of slabs which also minimizes the space required. Furthermore, stacking the slabs directly on top of each other and maintaining the stacked slabs in contact with each other gives the thermal advantages of a thicker slab. The temperature loss of the individual slabs is minimized with this stacked arrangement.

Fig. 5 is a side view of another embodiment of a slab storage container 280' according to the present invention. The slab storage container 280' includes a carriage 282' supported on a frame 298. The carriage 282' is vertically movable on the frame 298. The carriage 282' includes a front and back pair of slab engaging arms 300. As shown in Fig. 6, engaging points 302 of each engaging arm 300 engage the sides of a lowermost slab in a stack of slabs to engage and support the stack of slabs. Preferably, the slab engaging arms 300 are hydraulically operated to move into and out of engagement with the slabs. In addition to moving in and out of engagement with the slabs, the slab engaging arms 300 are preferably movable to accommodate various widths of the slabs. Side insulating plate 304 and top insulating plate 306 are attached to each slab engaging arm 300. As illustrated in Fig. 6, the top insulating plates 306 of opposed slab engaging arms 300 will overlap with each other to allow for the movement of the slab engaging arms 300 which provide for the accommodation of varying widths of the slabs.

The slab storage container 280' operates in a manner similar to the slab storage container 280 described above and provides similar advantages. In operation, the carriage 282' is lowered to a position over a slab and the slab engaging arms 300 are activated to securely clamp the slab therebetween and the carriage 282' is again raised holding the slab therein. To add a second slab to the slab stack, the carriage 282' is lowered, positioning the slab on top of the second slab to be positioned in the stack. Slab engaging arms 300 are disengaged from the first slab carriage moved down to align the engaging points 302 with the new lowermost slab in the stack and the slab engaging arms 300 engage to contact the new lowermost slab in the stack of slabs. This process is repeated until all of the slabs are positioned within the stack and the process is reversed for removing the slabs from the stack.

As discussed above, the slab storage container 280' provides the advantages of minimal space and efficient, effective thermal conservation of the slabs as with the slab storage container 280 described above. In addition, the slab storage container 280' provides a system that can be mounted directly over top of the slab conveyor table, further minimizing the floor space required for the overall system.

Although the present invention has been described in considerable detail with reference to certain preferred versions thereof, other versions are possible. Therefore, the spirit and scope of the appended claims should not be limited to the description of the preferred versions contained herein.

Claims

1. An intermediate thickness slab caster and inline hot strip and plate line comprising:

   a) a continuous strip caster means for forming an intermediate thickness strand;
   b) an inline cutoff downstream of said caster means for cutting said strand to a slab of a desired length;
   c) a slab storage and sequencing means for selectively storing and sequencing selected slabs;
   d) at least one reheat furnace positioned downstream of said slab storage and sequencing means;
   e) a feed and run back table positioned at an exit end of said at least one reheat furnace;
   f) a hot reversing mill means inline with said feed and run back table for reducing said slab exiting the reheat furnace to an intermediate product of a thickness sufficient for coiling; and
   g) a pair of coiler furnaces, one located upstream of said hot reversing mill means and the other located downstream, said coiler furnaces capable of receiving and paying out said intermediate product as it is passed between the coiler furnaces and through said hot reversing mill means so as to be reduced to an end product thickness.

2. The apparatus of claim 1 further including a slab conveyor table inline with said cutoff, wherein said slab sequencing and storing means includes:
   a slab transfer means adjacent said slab conveyor table operable transverse of said slab conveyor table and in communication with said feed and run back table; and
   a slab collection and storage area adjacent said slab transfer means adapted to selectively receive slabs therefrom.

3. The apparatus of claim 2 further including a pair of said reheat furnaces,
   a first said reheat furnace positioned between said feed and run back table and said slab conveyor table, and
   a second said reheat furnace downstream of and adjacent said first reheat furnace and having an entry end inline with said slab conveyor table and an exit inline with said feed and run back table.

4. The apparatus as claimed in claim 1 wherein said feed and run back table is positioned inline with said cutoff and adapted to receive slabs directly therefrom, and wherein said slab sequencing and storing means includes:
   a slab transfer table adjacent said feed and run back table operable transverse of said feed and run back table to selectively remove slabs from said feed and run back table;
   a slab conveyor table adjacent said slab transfer table and adapted to receive slabs from said slab transfer table; and
   a slab collection and storage area adjacent said slab conveyor table adapted to receive slabs from said slab conveyor table.

5. The apparatus of claim 1 further including a slab conveyor table inline with said cutoff wherein said slab storage and sequencing means includes at least one vertically stackable slab storage container positioned adjacent said slab conveyor table, wherein said slab storage container includes a vertically movable carriage for supporting a stack of said slabs.

6. A method of processing metal slabs comprising the steps of:

   a) continuously casting an intermediate thickness strand;
   b) cutting said strand into a plurality of slabs of predetermined lengths;
   c) selectively feeding each said slab to either

      i) a continuous processing line including a hot reversing mill having a coiler furnace on each of an upstream and downstream side thereof, or
      ii) an inline heating furnace from which said slab exits to said continuous processing line, or
      iii) a slab storing area and subsequently transferring said slab to said inline heating furnace;

d) flat passing said slab to be worked back and forth through said hot reversing mill to form an intermediate product of a thickness sufficient for coiling;

e) coiling said intermediate product in one of said coiler furnaces; and

f) passing said coiled intermediate product back and forth through said hot reversing mill to reduce said coiled intermediate product to an end product of desired thickness, said intermediate product being collected in and fed out of each of said coiler furnaces on each pass through said hot reversing mill.

7. The method of claim 6 further including supplying at least one slab to be worked to said inline heating furnace and said continuous processing line from said slab storing area which was not cast in said intermediate thickness caster.

8. The method of claim 6 wherein said slab storing area includes at least one vertically stacking slab container.

9. The method of claim 6 wherein said slab storing area includes a slab collection and storage area, and wherein a second heating furnace is positioned adjacent said inline heating furnace.

10. A slab container positioned between a continuous caster and a hot reversing mill adapted to selectively receive slabs from said caster, said container including a vertically movable carriage adapted to engage a lowermost slab in a stack of said slabs within said container, wherein said slabs in said stack are directly contacting each other.

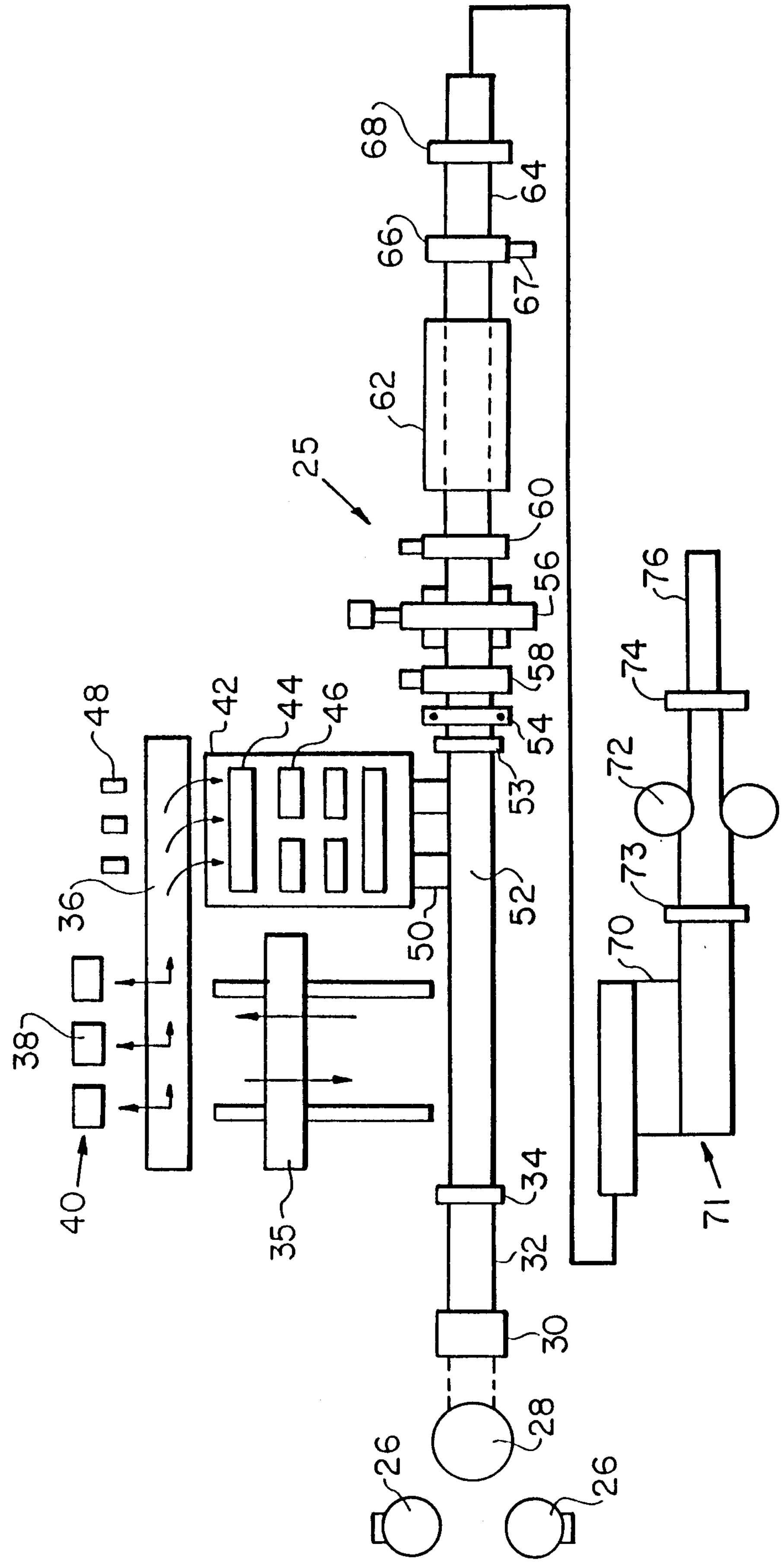

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FIG. 1A

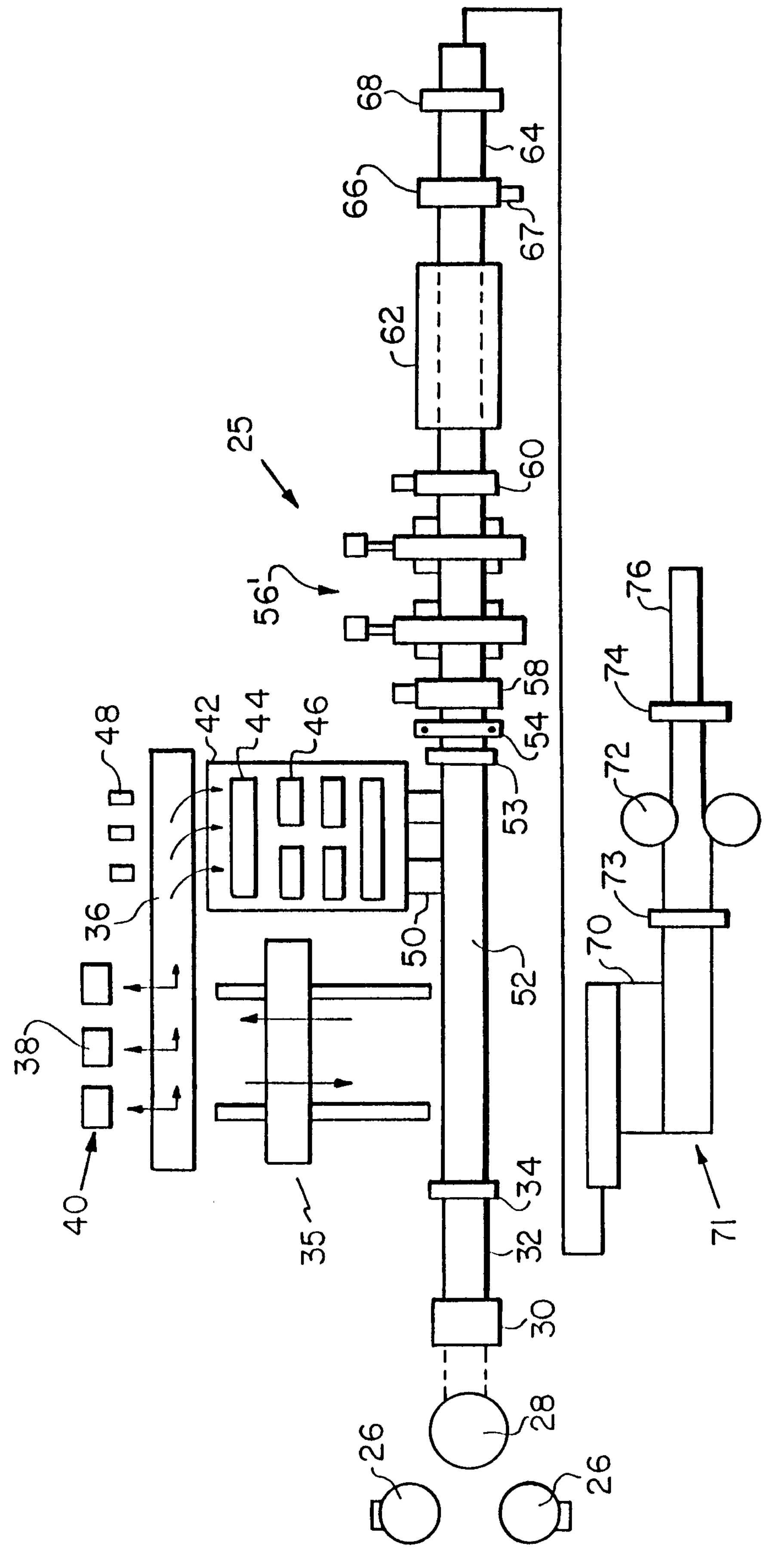
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FIG. 1B

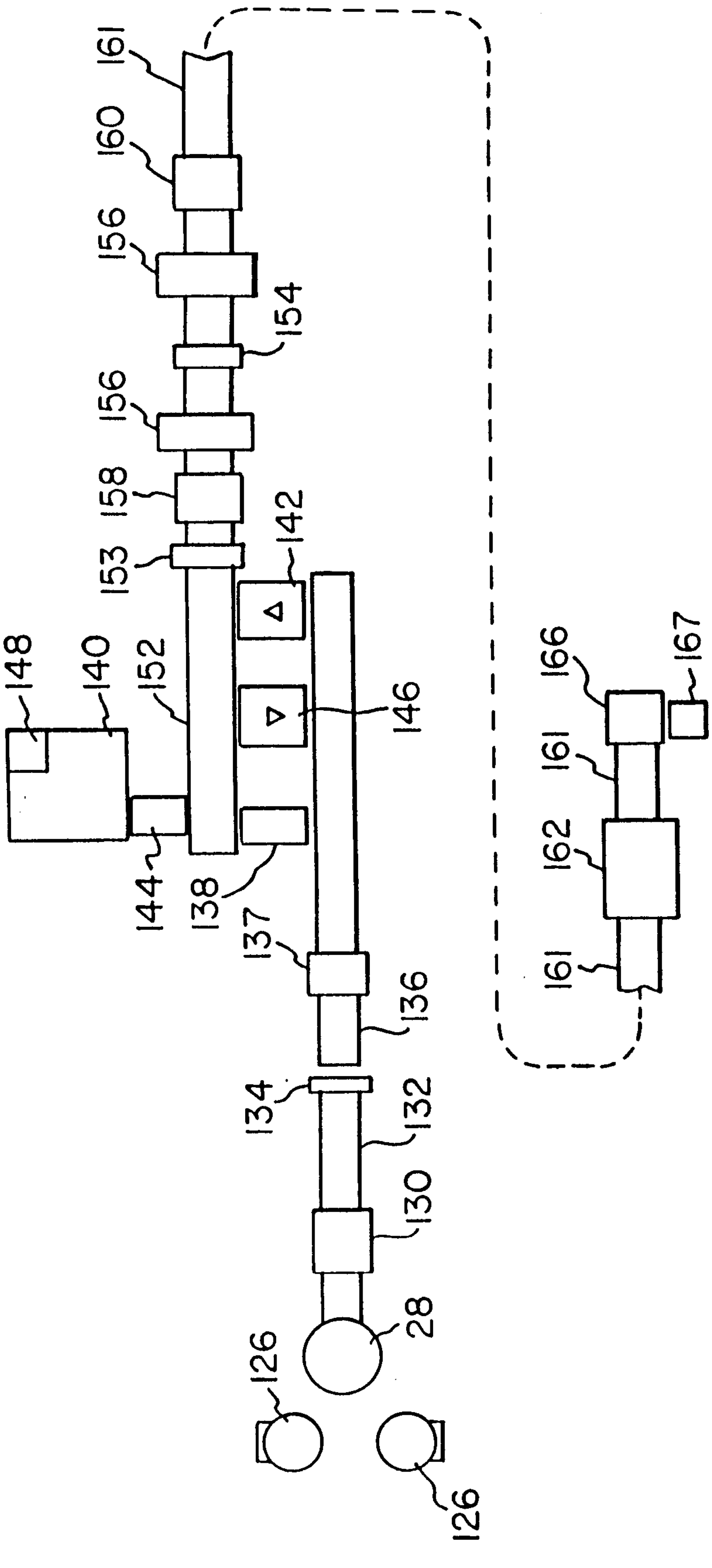
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FIG. 2

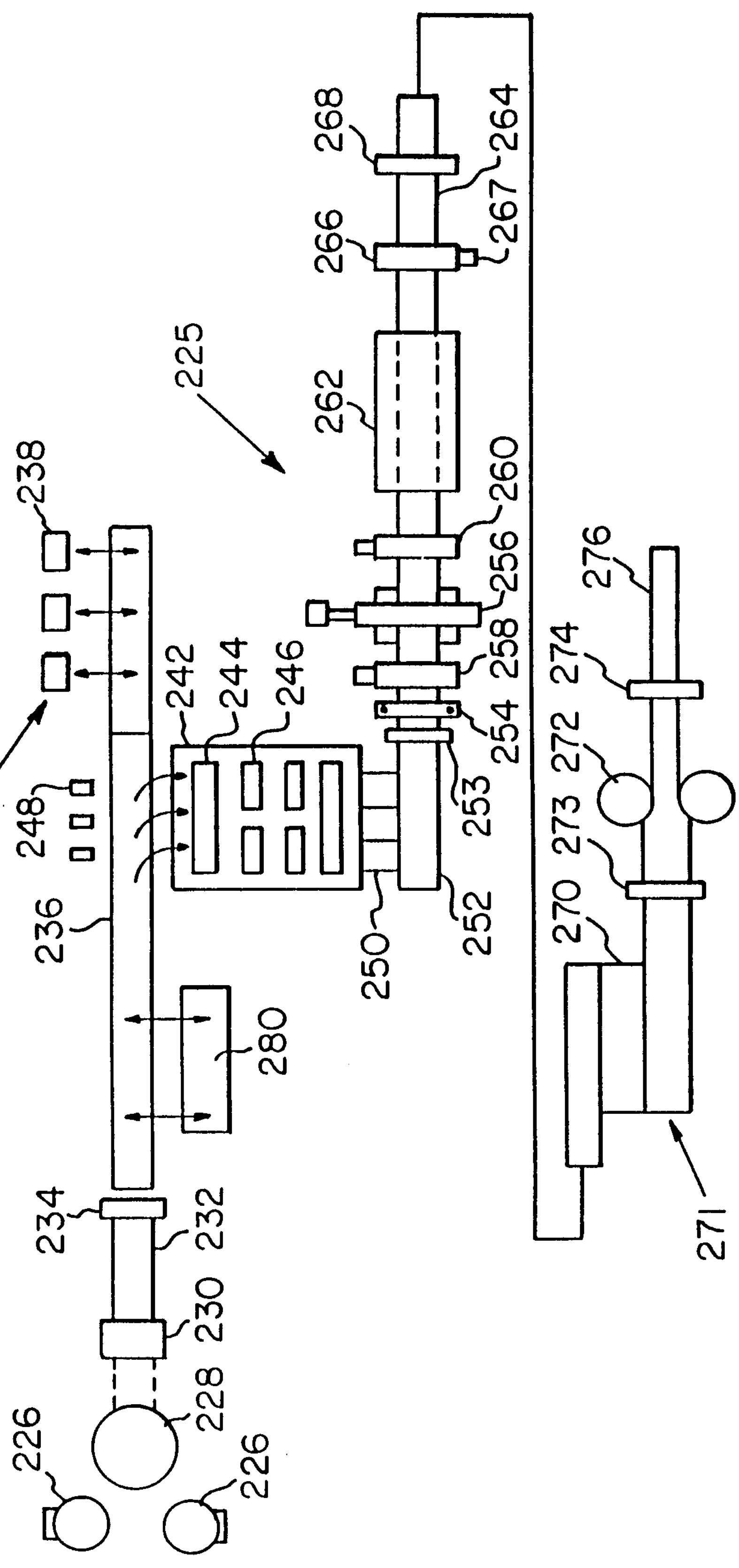
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FIG. 3A

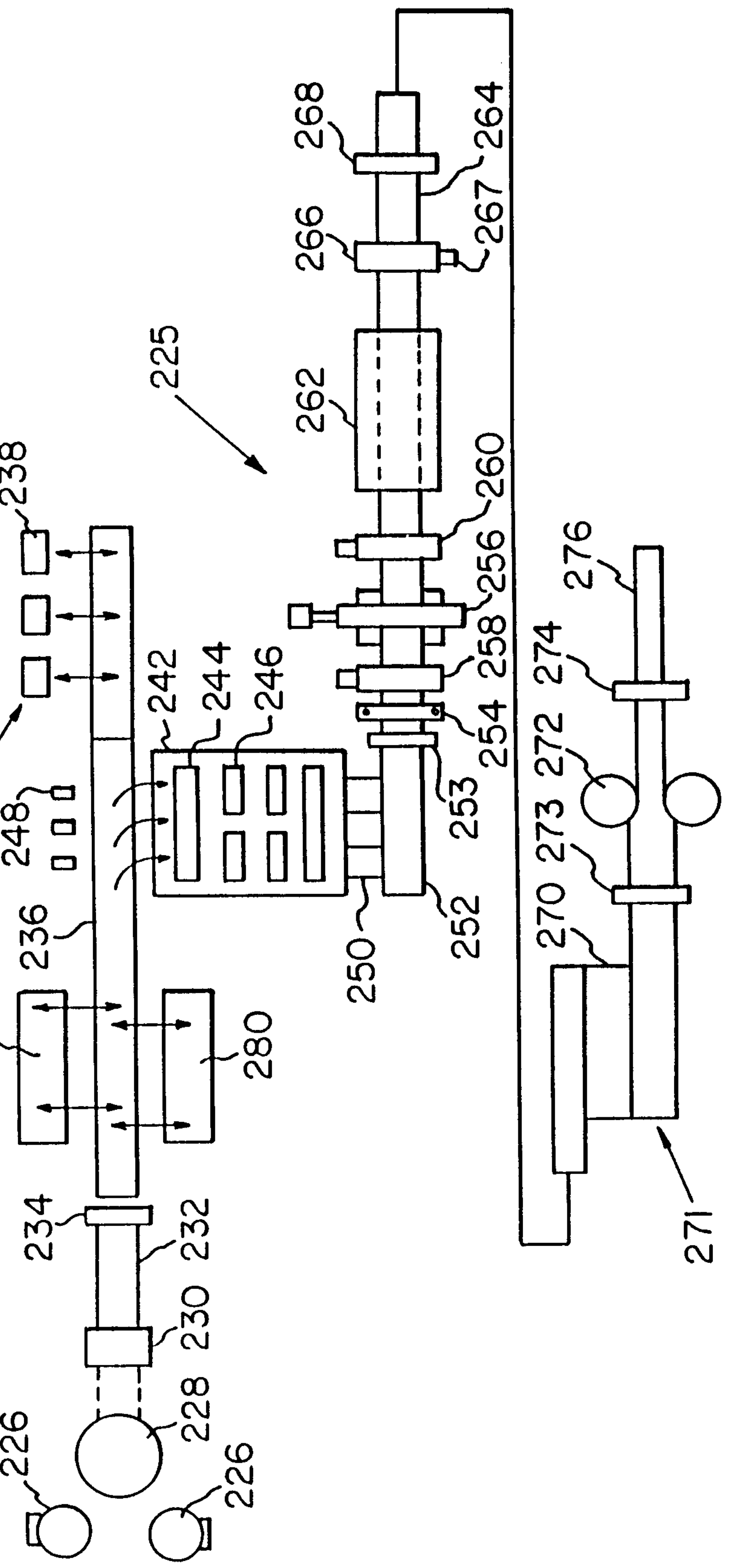
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FIG. 3B

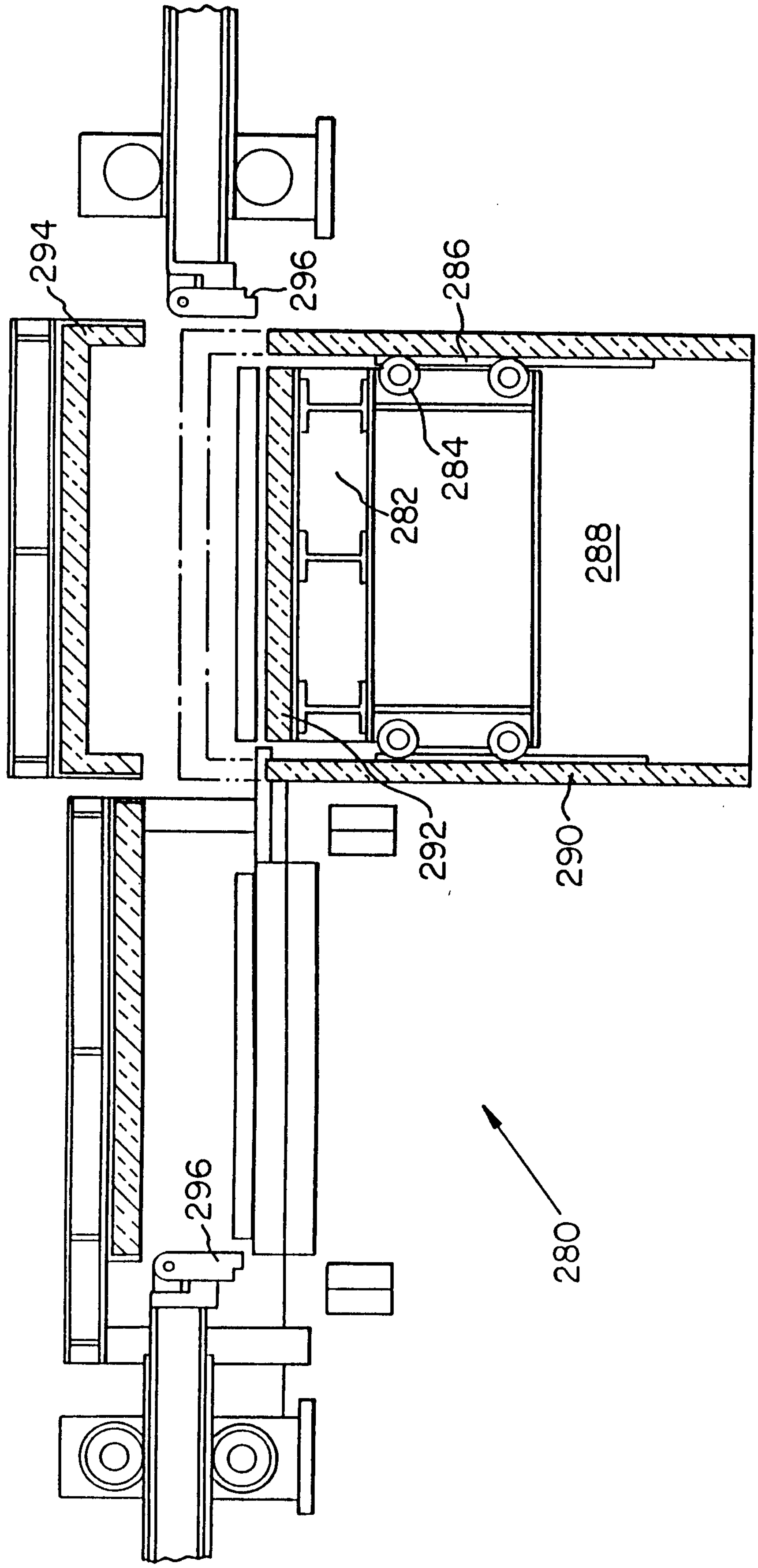

FIG. 4

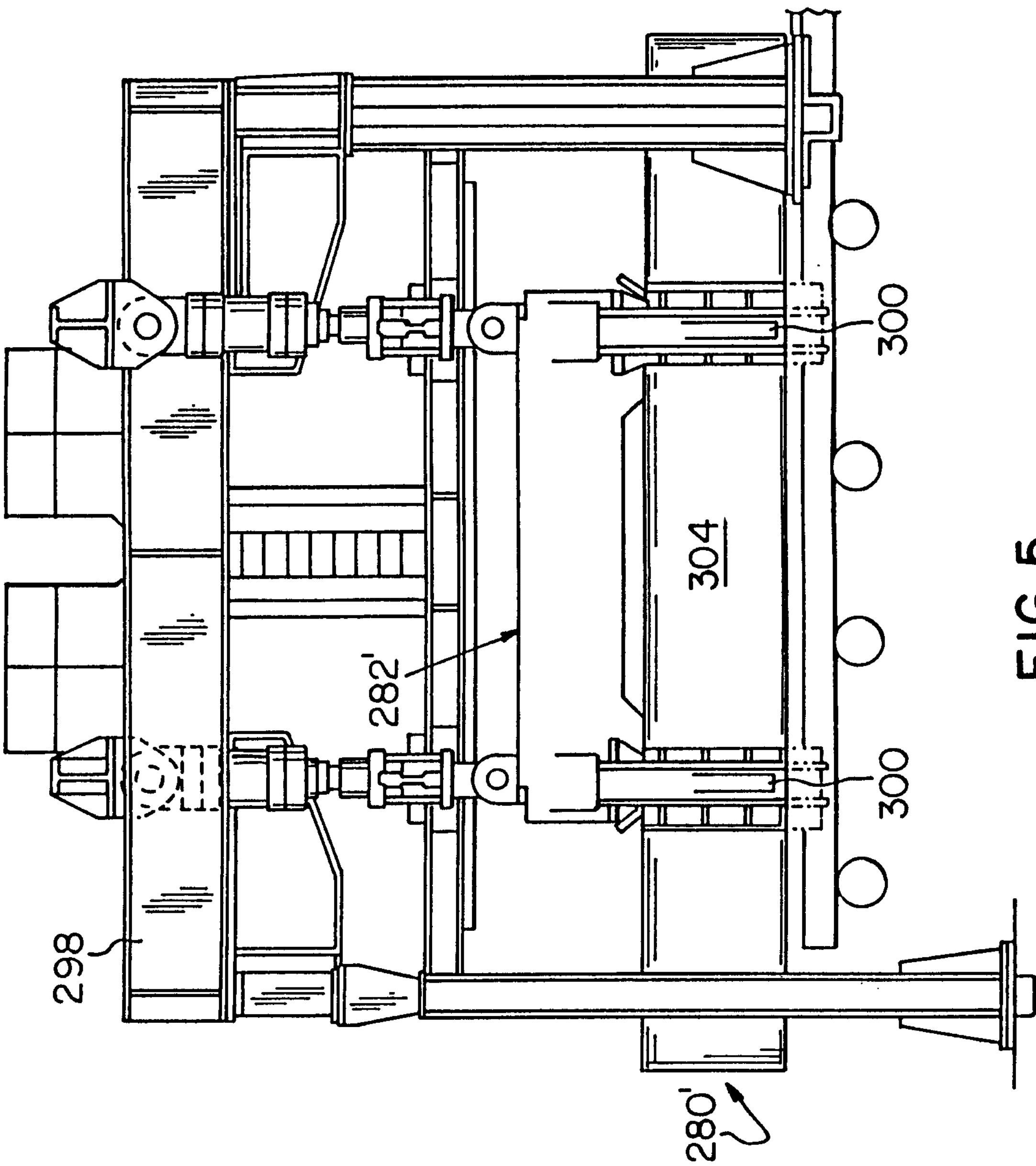

FIG. 5

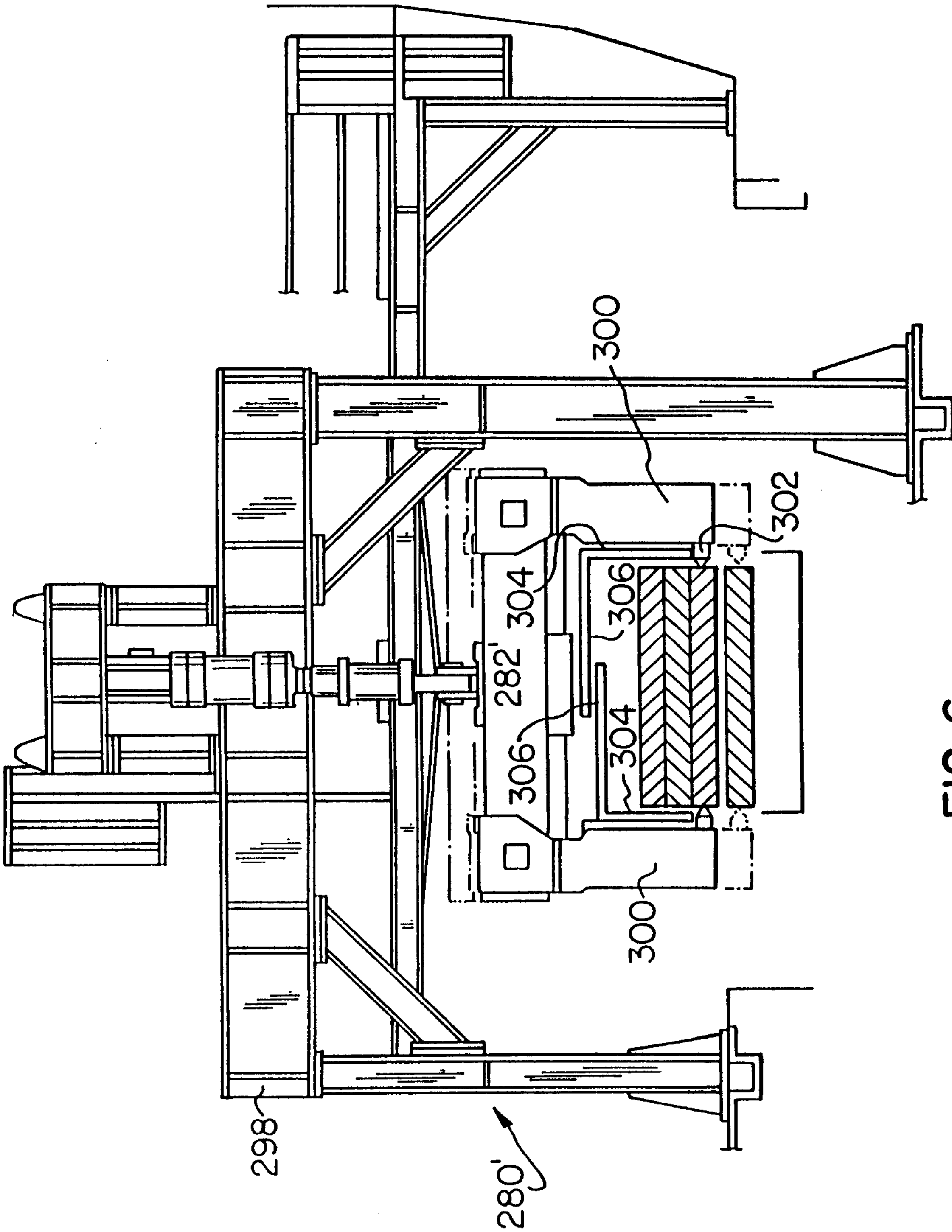

FIG. 6

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EUROPEAN SEARCH REPORT

Application Number
EP 95 20 3666

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Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
X Y	WO-A-93 23182 (TIPPINS INC) 25 November 1993 * pages 3-5,10-12; claims1,2,10; figure 2 *	1 2-10	B21B1/46 C21D9/00 F27D3/00
Y	PATENT ABSTRACTS OF JAPAN vol. 007, no. 079 (M-204), 31 March 1983 & JP-A-58 006701 (NIPPON KOKAN KK), 14 January 1983, * abstract *	2-4,6,7,9	
Y	EP-A-0 610 028 (HITACHI LTD) 10 August 1994 * column 6 - column 10; figures 1-7,9-11 *	5,8,10	
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Y	EP-A-0 257 540 (BRITISH STEEL CORP) 2 March 1988 * the whole document *	5,8,10	

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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	22 May 1996	Rosenbaum, H

CATEGORY OF CITED DOCUMENTS

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D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

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European Patent Office

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EP 95 20 3666

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
X A	EP-A-0 625 383 (DANIELI OFF MECC) 23 November 1994 * the whole document *	1 2,4-7,9	
X A	EP-A-0 584 605 (DANIELI OFF MECC ;UNITED ENGINEERING INC (US); INT ROLLING MILL CO) 2 March 1994 * column 13 - column 17; figures 9-10B *	1 2,4-7,9	
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A	EP-A-0 264 459 (SCHLOEMANN SIEMAG AG) 27 April 1988 * column 6 - column 11; figures 4-6 *	1-6,8-10	
A	US-A-5 150 597 (SEKIYA TERUO ET AL) 29 September 1992 * the whole document *	1-6,9	
A	HITACHI REVIEW, vol. 39, no. 4, August 1990, TOKYO JP, pages 195-200, XP000173200 T. KIMURA ET AL.: "Hitachi Mini Hot Strip Mill" * the whole document *	1-6,9	TECHNICAL FIELDS SEARCHED (Int.Cl.6)
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A	EP-A-0 429 328 (STEIN HEURTEY) 29 May 1991 * the whole document *	5,8,10	

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
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