METAL SLAB CONDITIONING SYSTEM

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ABSTRACT

A metal slab conditioning system including two or more slab-supporting and turnover devices in combination with a movable slab conditioning tool platform suspended thereabove. Each slab-supporting and turnover device includes a pair of independently rotatable leaves adapted for supporting slabs and to cooperate in transferring a slab from one leaf to the other. The slab-supporting and turnover devices are arranged to permit convenient transfer of a slab from one such device to another.

11 Claims, 36 Drawing Figures
METAL SLAB CONDITIONING SYSTEM

BACKGROUND OF THE INVENTION

Field of the Invention

This invention relates to the conditioning of metal slabs; more particularly to a system for conditioning the surfaces of metal slabs.

Description of the Prior Art

With the demand for metal products having close specifications in physical properties, manufacturers have found it necessary to condition metal in the semifinished state in order to insure its suitability for further processing; otherwise, excessive amounts of in-plant scrap metal are generated. The conditioning process is directed largely to the removal of defects in the surface of metal slabs, billets and the like, which defects, if not corrected, can cause fouling of equipment in subsequent rolling operations. Perhaps more importantly, these defects can also produce more serious physical defects in the metal processed in such rolling operations, making it unacceptable for end use.

Typical of the problems associated with surface conditioning of metals are those presented in the manufacture of steel. The primary technique for removing surface defects in semi-finished steel slabs, billets and blooms is by scarfing. Scarfing consists of the application of oxygen and gas to the steel surface, usually by a torch, to oxidize the steel and thereby generate elevated temperatures that cause the adjacent steel to become liquid, which is then blown away with the surface impurity. To a lesser extent, surface conditioning of steel is also carried out by grinding, particularly on stainless steel, and by hand chipping.

Traditionally, scarfing has been a manual operation performed in a mill yard by a workman standing on or near a steel slab and manipulating a scarfing torch. This means, of course, that the slab must be cooled sufficiently to permit the workman to walk upon or near it. When one surface is completed, the slab is lifted with a chain or magnet held by an overhead crane and by some means turned over and lowered on the scarfed side; the manual scarfing process is then repeated. Slab weights have recently reached up to 40 tons or more and have thus made this turnover operation dangerous to workmen nearby. Moreover, scarfing produces heat and noxious fumes, thereby presenting health hazards to the workmen involved in the scarfing operation. Also the arduous nature of the operation rapidly fatigues the worker and reduces his productivity.

More recently, automatic scarfing units have been installed in some plants in an in-line relationship with rolling mills. Automatic scarfing units consist of a number of scarfing torches so designed that they form a pass on the mill; accordingly, steel may be scarfed in the hot condition. However, scarfing is indiscriminate with automatic scarfing machines and may result in reductions in metal yield up to 3-4 percent, depending on the size of the slab or bloom and the depth of scarfing.

Other attempts have been made to mechanize discriminate scarfing operations; for example, a billet scarfing machine is shown in U.S. Pat. No. 3,176,971. That patent, however, contains no suggestion of a solution for the problems associated with scarfing heavy slabs and, in general, discloses a machine that lacks the versatility required for slab scarfing.

U.S. application Ser. No. 305,794, now U.S. Pat. No. 3,829,072, filed by two of the inventors named herein, discloses a marked improvement in apparatus for use in conditioning slab surfaces. The improved apparatus includes a slab-supporting and turnover device in combination with a movable slab conditioning tool platform suspended above the slab-supporting and turnover device. The slab conditioning tool platform is adapted for positioning and movement first with respect to one side of a slab supported in an inclined position by one side of the device, and next with respect to the opposite side of the slab supported in an inclined position by the other side of the device after the slab has been turned over by the device. The combination thus disclosed condition slabs in essentially "batch" fashion and requires a rotatable slab conditioning platform to perform operations on both sides of a slab.

The present invention is an even further improvement over the slab conditioning system of U.S. application Ser. No. 305,794. Ordinarily, increased productivity is achieved by eliminating steps from an operation; surprisingly, the present invention involves more mechanical motion but is accompanied by a sharp increase in production. Also, workers in the art normally strive to reduce the capital cost of any given apparatus; but with the present invention, capital costs are increased by the addition of at least one more slab-supporting and turnover device than employed in U.S. application Ser. No. 305,794, with the result that the slab conditioning operations permitted by the present invention become semi-continuous and overall productivity is increased. In addition, both edges of the slab are exposed for scarfing, an operation not possible with a single slab-supporting and turnover device.

SUMMARY OF THE INVENTION

The present invention provides a slab conditioning system comprising: at least two bases spaced apart from one another; a pair of leaves mounted to each of the bases, each of the leaves being pivotally mounted for independent rotation from a substantially horizontal position to an upright position, each of the leaves being adapted to support a slab and cooperate with the other leaf of the pair by rotation toward one another for transferring the slab from one leaf of the pair to the other, and the leaves being further adapted for transferring a slab from one to the other of adjoining leaves of adjacent pairs of leaves while the adjoining leaves are in their respective horizontal positions; means for independently rotating the leaves; and at least one slab conditioning tool platform mounted above the bases and adapted for motion with respect to the leaves.

In one embodiment, the present invention further comprises: at least one means for each adjacent pair of the bases for transferring a slab from one to the other of adjoining leaves of the pairs of leaves while the adjoining leaves are in their respective horizontal positions. Preferably, the transfer means is positioned along the longitudinal axis of the system and includes at least one piston means supported by at least one of the bases, the piston means having a slab engaging means connected thereto. Further, the transfer means preferably includes a plurality of spaced piston means supported beneath the leaves, each piston means having a slab engaging means connected thereto. Preferably, the slab engaging means of the present invention comprises dog means mounted to its respective piston means; the dog means may be pivotally mounted to its respective
piston means for engaging a slab at selected locations on the dog means.

In an alternate embodiment, the present invention provides that the adjoining leaves of adjacent pairs of leaves are interleaved with one another, whereby a slab supported on a first adjoining leaf is also supported on a second adjoining leaf when the first and second adjoining leaves are in their respective horizontal positions.

The motion of the slab conditioning tool platform of the present invention preferably includes longitudinal, lateral and vertical rectilinear motions with respect to the leaves.

The leaves of the present invention may be rotated to selected positions intermediate of the horizontal position and the upright position; and each of the leaves is rotatable from the horizontal position through more than 90 degrees in a direction toward the other leaf of the pair of leaves. The means for rotating the leaves preferably comprises at least one piston means for each leaf.

Also preferably, each of the leaves of the present invention includes slab stop means disposed at its inboard end for cooperating with the slab stop means of the other leaf of the pair of leaves.

The present invention further provides a method for conditioning slabs comprising: (A) delivering a slab to a first rotatable slab support means from a first direction; (B) rotating the first slab support means to incline the top surface of the slab; (C) inspecting the top surface of the slab for surface defects; (D) transferring the slab from the first slab support means to a second rotatable slab support means; (E) rotating the second slab support means to incline the bottom surface of the slab; (F) inspecting the bottom surface of the slab for surface defects; (G) transferring the slab to a third rotatable slab support means; (H) transferring the slab to a fourth rotatable slab support means and inclining the slab thereon to expose the top surface of the slab; (J) traversing the top surface of the slab with a conditioning tool to selectively remove the surface defects; (K) transferring the slab to a fifth rotatable slab support means; (L) transferring the slab to a sixth rotatable slab support means and inclining the slab thereon to expose the bottom surface of the slab; (M) traversing the bottom surface of the slab with a conditioning tool to selectively remove the surface defects; and (N) discharging the slab from the sixth slab support means in a direction opposite from the first direction.

Other advantages of the present invention will become apparent from a consideration of the following detailed description taken with the accompanying drawings wherein like reference numerals refer to like parts throughout the various views.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a plan view of a plant lay-out including the present invention;
FIG. 2 is an elevational view of FIG. 1;
FIG. 3 is an end view of FIG. 1;
FIG. 4 is an enlarged plan view of two slab supporting and turnover devices as employed in the present invention;
FIG. 5 is an elevational view taken along line V—V of FIG. 4;
FIG. 6 is a side elevational view taken along line VI—VI of FIG. 4;
FIG. 7 is a side elevational view taken along line VII—VII of FIG. 4;
FIG. 8 is an enlarged sectional view taken along line VIII—VIII of FIG. 7;
FIGS. 9–11 are partial elevational views showing the sequence of movement to accomplish slab turnover;
FIGS. 12–13 are partial elevational views showing minimum width and less than maximum thickness slabs, respectively, and the relationship of the opposed leaves of the slab turnover device;
FIG. 14 is a partial elevational view showing the relationship of the slab conditioning platform to a slab in position for conditioning;
FIG. 15 is an enlarged sectional view of FIG. 14 showing details of the slab conditioning tool platform;
FIG. 16 is a sectional view taken along line XVI—XVI of FIG. 15;
FIG. 17 is a view of the protective guard in front of the operator of the slab conditioning tool;
FIG. 18 is a sectional view taken along line XVII—XVIII of FIG. 17;
FIGS. 19–20 are elevational views showing the vertical movements of the slab conditioning tool platform;
FIG. 21 is a plan view of the slab conditioning tool platform and the crane runways;
FIGS. 22–27 are partial elevational views showing the operation of the slab transfer means for maximum and minimum width slabs;
FIG. 28 is a side elevational view of the pusher guides and dogs included in the slab transfer means;
FIG. 29 is a plan view of FIG. 28;
FIG. 30 is a sectional view taken along line XXX—XXX of FIG. 28;
FIG. 31 is a plan view of an alternate embodiment of the slab transfer means of the present invention;
FIG. 32 is an elevational view of FIG. 31;
FIG. 33 is a sectional view taken along line XXXIII—XXXIII of FIG. 31;
FIG. 34 is a plan view of another variation of the alternate embodiment of FIGS. 31–33;
FIG. 35 is an elevational view of FIG. 34; and
FIG. 36 is a schematic of the flow of slabs through the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to the drawings and particularly to FIGS. 1–3, there is shown the present invention as it may be applied in the scarfing of steel slabs in a steel mill. Ordinarily, the components of the present invention will be housed within a building 20 so that a fume collection system may be conveniently installed and the building is best located on a site which provides an "in-line" relationship with prior and subsequent slab treatment facilities. As shown by the arrow in FIG. 2, the flow of slabs through building 20 is from left to right. Sliding doors 22 and 22' located at opposite ends of building 20 help to provide a complete enclosure and maximize the collection of fume and noxious gases produced by the scarfing operation.

Located in spaced apart relationship longitudinally of building 20 are three slab handling units designated by the general reference numerals 24, 26 and 28, respectively. The term "longitudinal" as used herein is intended to mean a line generally parallel to the flow of slabs through the system of the present invention. Slab handling units 24, 26 and 28, which will be described
in detail shortly, may also be termed "slab-supporting and turnover devices." The present invention requires at least two of such slab handling units, 26 and 28, although the drawings illustrate (and the present invention may incorporate) a third unit 24 which is used to provide convenient slab inspection facilities as hereinafter described.

Suspended above slab handling units 26 and 28 is a slab conditioning tool platform generally designated by the reference numeral 30. Slab conditioning tool platform 30 (sometimes referred to herein as pulpit 30) is shown in FIG. 2 in two longitudinal positions along the centerline of building 20; the position marked on FIG. 2 as "A" is generally above slab conditioning unit 26 and the position marked "B" generally above slab conditioning unit 28. As shown in FIG. 2, pulpit 30 is at two different vertical positions but positions "A" and "B" refer only to longitudinal position. It will be understood by those skilled in the art that two slab conditioning tool platforms 30 may be employed in the present invention and, if this be the case, the longitudinal positions of the two slab conditioning tool platforms 30 could be fixed.

Slab scarfing operations take place only at pulpit positions "A" and "B" and, thus, a fume collection system (not shown) of any well-known type may be provided overhead of these positions in building 20. The fume collection system typically includes a duct 36 in the upper portion 32 of building 20 leading to the other components of the fume collection system as indicated in FIG. 2.

Referring now to FIGS. 4–8, slab handling units 24, 26 and 28 will now be described in detail. In particular, FIGS. 4 and 5 show two slab handling units, say 26 and 28, in spaced apart relationship. These units are identical so only the right-hand unit, generally designated by the numeral 28, will be described. Slab handling unit 28 is supported by a pair of elongated "I" beams 38 embedded in a concrete footer 40 which extends transversely of the centerline of building 20 below the floor level 42 thereof. Mounted to "I" beams 38 are spaced intervals therealong are longitudinally extending, pivot stand support beam sections 44, shown in the drawings as being of box beam construction. Mounted atop each of pivot stand support beam sections 44 is a pivot stand 46. As best shown in FIG. 8, pivot stand 46 includes a pair of upstanding, spaced side members 48 having aligned bores (not shown) for receiving a stationary pin 50 therethrough. Pin 50 is retained in position by opposed keeper plates 52 suitably secured to the outboard sides of side members 48. As best shown in FIG. 4, each pivot stand 46 has a pair of pins 50 retained by a common side member 48 extending along the longitudinal centerline of pivot stand 46.

Rotatably mounted to pins 50 in offset relationship and by means of bushings 53 are opposed pairs of lifting arms 54 extending longitudinally away from pivot stand 46 in opposite directions. The top surfaces of lifting arms 54 are bearing surfaces to support a slab thereon. Mounted beneath each series of lifting arms 54 is a transversely extending lifting arm beam 56. A series of lifting arms 54 together with its corresponding lifting arm beam 56 is termed a "leaf" herein; the left-hand leaf of each slab handling unit is designated "leaf 1" on the drawings and the opposite, right-hand leaf is designated "leaf 2" thereon.

As best shown in FIG. 5, the lifting arms 54 in each of leaves 1 and 2 respectively, have enlarged interior portions 58 and 58' respectively, configured to form aligned vertical surfaces 60 and 60' respectively, and thereby form slab stop means referred to hereinafter by the reference numerals 62 and 62' respectively. The oppositely offset mounting of lifting arms 54 and thus their interior portions 58 and 58' permits slab stop means 62 of leaf 1 to cooperate with slab stop means 62' of leaf 2 when leaves 1 and 2 are brought into facing relationship.

The means for independently rotating leaves 1 and 2 about their corresponding mounting pins 50 is identical; therefore, only the means for rotating one leaf, in this case leaf 1, need be described. Rotation of leaf 1 may be accomplished by means of an upright hydraulic lift cylinder 64 clevis mounted at its upper end to the bottom of lifting arm beam 56 through mounting plate 66 and clevis mounted at its lower end to the floor 67 of an elongated pit 68 extending along the longitudinal centerline of slab handling units 26 and 28. When cylinder 64 is actuated, leaf 1 moves from the normal horizontal position shown in FIG. 5 toward the vertical position. The pivotal mounting of the ends of cylinder 64 permits leaf 1 to move through the vertical to an angle in excess of 90° depending upon the length of cylinder 64.

The cooperative action of leaves 1 and 2 in turning over a slab will now be described by reference primarily to FIGS. 5 and FIGS. 9–11. With leaf 1 in the normal horizontal position (see FIG. 1) and supporting a slab 70 thereon (not shown in FIG. 1), the operator actuates hydraulic cylinder 64 to rotate leaf 1 toward the vertical. At the same time, the operator has actuated hydraulic cylinder 64' (see FIG. 9) to rotate leaf 2 until leaf 2 passes through the vertical and reaches a position about 100 degrees from its original horizontal position (see FIG. 9). Rotation of leaf 1 carrying slab 70 is continued until leaves 1 and 2 are substantially parallel and in the position shown in FIG. 10. A truly parallel condition of leaves 1 and 2 will exist only when slabs of maximum design thickness are being processed. Slabs of lesser width will cause leaves 1 and 2 to pinch slab 70 at its upper edge as shown in FIG. 13; this pinching position becomes more accentuated when slabs of lesser width are being processed as shown in FIG. 12.

When leaves 1 and 2 are in the position shown in FIG. 10, the top surface of slab 70 is very close to the bearing surfaces of lifting arms 54 of leaf 2; and practically all of the weight of slab 70 is being borne by slab stop means 62 of leaf 1. It should be noted that in this position slab stop means 62 of leaf 1 is elevated slightly above slab stop means 62' of leaf 2. Also, the offset positions of slab stop means 62 and 62' on the facing leaves permit them to overlap and thereby makes possible the close relationship of the top surface of slab 70 to the bearing surfaces of lifting arms 54 of leaf 2. This feature affords a relatively "soft" transfer of slab 70 to leaf 2 as next described.

The operator then actuates the lift cylinders 64 and 64' of both leaves 1 and 2, respectively, to cause them to move together to the right while maintaining a substantially parallel relationship of the leaves. When the leaves pass through the vertical, slab stop means 62 and 62' will be about horizontal, thereby permitting slab stop means 62' of leaf 2 to share the support of slab 70. As simultaneous rotation of the leaves continues, slab
stop means 62' of leaf 2 raises above slab stop means 62 of leaf 1 and assumes the entire burden of supporting slab 70. In this condition, leaf 1 is serving only to steady slab 70. When leaf 1 has rotated slightly more than 90° from its original horizontal position (see FIG. 11), the operator stops rotation of leaf 1 but continues the downward rotation of leaf 2 until the exposed surface (formerly the bottom) of slab 70 is inclined at an angle of about 75° (see FIG. 14). At the same time, the operator returns leaf 1 to its original horizontal position for receiving a new slab (see FIG. 14).

As shown in FIG. 14, pulpit 30 is then moved into position to perform the scarfing operation on slab 70 as will be described in detail hereinafter. When the scarfing operation is completed, leaf 2 may be rotated further downwardly to the horizontal position for subsequent manipulation of slab 70.

FIGS. 15-21 illustrate one embodiment of the slab conditioning tool platform 30 of the present invention. Slab conditioning tool platform 30 includes an enclosed, air-conditioned cab 72 suspended above slab handling units 26 and 28. Cab 72 includes an operator's seat 74 that faces an inwardly inclined glass shield 76 which spans the width of cab 72 to afford the operator maximum forward visibility. Located directly in front of operator's seat 74 and beneath glass shield 76 is an aperture assembly 78 through which slab conditioning tool 80 passes. In the drawings, slab conditioning tool 80 is depicted as a scarfing torch of any well known type. Aperture assembly 78 includes two concentric discs 82 and 84, each being laterally slidable with respect to the other within mounting brackets 86. Disc 84 has a central opening dimensioned to snugly receive the shaft of slab conditioning tool 80 while disc 82 has a central opening having a larger dimension. This arrangement provides a wide range of motion of tool 80, but by virtue of the sliding action of discs 82 and 84, the enclosed condition of cab 72 is preserved. This means that the operator is protected from the heat and fumes generated by the scarfing operation occurring immediately outside cab 72. As an additional safeguard, the atmosphere within cab 72 is maintained at a positive pressure relative to the outside ambient pressure to keep noxious fumes from entering cab 72.

As shown in FIG. 15, a tool balancing device 87, for example of the type employing a spring loaded reel, may be used to assist the operator in holding slab conditioning tool 80 in a selected position.

As best shown in FIGS. 19-21, cab 72 is movable vertically by means of a hydraulic or electric cylinder 88 mounted at its lower end to the center of the top of cab 72 and at its upper end to cab support member 90. Vertical telescoping guide posts 92 located at the four corners of the top of cab 72 serve to assure alignment during actuation of cylinder 88. Cab support member 90, in turn, is suspended from transverse rails 94 and is able to move laterally therealong by means of lifters 96. Rails 94 are suspended from longitudinal girders 98 and adapted for longitudinal movement therealong by means of rollers 100. Air film equipment may also be employed in place of the rollers or wheels shown.

Accordingly, cab 72 is able to move longitudinally, laterally and vertically with respect to a slab 70 inclined on leaf 2 as shown in FIGS. 19 and 20. A control system (not shown) may be provided to coordinate longitudinal and vertical movement of cab 72 so that cab 72 can move smoothly along a selected incline plane, thus keeping cab 72 equidistant from the inclined surface of slab 70.

A possible alternative to the moving cab 72 just described would be to provide a stationary cab 72 having a slab conditioning tool 80 movable within cab 72 to the same extent that cab 72 as described above is movable. This alternate arrangement would be considered equivalent to the present preferred embodiment.

Electric power, oxygen and fuel are supplied to cab 72 through flexible conduits (not shown). Furthermore, it is understood that suitable controls for moving cab 72 as described above, as well as for operating slab conditioning tool 80, are provided within cab 72 and/or remotely. It will also be apparent to those skilled in the art that the desired movements of cab 72 with respect to an inclined slab 70 resting on leaf 2 may be accomplished in a variety of other ways. For example, instead of stationary overhead girders, a gantry that is movable longitudinally with respect to slab handling units 26 and 28 may provide the suspension means for cab 72.

The operation of the present invention preferably utilizes means for transferring a slab supported by leaf 2 of a first slab handling unit, say 26 (see FIG. 5), to leaf 1 of the adjoining slab handling unit (in this case 28). The transfer operation is carried out while the adjoining leaves 2 and 1 are in the horizontal position. One means for accomplishing this transfer step is shown in the drawings, particularly FIGS. 4, 5 and 22-30. The transfer means shown includes a pair of hydraulic pusher units generally designated by the reference numeral 102. As shown in FIG. 4, for example, pusher units 102 are disposed in parallel relationship on opposite sides of the longitudinal centerline of slab handling unit 26.

Pusher units 102 are supported by longitudinally extending "I" beams 104 having mounted thereon pusher unit guide assemblies 106 best shown in FIGS. 28 and 30. Pusher unit guide assemblies 106 include an "I" beam 108 mounted through shims 110 to the top of an "I" beam 104. A guide member 112 in the form of a channel is mounted to the top of "I" beam 108 and provides the bearing surface for pusher units 102. Supporting "I" beams 104 are tied together by cross members 114.

Pusher units 102 include a horizontally arranged hydraulic cylinder 116 mounted to pusher guide 112 by means of bracket 118 (see FIG. 23). Extending from cylinder 116 is piston rod 120. Threadably mounted to the free end of rod 120 is dog assembly 122 (see FIG. 28).

Dog assembly 122 includes a body member 124 to which piston rod 120 is connected. Transversely extending through body member 124 is dog pin 126. Pivotally mounted to opposed ends of dog pin 126 through suitable bushings (not shown) are side support members 128. As best shown in FIG. 28, side support members 128 are generally hookshaped with the shank portion extending upwardly to the right above the top surface of body member 124. The right-hand ends of side support members 128 are joined by cross member 130 to provide lateral support. The left-hand ends of side support members 128 are joined by cross member 132. Mounted at the center of cross member 132 is an upper- standing dog 134.

As best shown in FIG. 22, when pusher unit 102 is in the normal retracted position, dog 134 is between the enlarged interior portions 58 of adjacent lifting arms 54.
and does not project substantially above these enlarged interior portions. Thus neither dog 134 nor the other components of pusher unit 102 offers any interference to the normal operation of leaves 1 and 2 as described above. It should be pointed out, however, that when dog assembly 122 is in its normal position, the right-hand ends of side support members 126, including cross member 130, project above the top surfaces of lifting arms 54. When a slab 70 is present on leaf 2, however, as shown in FIG. 22, the weight of slab 70 causes dog assembly 122 to pivot clockwise against dog pin 126 and force the right-hand ends of side support members 128 below the top surfaces of lifting arms 54.

The operation of pusher units 102 in moving a normal width slab from leaf 2 to leaf 1 is best illustrated in FIGS. 22 and 23. Upon actuation of cylinders 116, piston rods 120 extend and cause dogs 134 to engage the left-hand edge of slab 70. Continued extension of piston rods 120 causes slab 70 to be pushed from leaf 2 to a corresponding position on leaf 1 in snug engagement with slab stop means 62. Piston rods 120 are then retracted and dog assembly 122 assumes its normal position.

In the case of a slab of narrow width, a two-step transfer operation may be employed and that is easily accomplished because of the pivotally mounted dog assembly 122. Referring to FIGS. 24-27, a slab 70 of narrow width is shown positioned on leaf 2. The transfer operation begins as before by extending piston rods 120 to cause dog 134 to engage the left-hand edge of slab 70'. Rods 120 are extended to their maximum length as shown in FIG. 25 but it will be noted that slab 70' has not reached slab stop means 62 because of its narrow width. Piston rods 120 are then retracted slightly until the right-hand ends of side support members 128 have cleared the left-hand edge of slab 70', whereupon the pivotal action of dog assembly 122 causes the right-hand ends of side support members 128 to project above the top surfaces of lifting arms 54. Piston rods 120 are then extended again until cross member 130 engages the left-hand edge of slab 70'. Continued extension of rods 120 pushes slab 70' into snug engagement with slab stop means 62 of leaf 1 and rods 120 are fully retracted as described above. It will be appreciated that narrow width slabs may also be transferred without performing a two-step pushing operation by arranging pusher units 102 in a longitudinally overlapping, offset relationship.

It will be understood by those skilled in the art that pusher units 102 may be reversibly mounted in association with the slab handling units of the present invention and thereby operate to pull the slab instead of push it. In fact, the pair of hydraulic units generally designated by the reference numeral 136 in FIG. 1 operate in just that fashion.

An alternate means for accomplishing the slab transfer operation just described is shown in FIGS. 31-33. For purposes of this description, it is again assumed that slab 70 is to be transferred from leaf 2 of slab handling unit 26 to leaf 1 of slab handling unit 28. Instead of utilizing pusher units 102 for the slab transfer operations, leaf 2 of slab handling unit 26 is constructed to interleave with leaf 1 of slab handling unit 28 when these adjacent leaves are in their horizontal positions. That is, each opposed pair of lifting arms 54 is mounted to its corresponding base in offset relationship so that adjacent base assemblies 37 may be spaced closer together than in the embodiment shown in FIGS. 4-5.

As shown in FIGS. 31-33, each lifting arm 54 and leaf 2 is supported by a lift cylinder 64' and each lifting arm 54 of leaf 1 is supported by a lift cylinder 64. Leaf 2 is rotated by simultaneous actuation of all lift cylinders 64' and leaf 1 is rotated by simultaneous actuation of all lift cylinders 64. The result of this arrangement is that when slab 70 is lowered to the horizontal position on leaf 2 of slab handling unit 26 (see FIG. 32), slab 70 comes to rest substantially in position for immediate rotation of leaf 1 of slab handling unit 28. Accordingly, no longitudinal transfer step is required. If the width of slab 70 is such that the right edge of slab 70 does not extend to slab stop means 62 of leaf 1, some sliding movement of slab 70 toward slab stop means 62 will occur upon upward rotation of leaf 1.

A variation of the embodiment shown in FIGS. 31-33 is illustrated in FIGS. 34-35. There the lifting arms 54 are shown in offset relationship as before to provide for the interleaving of leaves 2 and 1. In this variation, however, a lifting arm beam 56 extends transversely of each series of lifting arms 54, closely inboard with respect to base assembly 37 in order to clear the free ends of lifting arms 54 of the adjacent leaf. As shown in FIGS. 34-35, a pair of lift cylinders 64' may be connected to the bottom surface of lifting arm beam 56 of leaf 2 to provide the means for rotating leaf 2; a pair of lift cylinders 64 may be similarly connected to the bottom surface of lifting arm beam 56 of leaf 1 to provide means for rotating leaf 1. This variation provides for the same operation of adjacent leaves as in FIGS. 31-33 and thus, again, the slab transfer operation is accomplished without pusher units for longitudinal movement of slab 70.

A still further alternate embodiment of the slab transfer means shown in FIGS. 31-33 and FIGS. 34-35 would be to eliminate the lift cylinders 64 and to provide a shaft through transversely aligned pivot points for each series of lifting arms 54 forming a leaf. This shaft could then be rotated by the application of torque thereto through suitable means to provide the necessary rotational movement of the leaf.

By reference to FIGS. 2 and 3, the typical operating sequence of the present invention will now be described. Metal slabs requiring conditioning are delivered and stacked in positions 1, 2 and 3 by a straddle carrier, crane or other materials handling apparatus. A charging gantry crane 138, either fully automated or operator controlled, picks up a slab from one of the piles and loads it on the slab handling table 140 located at position 4. An inspector 142 stationed at slab handling unit 24 moves the slab from position 4 to position 5 (on leaf 1 of slab handling unit 24) by means of hydraulic pulling units 136. Edge C of the slab may be inspected by stopping the slab short of the slab stop means of leaf 1. Surface A and edge D of the slab are inspected by inspector 142 with leaf 1 in either the horizontal or the inclined position. Inspector 142 then steps clear of slab handling unit 24 and turns the slab over to the position shown in FIG. 2 for inspection of surface B. Inspector 142 next lowers leaf 2 to position 6.

Inspector 142 moves the slab from position 6 (on leaf 2 of slab handling unit 24) to position 7 (on leaf 1 of slab handling unit 26) by means of hydraulic pusher units 102. Another view of edge C may be provided for inspector 142 by his moving the slab only a short dis-
What is claimed is:

1. A slab conditioning system comprising:
   a pair of leaves spaced apart from one another,
   at least two bases spaced apart from one another,
   at least two bases spaced apart from one another,
   a pair of leaves spaced apart from one another,
   at least two bases spaced apart from one another,
   at least two bases spaced apart from one another,
   at least two bases spaced apart from one another,
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A slab conditioning system as recited in claim 1 wherein:

10. each of said leaves includes slab stop means disposed at its inboard end for cooperating with the slab stop means of the other leaf of said pair of leaves.

11. A method for conditioning metal slabs comprising:

A. delivering a slab to a first rotatable slab support means from a first direction;
B. rotating said first slab support means to incline the top surface of said slab;
C. inspecting said top surface of said slab for surface defects;
D. transferring said slab from said first slab support means to a second rotatable slab support means;
E. rotating said second slab support means to incline the bottom surface of said slab;
F. inspecting said bottom surface of said slab for surface defects;
G. transferring said slab to a third rotatable slab support means;
H. transferring said slab to a fourth rotatable slab support means and inclining said slab thereon to expose said top surface of said slab;
J. traversing said top surface of said slab with a conditioning tool to selectively remove said surface defects;
K. transferring said slab to a fifth rotatable slab support means;
L. transferring said slab to a sixth rotatable slab support means and inclining said slab thereon to expose said bottom surface of said slab;
M. traversing said bottom surface of said slab with a conditioning tool to selectively remove said surface defects; and
N. discharging said slab from said sixth slab support means in a direction opposite from said first direction.