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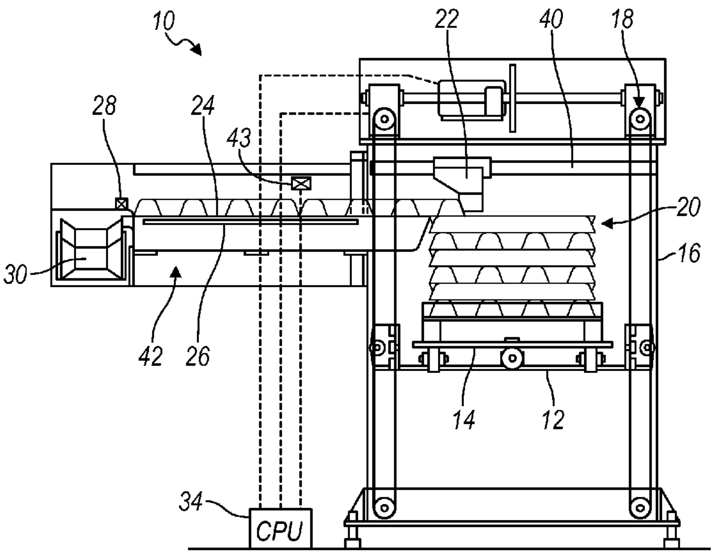

FIG. 1A

(57) Abstract: A method and apparatus for de-stacking and preheating metal ingots to be melted. The apparatus places cold ingots onto a transfer device. The transfer device transfers the ingots through a pre-heating chamber and discharges the pre-heated ingots individually onto a set of rolls or a rotating arm to charge a melting furnace filled with liquid metal. The melting furnace then adds sufficient energy to melt the heated ingots. Liquid metal can be removed from the melting furnace and used for casting, for example. When additional metal is needed in the melting furnace, the transfer device transfers an additional ingot from the pre-heating chamber to the melting furnace. When a top row of the metal ingots are removed from the stack, a platform rises to align a new row of metal ingots with the transfer device.

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SYSTEM AND APPARATUS FOR DE-STACKING, PRE-HEATING AND CHARGING METAL INGOTS FOR A MELTING FURNACE

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims the benefit of U.S. provisional application Serial No. 62/006,619 filed June 2, 2014, the disclosure of which is hereby incorporated in its entirety by reference herein.

TECHNICAL FIELD

[0002] The present disclosure relates to a de-stacking apparatus that de-stacks metal ingots from a stack and introduces them into a pre-heating device prior to introduction into a volume of molten metal.

BACKGROUND

[0003] The energy required to melt aluminum is typically introduced in the form of heat above the melt. This method exposes the furnace refractory lining or crucible, at and above, the melt surface to very high temperatures over extended periods of time. Very high temperature at the melt surface required for melting increases absorption of hydrogen and oxide formation in molten aluminum. Both of these conditions contribute to detrimental inclusions and porosity in the castings to be made.

[0004] Excessive temperature can be detrimental to the refractory furnace lining or crucible above metal level. The longer the molten metal and the refractory are exposed to the high temperatures required for melting, the greater the damage to the metal and the refractory.

[0005] To add additional aluminum to the already-melted aluminum, ingots of aluminum are provided to the melt. If the metal ingots are added to the melt while the ingots are at ambient or room temperature, the melt can succumb to adverse effects due to the temperature shock.

[0006] Previous attempts have been made to introduce new metal ingots while also mitigating the temperature shock. These methods include charging the flue of a fuel-fired melting furnace with an elevator or conveyor that dumps ingots or scrap into a pile within the flue of the melting furnace. With this method, efforts are made to keep a high level of material in the flue to avoid damage to the refractory floor and add to efficiency. This type of melting furnace is generally referred to as a "stack" melting furnace. Typically this type of melting furnace needs to be quite tall. Their efficiency varies with the height of the pile in the flue above the melting chamber and the density of the pile in the flue. In this type of furnace, all of the energy required to melt the charge of metal damages the refractory and contaminates the melt. Stack melters are fuel-fired. The products of combustion in fuel-fired melters (oxygen and hydrogen) contribute to inclusions and porosity in subsequent castings. Tall stack melters often interfere with over-head handling equipment in casting plants. Adding stack melting capability to existing equipment has not proven to be practical.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007] FIGURE 1A is a side view and FIGURE IB is a front view of a metal ingot de-stacking and pre-heating system, according to one embodiment.

[0008] FIGURE 2 is a side view of a pre-heated ingot on gravity rollers traveling from the de-stacking apparatus and pre-heating chamber into a melting furnace, according to one embodiment.

[0009] FIGURE 3 is a front view of a pre-heated ingot from the de-stacking apparatus and pre-heating chamber being lowered by a powered rotating arm into a melting furnace, according to one embodiment.

[0010] FIGURE 4A is a side view and FIGURE 4B is a front view of another embodiment of a metal ingot de-stacking and pre-heating system, according to one embodiment.

[0011] FIGURE 5 is a side view of a pre-heated ingot traveling from the de-stacking apparatus and pre-heating chamber on powered rollers into a melting furnace according to one embodiment.

DETAILED DESCRIPTION

[0012] Embodiments of the present disclosure are described herein. It is to be understood, however, that the disclosed embodiments are merely examples and other embodiments can take various and alternative forms. The figures are not necessarily to scale; some features could be exaggerated or minimized to show details of particular components. Therefore, specific structural and functional details disclosed herein are not to be interpreted as limiting, but merely as a representative basis for teaching one skilled in the art to variously employ the embodiments. As those of ordinary skill in the art will understand, various features illustrated and described with reference to any one of the figures can be combined with features illustrated in one or more other figures to produce embodiments that are not explicitly illustrated or described. The combinations of features illustrated provide representative embodiments for typical applications. Various combinations and modifications of the features consistent with the teachings of this disclosure, however, could be desired for particular applications or implementations.

[0013] Two embodiments of a system and apparatus for de-stacking, pre-heating and charging metal ingots are shown in Figures 1-3 and 4-5, respectively.

[0014] According to the embodiment illustrated in Figures 1-3, a metal ingot de-stacking apparatus 10 is shown in Figure 1 both from a side view (Figure 1A) and a front view (Figure IB). The apparatus 10 includes an elevator 12 supporting a 90 degree rotatable table 14 in an enclosure or housing 16. The elevator may include a pulley system 18 (e.g., including a series of cables) to move the rotatable table 12 vertically in the enclosure. A stack of ingots 20 can be loaded onto the rotatable table. The stack includes a series of rows of metal ingots 20 stacked one top of one another. Each row of the stack may be oriented 90 degrees relative to the adjacent row for packaging purposes.

[0015] During operation, the elevator 12 moves the stack of metal ingots 20 up the enclosure. A pushing device 22 or de-stacker is configured to move linearly in order to push or "de-stack" the top row of metal ingots 20 from the stack and onto rails 24 that extend into and through a pre-heating chamber having one or more pre-heating burners 26 beneath the rails. The rails may form part of a conveyer for the ingots. The conveyer may include a moveable transfer surface, or alternatively, the conveyer may be stationary in which movement of the ingots 20 along the conveyer depends on the pushing device 22. Once the entire top row of the stack of ingots 20 is de-stacked and removed from the stack, the elevator 12 can lower to clear the rails and allow the rotatable table 14 to rotate 90 degrees with the stack of ingots to orient the next top layer of ingots properly for the pushing device 22. The pushing device 22 then retracts in a direction away from the rails 24 or conveyer. After rotating the ingots 90 degrees, the elevator will raise to align a new top layer of ingots for the pushing device 22 for another de-stacking operation.

[0016] As will further be described, during each de-stacking operation, the pushing device 22 will push the top row until an ingot 20 exits the heating chamber, signaling the pushing device 22 to stop pushing. To do so, contact sensors or light sensors 28 can be used to signify the exit of an ingot 20 from the pre-heating chamber. Upon exiting the conveyer or rails 24, the ingots 20 drop onto rollers or a second conveyer 30, which is angled for gravity or powered separately via a motor or the like. The ingot 20 rolls into a melting furnace 32, shown in Figure 2. In one embodiment, a second rotatable table (not shown) rotates due to the weight of the ingot, gently dropping the ingot into the melting furnace 32 with minimal splash.

[0017] During pushing of the ingots 20, the pusher may pause while pushing the top row of ingots. The pushing device 22 may wait for a signal from the furnace or casting machine that indicates a desire for another ingot to be added to the melt. The signal may be in response to the amount output or removed from the melt, the rate of input of ingots, or may be set to a timer, for example. The signal is received by a receiver in communication with the pushing device, and a controller 34 can cause the pusher to push an additional ingot in response to the signal. When the entire stack of ingots has been exhausted, the elevator will lower and signal for more ingots to be raised, whereupon the pushing process will begin again with a new top row of ingots.

[0018] Additional structural detail and operation of the de-stacking apparatus 10 and pre-heating unit will now be provided. Unless otherwise stated, all moving components include an actuator that is connected to at least one controller, such as controller 34. The controller 34 is also connected to all sensors and is programmed to receive signals from the sensors, process the signals, and command actions by the moving components within the apparatus 10.

[0019] The housing 16 includes the elevator 12 and pulley system 18 therein. The housing 16 also includes an opening in the location of the conveyer or rails 24 to allow the ingots 20 to exit the housing 16. The pushing device 22 includes a contact surface for contacting one of the ingots 20 and for "pushing" the top row of ingots 20 onto the conveyer. The pushing device 22 may include arms 38 that are linearly moveable along rails 40. Sliding of the arms 38 along the rails 40 toward the conveyer enables the ingots 20 to be pushed onto the conveyer of an oven 42.

[0020] The ingots 20 may be stacked in a crisscrossed or 90 degree alternating fashion for packaging purposes. The 90 degree rotation of the table 14 enables the rows of ingots 20 to be properly positioned before moving onto the conveyer.

[0021] In the oven 42, the ingots are preheated before entry into the melting furnace 32. The controller 34 can be coupled to an actuator of the burners 26 as well as a temperature sensor 43 within the oven 42. The controller 34 controls the burners 26 so as to maintain heat and maintain the temperature of the ingots 20 to a temperature at or just above its melting temperature. This enables the metal of the ingots 20 to be closer to the temperature of the liquid metal 44 within the melting furnace 32, reducing shock associated with introducing metal of a different temperature into the melt.

[0022] At the end of the oven resides rollers 30 or a second conveyer for transporting the pre-heated ingots to the melting furnace 32. This second conveyer may end in a rocker 48 that moves the pre-heated ingots from the second conveyer to the melting furnace 32. The rocker 48 may be separately powered or may be configured to teeter and tilt the ingots into the melting furnace 32.

[0023] The melting furnace 32 includes a metal level sensor 46 configured to detect the height or level of liquid metal 44 in the melting furnace 32. The metal level sensor 46 is electrically connected to the controller 34. Liquid metal 44 in the melting furnace 32 can be removed and used for casting or other uses. As metal is removed from the melting furnace 32, the metal level sensor 46 sends a signal indicating the level of the liquid metal 44 falling below a threshold. In response to this signal, the controller 34 commands either the conveyer 24 or the pushing device 22 to move an additional ingot(s) from the pre-heating oven 42 into the melting furnace 32.

[0024] A location sensor of the pushing device 22 may indicate to the controller 34 that the entire top row of ingots 20 has been evacuated from the stack. When this occurs, the controller 34 commands the pushing device 22 to retract in a direction away from the conveyer 24. Once retracted, the controller 34 commands the table 14 to rotate 90 degrees to align a new top row of ingots 20 for pushing onto the conveyer. The controller 34 also commands the pulley system 18 and the elevator 12 to raise the table 14 and the stack of ingots 20 to bring the new top row of ingots 14 into horizontal alignment with the pushing device 22.

[0025] An alternative method of inserting heated ingots into a melting furnace shown is a power rotating arm 50 in Figure 3. In this embodiment, the power rotating arm 50 transfers a pre-heated metal ingot 20 individually from the end of the pre-heating oven 42 and lower the ingot 20 gently into the melting furnace 32.

[0026] The length of the pre-heating enclosure and the rails may depend on molten metal consumption rate as well as heater capability. Therefore the controller may be configured to provide a constant rate of transferring of the ingots throughout the preheating and de-stacking apparatus.

[0027] Many casting machines cast less than 1,000 pounds of aluminum per hour. The de-stack and preheater of Figures 1-3 increases the output of melting furnaces under 1,000 pounds per hour by 40%. Larger furnaces, up to 2,000 pounds per hour, that supply larger or multiple casting machines will require the de-stacking and pre-heating unit shown in Figures 4-5 to enable an output increase of 40%.

[0028] In another embodiment shown in Figures 4-5, in which similar components are numbered in an increment of 100 from the illustrations in Figures 1-3, a de-stacking and preheating apparatus 60 includes a 90 degree rotatable table 114 in a housing 116. A stack of ingots 120 is loaded onto the rotatable table, and if necessary, rotated 90 degrees with the stack of ingots to orient the top ingot layer properly for an unloading device 62. The unloading device 62 is attached to an elevator 64 positioned above the unloading device 62 and carried by a gantry carriage 66. The unloading device 62 advances over the stack of ingots 120 and lowers with sensing switches or contact sensors to determine the top layer of the ingot stack. The gantry carriage 66 will then travel until sensors on the unloading device 62 identify an ingot 120 that can be raised without disturbing other ingots. The unloading device will then close on and grasp the appropriate ingot from the stack, raise it above the level of the ingot stack and transport and deposit the ingot into a pocket 66 of the rails 124 if the pocket is vacant.

[0029] As the system calls for another ingot to be transferred into a melting furnace 132, a shuttle bar with pockets 66 will raise and transport all ingots on the stationary rails forward one increment through the pre-heating chamber and lower said ingots into pockets on the stationary rails directly over burners 126 in the pre-heating chamber. The last pocket on the transfer bar will place its ingot on power driven exit rollers 68 to be transported into the melting furnace 132.

[0030] This sequence continues until all ingots that are removed without disturbing other ingots in the current layer. Next, the remaining ingots in the current layer will be selected, one at a time, by the unloader. After closing on and grasping the selected ingot, the unloader will raise and rotate the ingot 180 degrees to permit the ingot to fit in a pocket 66 on the stationary rails. If the pocket 66 is vacant, the unloader will place the ingot in this pocket.

[0031] When all ingots have been removed from a layer, the table can rotate 90 deg. to position the next layer. When all layers have been removed from the rotatable table, the de-stacker signals for more ingots.

[0032] The power rotating arm 50 of Figure 3 can also be used in conjunction with the embodiment of Figures 4-5.

[0033] With respect to all embodiments, the pre-heating and de-stacking apparatus and system can use fuel or electricity for preheating the ingots within the preheater. The pre-heating oven can be coupled with any refractory lined, or crucible type melting furnace.

[0034] Automatic de-stacking of a stack of ingots eliminates physical lifting of the ingots. Inserting ingots into molten metal in a melting furnace eliminates a major safety condition. The apparatus of the present disclosure is a labor saving and safety device that allows the furnace to be kept full for the optimal melting efficiency.

[0035] While in a preferred embodiment the metal ingots are aluminum, the present disclosure is not intended to be limited to such metal. The metal ingots can also be magnesium, zinc, lead, or other metals that are melted.

[0036] The types of switches, sensors, cylinders, or motors required to operate this equipment may be carried in the individual stock rooms of the plants that use the device. Most of the motions required by this apparatus may be cylinder, ball screw, or chain driven.

[0037] The heat source, fuel or electric, for the pre-heat oven includes over-temperature protection, ignition monitoring, as well as any necessary flame controls. These can be monitored by various sensors, and controlled by a controller as part of a control system.

[0038] The control system for the apparatus of the present disclosure monitors all functions of the apparatus and is capable of storing and disseminating information as required. For example, at least one processor can receive signals from various locations around the de-stacking and pre-heating system. Such signals include, but are not limited to, location of the ingots, temperature of the ingots and the melt, size of the ingots, speed of dissemination of the ingots, consumption rate of the melt. In one example, the rate of consumption of the melt is measured, and a controller in the control system commands a corresponding amount of metal ingots is pushed into the pre-heater and loaded into the melt to maintain the melt at a relatively constant amount. The controller does so by commanding the pushing device to add additional ingots to the conveyer, and also command the power rotatable arm to supply the pre-heated metal ingots to the molten supply. The controls in this system can be specified by the end user to coordinate with the existing plant equipment, facilities and production schedules.

[0039] The pre-heater of the present disclosure reduces the time and energy, up to 40%, required to melt aluminum in the melting furnace and thereby reduce some of the damage to the aluminum and the crucible or the refractory lining of the melting furnace.

[0040] Heating aluminum in the solid state contributes very little contamination in the aluminum. Nearly 40% of the energy required to raise solid aluminum from ambient to the liquid state can be introduced in the pre-heater where the aluminum remains in solid state thus reducing proportionally the energy required from the heat source above the melt in roof heated "reverb" furnaces, through the crucible wall of crucible furnaces, or from immersion heaters in the melt for melting the aluminum in the melting furnace.

[0041] All functional actions described above can be carried out by a controller as part of the control system. The controller is specifically configured to receive the various signals regarding the temperature of the melt, the amount of ingots in the conveyer, the temperature of the ingots, the amount of melt available, etc., and output commands to actuate movement of the rotatable table, the elevator, the pushing device, and the power rotatable arm to maintain adequate ingots in the conveyer for preheating and adequate input of ingots into the melting furnace.

[0042] This apparatus 10 is designed to charge any existing or new conventional melting furnace 32. The apparatus increases the refractory life of a refractory lined melting furnace 32, and extends the crucible life of a crucible furnace. Further, the apparatus is designed to increase the molten metal thru-put, up to 40% of any conventional melting furnace. Use of the device results in fewer detrimental inclusions and porosity in the subsequent castings to be made. The apparatus is also a labor-saving device, eliminating unpleasant and unsafe operator conditions.

[0043] While exemplary embodiments are described above, it is not intended that these embodiments describe all possible forms encompassed by the claims. The words used in the specification are words of description rather than limitation, and it is understood that various changes can be made without departing from the spirit and scope of the disclosure. As previously described, the features of various embodiments can be combined to form further embodiments of the invention that may not be explicitly described or illustrated. While various embodiments could have been described as providing advantages or being preferred over other embodiments or prior art implementations with respect to one or more desired characteristics, those of ordinary skill in the art recognize that one or more features or characteristics can be compromised to achieve desired overall system attributes, which depend on the specific application and implementation. These attributes can include, but are not limited to cost, strength, durability, life cycle cost, marketability, appearance, packaging, size, serviceability, weight, manufacturability, ease of assembly, etc. As such, embodiments described as less desirable than other embodiments or prior art implementations with respect to one or more characteristics are not outside the scope of the disclosure and can be desirable for particular applications.

WHAT IS CLAIMED IS:

1. A system for de-stacking and pre-heating metal ingots for inclusion into a melting furnace, the system comprising:

a platform for supporting a stack of metal ingots, the platform configured to rise and lower vertically;

a pre-heating oven including a heat source for pre-heating the ingots and a conveyer for transferring the metal ingots across the heat source; and

a de-stacker configured to push a top row of the metal ingots onto the conveyer.

2. The system of claim 1, further comprising an elevator coupled to the platform for raising and lowering the platform, wherein the platform is rotatably coupled to the elevator such that the platform is capable of rotating at least 90 degrees with respect to the elevator.

3. The system of claim 1, wherein the de-stacker includes a rail extending toward the pre-heating oven, and a pushing arm coupled to the rail and slidable along the rail, wherein the pushing arm is configured to contact the top row of the metal ingots onto the conveyer while sliding along the rail.

4. The system of claim 3, wherein the pushing arm is retractable along the rail to enable a new row of metal ingots to be pushed onto the conveyer.

5. The system of claim 1, further comprising a second conveyer at least partially disposed outside of the pre-heating oven for transporting the metal ingots from the pre-heating oven to a melting furnace.

6. The system of claim 1, further comprising a robotic arm controlled by a controller, wherein the controller is programmed to cause the robotic arm to transfer one or more of the metal ingots from the pre-heating oven to a melting furnace.

7. The system of claim 1, wherein the conveyer is an immobile platform.

8. A system for de-stacking and pre-heating metal ingots, the system comprising

a housing;

a platform disposed within the housing for supporting a stack of metal ingots;

an elevator disposed within the housing, supporting the platform, and configured to move the platform vertically;

a pre-heating oven adjacent to the housing for receiving and pre-heating the ingots;

a conveyer at least partially disposed within the pre-heating oven and having a surface enabling the metal ingots to transfer from the platform toward a melting furnace;

a de-stacker within the housing and moveable linearly toward the conveyer, the de-stacker including a contact surface for engagement with a top row of the stack of metal ingots; and

at least one controller programmed to

command the de-stacker to move linearly to push a top row of the stack of metal ingots onto the conveyer,

based on the top row being evacuated from the stack, command the de-stacker to retract away from the conveyer, and

command the elevator to raise the platform to bring a new top row of metal ingots into alignment with the de-stacker.

9. The system of claim 8, further comprising a sensor configured to detect an exit of one of the ingots from the conveyer.

10. The system of claim 9, wherein the at least one controller is further programmed to cease movement of the de-stacker in response to the exit of one of the ingots from the conveyer into a melting furnace.

11. The system of claim 10, wherein the at least one controller is programmed to receive signals from a liquid metal level sensor in the melting furnace indicating a level of liquid metal in the melting furnace, and wherein at least one controller is further programmed to command the de-stacker to push another ingot from the stack onto the conveyer in response to a signal from the liquid metal level sensor indicating the level of metal in the melting furnace being below a threshold.

12. The system of claim 8, wherein the platform is rotatable relative to the elevator, and wherein the at least one controller is further programmed to command the platform to rotate 90 degrees after the top row is evacuated from the stack.

13. The system of claim 8, wherein the pre-heating oven includes a temperature sensor and a heat source disposed therein, and wherein the at least one controller is further configured to control the heat source to maintain a temperature within the pre-heating oven such as to not exceed a melting temperature of the metal ingots.

14. The system of claim 8, further comprising a second conveyer at least partially disposed outside of the pre-heating oven for transporting the metal ingots from the pre-heating oven to the melting furnace.

15. The system of claim 14, wherein the second conveyer is angled downward relative to the conveyer to facilitate transferring of the metal ingots from the pre-heating oven to the melting furnace.

16. A method of de-stacking and pre-heating metal ingots, the method comprising:

moving a de-stacker linearly to push a top row of a stack of metal ingots onto a conveyer at least partially disposed within an oven, wherein the top row includes a plurality of metal ingots;

transporting at least one of the ingots along the conveyer in the oven;

retracting the de-stacker away from the conveyer in response to the top row being evacuated from the stack;

raising a platform that supports the stack until a new top row of metal ingots is aligned with the de-stacker; and

moving the de-stacker linearly to push the new top row of metal ingots onto the conveyer.

17. The method of claim 16, further comprising heating the oven to a temperature at or below the melting temperature of the metal ingots.

18. The method of claim 16, further comprising ceasing movement of the de-stacker in response to an exit of one of the ingots from the conveyer into a melting furnace.

19. The method of claim 16, further comprising transferring at least one of the ingots from the conveyer into the oven in response to a metal-level sensor indicating a level of liquid metal in the melting furnace being below a threshold.

20. The method of claim 16, further comprising rotating prior to the step of moving the de-stacker linearly to push the new top row of metal ingots onto the conveyer.

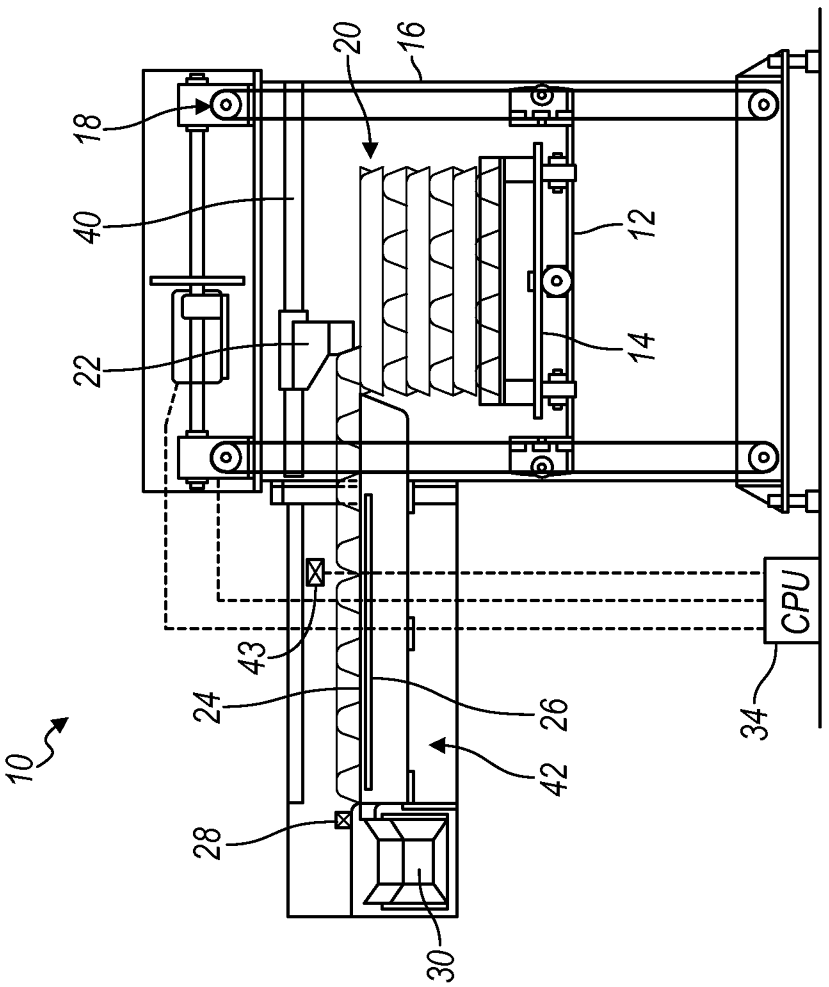
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FIG. 1A

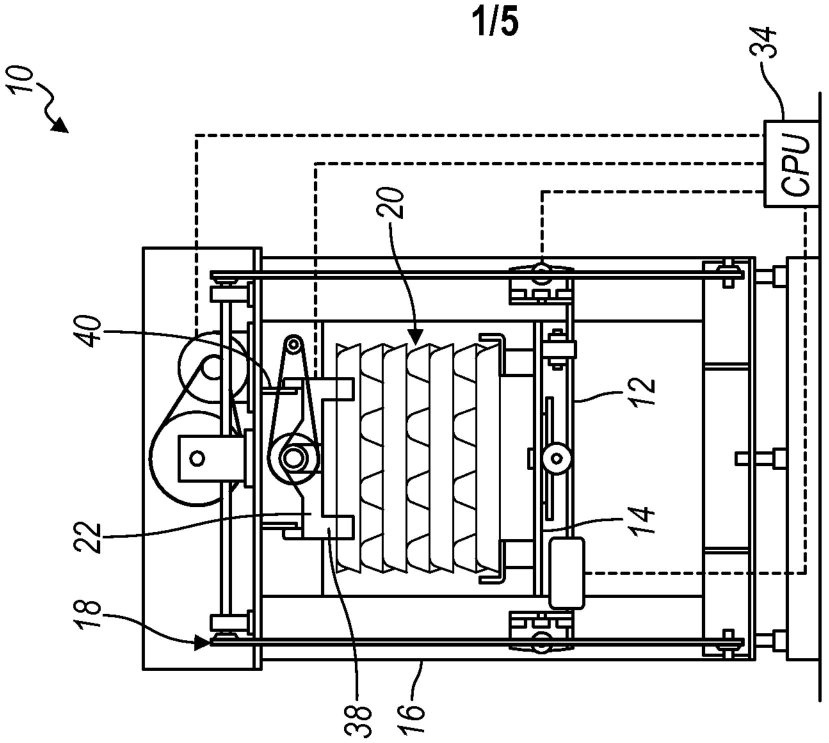
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FIG. 1B

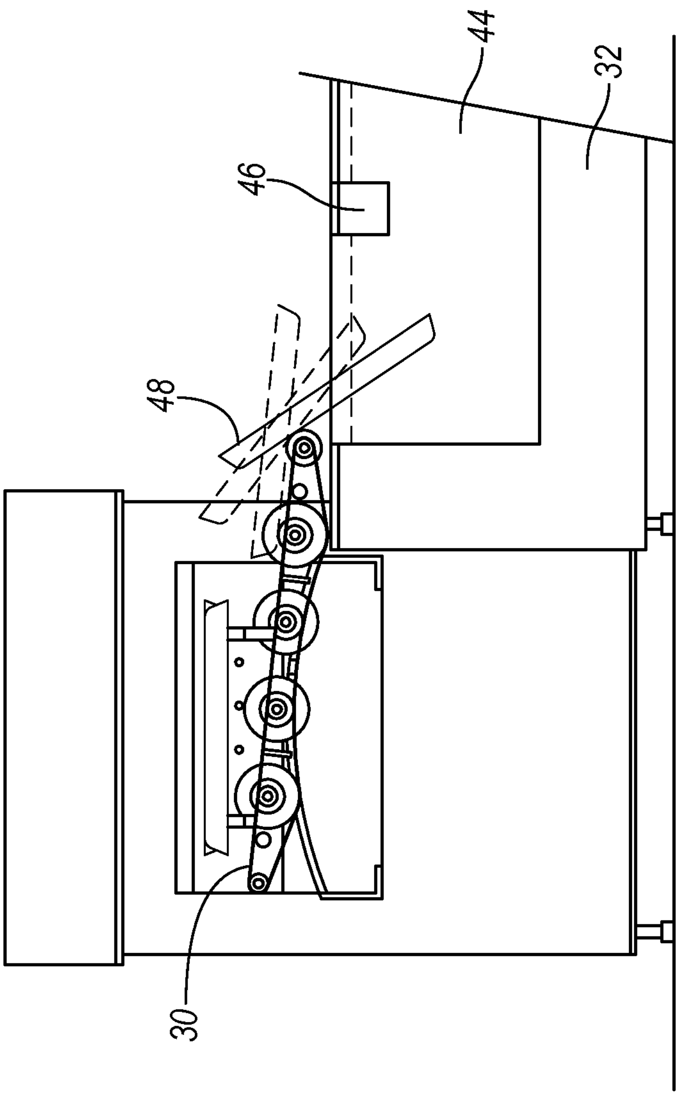

FIG. 2

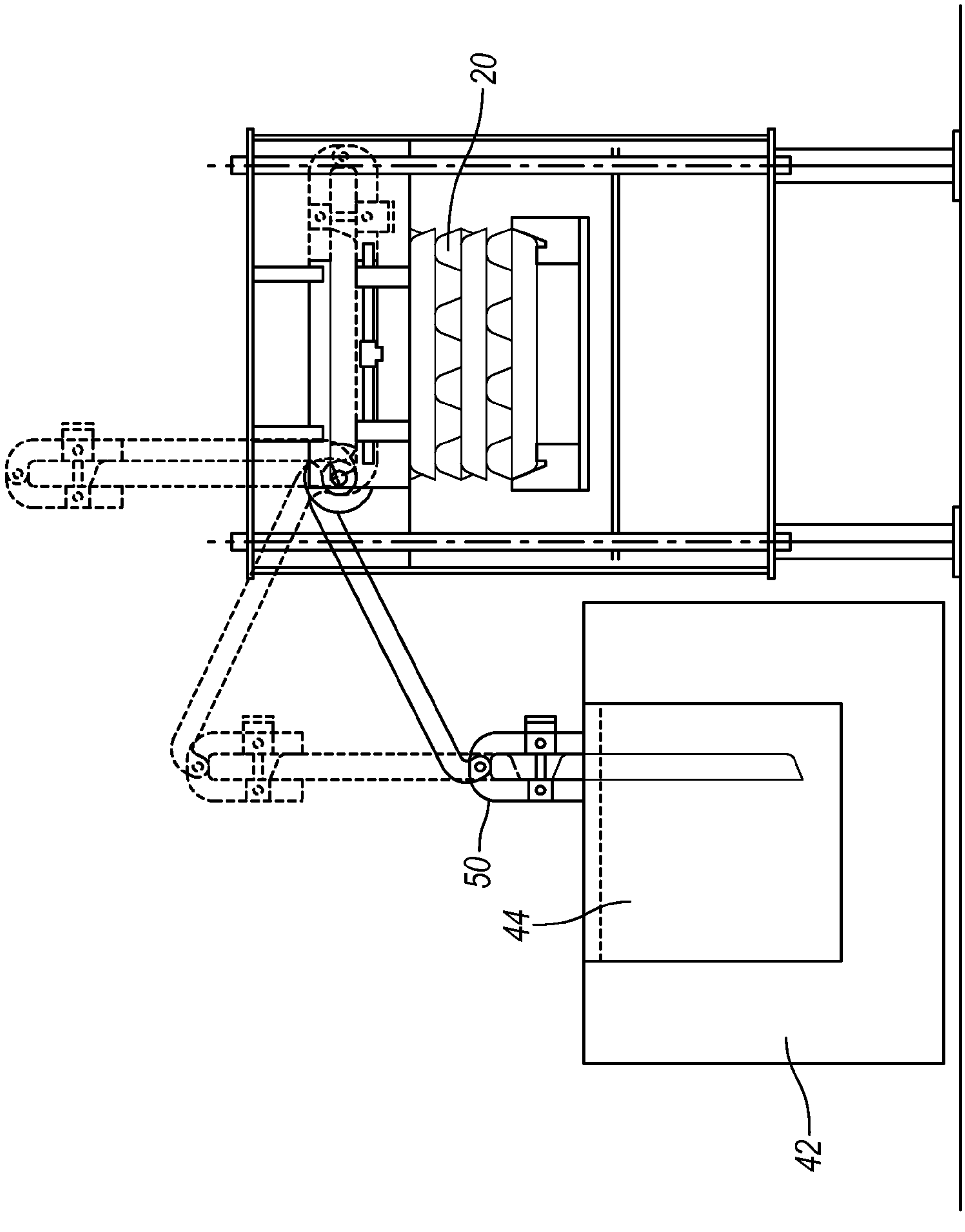

FIG. 3

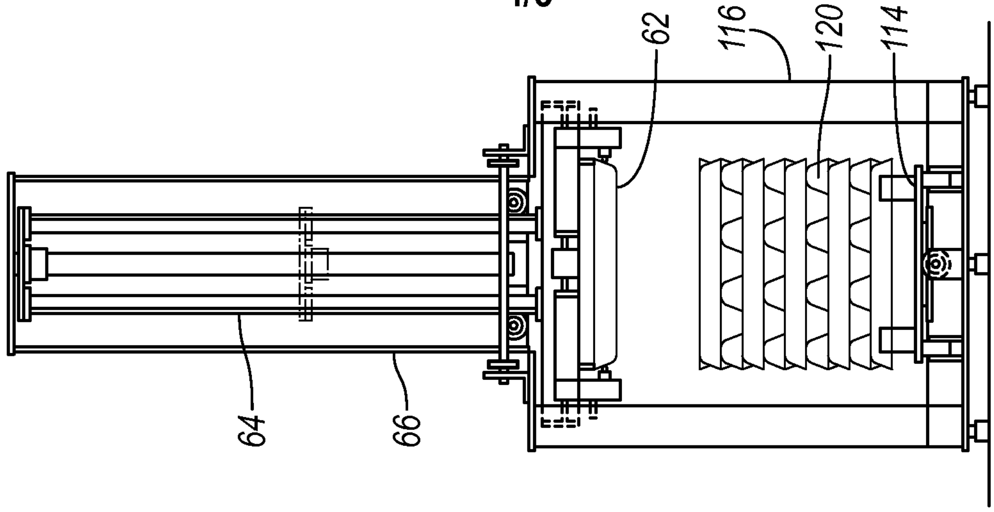

FIG. 4B

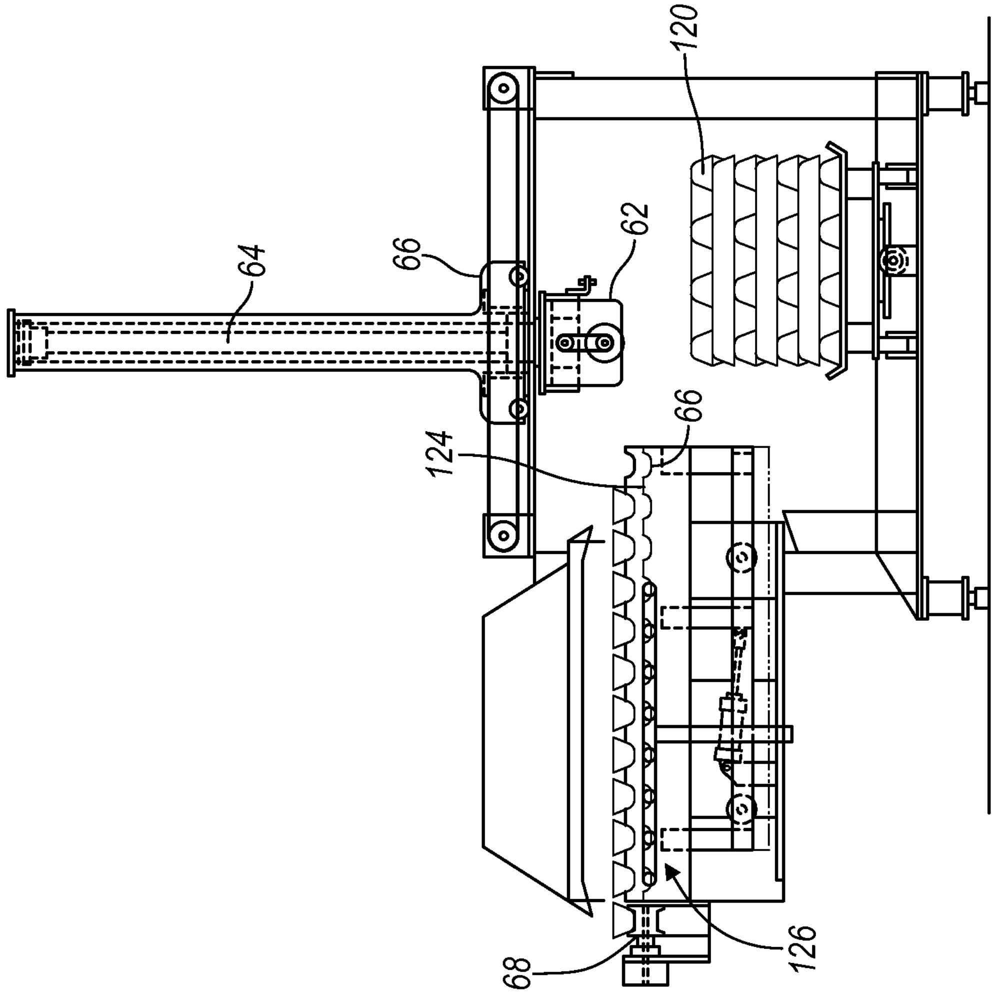

FIG. 4A

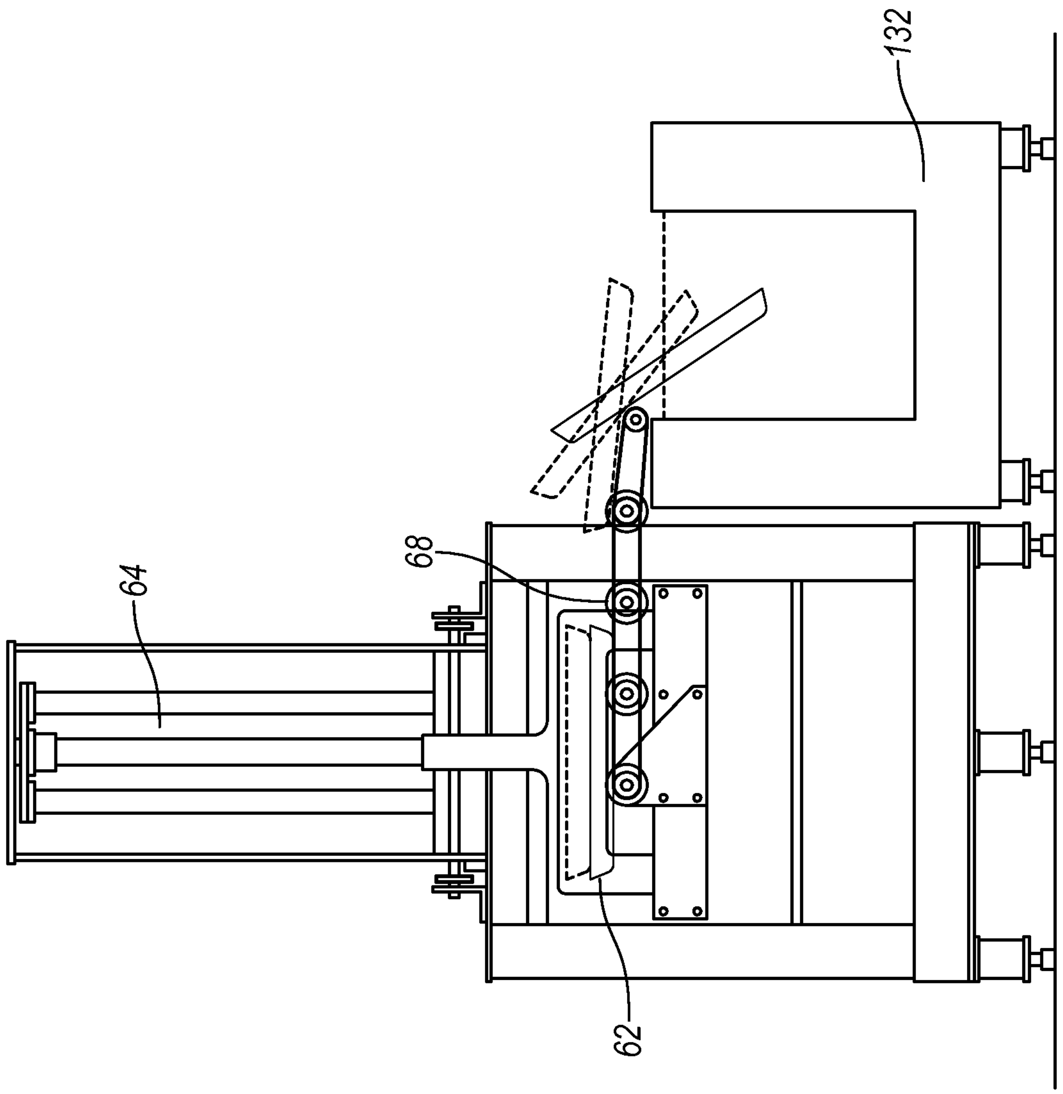

FIG. 5

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2015/031972

A. CLASSIFICATION OF SUBJECT MATTER
IPC(8) - B65G 59/02 (2015.01)
CPC - B65G 59/026 (2015.07)
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC(8) - B22D 5/00; B65G 59/02; C22B 9/16; F27D 3/00, 13/00 (2015.01)
CPC - B65G 59/02, 59/026, 59/06; F27D 3/0025; Y10S 266/901 (2015.07)

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
USPC - 75/392, 686; 148/559; 164/154.1, 155.1, 155.2; 222/591; 266/200, 205, 274, 900, 901; 373/80; 414/795.4, 796.5, 796.7, 796.8 (keyword delimited)

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
PatBase, Google Scholar, Google, YouTube.
Search terms used: ingot, furnace, melt, preheat, piston, plunger, push, ram, elevator, raise, rise, lift, rotate, vertical, actuator, stack, row, column, platform, table, sensor, transducer, detector, thermocouple, liquid, level

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 5,643,528 A (LE GRAS) 01 July 1997 (01.07.1997) entire document	1-20
Y	JP 8-91573 A (TOHO GAS CO LTD et al) 09 April 1996 (09.04.1996) see machine translation	1-20
A	US 2014/0138214 A1 (HONDA MOTOR CO LTD) 22 May 2014 (22.05.2014) entire document	1-20
A	US 2004/0081543 A1 (BROWN) 29 April 2004 (29.04.2004) entire document	1-20

FI Further documents are listed in the continuation of Box C. ☐ See patent family annex.

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