US009156132B2

(12) **United States Patent**
Yamamoto et al.

(10) **Patent No.: US 9,156,132 B2**
(45) **Date of Patent: Oct. 13, 2015**

(54) **SURFACE TREATMENT MACHINE**

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(73) Assignee: **SINTOKOGIO, LTD.**, Nagoya-Shi (JP)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 285 days.

(21) Appl. No.: **13/504,714**

(22) PCT Filed: **Mar. 1, 2011**

(86) PCT No.: **PCT/JP2011/054626**
§ 371 (c)(1), (2), (4) Date: **Jul. 10, 2012**

(87) PCT Pub. No.: **WO2012/014514**
PCT Pub. Date: **Feb. 2, 2012**

(65) **Prior Publication Data**
US 2013/0115853 A1 May 9, 2013

(30) **Foreign Application Priority Data**
Jul. 29, 2010 (JP) 2010-171022

(51) **Int. Cl.**
B24C 3/00 (2006.01)
B24C 3/08 (2006.01)
B24C 9/00 (2006.01)
B24C 3/06 (2006.01)

(52) **U.S. Cl.**
CPC ... ***B24C 3/00*** (2013.01); ***B24C 3/06*** (2013.01); ***B24C 3/08*** (2013.01); ***B24C 9/00*** (2013.01)

(58) **Field of Classification Search**
CPC B24C 3/00; B24C 3/08; B24C 3/06; B24C 9/00
USPC 451/80–84, 89, 2, 5, 6, 8, 11, 75; 198/502.2, 495, 341.04, 341.05
See application file for complete search history.

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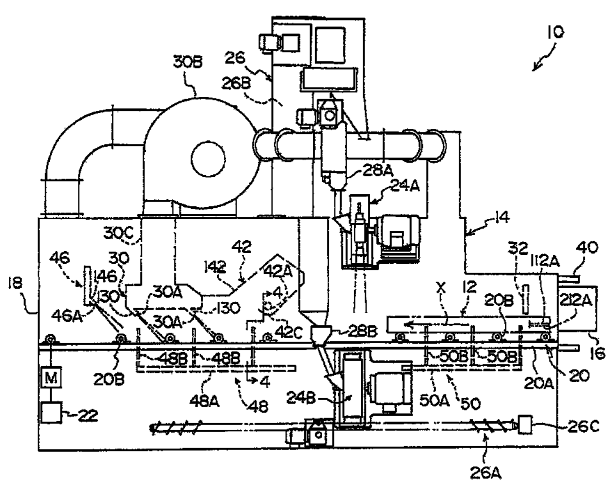
(74) *Attorney, Agent, or Firm* — Finnegan, Henderson, Farabow, Garrett & Dunner, L.L.P.

(57) **ABSTRACT**

Disclosed herein is a surface treatment machine that enables the inhibition or reduction of residual abrasives that remain on a workpiece that has been surface treated. An H steel (a workpiece to be treated) **12** is conveyed by means of a conveying device **20**. Blasting devices **24**A, **24**B are then projected abrasives on to the conveying H steel such that it is surface treated. In the downstream of the blasting devices **24**A, **24**B along the conveying direction, a blowing port **30**A of an air blower **30** is located above a conveying path to blow gas to the upper surface **112**A of the H steel **12** such that the abrasives on the H steel **12** are blown off and removed therefrom.

17 Claims, 5 Drawing Sheets



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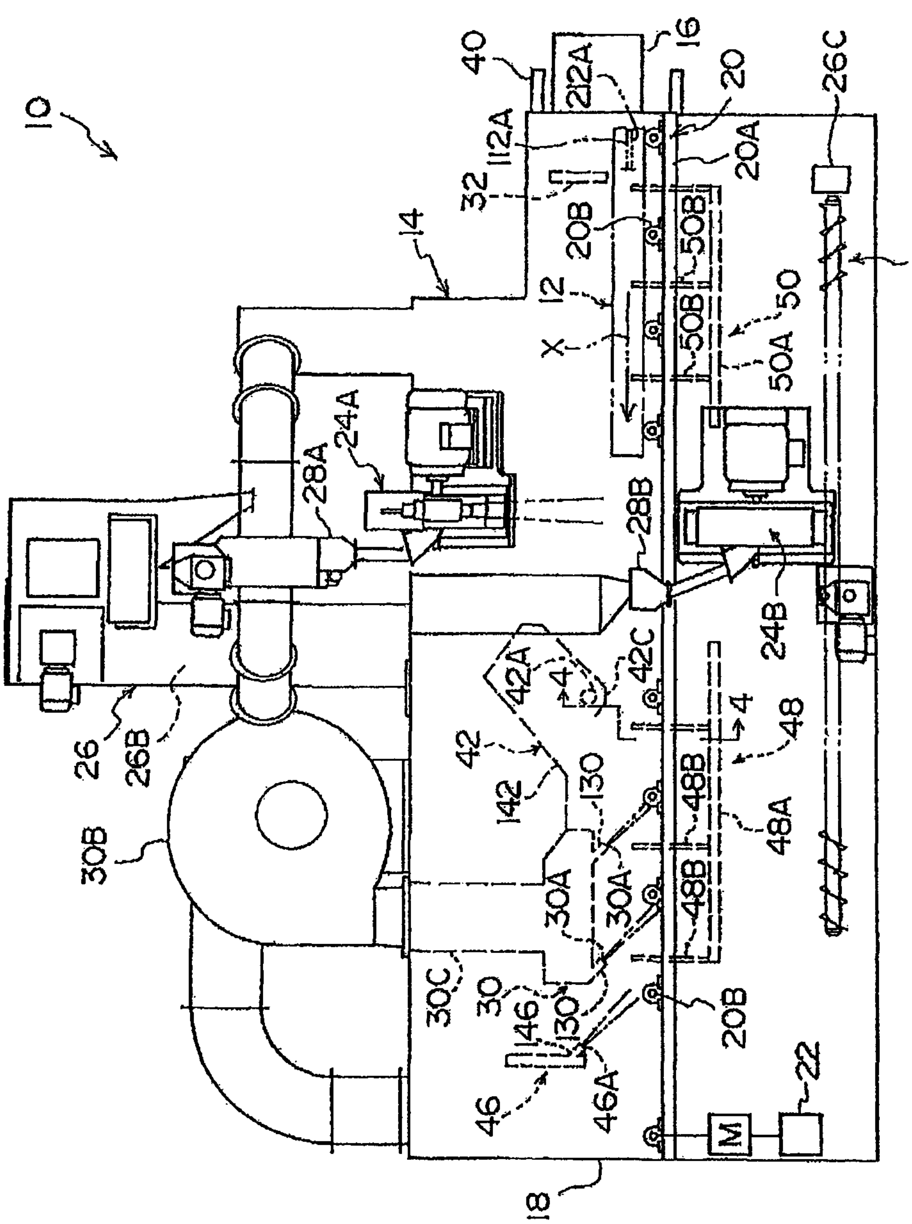

10
40
16
212A
20
112A
20A
26C
32
14
20B
50B
12
50B
50
X
26A
50A
24A
28A
28B
24B
42A
42C
4
4
48
26
26B
42
142
130
48B
30B
48A
30A
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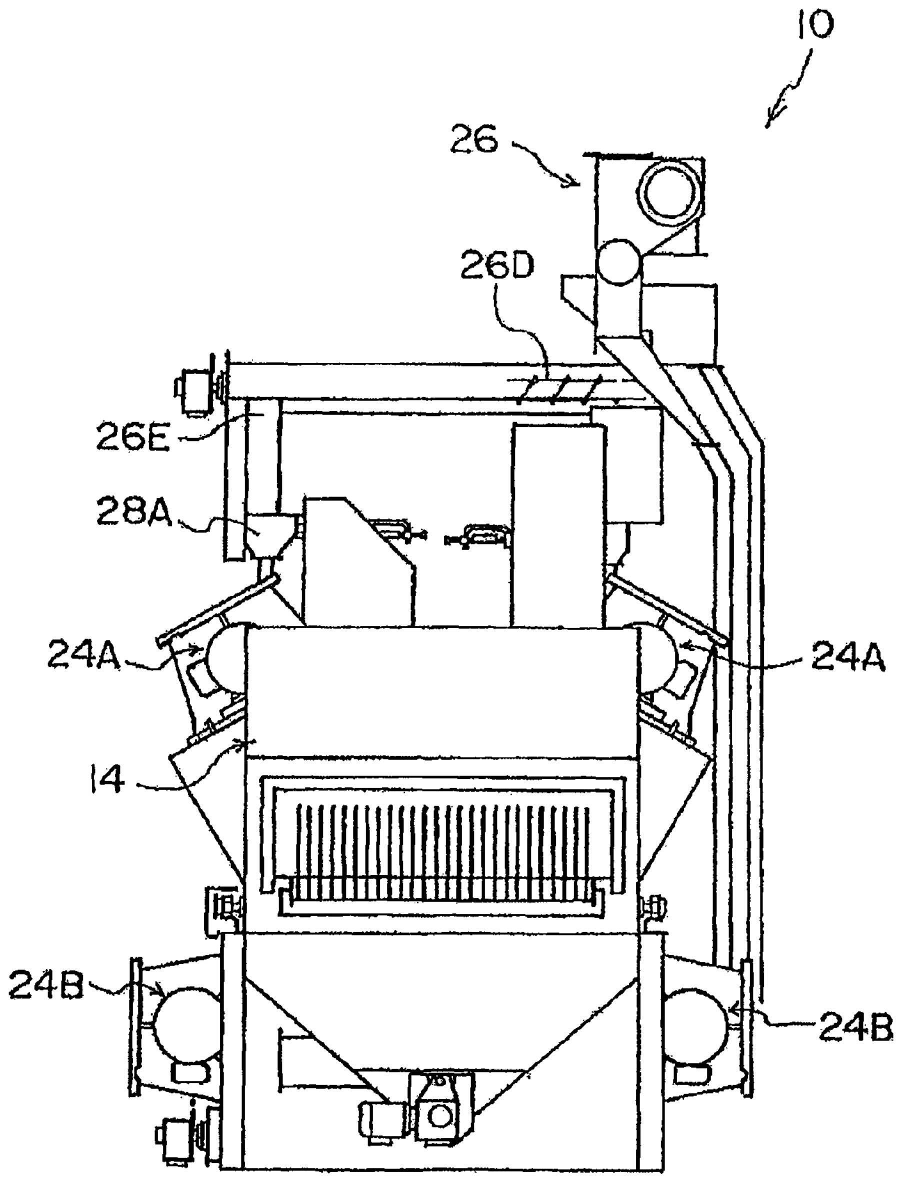
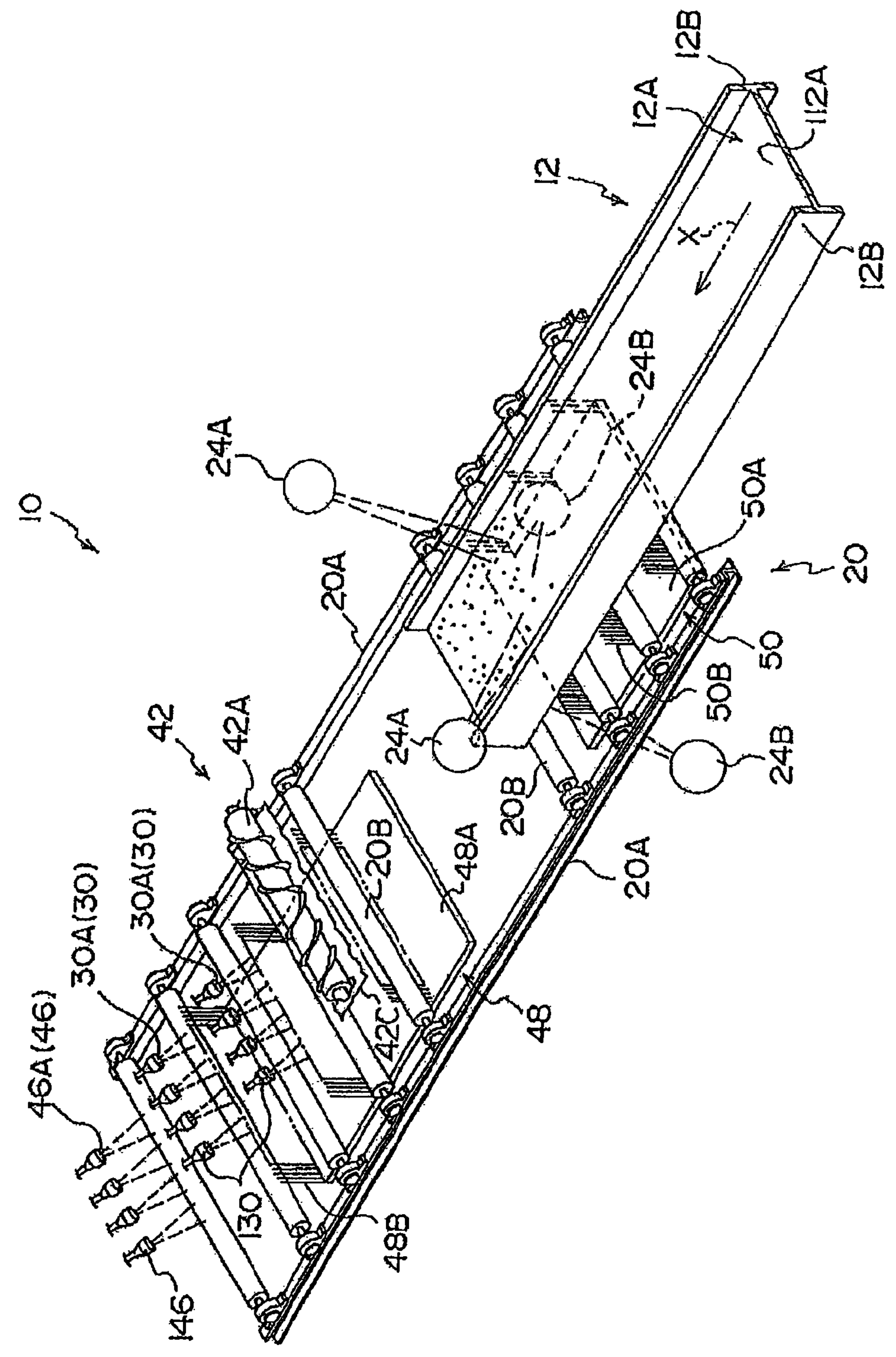
48B
30C
30
146
130
20B
22
46
46A
M
18

Fig. 1

Fig. 2




10
12
12A
12B
112A
X
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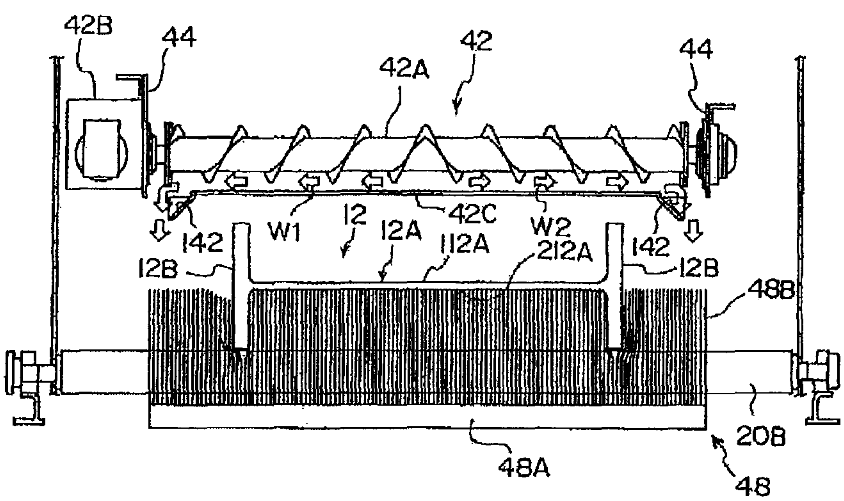
20A
20B
24A
24B
50
50A
50B
42
42A
42C
48
48A
48B
30A(30)
130
46A(46)
146

Fig. 3

Fig. 4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42A
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W1
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42C
W2
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212A
12B
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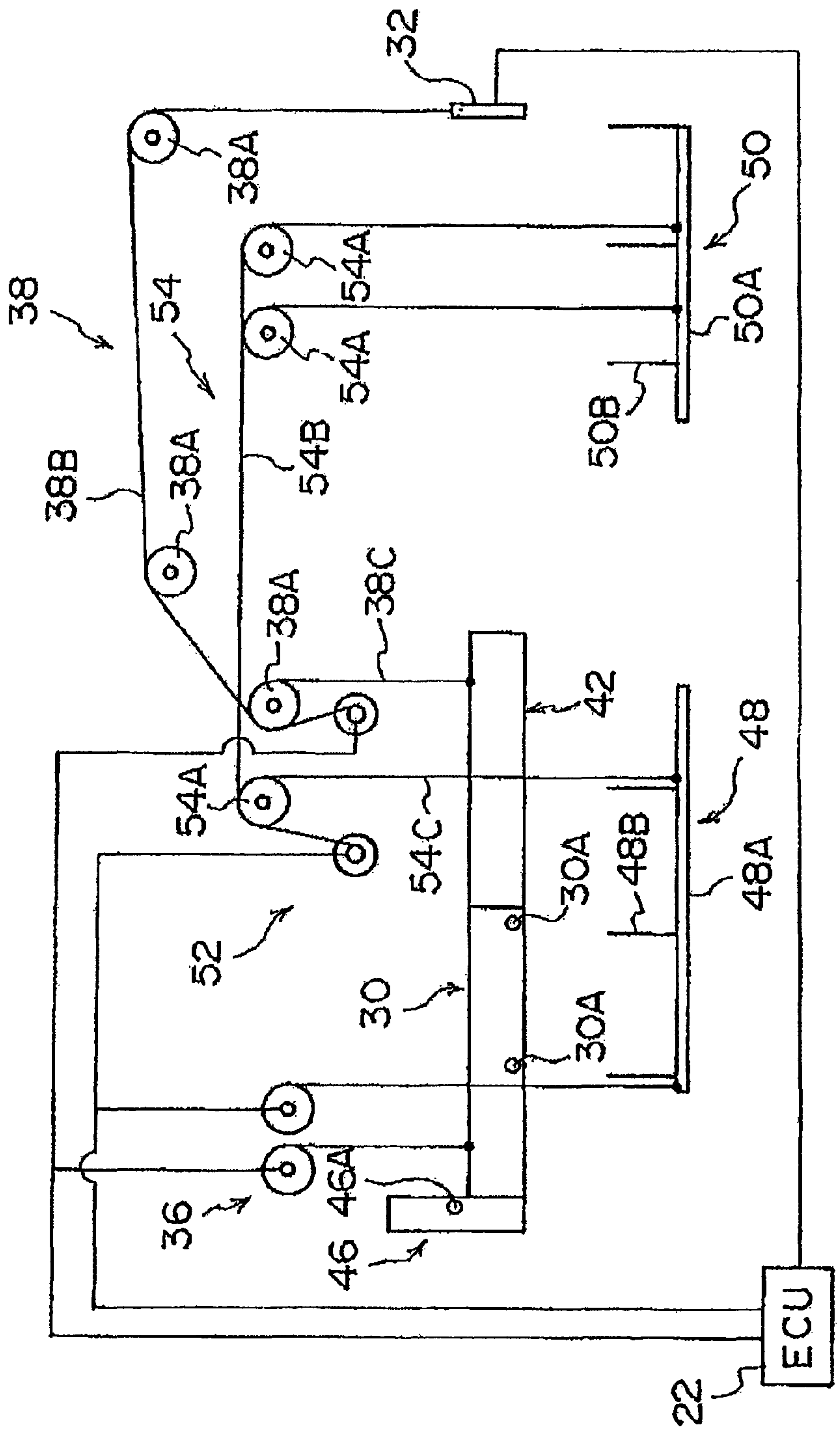
48B
20B
48A
48


32
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38A
54B
38A
38C
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54A
54C
30A
48B
48A
52
30
30A
36
46A
46
ECU
22

Fig. 5

SURFACE TREATMENT MACHINE

TECHNICAL FIELD

This invention relates to a surface treatment machine for projecting abrasives on the surface of a workpiece and for surface treatment thereon.

BACKGROUND

One conventional surface treatment machine, as disclosed in, e.g., Patent Literature 1, blast finishes an elongated members or workpiece. In such a conventional machine, if the elongated workpiece to be blast finished is, for instance, an H steel having an H-like cross section, the H steel is positioned in an H-like position in which its web surfaces are in their lateral positions, such that abrasives are projected on to the positioned H steel for surface treatment. In this case, because the upper side of the positioned H steel is formed almost like a slot, the abrasives that have been projected may remain therein. Therefore, this type of conventional machine requires that an H steel that has been surface treated should conveyed in its I-like position, in which the web surfaces are in their longitudinal position, to prevent the abrasives that have been projected from remaining on the treated H steel. However, this conveying position of the H steel to be conveyed lacks stability. In contrast, if the H steel is conveyed in its H-like position, as described above, the abrasives that have been projected may remain thereon.

PRIOR ART LITERATURE

Patent Literature

[Patent Literature 1] Japanese Patent Publication No. 2549137 (Sintokogio, Ltd.)

SUMMARY OF THE INVENTION

Problem to be Solved by the Invention

Accordingly, one purpose of the present invention is to provide a surface treatment machine that enables the inhibition or a reduction of residual abrasives on a workpiece that has been surface treated.

Means to Solve the Problem

The surface treatment machine for surface treating a workpiece to be treated with of the present invention comprises:

- conveying equipment that forms a conveying path for conveying the workpiece along the conveying path in a conveying direction;
- a blasting device for projecting the abrasives on the conveying workpiece to be surface treated; and
- a blower for blowing gas from downstream of the blasting device along the conveying direction and above the conveying path toward the upper surface of the conveying workpiece.

With this surface treatment machine, the workpiece to be treated is conveyed by the conveying equipment. The blasting device then projects the abrasives to the conveying workpiece such that it is surface treated. In this surface treatment, downstream of the blasting device along the conveying direction, the blower blows the gas from above the conveying path to the upper surface of the workpiece such that the abrasives on the workpiece are blown off and removed therefrom. Therefore, abrasives remaining on the workpiece can be prevented or inhibited.

In one embodiment of the present invention, the blower is preferably configured such that the streamline of the blowing gas toward the workpiece is downwardly inclined from downstream to upstream along the conveying direction.

In this configuration, because the blower blows the gas to the residual abrasives on the upper surface of the workpiece in the opposite direction of the conveying direction, the abrasives on the upper surface of the workpiece can be efficiently blown off therefrom.

The surface treatment machine of the present invention may further include a receptacle for receiving the abrasives that are blown off the workpiece by blowing gas from the blower. The receptacle is located above the conveying path downstream of the blasting device along the conveying path.

With such a receptacle, because the abrasives that are blown off the workpiece are kept therein, the falling therein and thus remaining thereon of the abrasives that are blown off the upper surface of the workpiece is prevented or inhibited.

In one embodiment of the present invention, the surface treatment machine may further comprise:

- transferring mechanism for transferring the abrasives that are projected; and
- circulating device for circulating the transferred abrasives into the blasting device.

In this configuration, because the abrasives that are projected are transferred by the transferring mechanism such that the circulating device circulates them into the blasting device, they can be reused.

In this configuration, the receptacle preferably communicates with the transferring mechanism to reuse the accommodated abrasives kept in the receptacle.

In one embodiment of the present invention, the surface treatment machine further comprises:

- a height sensor for sensing the height level of the conveying workpiece, wherein the height sensor is located on the upstream of the blower along the conveying direction; and
- a lifting and lowering device for vertically moving the blower in response to the sensing result from the height sensor.

In such an embodiment, the height sensor, which is located on the upstream of the blower along the conveying direction, senses the height level of the workpiece in its conveying condition. The lifting and lowering device vertically moves the blower in response to the sensing result from the height sensor. Therefore, the blower can be positioned at an appropriate height level relative response to the height level of the workpiece.

In such an embodiment, the height level of the lower end of the height sensor may be positioned at a height level that is the same as or lower than the height level of the lower end of the blower. Also, the surface treatment machine may further include a synchronizing mechanism for synchronizing the vertical movement of the height sensor with the vertical movement of the blower.

This configuration enables the positioning of the lower end of the height sensor to a position to avoid collision with the workpiece. Further, the synchronizing means synchronizes the vertical movement of the height sensor with the vertical movement of the blower. Therefore, a collision between the blower and the workpiece can readily be prevented.

In one embodiment of the present invention, the surface treatment machine may further comprise:

- an edge detection sensor for detecting when the leading edge and the following edge of the conveying workpiece passes therethrough, wherein the edge detection sensor is located upstream of the blasting device along the conveying direction; and

a controlling means for actuating the blasting device and the blower when the controlling means determines that the workpiece on the conveying path is in a predetermined range along the conveying path, in response to a detection result from the edge detection sensor and the conveying velocity of the workpiece by means of the conveying equipment.

In such an embodiment, the edge detection sensor detects when the leading edge and the following edge of the workpiece along the conveying direction pass therethrough. Based on this detection result and the conveying velocity of the workpiece by means of the conveying equipment, the controlling means can adequately control the timing of the operation of the blasting device and the blower.

The surface treatment machine of the present invention may further comprise a further blower for blowing gas from downstream of the blower along the conveying direction and above the conveying path toward the upper surface of the conveying workpiece.

With this configuration, even in the possible case in which the abrasives on the workpiece cannot be completely removed with only the blowing of the gas from the=blower, the residual abrasives on the workpiece may be removed by the further blower. Therefore, residual abrasives on the workpiece may be effectively prevented or inhibited.

This further blower is preferably configured such that the streamline of the blowing gas toward the workpiece is downwardly inclined from downstream to upstream along the conveying direction.

The surface treatment machine of the present invention further comprises antiscattering equipment that is arranged beneath the conveying path of the workpiece and includes antiscattering members for preventing the abrasives that are projected onto the workpiece from scattering through the lower surface of the workpiece.

With this antiscattering equipment, the abrasives that are projected on the lower surface of the workpiece can be prevented from scattering through the workpiece.

The antiscattering members of the antiscattering equipment preferably include a plurality of self-standing and elongated members. Each elongated member has flexibility to deflect in the conveying direction of the workpiece when the workpiece passes through the elongated member.

In this configuration, the scattering of the abrasives can be prevented, even if the width of the workpiece is varied.

The surface treatment machine that incorporates the antiscattering equipment may further comprise a height sensor, which is located upstream of the blower along the conveying direction, for sensing the height level of the conveying workpiece; and a further for vertically moving the antiscattering equipment in response to the sensing result from the height sensor.

In this configuration, based on the detection result from the height sensor, the further lifting and lowering device vertically moves the antiscattering equipment. Therefore, the height level of the antiscattering equipment can be positioned at an appropriate height level in response to the height level of the workpiece.

The surface treatment machine of the present invention may further comprise an edge detection sensor for detecting when the leading edge and the following edge of the conveying workpiece pass therethrough; and a controlling means for suspending the conveying equipment when the controlling means determines that the time period in which a workpiece on the conveying path is nonexistent is longer than a predetermined value, in response to the detection result from the edge detection sensor.

In this configuration, the edge detection sensor, which is located upstream of the blasting device along the conveying direction, detects when the leading edge and the following edge of the conveying workpiece pass therethrough. In response to the detection result from the edge detection sensor, the controlling means suspends the operation of the conveying equipment when the controlling means determines that the time period in which a workpiece on the conveying path is nonexistent is longer than a predetermined value. Therefore, the operation of the conveying equipment can be adequately controlled.

The surface treatment machine of the present invention may further comprise a variable feeder for feeding the abrasives into the blasting device with a variable feeding rate.

In this configuration, appropriate quantities of abrasives can be adequately fed from the feeder to the blasting device.

Advantage of the Invention

As described above, the surface treatment machine of the present invention enables prevention or inhibition of residual abrasives on a workpiece that has been surface treated.

The accompanying drawings, which are incorporated in and constitute a part of the specification, schematically illustrate a preferred embodiment of the present invention, and together with the general description given above and the detailed description of the preferred embodiment given below, serve to explain the principles of the present invention.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a schematic side view of a shot-blast machine of one embodiment of the present invention.

FIG. **2** is a schematic front view of the shot-blasting machine of FIG. **1**.

FIG. **3** is a perspective view illustrating a part of the shot-blasting machine of one embodiment of the present invention.

FIG. **4** is an enlarged cross-sectional view along **4-4** lines in FIG. **1**.

FIG. **5** is a schematic side view illustrating the vertical moving mechanism in the shot-blasting machine of one embodiment of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

As one example of the surface treatment machine of one embodiment of the present invention, a shot-blasting machine **10** will be explained with reference to FIGS. **1** to **5**. FIG. **1** illustrates a side view of a schematic configuration of the shot-blast machine **10** of one embodiment of the present invention. FIG. **2** illustrates the front view of a schematic configuration of the shot-blasting machine **10**. FIG. **3** is a perspective view of one part of the shot-blasting machine **10** and an H steel **12** to be surface treated. In this embodiment, as illustrated in FIG. **3**, note that the H steel **12** is an elongated material that includes a web **12**A and a flange **12**B such that it is conveyed along its longitudinal in its H-like position in which the surface of the web **12**A is in a lateral position. In this conveying position of the H steel, one surface that is upwardly faced of the web **12**A is referred to as the upper surface.

As illustrated in FIG. **1**, the shot-blasting machine **10** includes a cabinet **14** whose interior forms an elongated treating chamber along the conveying direction (as denoted by an arrow X) of the H steel **12**. The cabinet **14** forms a service entrance **16** for carrying in a workpiece at the side for carrying in (the right side in the drawing) and an outlet **18** for carrying out the workpiece at the side for carrying out (the left side in the drawing).

Interior to the cabinet **14**, conveying equipment (conveying equipment) **20** for conveying the H steel **12** is provided. As illustrated in FIG. **3**, the conveying equipment **20** is provided with conveying bases **20**A on both sides of the width across the conveying direction. On the conveying bases **20**A, a plurality of round bar-like conveying rollers **20**B are rotatably supported. These rollers **20**B are arranged along the conveying direction (the X-direction denoted by the arrow) such that the longitudinal of the conveying rollers **20**B is perpendicular to the conveying direction with appropriate intervals adjacent them, to form a conveying path for the H steel **12**. As shown in FIG. **1**, the conveying rollers **20**B are coupled with a driving motor M, which is schematically illustrated on the left side of FIG. **1**, such that they are rotated by the driving force of the driving motor **12**. Thus, the conveying equipment **20** is configured such that the H steel **12** is loaded on the conveying rollers **20**B to convey it. The driving motor M is connected to an electronic control unit (ECU) (a controlling means or a controlling section) **22**. The ECU **22** is illustrated as a schematic block diagram in FIG. **1**.

As illustrated in FIGS. **1** and **2**, blasting devices **24**A and **24**B (at least one blasting device) are arranged on the both sides of the ceiling and the lower portions of the lateral sides of the cabinet **14**. The blasting devices **24**A and **24**B are, but are not limited to, centrifugal shot-blasting devices (impeller units) for centrifugally accelerating abrasives (shots) to project them in the predetermined direction.

As illustrated in FIG. **3**, the upper blasting device **24**A is installed on the upper side of both sides of the conveying path such that it projects the shots from obliquely and upward to the H steel **12**. Although the blasting devices **24**A and **24**B are schematically illustrated in FIG. **3** for the convenience of explanation, they are connected to the ECU **22** that is shown in FIG. **1**, but is not shown in FIG. **3**.

As illustrated in FIG. **1**, the blasting devices **24**A and **24**B are coupled to shot feeders **28**A and **28**B for supplying the shots thereto. Each shot-feeding device **28**A or **28**B is provided with an openable and closable gate (not shown) in a supplying section for supplying the shots. The shot feeders **28**A and **28**B can carry out a multistep and variable regulation in amount of the supplied shots to the blasting devices **24**A and **24**B by varying the degree of the opening of the corresponding gates. Although the variable supply for supplying the shots by means of the shot feeders **28**A and **28**B is the two-step supply in this embodiment, it may be replaced by a nonstop supply.

The blasting devices **24**A and **24**B are coupled to a circulating device **26** through the shot feeders **28**A and **28**B. The circulating device **26** transports the shots that have been projected from the blasting devices **24**A and **24**B to circulate the projected shots thereto. The circulating device **26** is provided with screw conveyors **26**A, which are arranged on both sides of the bottom portion of the cabinet **14**, and a bucket elevator **26**B, which is vertically extended along the height of the machine. Each screw conveyor **26**A is axially extended such that the direction of its shaft is along the conveying direction (the direction denoted by arrow X) of the H steel **12**. The part (not shown) of the shaft of each screw conveyor **26**A is rotatably supported on the cabinet **14**. Each screw conveyor **26**A is provided with a bilaterally symmetric screw, which is drivingly and rotatably coupled to a driving motor **26**C to feed the shots from both sides the center portion in the drawing when it rotates by means of the driving motor **26**C. The lower end of the bucket elevator **26**B is arranged facing the upper part of the center portion of each screw conveyor **26**A. The detailed explanation of the bucket elevator **26**B is omitted, since it includes a well-known structure in which a plurality of pulleys (not shown) are arranged at the top and bottom of the shot-blasting machine **10** such that an endless belt (not shown) on which many buckets (not shown) are attached is entrained on the pulleys. With this configuration of the bucket elevator **26**B, the buckets scoop the shots that have been collected by means of the screw conveyors **26**A to transport the shots within the buckets to the upper side of the machine by rotating the pulleys by means of a motor.

Further, as illustrated in FIG. **2**, in the circulating device **26**, the upper side of the bucket conveyor **26**B (see FIG. **1**) is provided with the one end of an upper screw conveyor **26**D for horizontally transporting the shots. Beneath the upper screw conveyor **26**D, a shot tank **26**E for storing the shots is provided. The shot tank **26**E is coupled to the shot feeders **28**A, **28**B (see FIG. **1**).

Also, as illustrated in FIGS. **1** and **3**, a blowing port **30**A of an air blower **30** is arranged at the side downstream of the blasting devices **24**A, **24**B and above the conveying path. As illustrated in FIG. **1**, the air blower **30** includes a blower fan **30**B, which is provided on the upper portion of the cabinet **14**. The blower fan **30**, which is operated by means of a driving force of a driving motor (not shown), is coupled on a duct **30**C. The lower portion of the duct **30**C forms a vertically movable part and a nozzle portion **130** having the blowing port **30**A at the tip of the lower portion of the duct **30**C. The air blower **30** can be gas (air) blown from the blowing port **30**A to the upper surface **112**A of the H steel **12** when the driving motor is driven.

The air blower **30** is preferably configured such that the direction of the streamline of the gas to be blown to the workpiece is downwardly inclined from the downstream to the upstream along the conveying direction. To this end, in this embodiment, the orientation of the gas to be blown from the air blower **30** is established by an inclination angle of the nozzle portion **130**. Namely, the blown gas from the air blower **30** is established such that the direction of the streamline of the blown gas is downwardly inclined from the downstream to the upstream along the conveying direction. In addition, the driving motor (not shown) of the blower fan **30**B is controllably coupled to the ECU **22**.

Upstream side of the conveying direction of the air blower **30**, a transferring mechanism **42** is disposed such that it is coupled to and integrated with the air blower **30**. The transferring mechanism **42** includes a housing **142** whose lower portion has a lower opening near the air blower **30** such that the lower opening faces to the conveying path. Note that the housing **142** in FIG. **1** is schematically illustrated as its cross section that includes the lower opening. The housing **142** is integrally provided with a backing plate **42**C at the location adjacent to the lower opening of the housing **142** and upstream of the conveying direction. The baking plate **42**C is arranged such that its height level is substantially the same as that of the blowing port **30**A of the air blower **30**.

Further, as illustrated in FIGS. **1** and **3**, the transferring mechanism **42** includes a screw conveyor **42**A in proximity to above the backing plate **42**C. In this embodiment, the backing plate **42**C forms a receptacle for collecting the shots such that the receptacle is located downstream of the conveying direction and above the conveying path. The backing plate **42**C is configured to receive the shots that are blown off the H steel **12**, especially the shots that are blown off the upper surface **112**A of the H steel **12**, i.e., the shots that are lifted up with the reflected gas from the upper surface **112** of the H steel **12**. The screw conveyor **42**A is extended along its axial direction that is oriented widthwise, which corresponds to a perpendicular line against the plane of FIG. **1**, of the conveying direction and is opposed to the receptacle (the backing plate) **42**C.

FIG. **4** illustrates an enlarged cross-section view along **4-4** lines in FIG. **1**. As illustrated in FIG. **4**, a shaft of the screw conveyor **42**A is rotatably supported by brackets **44** on both sides. The brackets **44** are coupled to one portion of the air blower **30** that is shown in FIG. **1**.

The screw conveyor **42**A is provided with a bilaterally symmetric screw, which is drivingly and rotatably coupled to a driving motor **42**B to feed the shots on the backing plate **42**C from the center portion to both sides (denoted by arrows W**1** and W**2**) in the drawing when it rotates by means of the driving motor **42**B. The backing plate **42**C forms a discharging opening **142** at the outside more than the H steel **12** in the width of the conveying direction, to allow the shots to fall downward. The discharging opening **142** is located above the screw conveyor **26**A in the bottom portion of the cabinet **1** as illustrated in FIG. **1**. Transferring mechanism **42** thus transfers the shots, which are blown off the upper surface **112**A of the H steel **12** caused by the blown gas from the air blower **30**, to the circulating device **26**.

As illustrated in FIGS. **1** and **3**, a blowing port **46**A of a final blower (a further blower) **46** is located downstream of the air blower **30** in the conveying direction and above the conveying path. The blowing port **46**A is formed on the tip end of a nozzle **146** of the final blower **46**. In this embodiment, a lower portion (a movable portion) of the final blower **46** can be moved with a lower portion (a movable portion) of the air blower **30** in unison. The blowing port **46**A of the final blower **46** is located slightly higher than the blowing port **30**A of the air blower **30**. The final blower **46** is configured such that the blowing port **46**A can blow compressed air (or compressed gas) toward the upper surface **112**A of the H steel **12**. Similar to the air blower **30**, the final blower **46** is preferably configured such that the direction of the streamline of the gas to be blown to the workpiece is downwardly inclined from the downstream to the upstream along the conveying direction. To this end, in this embodiment, the orientation of the streamline of the gas to be blown from the blowing port **46**A of the final blower **46** is established such that it is downwardly inclined from the downstream to the upstream along the conveying direction.

As illustrated in FIG. **1**, a height sensor **32**, which also functions as a collision avoidance device, is located upstream of the air blower **30** and the blasting devices **24**A, **24**B in the conveying direction. The height sensor **32** senses the height level of an incoming workpiece under the conveying condition. As in this embodiment, if the workpiece **12** is the H steel, the height level to be sensed by the height sensor **32** is positioned on the top end of the flange of the H steel **12**.

As illustrated in FIG. **5**, the height sensor **32** is coupled to a first lifting and lowering device (a first lifting and lowering means) **36** through the ECU **22**. The first lifting and lowering device **36** is configured to have a winch. The first lifting and lowering device **36** lifts and lowers the movable portion on the side of the blowing port **30**A of the air blower **30** to a position in which the air blower **30** cannot contact with the H steel **12** that is shown in FIG. **1**, and lifts and lowers the movable portion of the final blower **46** in unison.

In this embodiment, the height level of the lower end of the height sensor **32** is positioned on a level substantially the same as the height level of the lower end of the air blower **30**. Alternatively, the height level of the lower end of the height sensor **32** may be positioned on a level that is slightly lower the height level of the lower end of the air blower **30**. The height sensor **32** is preferably coupled to the air blower **30** thorough a gearing mechanism **38**. The gearing mechanism **38** includes a wire **38**B and a chain **38**C, both entrained on a pulley **38**A to couple the height sensor **32** with the air blower **30** to interlock the vertical motion (the vertical displacement) of the height sensor **32** with the vertical motion (the vertical displacement) of the air blower **30**.

As illustrated in FIG. **1**, in the upstream of the blasting devices **24**A, **24**B, an edge detection sensor **40** is located in proximity to a service entrance **16**. The edge detection sensor **40** detects events in which the leading edge and the following edge of the H steel are passed and generates detection signals. The edge detection sensor **40** is coupled to and provides detection signals to the ECU **22** (its coupling manner is not shown). Based on the detection results of the edge detection sensor **40** and the setting velocity of the conveying roller **20**B (i.e., the conveying velocity of the conveying device **20**), if the ECU **22** determines that the H steel **12** is in a predetermined range on the conveying path along the conveying direction (the direction denoted by an arrow X), the ECU **22** actuates the blasting devices **24**A, **24**B and the air blower **30**. Based on the detection results of the edge detection sensor **40**, if the ECU **22** determines that the time period in which the H steel **12** on the conveying path is nonexistent is longer than a predetermined value, the ECU **22** suspends the driving motor M to hold the operation of the conveying device **20**.

As illustrated in FIGS. **1** and **3**, antiscattering equipment **48**, **50** is arranged beneath the conveying path of the H steel **12**. The antiscattering equipment **48**, **50** includes supporting brackets **48**A, **50**A, which are horizontally arranged along the conveying path, and a plurality of antiscattering members **48**B, **50**B, which are arranged on the supporting brackets **48**A, **50**A along the conveying direction (the direction denoted by the arrow X). The antiscattering members **48**B, **50**B compose of a highly resilient (elastic) material such as a resin. The lower ends of the antiscattering members **48**B, **50**B are fixed on the supporting brackets **48**A and **50**A. As illustrated in FIG. **4**, the antiscattering members **48**B, **50**B are configured by a plurality of self-standing, elongated, flexible members such that they deflect to the conveying direction of the H steel **12** when it passes through them. The antiscattering members **48**B, **50**B illustrated in FIG. **1** thus prevent the projected shots on the lower surface **212**A of the H steel **12** from scattering therethrough.

As illustrated in FIG. **5**, the antiscattering members **48**B, **50**B are coupled to a second lifting and lowering device (a lifting and lowering means) **52**. In turn, the second lifting and lowering device **52** is coupled to the height sensor **32** through the ECU **22**. The second lifting and lowering device **52** is configured to have a winch. Based on the detection results of the height sensor **32**, the ECU **22** instructs that the second lifting and lowering device **52** lift and lower the antiscattering equipment **48**, **50** (see FIG. **5**) to the height level in which the top edges of them contact with the lower surface **212**A of the H steel **12**, as illustrated in FIG. **4**.

In this embodiment, the detection results of the height sensor **32** to detect the height level of the H steel **12** are used in the vertical motion of the antiscattering equipment **48**, **50** by means of the second lifting and lowering device **52** and the vertical motion of the air blower **30** by means of the first lifting and lowering device **36**.

In this embodiment, as illustrated in FIG. **5**, the downstream antiscattering equipment **48** and the upstream antiscattering equipment **50** that are located on the sides downstream and upstream of the conveying direction are coupled to each other through a synchronization mechanism **54**. The synchronization mechanism **54** includes a wire **54**B and a chain **54**C, both entrained on a pulley **54**A to couple the antiscattering equipment **48** with the antiscattering equipment **50** to interlock the vertical motion (the vertical displacement) of the antiscattering equipment **48** with the vertical motion (the vertical displacement) of the antiscattering equipment **50**.

Below the operation of the shot-blasting machine **10** will be explained, while the function and the advantage of the above embodiment will be explained.

As illustrated in FIG. **1**, when the H steel **12** in its H-like position (in which the web surfaces are in their lateral position) is carried in the shot-blasting machine from the service entrance **16**, the edge sensor **40** detects when both edges (the leading edge and the following edge) of the conveying direction of the H steel **12** pass through to rotate the conveying rollers **20**B to convey it to the conveying direction (the direction denoted by the arrow X). Based on the detection results of the edge detection sensor **40** and the setting velocity of the conveying roller **20**B (i.e., the conveying velocity of the conveying device **20**), if the ECU **22** determines that the H steel **12** is in a predetermined range on the conveying path along the conveying direction (the direction denoted by an arrow X), the blasting devices **24**A, **24**B and the air blower **30** are actuated by instruction from the ECU **22**.

Specifically, under the control of the ECU **22**, the operations of the blasting devices **24**A, **24**B begin immediately before the H steel **12** arrives at the blasting area where the shots are projected and are then completed immediately after the H steel **12** passes through the blasting area. Also, the operation of the air blower **30** begins immediately before the H steel **12** arrives at the blowing area where the air is blown and is then completed immediately after the H steel **12** passes through the blowing area. These controls inhibit unnecessary operations.

When the blasting devices **24**A, **24**B are actuated, the H steel **12** is shot-blasted by means of the shots projecting from the blasting devices **24**A, **24**B. As a result, some of the shots remain on the upper surface **112**A of the H steel **12**. Under this condition, the air blower **30** blows gas to the upper surface **112**A of the H steel **12** to blow away and to remove the residual shots therefrom. Namely, the residual shots can be removed without contacting the H steel **12** with any brushing means for brushing off the shots.

Because the air blower **30** is configured such that the direction of the streamline of the gas to be blown is downwardly inclined from the downstream to the upstream along the conveying direction, the gas is blown to the residual shots on the upper surface **112**A of the H steel **12** in the opposite direction of the conveying direction. Therefore, the shots on the upper surface **112**A of the H steel **12** can be efficiently blown away therefrom.

As described above, downstream of the blasting devices **24**A, **24**B and in the upstream direction of the air blower **30** in the conveying direction, the backing plate (the receptacle) **42**C for receiving and accommodating the shots that are blown off the upper surface **112**A of the H steel **12** due to the blowing of the gas from the air blower **30** and the screw conveyor **42**A are provided above the conveying path. With this arrangement, the case which the blown up shots return to the upper surface **112**A of the H steel **12** can be prevented or reduced.

With the shot-blasting machine **10** of this embodiment, the residual shots on the H steel **12** thus can be prevented or reduced even when the H steel **12** is subjected to a blasting (a surface treating), while it is conveyed in its H-like position.

To remove the shots from the H steel **12** in the conventional surface treatment machine, one possible configuration may incorporate a contact-type removal means for removing the shots, typically a rotating brush and a fixed scraper. Such a configuration, however, involves disadvantages in which the shots cannot be sufficiently removed if the removal means is worn; the distance between the H steel **12** and the removal means should be fine adjusted on a case-by-case basis; and unnecessary dust generates as the rotating brush or other removal means become worn. In contrast, the shot-blasting machine **10** of this embodiment is free from these disadvantages. Further, with the shot-blasting machine **10** of this embodiment, a worker's labor to manually remove the shots on the H steel **12** after projecting the shots can be eliminated or completed in a significantly shorter time.

As illustrated in FIG. **4**, the shots blown up on the backing plate **42**C convey from the center to both sides of the axial direction (directions denoted by arrows W**1** and W**2**) of the screw conveyor **42**A. The conveyed shots then fall out of the exhaust **142** at both sides of the screw conveyor **26**A in the bottom of the cabinet **14** (as shown in FIG. **1**). The shots that are blown up from the upper surface **112**A of the H steel **12** by means of the blowing gas from the air blower **30** then transfers to the circulating device **26**.

In the circulating device **26**, the shots that are conveyed to the lower side of the bucket elevator **26**B through the screw conveyor **26**A are then conveyed to the upper side of the machine **10** by means of the bucket elevator **26**B. The shots are then passed through the upper screw conveyor **26**D and the shot tank **26**E (both shown in FIG. **2**) such that they are fed from the shot feeders **28**A, **28**B (as shown in FIG. **1**) to the blasting devices **24**A, **24**B. In other words, the projected shots are circulated to the blasting devices **24**A, **24**B through the circulating device **26**. Further, because the feed rate of the shots to be fed from each shot feeder **28**A or **28**B (as shown in FIG. **1**) to the corresponding blasting device **24**A or **24**B can be variably controlled by adjusting a degree of opening of a gate, the appropriate quantities of the shots can be fed to the blasting devices **24**A, **24**B.

Also, in this embodiment, the height sensor **32**, which is equipped on the side of the service entrance **16**, detects the height of the incoming H steel **12** in its conveying condition. In response to a detection result from the height sensor **32**, the first lifting and lowering device **36** vertically moves the air blower **30** (as shown in FIG. **5**). The air blower **30** is thus positioned at the appropriate height level in relation to the height of the H steel **12** (see FIG. **1**) to blow away the shots on the upper surface **112**A (see FIG. **1**) of the H steel **12**.

Further, the height level of the lower end of the height sensor **32** is positioned to the same height as that of the lower end of the air blower **30**, while the vertical movement of the height sensor **32** gears or synchronizes with that of the air blower **30** through the gearing mechanism **38**. Therefore, positioning the lower end of the height sensor **32** to a height level on which it is free from a collision with the H steel **12** (see FIG. **1**) causes the air blower **30** to avoid colliding with the H steel **12**.

As illustrated in FIG. **1**, in this embodiment, the blowing port **46**A of the final blower **46** is located above the conveying path downstream of the air blower **30** in the conveying direction such that the final blower **46** can blow the gas toward the upper surface **112**A of the H steel **12**. With this configuration, even in the possible case in which the shots on the H steel **12** cannot be completely removed with only the blowing of the gas from the air blower **30** and thus the shots are still partially remained thereon, the residual shots on the H steel **12** may be removed by means of the blowing of the gas from the final blower **46**.

Beneath the conveying path of the H steel **12**, the antiscattering members **48**B,**50**B of the antiscattering equipment **48**, **50** are arranged to prevent the projected shots on the lower surface **212**A of the H steel **12** from scattering around the periphery of the machine. As described above, the antiscattering members **48**B, **50**B are configured by a plurality of self-standing, elongated, flexible members such that they deflect to the conveying direction (denoted by the arrow X) of the H steel **12** when it passes through them. Therefore, the scattering of the shots can be prevented, even if the width of the H steel **12** varies when it is conveyed in the H-like position. As illustrated in FIG. **5**, in response to the detection result from the height sensor **32**, the second lifting and lowering device **52** vertically moves the antiscattering members **48**B, **50**B. The antiscattering equipment **48**, **50** is thus positioned at the appropriately height level in response to the height of the H steel **12** (see FIG. **1**).

When the H steel **12** as shown in FIG. **1** conveys out from the shot-blasting machine and thus the ECU **22** determines that the time period in which H steel **12** on the conveying path is nonexistent is longer than a predetermined value in response to the detection result from the edge detection sensor **40**, the driving motor M is suspended by instructions from the ECU **22** to hold the operation of the conveying device **20**.

As described above, in this embodiment, the air blower **30** is configured such that the direction of the streamline of the gas to be blown is downwardly inclined from the downstream to the upstream along the conveying direction. This configuration is preferable in view of the efficiency of blowing out the shots on the upper surface **112**A of the H steel **12** (the workpiece to be treated). However, the orientation of the direction of the gas to be blown from the blower is not limited to this configuration. That is, the blowing gas from the blower may be configured such that the direction of the streamline of the flowing gas may be downwardly inclined, or it may be downwardly inclined toward the downstream along the conveying direction.

In the above embodiment, although the orientation of the direction of the blowing gas from the air blower **30** is controlled by adjusting the tilting angle of the nozzle **130** of the air blower **30**, it may be controlled by means of another configuration. For instance, a deflection plate may be arranged adjacent to the blowing port of the blower such that the orientation of the direction of the blowing gas may be controlled by adjusting the positions of the deflection plate.

Further, in the above embodiment, the backing plate (the receptacle) **42**C for receiving and accommodating the shots that are blown up from the upper surface **112**A of the H steel **12** and the screw conveyor **42**A are incorporated. This configuration is more preferable in view of inhibiting or preventing an event in which the shots that are blown up from the upper surface **112**A of the H steel (the workpiece to be treated) **12** are returning thereto. However, one embodiment eliminating both the backing plate **42**B and the screw conveyor **42**A may also be possible.

Also, in the above embodiment, the transferring mechanism **42** transfers the shots that are blown up from the upper surface **112**A of the H steel **12** by means of the blowing gas from the air blower **30** to the circulating device **26**. This configuration is more preferable in view of reusage of the shots that are blown up from the upper surface **112**A of the H steel (the workpiece to be treated) **12**. However, one embodiment eliminating the transferring mechanism **42** may also be possible. Although the shot-blasting machine (the surface treatment machine) **10** is preferably configured with the transferring mechanism **26**, one surface treatment machine eliminating the transferring mechanism may be established.

In the above embodiment, the first lifting and lowering device **36** vertically moves the movable portion of the side of the blowing port **30**A of the air blower **30**, the movable portion of the final blower **46**, and the height sensor **32**, while the second lifting and lowering devise **52** vertically moves the antiscattering equipment **48**, **50**. The respective portions to be vertically moved by means of the first and second lifting and lowering devices **36** and **52** may be configured such that they are vertically moved manually instead of by the lifting and lowering devices **36** and **52**.

In the above embodiment, the first lifting and lowering devise **36** vertically moves the movable portion of the side of the blowing port **30**A of the air blower **30** automatically, in line with the instructions from the ECU **22** in response to the detection result from the height sensor **32**. Instead of this configuration, an alternative configuration may be configured. For instance, an operator may manually input data for the detection result from the height sensor **32** to a terminal that is coupled to the ECU **22**. In response to the inputted data, the ECU **22** may then causes the first lifting and lowering devise **36** or other lifting and lowering means to vertically move the movable portion of the side of the blowing port of the blower.

Although the air blower **30** and other components are vertically moved in response to the detection result from the height sensor **32** in the above embodiment, an alternative embodiment may be configured. For instance, in response to the detection result from the height sensor **32**, the ECU **22** may predict an event in which the air blower **30** collides with the H steel **12** to suspend the driving motor M of the conveying roller **20**B. The ECU **22** may then generate an auditory or visual alarm (for instance, an alarm tone or an indication shown on a display) to urge the operator to readjust the height level by means of the first lifting and lowering device **36** (see FIG. **5**).

In the above embodiment, the ECU **22** actuates the blasting devices **24**A, **24**B and the air blower **30** when it determines that the H steel **12** is in the predetermined range along the conveying direction (denoted by the arrow X) on the conveying path, in response to the detection result from the edge detection sensor **40** and the setting velocity of the conveying roller **20**B (or the conveying velocity of the conveying devise **20**). However, an alternative embodiment may be configured such that the ECU **22** actuates the blasting devices and the blower when it determines that the workpiece to be treated is in a predetermined range along the conveying direction on the conveying path, in response to, for instance, a detection result on which the leading edge of the workpiece is detected by the edge detection sensor for detecting the edge of the workpiece along the conveying direction, pre-entered information about the length of the workpiece along the conveying direction, or the conveying velocity of the conveying device.

To more effectively inhibit or prevent the shots from remaining on the workpiece (the H steel **12** as in the above embodiment), as described above, the final blower (a further=blower) **46** is preferably provided. However, one embodiment eliminating the final blower may be possible.

To prevent the shots that are projected on the lower surface **212**A of the workpiece from scattering through therefrom, as described above, the antiscattering equipment **48**, **50** is preferably provided. However, one embodiment eliminating the antiscattering equipment may be possible.

In the above embodiment, the antiscattering members **48**B, **50**B are configured by a plurality of self-standing, elongated, flexible members such that they deflect the conveying direction of the workpiece when it passes through them. This configuration is preferable in view of accommodating different H steels **12** having various widths. However, in a case in which trajectories of the scattering shots from the workpiece can be expected, for instance, when shape of the incoming workpiece and its loading position in the width direction across the conveying direction are preliminarily specified, the antiscattering members may be a cover that is located such that it intercepts the expected trajectories of the scattering shots.

In the above embodiment, the second lifting and lowering device **52** vertically moves the antiscattering equipment **48**, **50** such that the top ends of the antiscattering members **48**B, **50**B are positioned on the height level at which those top ends contact to the lower surface **212**A of the H steel **12** (see FIG. **1**), in line with the instructions from the ECU **22** in response to the detection result from the height sensor **32**. Instead of this configuration, an alternative configuration may be configured. For instance, an operator may manually input data for the detection result from the height sensor **32** to a terminal that is coupled to the ECU **22**. In response to the inputted data, the ECU **22** may cause the second lifting and lowering devise **52** or other lifting and lowering means to vertically move the antiscattering equipment.

In the above embodiment, the ECU **22** suspends the driving motor M to hold the operation of the conveying device **20** when the ECU **22** determines that the time period in which the H steel **12** on the conveying path is nonexistent longer than a predetermined value, in response to the detection result from the edge detection sensor **40**. This configuration is preferable in view of an appropriate control for the operation of the conveying device **20**. However, an alternative embodiment may be configured such that the ECU **22** generates an auditory or visual alarm (for instance, an alarm tone or an indication shown on a display) to urge the operator to hold the operation of the conveying device when the ECU **22** determines that the time period in which the workpiece on the conveying path is nonexistent is longer than the predetermined value, in response to the detection result from the edge detection sensor **40**.

In view of the fact that an adequate feed of the shots to the blasting devices **24**A, **24**B is achieved, as described above, the embodiment preferably incorporates the shot feeders **28**A, **28**B that enable the variable control of the feed rate of the shots to be fed to the blasting devices **24**A, **24**B. However, an embodiment incorporating shot feeders for feeding shots to the blasting devices at a constant feed rate, instead of the variable shot feeders, may be possible.

Although the surface treatment machine in the above embodiment is the shot-blasting machine **10**, the surface treatment machine of the present invention is not limited to it, and thus may be applicable to such machines as a surface treatment machine for shot peening, or for surface treating with other abrasives.

Although the workpiece to be treated in the above embodiment is the H steel that has an H-like cross section, it may be a U-section steel with a U-like cross section or a J-section steel with a J-like cross section, or so forth. The surface treatment machine of the present invention may be applicable to a surface treatment in which the U-section steel conveys in its U-like position or the J-section steel conveys in its J-like position.

The forgoing descriptions are intended for an illustrative purpose rather than a limitation on the present invention. For instance, the above embodiments and their modifications may be adequately combined. Further, in consideration of the forgoing descriptions, those skilled in the art may be conceived various modifications without departing from the scope of the present invention recited in the claims.

BRIEF DESCRIPTIONS OF NUMERAL

10 Shot-blasting machine (Surface treatment machine)
12 H steel (Workpiece to be treated)
20 Conveying device
22 ECU (Controller)
24A, **24**B Blasting devices
26 Circulating device
30 Air blower
30A Blowing port
32 Height sensor
36 First lifting and lowering device
38 Gearing mechanism
40 Edge detection sensor
42 Transferring mechanism
42A Screw Conveyor
42 Bucking plate (Receptacle)
46 Final blower (Further blower)
46A Blowing port
48, **50** Antiscattering equipment
48B, **50**B Antiscattering members
52 Second lifting and lowering device (Further lifting and lowering device)

The invention claimed is:

1. A surface treatment machine for surface treating a workpiece to be treated with abrasives, the machine comprising:
- conveying equipment that forms a conveying path for conveying the workpiece along the conveying path in a conveying direction;
- a blasting device for projecting the abrasives to the conveying workpiece to be surface treated;
- a blower for blowing gas from the downstream of the blasting device along the conveying direction and above the conveying path toward the upper surface of the conveying workpiece;
- a height sensor for sensing a height level of the conveying workpiece, wherein the height sensor is located upstream of the blower and along the conveying direction; and
- a lifting and lowering device for vertically moving the blower in response to a result that is sensed by the height sensor.

2. The surface treatment machine of claim **1**, wherein the blower is configured such that the streamline of the blowing gas toward the workpiece is downwardly inclined from the downstream to the upstream along the conveying direction.

3. The surface treatment machine of claim **1** or **2**, wherein the machine further includes a receptacle for receiving the abrasives that are blown up from the workpiece by blowing the gas from the blower, wherein the receptacle is located above the conveying path in the downstream of the blasting device along the conveying path.

4. The surface treatment machine of claim **3**, the machine further comprising:
- a transferring mechanism for transferring the abrasives that are projected; and
- a circulating device for circulating the transferred abrasives into the blasting device.

5. The surface treatment machine of claim **4**, wherein the receptacle is integrated with the transferring mechanism.

6. The surface treatment machine of claim **3**, the machine further comprising:

an edge detection sensor for detecting when the leading edge and the following edge of the conveying workpiece passes therethrough, wherein the edge detection sensor is located upstream of the blasting device along the conveying direction; and

a controlling unit for actuating the blasting device and the blower when the controlling unit determines that the workpiece on the conveying path is in a predetermined range along the conveying path, in response to a detection result from the edge detection sensor and the conveying velocity of the workpiece by means of the conveying equipment.

7. The surface treatment machine of claim **3**, the machine further comprising a further blower for blowing gas from the downstream of the blower along the conveying direction and above the conveying path toward the upper surface of the conveying workpiece.

8. The surface treatment machine of claim **1** or **2**, the machine further comprising:

a transferring mechanism for transferring the abrasives that are projected; and

a circulating device for circulating the transferred abrasives into the blasting device.

9. The surface treatment machine of claim **1** or **2**, wherein a height level of the lower end of the height sensor is positioned at a height level that is the same as or lower than the height level of the lower end of the blower; and

wherein the surface treatment machine further includes a synchronizing mechanism for synchronizing the vertical movement of the height sensor with the vertical movement of the blower.

10. The surface treatment machine of claim **1** or **2**, the machine further comprising:

an edge detection sensor for detecting when the leading edge and the following edge of the conveying workpiece passes therethrough, wherein the edge detection sensor located upstream of the blasting device along the conveying direction; and

a controlling unit for actuating the blasting device and the blower when the controlling unit determines that the workpiece on the conveying path is in a predetermined range along the conveying path, in response to a detection result from the edge detection sensor and the conveying velocity of the workpiece by means of the conveying equipment.

11. The surface treatment machine of claim **1** or **2**, the machine further comprising a further blower for blowing gas from the downstream of the blower along the conveying direction and above the conveying path toward the upper surface of the conveying workpiece.

12. The surface treatment machine of claim **11**, wherein the further blower is configured such that the streamline of the blowing gas toward the workpiece is downwardly inclined from the downstream to the upstream along the conveying direction.

13. The surface treatment machine of claim **1** or **2**, the machine further comprising antiscattering equipment that is arranged beneath the conveying path of the workpiece and includes antiscattering members for preventing the abrasives that are projected to the workpiece from scattering through the lower surface of the workpiece.

14. The surface treatment machine of claim **13**, wherein the antiscattering members include a plurality of self-standing and elongated members, wherein each elongated member has the flexibility to deflect to the conveying direction of the workpiece when the workpiece passes through the elongated member.

15. The surface treatment machine of claim **13**, the machine further comprising:

a lifting and lowering device for vertically moving the antiscattering equipment in response to the sensing result from the height sensor.

16. The surface treatment machine of claim **1** or **2**, the machine further comprising:

an edge detection sensor for detecting when the leading edge or the following edge of the conveying workpiece passes therethrough, wherein the edge detection sensor is located on the upstream of the blasting device along the conveying direction;

controlling unit for suspending the operation of the conveying equipment when the controlling unit determines that a time period in which workpiece on the conveying path nonexistent is over that a predetermined value, in response to a detection result from the edge detection sensor.

17. The surface treatment machine of claim **1** or **2**, the machine further comprising a variable feeder for feeding the abrasives into the blasting device with a variable feeding rate.

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